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magazine

DECEMBER 1974

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December, 1974
volume 7, number 12

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Greenville, New Hampshire 03048
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ham radio magazine is
published monthly by
Communications Technology, Inc
Greenville, New Hampshire 03048

Subscription rates, world wide
one year, \$7.00, three years, \$14.00
Second class postage
paid at Greenville, N.H. 03048
and at additional mailing offices

Foreign subscription agents
United Kingdom
Radio Society of Great Britain
35 Doughty Street
London WC1N 2AE, England

All European countries
Eskil Persson SM5CJP
Frotunagrand 1
19400 Upplands Vasby, Sweden

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Communications Technology, Inc
Title registered at U.S. Patent Office
Printed by Wellesley Press, Inc
Framingham, Massachusetts 01701, USA

Microfilm copies of current
and back issues are available
from University Microfilms
Ann Arbor, Michigan 48103



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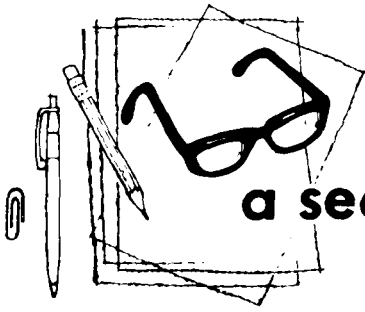
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a second look

by jim
fisk

Earlier this fall, an engineer from General Electric made news, if not the headlines, with a five-watt handie-talkie and an antenna fashioned from an old golf umbrella. His stunt? He had sent a Morse message through a communications satellite by depressing the mike switch on his handie-talkie, dramatically demonstrating the potential of space satellites for earth-bound search-and-rescue missions. I don't want to belittle his accomplishment, but many amateurs whose two-meter equipment was limited to small, hand-held fm transceivers used almost exactly the same technique to work through Oscar 6 during its early orbits.

Nevertheless, the long-distance transmission showed that simple radio gear and a collapsible antenna — plus a space satellite orbiting somewhere overhead — would enable persons in distress to summon help from any point on earth. In the demonstration, conducted for officials of NASA, Roy Anderson sent the Morse message from NASA Headquarters in Washington to the ATS-3 satellite in geostationary orbit over the mouth of the Amazon River, which in turn relayed the signals to GE's Radio-Optical Observatory near Schenectady, New York, which is equipped with a 30-foot dish.

After receiving the message, Observatory personnel transmitted voice signals back through the satellite to Anderson, showing that downed pilots, survivors of shipwrecks and others in need of help could readily receive a voice reply from a search-and-rescue station, acknowledging the SOS and providing rescue information.

Anderson, who holds the basic patent on locating vehicles by ranging

measurements from satellites, has proposed a global search-and-rescue system which would require only six geostationary satellites to provide worldwide coverage (except for the polar regions). The satellites would be monitored by three ground stations that could use ranging measurements to locate persons in trouble, and then dispatch assistance. The six satellites could routinely be used for other important activities since the search-and-rescue function would require less than 0.1% of the satellite's transmission power. By equipping future geostationary satellites with a modified antenna, reliable voice signals could even be transmitted from a person in distress to the monitoring station.

On the surface this sounds like a worthwhile proposal, one that could save hundreds, perhaps thousands, of lives. However, who decides what emergency situations should be relayed through the system? Or those that should not? Downed airplanes, foundering ships and other major disasters obviously qualify. How about a man and his family whose Jeep breaks down in the desert? Or a hunter lost in the mountains? The system couldn't possibly handle all the emergencies that occur on the earth at any one time, but human nature being what it is, if everyone is allowed access to the system, it would shortly be hopelessly clogged. On the other hand, not allowing everyone access to the search-and-rescue system defeats its whole purpose. Who is to make that possibly life or death decision?

Jim Fisk, W1DTY
editor-in-chief



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OSCAR 7 LAUNCH AGAIN DELAYED, due to continuing problems with Thor-Delta launch vehicle, but should be in orbit by the time you receive this issue. The new satellite won't be available for use for several days after it is finally launched, as it has to stabilize and undergo complex telemetry checkout -- after that, however, its round-the-clock operation will greatly increase satellite communicators' QSO time.

AMSAT Has Some Fine Slides of Oscar 7, other material for a first-class club program, available on request. Write to AMSAT, Box 27, Washington, D.C. 20044. HR Report will become the "official information source" for AMSAT news in an arrangement currently being worked out. Details will be announced shortly by AMSAT.

FCC COMMISSIONER LEE APPLAUDS AMATEUR SERVICE in "A Tribute and a Challenge," his banquet speech before the Quarter Century Wireless Association annual convention in Orlando, Florida. Lee's speech was both a review and a look forward. He had obviously done his homework, particularly with some of the people who are preparing for the 1979 World Administrative Conference of the ITU. He endorsed the proposals to eliminate sharing of the amateur bands with other services and to establish new bands at 10.1, 18.1 and 24 MHz, recognizing that a great deal of effort would be required before adequate support can be mustered for such far-reaching ideas to have any chance of success.

REPEATER AUTOMATIC TRANSMISSION of "public service" information is the subject of a recent FCC policy letter. The problem is that unrequested regular weather or time announcements can be interpreted as "broadcasting" and are thus illegal; any repeater with automatic time ID, weather or similar automatically transmitted information must discontinue it as soon as possible.

Repeaters May Still Provide this type information, but only on request. It's OK to dial up a phone company's time or weather with an autopatch, or program a repeater to transmit time and ID for logging purposes while it's being used.

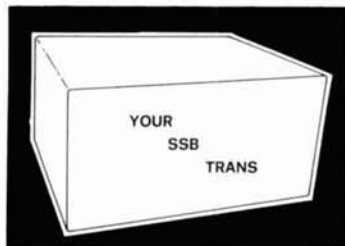
FCC "ORIGINAL AND 14 COPIES" REQUIREMENT attacked in Petition for Rule Making submitted by WB5BBH and WA5VTA on behalf of the Handicappers Information Net. Though there are good logistical reasons for continuance of this FCC requirement, there is no doubt that it stifles amateur participation in the rule-making process.

Ham Radio Magazine will help anyone without access to a copy machine meet the 14 copy requirement. Simply send your original response to Ham Radio, Greenville, NH 03048 and we'll make and collate 14 copies and send them First Class mail to the FCC, all for a less-than-cost \$1.00 per original page.

FCC LICENSE BACKLOG is on the increase again, after having been under control just a few months ago. Turn-around time for a "typical" amateur application is running about 25 days with any special considerations likely to extend those times considerably. FCC is working very hard to reverse the situation, has even started contracting for outside data-handling assistance.

RSGB PLANNING HISTORICAL UPDATE, and editor Ron Ham is looking for useful inputs particularly concerning the last ten years. RSGB's first half century (1913-1963) was covered in "World At Their Fingertips," and now the RSGB plans a sequel. Anyone with info to contribute should write to Ron Ham, Faraday, Greyfriars, Storrington, Sussex, England as soon as possible.

SEVERE RECESSION HITS JAPANESE ELECTRONICS INDUSTRY, with a number of firms reported to be threatened with failure. Parts industry is operating at an estimated 60% of capacity, with lay-offs and early retirements widespread. No firms directly involved with the amateur field have as yet been reported in difficulty, and it may well be the U.S. and European amateur markets that are keeping those firms healthy.



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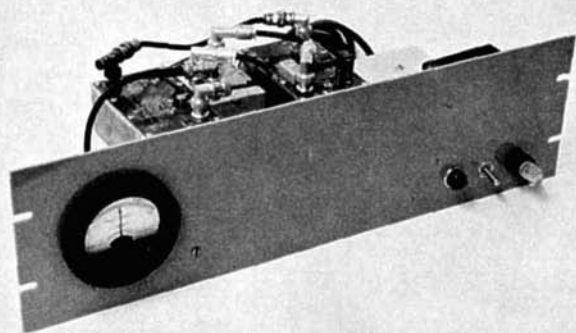
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frequency synthesizer for 220 MHz

Construction details
for a simple
frequency synthesizer
for the 220-MHz
amateur band

The business of generating a crystal-controlled 220-MHz signal is usually accomplished by using a high-frequency crystal oscillator followed by frequency multipliers. For example, you can use any of the systems described in **fig. 2**. The multiplier chain using an 8-MHz crystal (**fig. 2A**) has a familiar look because it is much like many two-meter systems that use surplus FT243 crystals. In fact, crystals between 8.148 and 8.222 MHz may be used for *both* 2 meters and 220 MHz (8150-, 8175- and 8200-kHz crystals in the standard FT243 series).

At about 20 MHz, fundamental-mode crystals are replaced (in availability) by higher-mode types. This means that the systems in **figs. 2A** through **2D** will probably use fundamental-mode crystals, in parallel-resonance, to control their oscillators. The systems in **figs. 2E** through **2G** use higher-mode crystals (3rd or 5th overtone) in series-resonance. As it happens, there are some surplus crystal types (CR-8/U and CR-24/U) that encompass this latter 18.333- to 27.5-MHz region.

By purchasing more expensive higher-mode crystals which operate in the vhf

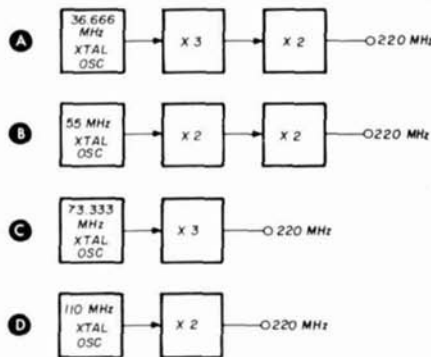


fig. 1. Frequency multipliers that use higher-mode crystals require less multiplier stages and provide greater separation between undesired harmonics.

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

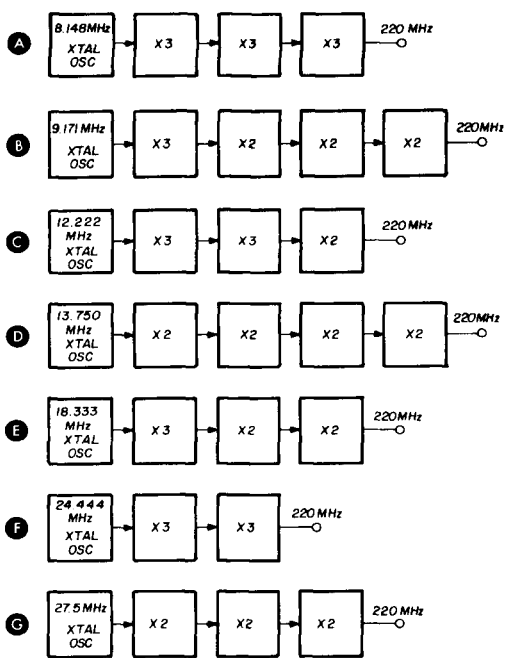


fig. 2. Several frequency-multiplying schemes using low-frequency crystals which are suitable for operation on 220 MHz.

spectrum, the number of multipliers can be reduced. Several systems of this type are shown in fig. 1. The use of vhf crystals has one important advantage: the Q of the tuned circuits in the frequency multipliers becomes less important because of the wider *percentage* difference between undesired, adjacent harmonics. That is, when you multiply 8.148 MHz by 27 to get to 220 MHz, there is also a probability of producing times-26 (211.8 MHz) and times-28 (228.1 MHz). If significant 211.8-MHz energy is present, you will no doubt be hearing from your neighbors trying to see the football game on Channel 12. On the other hand, multiplying to 220 MHz from 110 MHz involves only one step: times 2. While it's possible to have both 110-MHz and 330-MHz energy present in the output (times 1 and times 3), these other components differ by such large frequency *percentages* the output tank circuit usually discriminates against them.

There is also a difficulty which arises when using vhf crystal oscillators and few multiplier stages. This difficulty is in the crystal oscillator itself, and is in addition to the fact that the crystals themselves are not usually available at low cost. The vhf crystals used in the systems shown in fig. 1 are usually 5th-, 7th- or 9th- overtone types. To insure that the crystal oscillates on the desired mode, the oscillator circuit must have some built-in mode suppression to prevent oscillation at lower modes. The oscillator has a tendency to oscillate in lower modes simply because the Q of the crystal is generally higher in these lower modes (i.e., the series resistance at series resonance is lower).

For third- and fifth-overtone crystals a simple parallel circuit, resonant at the desired frequency of operation, formed by the crystal holder capacitance and an added inductor is often adequate. Such a circuit is shown in fig. 3. For 7th- and 9th-overtone oscillators it is sometimes necessary to add series-resonant traps at the frequencies of the undesired lower-frequency modes as shown in fig. 4. In short, 7th- and 9th-overtone crystals tend to have more complex oscillator circuits, requiring more critical tuning.

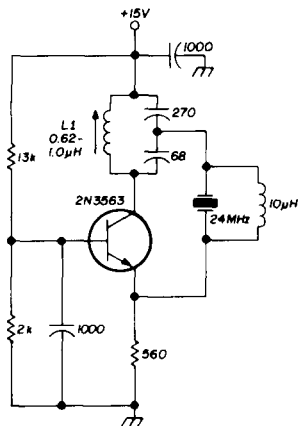
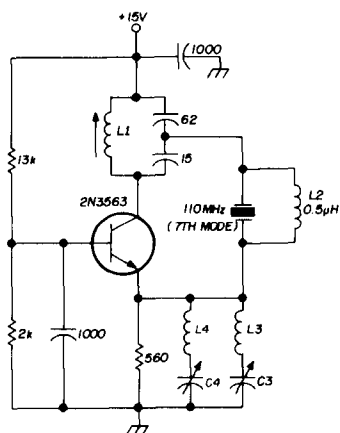


fig. 3. Crystal oscillator for third- and fifth-overtone crystals. Mode suppression is provided by the 10-µH inductor which, with the 4.5-pF holder capacitance of the crystal, is series resonant at 24 MHz.

A relatively new method of frequency multiplication that has become practical with modern frequency synthesis techniques is shown in fig. 5. With the newer ECL (emitter-coupled logic) ICs capable of frequency division up to 1 GHz, the 220-MHz band falls easily within the synthesis method of frequency multiplication. The particular system shown in fig. 5 uses a divide-by-ten from a 220-MHz vco and a 22-MHz crystal oscillator, but the choice of multiplication ratio is almost arbitrary with this method. The primary requirement for being able to multiply by N is that you find a way to digitally divide by N. Since, at least at lower frequencies, N can be any integer, frequency multiplication by even large prime numbers is possible.

For an actual circuit look at the times-10 multiplier shown in fig. 6. Here, a Fairchild 95H90 (U3) is used to divide



- C3- series resonant at approximately 5/7(110 MHz), 1 μ H and 0.6-10 pF
- C4- series resonant at approximately 3/7(110 MHz), 2.2 μ H and 0.6-10 pF
- L2 0.5 μ H (parallel resonant at 110 MHz with 4.5-pF holder capacitance)

fig. 4. In crystal oscillators designed for 7th- and 9th-overtone crystals it is often necessary to include series-resonant traps at the frequencies of the lower, undesired modes. In this circuit L3-C3 are resonant at 5/7 the output frequency and L4-C4 are resonant at 3/7 the output frequency. Inductor L2 in parallel with the crystal holder capacitance is resonant at the desired output frequency.

the vco output frequency by 10. The 22-MHz output of the 95H90 is compared in phase with the output of the 22-MHz crystal-controlled oscillator. The phase comparator (U1) in fig. 6 is a

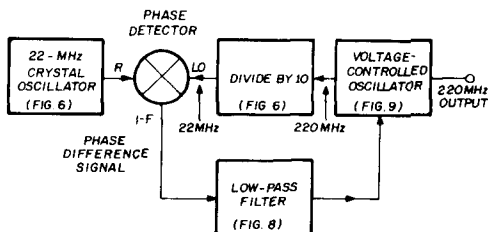


fig. 5. Basic phase-locked frequency synthesizer for 220 MHz. In this circuit a doubly-balanced mixer is used as a phase detector.

standard doubly-balanced mixer, manufactured by a number of firms. The doubly-balanced mixer can even be home made,¹ but there are several commercial units available for less than \$10. Fig. 7 shows how a typical doubly-balanced-mixer performs as a phase detector; note that the dc output voltage is only a few tenths of a volt.

The output of the phase detector is passed through a special form of active low-pass filter. This low-pass filter (fig. 8) is often called a tracking filter, and one form of it or another is almost always used in phase-locked-loop systems. The active low-pass filter shown here not only provides filtering, it also provides gain. The gain makes up for the low sensitivity of the doubly-balanced mixer used as the phase detector. The maximum gain of the active filter (at dc) is ten, the ratio of 1 megohm to 100 kilohms.

The output of the tracking filter is used to control the vco. The vco circuit and its buffer amplifier are shown in fig. 9. The vco is a type of Colpitts oscillator commonly used at vhf, modified to allow for voltage-tuning by means of diodes CR1 and CR2 — 6.8-pF varicaps (capacitance specified at a reverse bias of four volts). In this circuit they are operated in series with a reverse bias of five volts. Therefore, the total capacitance across

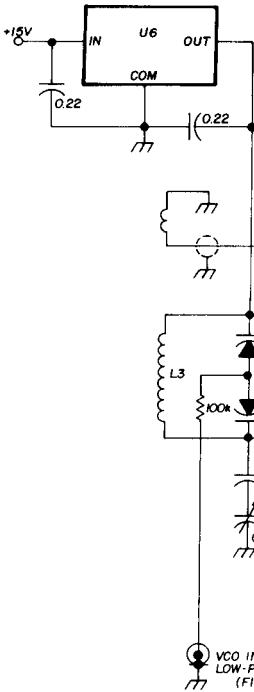
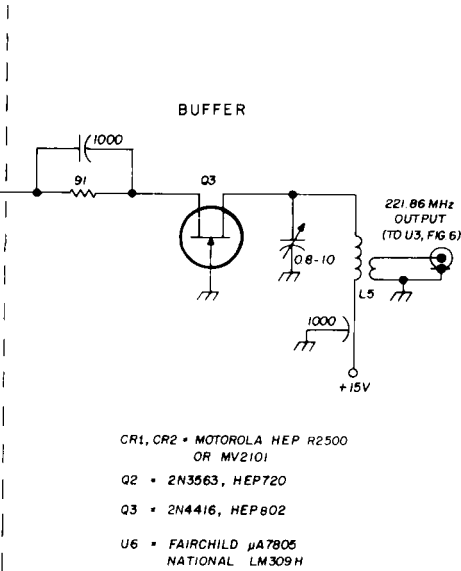


fig. 9. Voltage-controlled oscillator and buffer stages. U6 is a 5-volt regulator for the vco.



- CR1, CR2 • MOTOROLA HEP R2500 OR MV2101
- Q2 • 2N3563, HEP720
- Q3 • 2N4416, HEP802
- U6 • FAIRCHILD μ A7805 NATIONAL LM309H

- L3 3½ turns no. 20, 3/16" (4.5 mm) ID, 1/4" (6.5 mm) long. Output link is 1 turn on cold end of L3
- L4 5 turns no. 28, 1/8" (3 mm) ID, 3/16" (4.5 mm) long

- L5 hairpin of no. 16 wire, 1.5" (76 mm) long, 7/16" (11 mm) wide, spaced 1/4" (6.5 mm) above board. Output link is 1" (25.5 mm) long

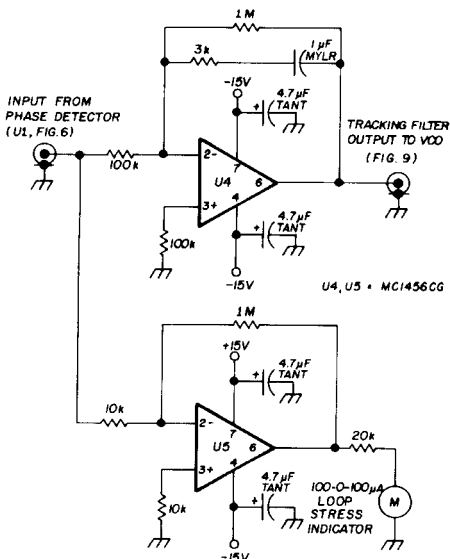


fig. 8. Active low-pass filter used in the 220-MHz frequency synthesizer. U4 and U5 are operational amplifier ICs.

aluminum boxes was actually built on pieces of copper-clad PC board the same size as the plates which come with the boxes. This allows for ease of soldering grounds and provides a near perfect copper ground plane.

alignment

Adjustment of the 220-MHz system can be done with a vtm and a grid-dip meter. It is best to take it one section at a time. First, with the gdo coupled to the crystal oscillator collector coil (L1), tune for maximum oscillation level consistent with reliable starting. The 22-MHz signal at the R port of the doubly-balanced mixer (as measured with an rf probe on the vtm) should be 0.5 volts rms.

With the vco input shorted to ground (reverse biasing the varicaps with a constant five volts), the vco should be adjusted for oscillation at 220 MHz (using

locking; this occurs at the points where the 95H90 is marginally triggering — even with the vco input grounded. It occurs as the vco gets too far from the center frequency of the buffer amplifier's pass-band and the output begins to fall. Less voltage will cause the counter to miss

carrier *are* visible. but they are all more than 50-dB down.

phase modulation

Finally, it must have occurred to some of you that it is possible to phase modulate the vco by simply operationally

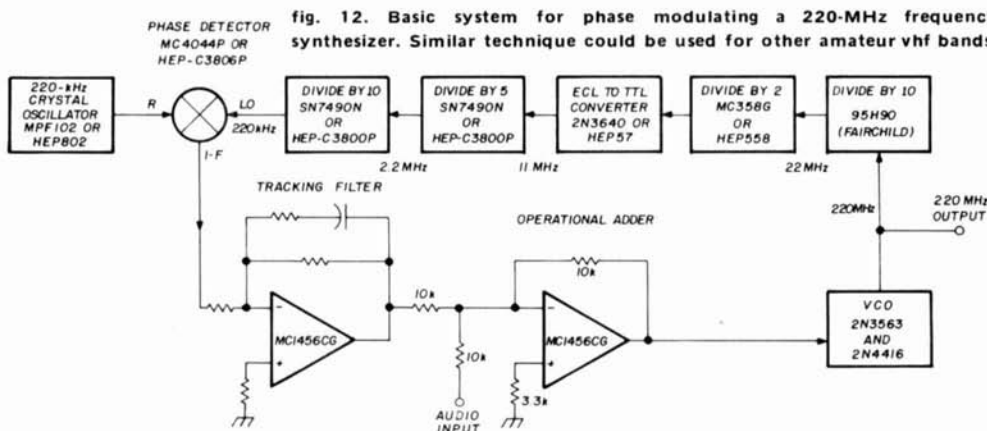


fig. 12. Basic system for phase modulating a 220-MHz frequency synthesizer. Similar technique could be used for other amateur vhf bands.

counts, and the net affect is a false lock indication.

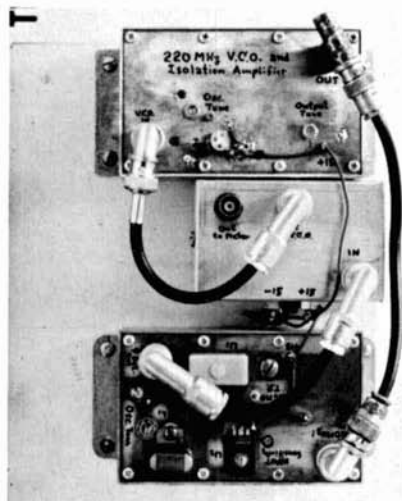
The final result of proper tuning and care in construction is a signal that looks like that shown in fig. 11. Note that sidebands spaced 22 MHz around the

adding an audio voltage into the vco (after the tracking filter). The only trouble with this is that the audio is only allowed to swing the phase $\pm 90^\circ$ (at most) as seen at the phase detector. This means the vco phase may be swung $\pm 900^\circ$ because of the divide-by-ten circuit between it and the phase detector — not much deviation. However, by going to three decades and a 220-kHz crystal, you can get up to $\pm 90,000^\circ$. If this seems to be bringing back the days of the old Serrrodyne modulation, it is— except that the times-1000 multiplier is easier. Fig. 12 shows a block diagram with suggested digital ICs in a system for phase modulation of this type.


references

1. William Ress, WA6NCT, "Broadband Double-Balanced Modulator," *ham radio*, March, 1970, page 8.
2. Everett Emerson, W6PBC, "Advanced Divide-by-Ten Frequency Scaler," *ham radio*, September, 1972, page 41.
3. Everett Emerson, W6PBC, "Circuit Improvements for the Advanced Frequency Scaler," *ham radio*, October, 1973, page 30.

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understanding Q

A discussion of
the Q of
LC tank circuits,
and its effect
on transmitters,
receivers and antennas

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In World War I some merchant ships were heavily armed but disguised to appear as unarmed trawlers. German submarines, not wanting to expend an expensive and scarce torpedo on a mere merchant vessel, would surface to sink it with gun fire. Then the Q ship would drop its false sides, revealing mighty guns that would destroy the submarine. Maybe that's how Q got a reputation of being not only a deep mystery but also something not really on the up and up. Many of the references to Q in the literature have done little to dispel the confusion.

Q is a "figure of merit," every textbook tells. If it's good, why don't we use lots of it in the plate tank of a transmitter? Oh, no, say the books; too much Q will make the circuit inefficient! A contradiction? A high Q dissipates little power in the form of heat, but a high-Q antenna is to be avoided like a plague! Why?

A high-Q circuit is one with little resistance, one page of a text tells us; three pages later in the same book you read, "Use a high value of resistance in the circuit so as not to lower its Q." Which do you believe? High Q means a good flywheel effect. Flywheel? What has that got to do with electronics? Q concerns the relation of stored energy to released energy. Oh, so we measure the efficiency of lead-acid storage batteries by their Q? Seemingly, there's just no logic to Q!

There is logic, but you must have a clear

concept of the many faces of Q before that "logic" appears logical! Let's start with a look at **fig. 1**. **Fig. 1A** shows a basic LC circuit, one with provision for applying a momentary pulse of power to it. Although a battery and a switch are shown, the switch could be replaced by a vacuum tube pulsed into conduction by the application of a positive-going spike to its grid. Now glance at **fig. 1B** and imagine a very brief closure of the switch, with its reopening a tiny fraction of a second later. During the small period of time it was closed, energy flowed from the power source into the LC circuit. Because of this ability to accept energy, an LC circuit often is called a tank.

While considering this tank, let's see what the incoming current attempts to do and what it does, step by step. It attempts to flow equally through both legs of the tank. It can't, initially, for the very nature of inductive reaction in the inductance leg retards the effort of the current to traverse that path. But a portion of the current flows unimpeded into the capacitance leg, building up an electrostatic change in the form of excess electrons on the surface of the dielectric adjacent to the upper plate of the capacitor.

If it helps your understanding, you might say that an equal number of electrons flowed out of the dielectric next to the bottom plate, leaving an excess of *holes* there. That might sound more familiar to those of you who have become accustomed to thinking in terms of semiconductors.

While the electrostatic charge was accumulating in the capacitor, the current hadn't abandoned its attempt to flow through the inductor. It was slowly making its way down that leg. As it moved through the inductor, it created an inductive field which spread out from the coil. This field contained, in the form of electromagnetic lines of force, a portion of the initial energy supplied by the power source. As the initial energy pulse was very brief compared to the natural

period of the tank (the period = $1/f$, where f equals the frequency at which $X_L = X_C$), additional energy from the excess electrons accumulated on the capacitor's upper plate join in the attempt to push current through the inductor. In time, they succeed.

As these incoming electrons neutralize the excess of holes on the lower plate, current flow tries to stop. It can't, just yet. For as it falters, the inductive field collapses. The energy stored in it is returned to the coil, causing a continuing flow of current. But this flow has to stop, too. When it does, the excess electrons built up on the lower plate by the current flow caused by the collapsing magnetic field tries to return to the upper plate, which now has a deficiency of electrons.

This flow of electrons, a current slightly weakened by unavoidable losses, meets the same obstacles as did the initial flow through the inductor. Like the other it succeeds, and one cycle of oscillation has taken place in the LC tank. Then starts a new cycle of oscillation, duplicating the original cycle but less the pulse of energy from the external power source. Again the cycle is accomplished. But, this time, the magnitude of current flowing, the magnitude of electrostatic potential built up on the capacitor, and the magnitude of electromagnetic force built up in and returned from the inductor's field will all be less than previous cycles. This is where Q comes in.

circuit losses

Let's think about *why* those three magnitudes decayed. The decay was caused by losses. Where did the losses lurk? The capacitor leg is a good place to start. This is an imperfect world, and no insulator is perfect; therefore some losses came about from leakage across the insulation incidental to the capacitor. Even though the capacitor may have had silver plates, some ohmic losses were present. And the dielectric itself contributes to the loss total by requiring the expenditure of

some energy to rearrange its molecular structure in order to accommodate the excess of electrons (or holes) on first one plate and then the other. All of these losses are additive.

In the low-frequency (30 to 300 kHz), medium-frequency (300 kHz to 3 MHz) and high-frequency (3 to 30 MHz) ranges,

to the inductor to find the main cause of loss. Like the capacitor, it has certain insulation losses, divided between leakage and dielectric hysteresis. Unique to it, however, is the fact that not all the electromagnetic force stored in its field is restored to the inductor when the field collapses. Some of it is radiated, some of

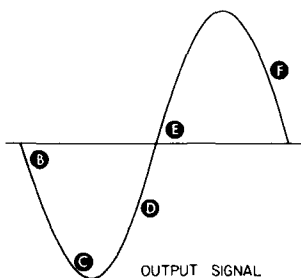
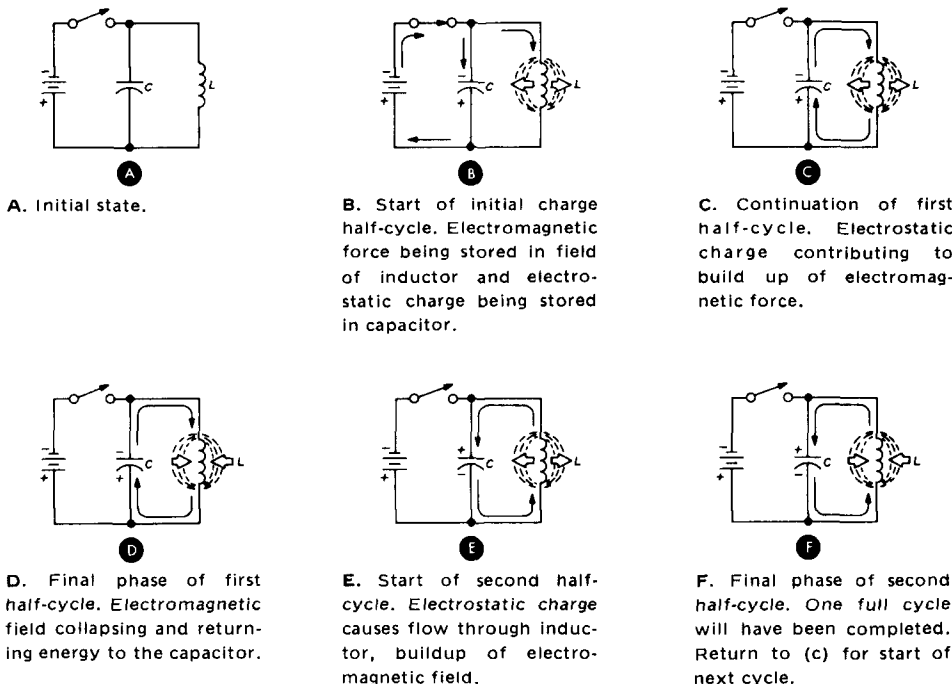


fig. 1. Oscillation cycle in an LC tank circuit.

the total losses associated with the capacitor are so low they usually are not considered. The capacitor accepts energy during one half-cycle and restores it to circulation during the following half-cycle with an efficiency approaching perfection!

Instead, for those frequencies, we look

it is transliterated into heat by hysteresis effect in nearby metallic and dielectric objects. All of these add up to a quite considerable sum of losses. So large, in fact, that we think of the inductor exclusively when we talk about losses that deteriorate Q in a high-frequency circuit.

You should not lose sight of the phenomenon of energy being extracted from the tank and stored in the electromagnetic field during one part of the oscillation cycle and then being returned to the inductor during the next half-cycle. If the inductor losses are low, then a very substantial portion of the stored power will be recaptured. Low losses contribute to a high circuit Q so we associate high Q with a high percentage of

stored power being returned to the circuit.

In considering the matter of stored and returned power, you should not overlook one striking difference between energy stored in a capacitor and that stored in the field of an inductor. The electrostatic charge stored in a capacitor can be retained there for long periods. A well-insulated capacitor will hold a high percentage of its charge for days. The electromagnetic force contained in the field of an inductor, however, can never be static. It *must* be in a state flux. The moment it ceases expanding from the impetus of current flowing through the coil, then it starts collapsing.

Usually all losses are lumped into one heap when we talk about Q. As these losses dissipate energy as a resistor dissipates energy, it's both convenient and accurate to label these several losses as resistive, to lump them as one, and to refer to the aggregate as the "equivalent resistance" of the circuit. That agreed upon, let's look at fig. 2, which shows circuits with lumped losses depicted as resistors. Fig. 2A has the resistor in series with the inductive leg. In such a circuit, losses are lower when the resistance is low. With losses low, Q is high, and the formula $Q = X/R$ applies. We usually have this circuit in mind when we talk about keeping Q high by cutting resistive losses.

Fig. 2B takes on more meaning when you glance on to fig. 2C. You know from experience that having a grid resistor that is too low in value results in circuit losses that reduce both signal strength and circuit selectivity. For this arrangement you'd use the Q formula $Q = R/X$.

With a little mathematical juggling, you can transform the circuit in fig. 2A to that of 2B or vice versa. As this article is concerned only with identifying Q, I'll refer you to any of the numerous texts that explain the mathematical manipulations.

Knowing that high Q relates to low circuit losses, let's talk about ways of increasing Q by decreasing effective resistance. We'll limit our consideration to circuits in the low-, medium- and high-

frequency spectrum. That means we'll be talking about only the inductive leg.

practical inductors

The turns of wire (usually) constituting an inductor provide a fertile ground for Q improvement. If you can have the same inductance with fewer turns (shorter wire length), it stands to reason that ohmic losses will be reduced. This suggests a ferrite core. Good, providing that the proper type of ferrite is used because ferrite is frequency sensitive. Ferrite can be very lossy so be sure that the type you select won't contribute more hysteresis loss than it deletes ohmic loss!

The magnetic field is another good spot for a bit of spade work. The field can be confined by winding the inductor in the form of a toroid. Although air-core toroids have been made (and once were very popular in TRF receivers), most now are made with ferrite or powdered-iron cores. Even better than the toroid is the cup-core or pot-core configuration. Although very effective in field containment, it's not convenient to work with, is rather expensive, and is not often used by amateurs.

If you prefer not using a confined-field type of inductor, you must be careful not to introduce excessive loss by mounting the inductor too close to other objects. Especially guard against getting it too close to shielding. Copper is bad enough, but iron and steel are much worse! An old rule-of-thumb is to keep the coil at least a half-diameter away from any shielding. Insulators also introduce loss so keep down the amount of insulating material in the inductor's field. Air-core coils have quite small losses, especially when wound with spaced turns, and ridged coil forms have lower losses than those which provide continuous support to the wire. Since some insulating materials have much lower loss than others, investigate and select the type that'll serve you best.

Thus far we've talked about the Q of the tank circuit by itself, but tank circuits just don't live that way in real life. You'll always find them associated with other

circuits or circuit elements. These associations inevitably tend to reduce the Q . This is too bad, for you make careful effort to keep the tank's Q high, then, when you put it to use, the Q is sliced down in a disheartening manner. However, don't let this situation keep you from designing and using a high- Q tank because any losses caused by a low Q in the basic tank are lost to you forever! On the other hand, the lowered Q that comes about from coupling the tank to other circuits may mean only that you've used

that was in common use 30 or 35 years ago.

With the link very loosely coupled to the tank coil, very little of the 72-ohm load will be reflected into the inductive leg of the tank. The tank's impedance (and Q), therefore, will be high. When the tank is tuned to resonance only a little plate current will flow. When tuning into resonance, a sharp and deep dip in plate current will be seen. When the link is moved into closer relationship with the plate coil it will reflect more resistance into the tank and its impedance (and Q) will decrease. Plate current will increase. The plate current dip, at resonance, will be broad and shallow. Power is being extracted from the tank and fed to the antenna. You don't regret lowered Q in such instances!

This circuit depicts another contributor to lowered Q . It's the vacuum tube supplying power to the tank. Every power-generating (or power-converting) device has internal resistance. The vacuum tube is no exception. Its resistance is in parallel with the tank, as shown in **fig. 2B**. The Q of the tank circuit, therefore, is lowered.

flywheel effects

While looking at the circuit of **fig. 3** let's think about another aspect of Q , the flywheel effect. The vacuum tube, unless it's operating class A, does not supply a steady flow of power into the plate tank. Instead, the power is applied in pulses. As the tank is tuned (synchronized) to the frequency (repetition rate) of the pulses, a burst of power is fed to the tank in such a time relation that it is in phase coincidence with the power circulating within the tank. To illustrate, at the moment when the top plate of the capacitor is providing its excess electrons to reinforce those pushing their way down through the inductor, the plate of the tube also is providing a pulse of current to further reinforce the flow.

You'll recall from the foregoing discussion that, unless "recharged" from an external power source, each reversal of

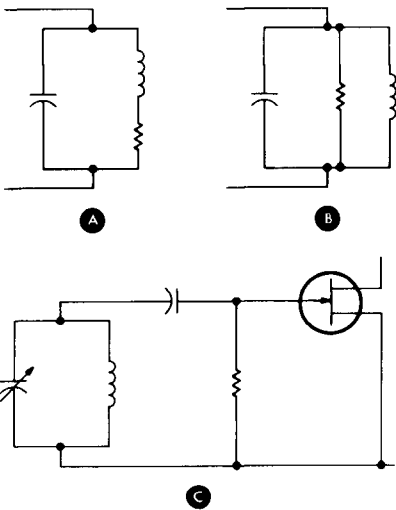


fig. 2. Resistance in practical LC circuits. Series resistance in (A) and parallel resistance in (B) are contributed by the LC components used in the circuit. Resistance in (C) is gate resistor of following fet stage.

power from the tank, used to excite a following stage or to be radiated from an antenna. So it was not lost, just transformed.

Let's look at a circuit that lowers Q yet serves a desired purpose (**fig.3**). This is the plate tank circuit of a transmitter. It's coupled, by means of an adjustable pick-up link, to an antenna through a 72-ohm transmission line. We'll assume that the line is matched to the feedpoint of a resonant antenna so there'll be a 72-ohm resistive load presented to the pick-up link. This is a form of output coupling

the oscillating electron flow in the tank circuit results in less current and less voltage than the preceding one. Nevertheless, there is a current flow and there is a voltage developed. This phenomenon, the fact that current continues to flow after the initiating energy pulse has been cut off, is known as the flywheel effect. It is desirable that there be a very minimum of deterioration of power circulating in the tank between energy pulses because any drop in power is conducive to the generation of harmonics.

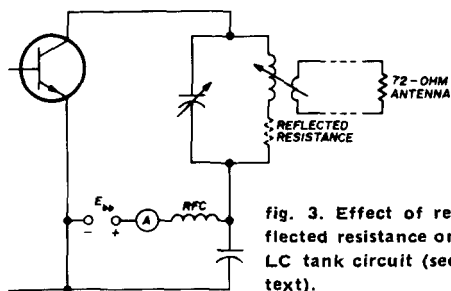


fig. 3. Effect of reflected resistance on LC tank circuit (see text).

Also touched upon previously is the fact that low circuit losses tend to keep the circulating current constant. This leads to the conclusion that low losses indicate high Q which, in turn, means good flywheel effect.

loaded and unloaded Q

Now, let's take up the matter of unloaded and loaded Q. It's not complex. The tank circuit, isolated from all else exhibits unloaded Q. When you associate it with anything else, the Q will deteriorate; this is loaded Q. Usually loaded Q refers to the Q at some stipulated load and the total load is often made up of several contributory loads.

Thus far I've talked about tank circuits in relation to transmitters. There's a reason for this. With the meters associated with a well-designed transmitter you can observe the effects of changes in Q and the manipulations that cause changes in Q. This is not so easily done in receivers.

Before leaving transmitters, let's con-

sider the importance of Q. The prime purpose of a transmitter is to produce a signal on one selected frequency. It is not desired to produce signals on harmonics of that frequency or upon any other spurious frequency. It's unfortunately true that all efficient generators of radio-frequency power tend to generate something other than a pure sinusoidal wave; they generate waves rich in harmonics. A high-Q tank circuit introduces a healthy element of selectivity into the situation. The tank selects the desired frequency, passes it, and rejects (to a degree) all others including those troublesome harmonics. So, following an active device (vacuum tube, transistor, etc.) in an rf circuit we like to insert a tank circuit of moderate Q.

Why "moderate" Q? Let's go back to fig. 1. You'll recall that, as this is a resonant circuit, $X_L = X_C$, and therefore if L is reduced in an effort to raise Q by reducing the length of wire in the inductor, C must be made larger to restore resonance. Circuit power remains unchanged. To accommodate this power, a tremendous store of electrons must accumulate on one plate of the capacitor. As the circuit oscillates, this great store of electrons must flow through the inductor to reach the other plate, creating a much heavier current flow than would have been the case had the capacitance been less and the inductance greater. The heavy current encounters some ohmic resistance in the coil, which results in the generation of heat. For heat, read, "unretrievable loss of radio-frequency power." Not only is power lost, but the resultant heat often damages the coil and adjacent components. So, you see, the effort to increase efficiency by going too enthusiastically after high Q can lead to greatly reduced efficiency. Here, as in many other aspects of life, moderation is the keyword!

receiver selectivity

In association with receivers, Q performs perhaps an even more important role than in transmitters. Although the

growing use of filters (active, crystal, mechanical and ceramic) for setting the ultimate selectivity of a receiver has taken over a function in fixed-frequency circuits that was once reserved for high-Q LC tanks, there are applications for which no better alternatives have been found.

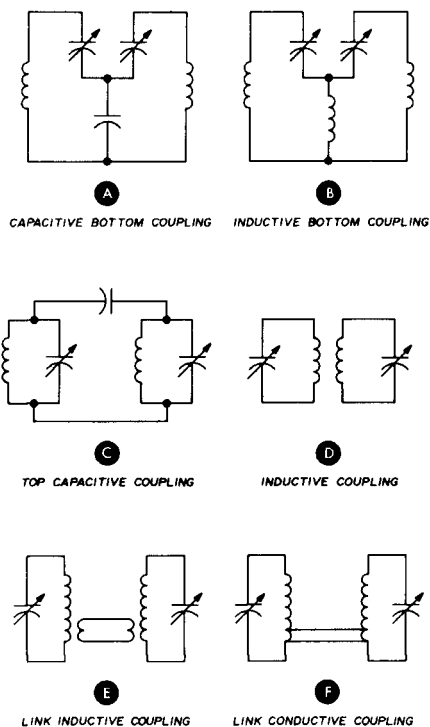


fig. 4. Common methods of coupling LC tank circuits.

These are in the tunable section of a receiver.

Whether a receiver's circuit is the classic TRF, the conventional superheterodyne with a fixed intermediate frequency, or a superheterodyne with semi-tuned input and variable i-f, current practice involves the use of LC circuits to establish a certain degree of selectivity.

Ideally, a receiver should have all needed selectivity before the first active device. Whether that active device is a vacuum tube or a transistor, it deteriorates the performance of the receiver.

Why? Because, with the possible exception of the beam-deflection tube, it introduces a degree of non-linearity. Non-linearity means intermodulation products can be generated when a strong undesired signal is present along with the desired signal. Once generated, these products are very difficult to cope with. So you'd like to eliminate that strong undesired signal before it reaches an active device. This calls for highly-selective tuned circuits. One way of getting these is by using LC circuits of sufficiently-high Q.

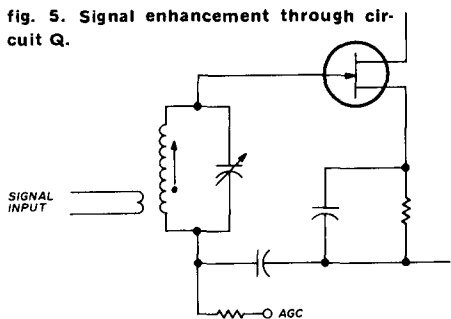
Only by the use of superconductivity can a single LC tank achieve such a remarkable Q, but cryogenic superconductivity is expensive so its use is limited almost exclusively to receivers for reception of signals from outer space. The designers of ordinary receivers must look to other means of achieving selectivity. Fortunately, a ready solution lies in the fact that the Q of two or more cascaded circuits are multiplicative. For example, if you have two cascaded tuned LC circuits, each with a Q of 10, the total Q of the chain is 100. Add another like circuit, and the total Q becomes 1000. This phenomenon permits achieving the high Q needed for reasonable selectivity but does so at the cost of requiring a multiplicity of tuned circuits, circuits that must be ganged and tracked for convenience in tuning. Each of these tuned circuits introduces some unavoidable losses, but it's a price you must pay.

There are many ways of cascading tuned circuits. Each has its proponents, but there seems to be little difference in their performance. Several of the many available circuits are shown in fig. 4. Two bottom-coupled circuits appear in 4A and 4B, and 4C shows top-coupling. Conventional inductive coupling is illustrated in 4D. Link coupling appears in 4E, with a variant in 4F. The choice of which circuit to use seems to lie with consideration of physical rather than electrical characteristics.

The magnitude of Q needed to achieve a specific amount of selectivity, say, 6-dB down at 10-kHz bandwidth, varies

with the frequency of the signal being processed. When bandwidth is an appreciable fraction of the signal's frequency, selectivity can be had with reasonable Q . On the other hand, if the bandwidth is very small in relation to the frequency, extremely high values of Q are needed.

fig. 5. Signal enhancement through circuit Q .



Other than the matter of selectivity, there's another aspect of Q that's important to the receiver designer. It concerns the voltage presented to a vacuum tube's grid or an fet's gate. Look at fig. 5. If a voltage e is induced from the adjacent link into the inductive leg of the tank, the magnitude of the voltage available between the grid and cathode of the tube will be e times Q . Therefore, high Q in receiver tank circuits contributes to the overall gain of the receiver.

antenna Q

When we consider Q in relation to antennas, several factors must be kept in mind. Usually, the ohmic resistance (and, therefore, the ohmic loss) is so small it is swallowed by the much greater "radiation resistance" of the antenna. Quotes are used to head off any assumption that the term has anything to do with real resistance. An antenna, to serve its purpose, radiates radio-frequency power. A resistor will transliterate radio-frequency energy into heat. Each disposes of power so they have a common element of action and the power could be measured in watts by the formula $W = I^2 R$. In a resistor true resistance is used in the formula. For the antenna, however, we create an imaginary

resistor which, if it existed, would consume the same amount of watts. For example, if a radio-frequency current of two amperes were fed into a 50-ohm resistor, 200 watts of power would be dissipated in the form of heat. If that same two-amperes of current were fed into an antenna and 200 watts of power were to be radiated into space (less that tiny bit lost in heat because of the small ohmic resistance), then we could conclude that the antenna's "radiation resistance" was 50 ohms.

It would appear that the higher the radiation resistance, the greater (for a given amount of antenna current) would be the radiated power. Unfortunately, that radiation resistance appears as a series resistance in the equivalent circuit of the antenna. What's it going to do to the antenna's Q ? Lower it, of course! From these considerations we can conclude that low- Q antennas are desirable, but that's true only when the low Q comes about because of high radiation resistance and not because of high ohmic resistance, high losses or any of the other factors that can lower Q .

summary

In preparing this article, I've intentionally avoided the more conventional approaches for presenting facts relating to Q . There are many excellent texts that deal with such aspects in a thorough and rigorous treatment. I have found *Radio Engineering*, by F.E. Terman¹ especially useful and recommend it highly.

What I've tried to present is an easily-read but factual identification of Q , an account of how it is achieved and enhanced in a circuit, and a limited number of examples of how optimum values of Q are used to accomplish the desired results in transmitters, receivers and antennas.

reference

1. F. E. Terman, *Electronic and Radio Engineering*, McGraw-Hill, New York, 1952.

ham radio



making your
Collins 75A4
perform like new

How to
clean up
the all-too-common
tuning problems
of an
old but popular
receiver

Many amateur radio operators believe the Collins 75A4 to be the best amateur receiver ever made. Particularly for CW use, there is much truth to this. Unfortunately, the 75A4 is long out of production and—for some, at least—out of style.

Some of the reasons for this fine receiver's going out of style include: Size, weight and (relatively) high power consumption, old-fashioned appearance (black crackle, square corners), not set up for transceive operation, not equipped for break-in muting, vacuum tube instead of solid-state design, objectionably high noise figure, especially on 10 and 15 meters, and insufficient dynamic range and front-end selectivity.

Of these factors, the latter two are true of *all* receivers, no matter what their vintage, but the 75A4 actually does better with them than almost any current receiver! The noise figure and dynamic range problems have been attacked before,¹ and a good preamp can help the former at the expense of the latter. Another factor, one of the most frustrating and yet most easily overcome, is the age-connected problem of stiff tuning and

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frequency jump. Solving this difficulty is the subject of this article.

The 75A4 is at its best as a CW receiver, and CW requires delicate and smooth tuning. As 7A4s age, however, many begin to get stiff and require irregular torque on the tuning knob and some may jump frequency a kHz or two even while not being tuned. Both of these problems have their cause in the permeability-tuned oscillator and dial assemblies. Many amateurs have learned

to live with sticky tuning, at least up to a point, but frequency jump is intolerable. It is probably safe to say that these problems account for many of the 75A4s being offered on the market today.

Some discussion of the causes of frequency jump was given in the previously cited article. It is now believed that the two problems are inter-related, and that if sticky tuning is tackled first, the frequency-jump problem will usually disappear along with it.

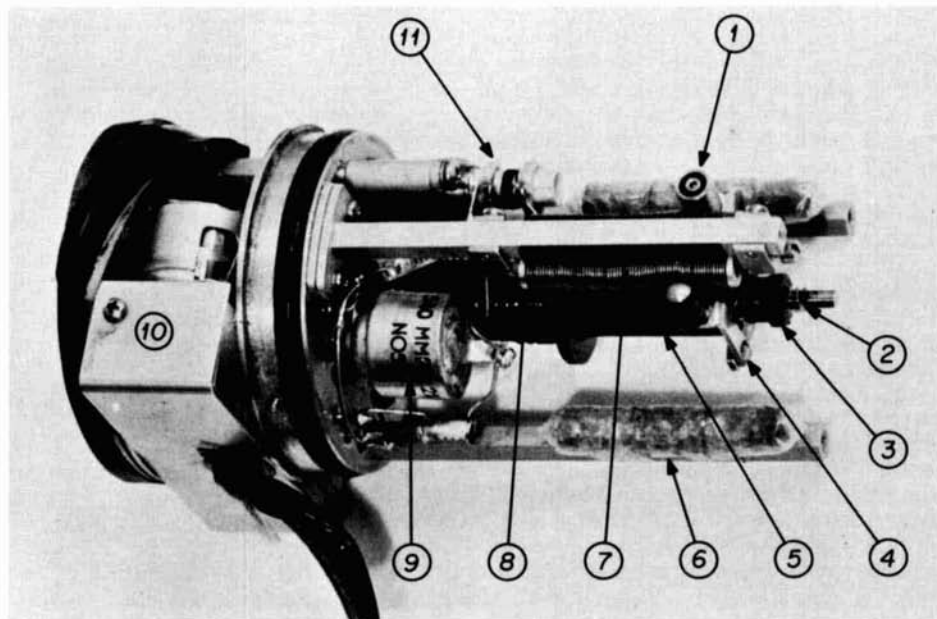


fig. 1. Inside the Collins 75A4 permeability-tuned vfo (PTO). The numbers identify the critical parts of the PTO assembly, described below.

1. Cam idler wheel, which rides on cam stack to control idler.
2. Lead screw, whose rotation moves the tuning slug through the tuning coil.
3. Lead-screw lubricating washer; should be saturated with oil.
4. Cam idler assembly, whose movement makes minor adjustments in oscillator tuning linearity.
5. Tuning slug.
6. Moisture-absorbing silica-gel sacks, blue when dry and pink when saturated.
7. Cam stack, used to compensate for non-linearities in oscillator tuning.
8. Tuning coil, wound with varying pitch to approximate linear tuning with slug travel.
9. Padding capacitor, which establishes oscillator tuning range.
10. Cover for tube bases and non-critical PTO components.
11. Trimming inductor, used to set the PTO tuning range to precisely one MHz for ten turns of the lead screw.

The bulk of the problem exists inside the PTO (fig. 1), and this is where you are going to have to go. Pay no attention to the manufacturer's caution about not breaking the seal of the PTO—these units were never hermetically sealed, even when brand new. They could breathe through the bearings and, perhaps, the rubber O-ring. Moisture-laden air, breathed in a little at a time each time the receiver was turned off and cooled down, usually turned the silica-gel sack pink within the first year's operation—and that was a long time ago. If moisture is a worry, as it might be in a basement shack or in a particularly humid part of the country, you could let the receiver run around the clock (bad from the energy point of view). Better, install a 7½-watt, 115-volt pilot lamp near the PTO, wired directly to the power line, and let it run all the time to keep the PTO warm. At any rate, moisture is not a problem with 99.9% of the 75A4s around, but sticky tuning is present to some degree in almost all of them.

This operation will be a painful one for anyone who doesn't like working with tools. Assuming only the usual number of minor problems along the way, you can expect the complete job of removal, repair and reinstallation of the PTO will consume the better part of a day. If your time and patience are too thin, you might try a partial job—but then don't expect miracles.

pto removal

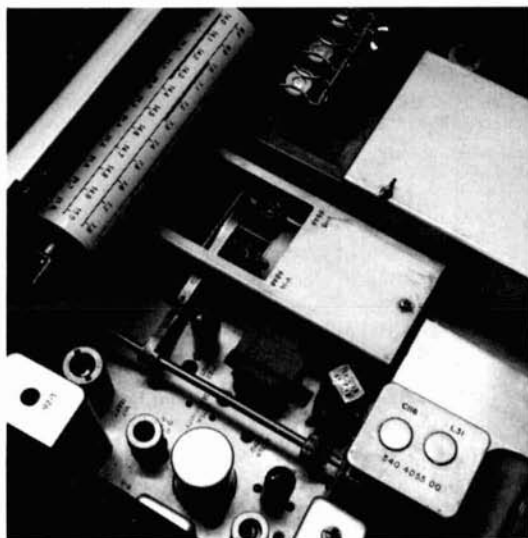
The first step (after taking the receiver out of the cabinet) is to set the tuning dial to 14.000 MHz. Next remove the vernier knob, mounting plates, ring gear and pinion. Put the metal parts into a half-pint jar of mineral spirits to soak, or better, clean them in an ultrasonic cleaner if you happen to have one. Make sure all dried grease is removed before you take out the parts and dry them. Set up a row of saucers or ash trays so that all the small hardware can be placed in them in sequence as it is removed. This not only

keeps them from getting lost, but is also a nice memory jogger when reassembly time comes.

From the top of the receiver remove the tuner dust cover, top and side screws of the PTO rear cover plate, and set screw and spring of the passband-tuning bronze band. Loosen the two set screws of the tuning shaft, immediately to the rear of the flexible coupling.

Remove the bottom plate from the bottom of the receiver. On the middle-bracing chassis cover plate remove the front two screws and loosen the rear two screws. This will permit the plate to be tilted so the PTO can be pulled out of its shaft coupler when the time comes. Make a sketch of the PTO connections and mark the chassis with a felt-tipped pen to facilitate reconnecting the wiring correctly when the unit is reinstalled. Unsolder the three power leads and the coax.

Pull out the PTO. The first thing to examine and repair is the tuning-shaft grounding wiper. This is the small L-shaped arm at the front, secured by two tiny Phillips-head screws. Its purpose is to provide a good ground return on the shaft



Inside the 75A4. The PTO is hidden by the square cover although the two 6BA6 oscillator tubes, V14 and V15, are clearly visible.

so that rf currents do not have to circulate through the front bearing. When the receiver is new, this wiper rides on the polished finish of the shaft. However, continued use may have caused the shaft to gall at this point—check it with your fingernail. Roughness here can be a major contributor to sticky tuning, so if the shaft is rough loosen the screws, bend the wiper slightly forward so it rides on a smooth portion of the shaft, and apply a touch of grease to the contact point.

lubricants

There are a lot of misconceptions about lubricants. For purposes such as this one, plain axle grease and *3-in-1 Oil* are well up on the list. Axle grease is not as strange a choice as it sounds, as pressures (i.e., pounds per square inch) at some contact points can become very high and axle grease is very good at staying put. For those who want something better than axle grease, Aero Shell 7 — a general-purpose aircraft grease—is excellent. However, it is hard to find, expensive, and sells in five-pound (minimum) cans. Shell calls it a “Microgel Diester Synthetic,” and it has an operating temperature range of -100 to +300°F. Silicone grease is not good for this purpose because of its inferior high pressure performance.

inside the pto

Now comes the moment of truth! ignoring the red-lettered warning decals, remove the screws holding the PTO cover and carefully slide it off. Examine the PTO assembly, noting the locations of the various components identified in fig. 1. Drop a few drops of *3-in-1 Oil* on the front bearing, on the rear felt washer, and on the cam rollers. Put a dab of grease in

the rear sleeve bearing (inside the rear of the PTO can). Rotate the tuning shaft back and forth a few times—it should be easy to turn at this point, even with greasy fingers. Work the cam followers in and out about an eighth-inch (3-mm) or so and lubricate them. Grease the cam surfaces. You can now replace the PTO cover.*

reassembly

Replace and reconnect the PTO. Oil the turns counter, located between the PTO and the front panel. It should be possible, from the front panel, to turn the dry shaft with bare fingers. Grease the vernier knob assembly, gears and bearings, and remount the knob. Reset the knob to 14000 kHz, using the crystal calibrator to make sure the receiver is actually *tuned* to 14000 kHz, and try it out. Feels like a new receiver, doesn't it?

frequency jump

If your 75A4 was one of those that suffered from this annoying problem before, it should be gone now. The explanation is that the cam follower in a dried out, sticky PTO no longer rode easily on the cam. Instead, when the cam pitch changed slightly the follower hung up on dust off the cam, later dropping into proper position and causing that annoying jump in frequency.

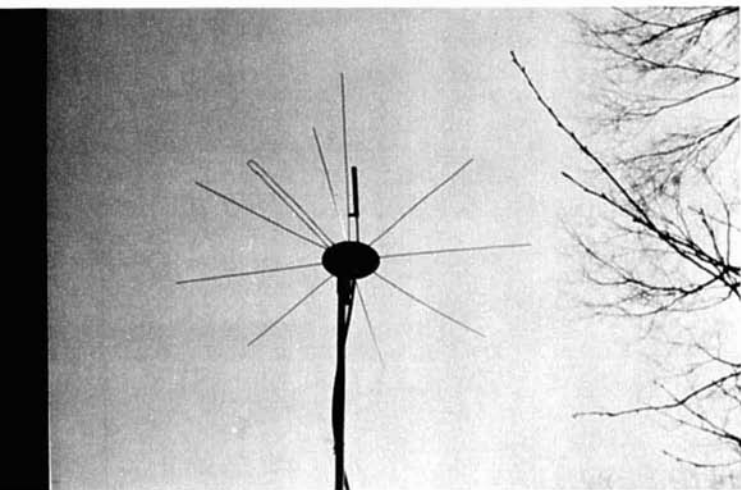
One final caution. Keep your eyes open, both inside the PTO and around the drive train and dial mechanism, for dried grease, dirt, metal chips, galled surfaces, loose rivets or screws, or misaligned shafts or bearings. These can all be taken care of much more easily now, when the receiver is all apart, than they can late some night during the middle of the DX contest!

*A previous article on servicing Collins 51J series PTOs² has several worthwhile suggestions that apply to Collins 75A-series receivers as well. One of these is to replace the relatively unreliable tubular ceramic bypass capacitors in the PTO with disc ceramics, an easy job with the PTO removed from the receiver. editor

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ham radio



circularly-polarized ground-plane antenna for satellite communications

Combining the characteristics of two popular satellite antennas to yield a novel design optimized for satellite communications

Dale W. Covington, K4GSX, Marietta, Georgia 30060

Signal fading is a frequent source of frustration in amateur satellite communications. Much of the fading can be attributed to foibles in the patterns of simple ground-station antennas. The search for a stationary antenna with improved pattern characteristics led to the development of a circularly-polarized ground-plane antenna. This is a novel design that combines the best antifading features of two antennas often used in satellite work — the turnstile and the tilted-vertical, ground plane.¹

The discussion of the circularly-polarized, ground-plane antenna has been organized in the following fashion: Two theoretical sections present the basic concept and the computed patterns. The next section examines certain problem areas which arise in achieving a practical antenna. Details of the construction, tune-up and operation of a two-meter prototype provide concrete illustrations of the design concepts.

the basic idea

Before plunging into the theoretical aspects of antenna design, let's list some general requirements placed upon fixed antennas used to communicate with OSCAR satellites. As indicated in the *appendix*, undesirable fading can be reduced if the ground-station antenna provides a good response overhead while focusing additional energy near the horizon where path losses are greater. Furthermore, vertical plane patterns should be independent of bearing azimuth, and the antenna should preferably be circularly polarized. The basic concept developed below is that each of these requirements is approached by a simple arrangement of two tilted-vertical antennas.

In discussing satellite applications for fixed antennas, it is convenient to map the far field radiation on an imaginary hemisphere centered over the antenna. Grid coordinates locating any observation point on the hemisphere are designated by an azimuth angle and an elevation angle. **Fig. 1A** shows a far field hemisphere over a quarter-wavelength vertical erected above a perfectly conducting ground plane. Vectors indicating the electric field magnitude and direction at selected points on the hemisphere are represented by arrows.

While the magnitude of the electric field is independent of azimuthal bearing, it does vary with elevation angle. Notice how small the vectors become as elevation angles increase. The conventional plot of this effect is shown in the vertical-plane pattern in **fig. 2**. Here the dotted line plots the declining field intensity at elevation angles near 90 degrees. The pattern null directly overhead can be eliminated if the vertical is tilted away from the normal. **The heavy solid line in fig. 2** illustrates the relative pattern for a vertical antenna tilted at a 45-degree

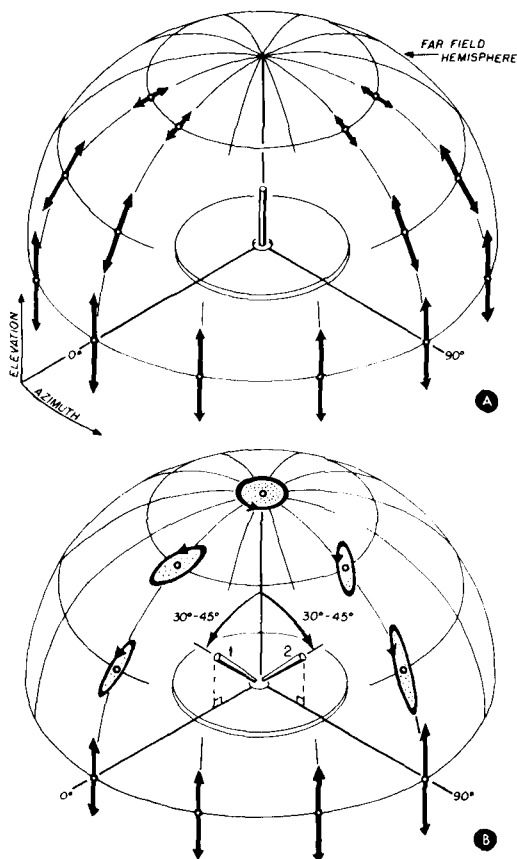


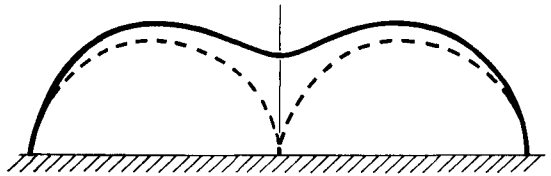
fig. 1. Isometric views of a single quarter-wavelength vertical (A) and two tilted verticals (B) above perfectly conducting ground planes. Grid coordinates marked on the far-field hemisphere locate directions in space above the antennas. Loci of the vector components of the radiated fields have been drawn at selected coordinate points.

angle. In fact, this latter pattern does a good job of meeting the first two requirements listed above for ground-station antennas.

Returning to **fig. 1A**, observe that the electric-field vector is confined to oscillate in a plane containing the antenna and the observation point. The radiation under these conditions is linearly polar-

ized. A maximum transfer of energy will occur if the polarization of the ground-station antenna matches that of the satellite antenna. However, a deep fade will develop if a linearly polarized wave emitted by the satellite, for example, becomes oriented along a line of constant elevation angle instead of a line of constant azimuth angle. Such a turn of events could be introduced by satellite

fig. 2. Relative vertical plane patterns for quarter-wavelength verticals. Dotted line: vertical antenna normal to perfectly conducting ground plane. Solid line: vertical antenna tilted away from normal by 45 degrees.



spin and/or Faraday rotation. The cure is to make either the ground or satellite antenna sensitive to fields oriented along any angle lying in a plane perpendicular to the propagation direction. A turnstile antenna achieves this characteristic if the excitation currents for the two perpendicularly crossed dipoles are of equal magnitude and in phase quadrature.

Fig. 1B gives an indication of the electric field components for two tilted verticals located in perpendicular planes. These quarter-wavelength verticals are fed by currents that are equal in magnitude but 90 degrees out of phase. For the special case where observation points lie on the horizon, the field is linearly polarized along the hemispheric meridians. At other elevation angles the tip of the instantaneous electric-field vector is generally not confined to oscillate in a meridian plane. Instead, the locus of its motion describes an ellipse. Directly over the antenna the ellipse degenerates into a circle. The important point is that the elliptical polarization of this antenna offers a degree of freedom from the undesirable effects of rotation of the plane of polarization while maintaining desirable, tilted-vertical behavior in the vertical plane radiation patterns.

computed patterns

Mathematical expressions were derived which yield the vector components of the field radiated by thin tilted verticals erected above a perfectly conducting ground. Input variables for the expressions included the angular designation of the observation point, lengths and tilt angles of the radiators, and the amplitude and phase of the excitation currents.

The results of a series of numerical calculations using these expressions are presented below for the antenna shown in fig. 1B. Tilt angles of 45 degrees were chosen for the quarter-wavelength radiators. While current amplitudes were identical for the two radiators, the current flowing on radiator 2 was adjusted to lag the current flowing on radiator 1 by 90 degrees.

Fig. 3 gives the transverse projection of the locus of the electric field vector for discrete observation points on the far field hemisphere. The points are spaced around the hemisphere at increments of 45 degrees in azimuth and 30 degrees in elevation.

As fig. 3 indicates, in general the field from the antenna is elliptically polarized. Right on the horizon, however, the field becomes linearly polarized. There is some dependence here upon azimuthal bearing. This is shown by the change in arrow length as the antenna is encircled and by the variation in the azimuthal pattern which is plotted in fig. 4A. The field strength on the horizon improves by 5.25 dB in moving from the position of minimum to maximum field. Fig. 3 also reveals that the polarization sense is largely right-handed for outwardly propa-

gating waves although one quadrant of the hemisphere contains significant amounts of left-handed polarization. This reversal is denoted by the reversed rotation of the field vector loci.

Changing the 90-degree phase shift of the excitation current for radiator 2 from lagging to leading reflects the radiation pattern of **fig. 3** through the vertical plane which bisects the angle between the

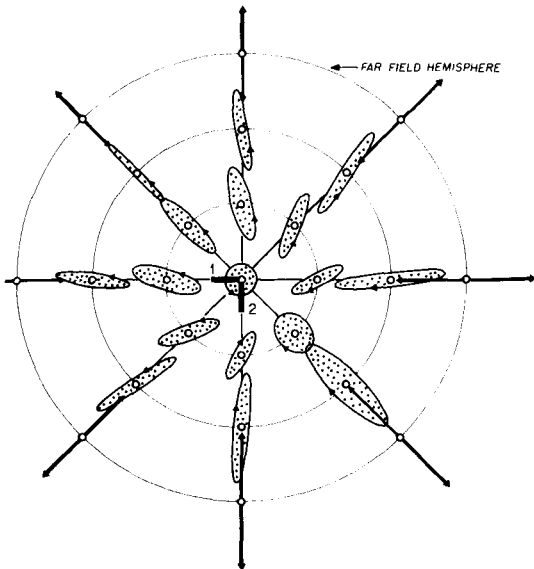


fig. 3. Far-field radiation pattern for the antenna shown in **fig. 1B**. Each radiator is tilted away from the normal by an angle of 45 degrees. The current exciting radiator 2 lags the current exciting radiator 1 by 90 degrees. Exciting currents are equal in magnitude.

two radiators. This means that the field polarization directly over the antenna changes from right-handed circular to left-handed circular. **Fig. 4** gives an example of the azimuthal pattern reflection arising from a relative phase reversal in the excitation currents.

practical considerations

The theory discussed so far deals with ground-based, quarter-wavelength verticals. However, planting verticals for the two-meter band among the roses and

tulips in the backyard flower bed doesn't hold particular promise in raising satellite contacts. The practical alternative at short wavelengths is to simulate the ground with a plane of quarter-wavelength radials. The resulting ground-plane antenna can then be installed in the clear where the electrical properties of local terrain features are less influential. It is difficult to evaluate the impact of such construction upon antenna radiation using simple theoretical models. Relatively little work has been reported which includes the effects of waves reflected from real ground beneath elevated ground-plane antennas cut for the satellite frequencies.

Experimental patterns of isolated verticals with limited ground planes exhibit the general characteristics of the ideal model where ground is infinite in extent and conductivity.² The principal deviation in practice occurs as slightly enhanced radiation at high elevation angles and slightly reduced radiation at the horizon. Therefore, a reasonable conjecture is that the fundamental framework of the radiation pattern shown in **fig. 3** remains essentially intact after the ground radials are introduced. Some experimental results supporting this premise are presented in a subsequent section.

Interesting matching problems were posed by the constraints placed upon radiator currents I_1 and I_2 . The 90-degree phase shift is conveniently obtained with a quarter-wavelength section of transmission line. Equal currents require careful selection of impedance levels at each end of the phasing line. Since the radiation resistance at resonance for a thin, quarter-wavelength vertical tilted by 30 to 45 degrees is of the order of 25 ohms, and the impedances of popular coaxial lines lie near 50 and 75 ohms, some impedance juggling has to be done.

Three possible approaches were considered. They are outlined schematically in **fig. 5**. At first glance the mechanical simplicity of **fig. 5A** is appealing. A phasing section of 26-ohm line is formed by paralleling two lengths of 52-ohm

coax. The net impedance at the antenna input is roughly 13 ohms. This is stepped up to 52 ohms by a 1:4 toroidal transformer.³ A definite drawback to **fig. 5A** is the lack of electrical tuning for trimming-up the radiator currents. Of course, some tuning could be accomplished by pruning the element lengths and varying the tilt angles. On balance, the design seems to be more suitable for low-frequency operation where lumped-circuit tuning elements could be used.

Fig. 5C supplies considerable tuning flexibility at the expense of greater mechanical complexity. Each gamma section is adjusted for a 50-ohm match, and a simple coaxial transformer matches the 25-ohm impedance of the antenna to a 52-ohm feedline.

construction details

Since ground-plane antennas have long been popular with amateurs, the construction of a circularly-polarized, ground

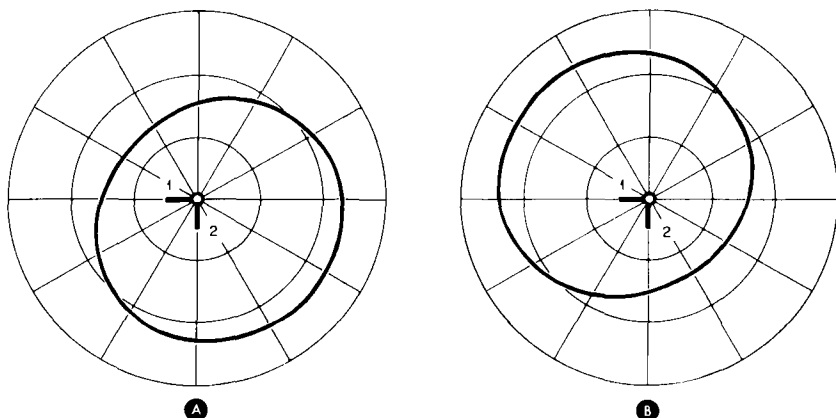


fig. 4. Azimuthal radiation patterns at elevation angles of zero degrees for the antenna drawn in **fig. 1B**. In **(A)** current exciting radiator 2 lags current exciting radiator 1 by 90 degrees. In **(B)** current exciting radiator 2 leads current exciting radiator 1 by 90 degrees.

The second design, **fig. 5B**, offers some tuning flexibility. When the gamma section is adjusted for 50 ohms, the 75-ohm, quarter-wavelength line transforms this value to an input impedance of 112.5 ohms:

$$Z_{in} = \frac{(Z_{line})^2}{Z_{load}} = \frac{(75)^2}{50} = 112.5 \text{ ohms}$$

If both conductors of the folded dipole radiator have the same diameter, then the dipole construction provides an impedance step-up by a factor of four:

$$Z_{dipole} = 4 \times 25 = 100 \text{ ohms}$$

Therefore, a good match to 52-ohm coax results by simply connecting the phasing line input and the dipole radiator in parallel.

plane poses no mystery once the basic design has been established. Formulas for the lengths of radiators, radials and quarter-wavelength coaxial lines at both hf and vhf have been listed recently¹ These formulas were used to determine the dimensions of a two meter prototype antenna based on the design given in **fig. 5B**.

Fig. 6 presents an exploded view of the gamma match⁴ along with the dimensions of the two tilted radiators. The radiators are cut slightly longer than necessary from 1/8-inch (3-mm) diameter copper wire (number 8, B&S gauge). A threaded end (6-32 thread) of each radiator is fastened to a 6-inch (15.2-cm) diameter ground-plane disk with lock-washers and nuts. The remaining end of the dipole radiator and the center ele-

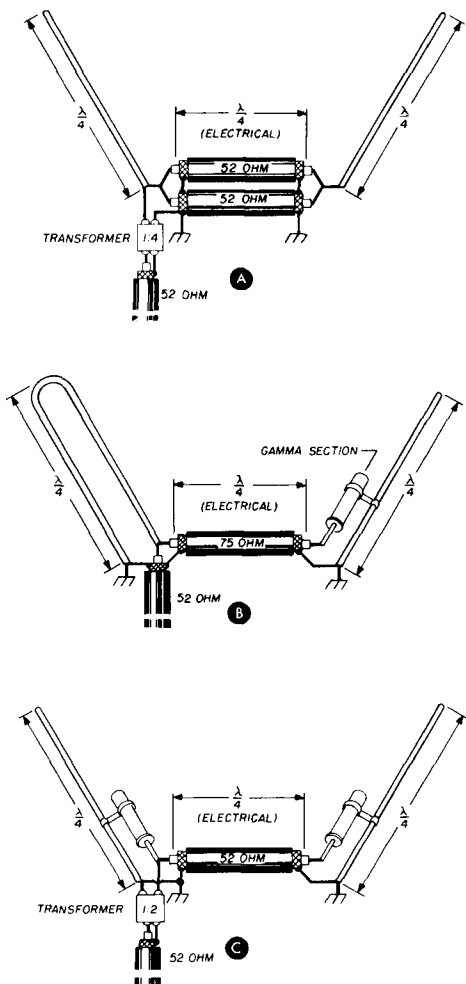


fig. 5. Three different ways to feed the tilted radiators of circularly-polarized, ground-plane antennas. Technique shown in (B) was adopted for the two-meter prototype antenna described in the text.

ment of the gamma match are connected to SO-239 coaxial panel connectors attached to the disk. These details are shown in fig. 7. The third SO-239 connector is used for attaching the feedline to the antenna. A tee would do this job better if the additional expense of the required connectors is no economic burden. Incidentally, the exposed upper

portions of the SO-239 connectors should be protected from the weather with silicone sealant such as Dow Corning 3145.⁵ Otherwise moisture will seep into the coaxial phasing line and the feedline.

Sixteen slits are cut around the outer edge of the disk to receive the eight ground-plane radials. The radials are also cut from 1/8-inch (3-mm) diameter copper wire. As fig. 7 indicates, the disk is deformed slightly around each slit. This deformation not only holds the radials securely for soldering to the disk, it also adds considerable strength to the completed disk assembly. A right-angle bracket is a convenient way to attach the disk to a support mast.

tune-up

A simple tune-up procedure was devised for the two-meter antenna. The only instrumentation required is a transmitter and a vswr meter balanced for 50-ohm lines. Initially each radiator is individually pruned for resonance as indicated by a dip in vswr. Next, a 100-ohm carbon resistor is shunted across the dipole radiator, and the gamma section is installed on the single rod radiator. The vswr meter is connected to the gamma section input. The outer gamma tube and the sliding copper strap are alternately adjusted for a minimum vswr (below 1.3:1). The dipole resistor is removed, and the 75-ohm phasing line is then connected between the two radiators. A low vswr should now be observed at the antenna input (below 1.6:1). This figure may be improved by minor adjustments of the gamma section and the lengths of the phasing line and radiators. However, the primary reason for tuning adjustments at this stage is to balance the currents flowing in the radiators.

There are some simple ways to check the current balance. One check is to monitor the antenna vswr as the radiators are slightly detuned.⁴ Under balanced conditions the vswr will increase by the same amount when a wire stub is clipped on to either radiator.

Another check is to measure the actual

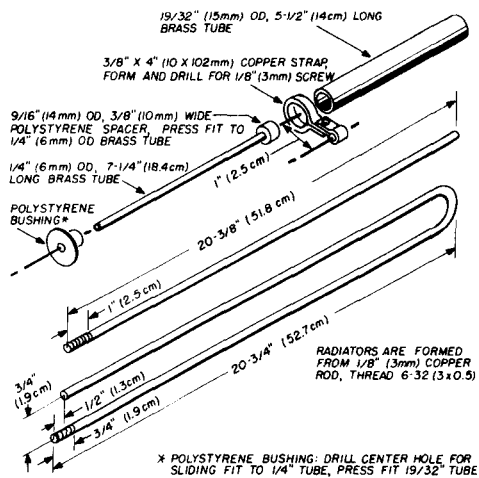


fig. 6. Dimensional details of the gamma match assembly and the two tilted radiators for the two-meter antenna.

radiation pattern of the antenna. Unambiguous pattern and polarization measurements are not easily made for low gain antennas. Yet there are two pattern characteristics that can be examined with an auxiliary dipole antenna coupled to a field-strength detector. Does rotation of the auxiliary dipole over the test antenna produce a highly elongated, dumbbell-type response? Does the vertically-polarized azimuthal pattern at low elevation angles show deep nulls which differ markedly from the anticipated patterns of fig. 4? If the test range is working properly, neither question will be answered affirmatively when balanced currents are flowing on the ground-plane antenna.

operation

Operating experiences with the antenna shown in fig. 7 appear to validate the pattern characteristics predicted by the theoretical model. Once the radiator currents were balanced, spot checks of the azimuthal pattern at low elevation angles revealed no deep nulls. Turning a dipole probe from the vertical to the horizontal position during these measurements indicated that the horizontally polarized components were down by at least 12 dB. A point of near circular

polarization (variation of 1.4 dB as the probe dipole rotated through 360 degrees) was observed to lie within 15 degrees of the zenith.

A 20-watt transmitter connected to the antenna has been used successfully in establishing two-way contacts through OSCAR 6. It must be admitted in all candor that this is a marginal uplink arrangement if a high density of operators are concurrently using the satellite. AMSAT recommends radiated power levels of 80 to 100 watts for consistent satellite operation. The antenna gives particularly satisfying results during portions of orbits defined by large elevation angles. Near the zenith signals were strong and steady. As the satellite approaches the horizon, there is a gradual increase of signal fading characteristic of polarization rotation. Although signal levels fall at the lowest elevation angles where ground-plane limitations become important, the uplink signals are returned even when the satellite is less than 10 degrees above the horizon.

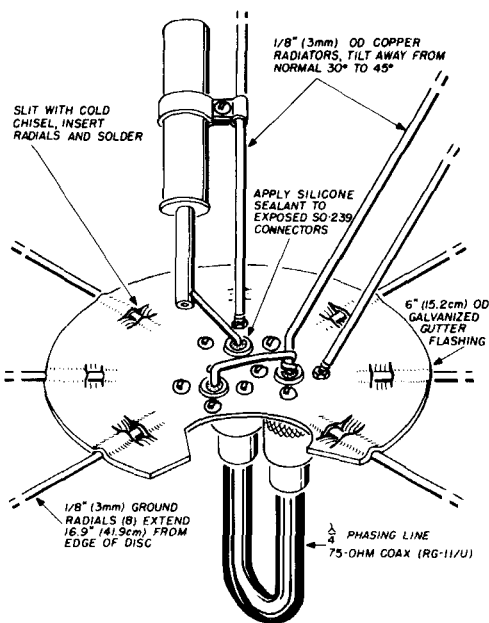


fig. 7. Assembly of a circularly-polarized, ground-plane antenna for the two-meter band. The electrical design is shown schematically in fig. 5B.

It stretches the imagination to come up with a single, fixed antenna which has all three of the pattern characteristics listed for ground-station antennas. The circularly-polarized, ground-plane provides a realistic compromise approach. The antenna does more right things than either turnstiles or tilted verticals. Moreover, building and implementing the

ground-plane design is a very simple process — a lot simpler than trying to translate dreams of a tracking helix or crossed Yagi into fiscal and physical reality!

It is a pleasure to acknowledge that creative ideas and practical assistance were supplied by W4LKB during the construction and test phases.

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appendix

fading mechanisms

Many factors contribute to amplitude fluctuations in signal levels from OSCAR satellites revolving in circular, polar orbits. Some fading is inherent in the power-sharing feature of the linear satellite repeater. Other fading results from the changing geometric distance separating the ground observer and satellite. More complex fading is associated with the propagation of electromagnetic fields in an inhomogeneous and anisotropic ionosphere. The rich variety of the principle fading mechanisms is shown by the diverse entries in the first column of table 1.^{6,7}

The second column in table 1 gives some

azimuthal bearing, vertical plane pattern showing a gradual increase in radiation as elevation angles decrease and circular polarization.

A qualifying word should be added about the sense of circular polarization if both the satellite antenna and the ground station antenna are circularly polarized. Both antennas should be polarized in the same sense, i.e., right-handed, circular polarization (RHCP) or left-handed, circular polarization (LHCP). The vhf antennas planned for AMSAT OSCAR B will be circularly polarized. Once the satellite has stabilized, the correct polarization sense for ground station antennas are as shown below for stations in the Northern Hemisphere.

mode		2-10 m repeater	432-145.9 MHz repeater	435.1 MHz beacon
polarization sense	transmitting	LHCP	RHCP	*
	receiving	*	RHCP	LHCP

feeling for the physical conditions which enhance the individual fading mechanisms. Admittedly these statements are generalizations. Nevertheless, they are a useful guide in selecting antennas and operating conditions which minimize fading.

The last column in table 1 lists several design techniques for improving the performance of ground station antennas. Examination of these techniques suggests three pattern characteristics that are desirable for stationary antennas: vertical plane pattern which is independent of

The senses are reversed for stations in the Southern Hemisphere.

When a satellite using circularly-polarized antennas tumbles in space, the polarization sense becomes more difficult to define. In any event, the problem can be avoided for fixed ground-station antennas by installing a switch which selects the correct sense. The selection may be derived either from two separate antennas of opposite sense or from a single antenna which possesses sense reversal capabilities. The latter approach can be implemented

table 1. Principal fading mechanisms encountered with OSCAR satellites.

fading mechanism	conditions enhancing the fading mechanism	design techniques for ground station antennas which minimize fading
Operator loading	operators using excessive radiated power satellite moving in regions of the local sky visible to a high density of operators	position antenna for increased radiation along weak signal directions
Satellite moving over pattern nulls of fixed ground-station antennas	multi-lobed antenna patterns	select antenna type and height with a minimum number of pattern lobes switch in alternate antennas mechanically steer the antenna to track the satellite
Changing slant range	orbits passing over the local zenith	increase radiation at low elevation angles while maintaining some high-angle radiation
Spinning satellite	observer direction lies within a cone generated by a dipole antenna moving around the spin axis	use circular polarization use selectable antennas having orthogonal polarizations
	cross polarization between circularly-polarized ground and satellite antennas	switch polarization sense
Faraday rotation	low frequency daytime propagation along geomagnetic lines of force	use circular polarization use selectable antennas having orthogonal polarizations
Scintillation	low frequency nighttime ray paths traverse auroral zone ray paths traverse geomagnetic equatorial regions high sunspot activity	space diversity operation (this is not very practical for amateurs)
Ionospheric attenuation	low elevation angles low frequency daytime severe ionospheric disturbances	increase radiation at low elevation angles

rather easily by simply moving the transformer to the opposite radiator in the symmetrical designs (fig. 5A and fig. 5C) of the antenna discussed in the text.

The above comments place emphasis on

fading control through proper antenna design. It is clear from table 1 that careful choices of orbits, schedule times and operating frequencies also offer control over signal fading.

ham radio

three-digit touch-tone decoder

for selective calling

Using tapped toroids
to build a
compact, low-cost
Touch-Tone
decoder

With so many amateurs now occupying the limited number of channels in the whf/uhf bands, the ability to be paged without having to continually listen to the chatter on the channel is a real asset. Since many amateurs can already transmit Touch-Tone signals, a reliable selective-call system can be built using the Touch-Tone approach. This article

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describes a Touch-Tone decoder that is suitable for a solo or group project and is inexpensive to build. It will allow the user to be alerted whenever his three-digit Touch-Tone number is received by his station by means of outputs which can ring bells, light lamps or enable speakers on receivers. The decoder is designed to operate on twelve volts, allowing mobile use, and it can be programmed to respond to any three-digit number.

basic design

Most commercial Touch-Tone decoders have separate filters for each tone channel to be decoded. The result is a large, expensive package. Since tapped toroid transformers are readily available,* I decided to use a single tapped coil for each of the two groups of tones recognized by the decoder. By pulling the

*Tapped Touch-Tone toroids can be salvaged from any scrapped (unrepairable) Touch-Tone pad, or purchased new from a number of commercial sources. Two such sources are: Aladdin Electronics, 701 Murfreesborough Road, Nashville, Tennessee 37210. L1 (low group) part number 426-847; L2 (high group) part number 426-848. Sangamo Electric Company, Communications Products Division, 11th and Converse Streets, Springfield, Illinois 62705. L1 (low group) part number 191983; L2 (high group) part number 191984.

appropriate tap to ground the coil can be tuned to the desired frequency.

In its initial state, the decoder toroids are tuned to the first digit pair of tones. Upon receipt of these tones the logic circuit switches taps on the toroid, tuning the decoder for the second digit pair of tones. Upon receipt of these tones the toroid taps are again switched and the

circuit boards. Six wires are used for this purpose. In this manner, each user on a channel or net can have his own private paging number within the group of 1000 possibilities.

circuit

The circuit was constructed on two boards. Board A contains the pre-

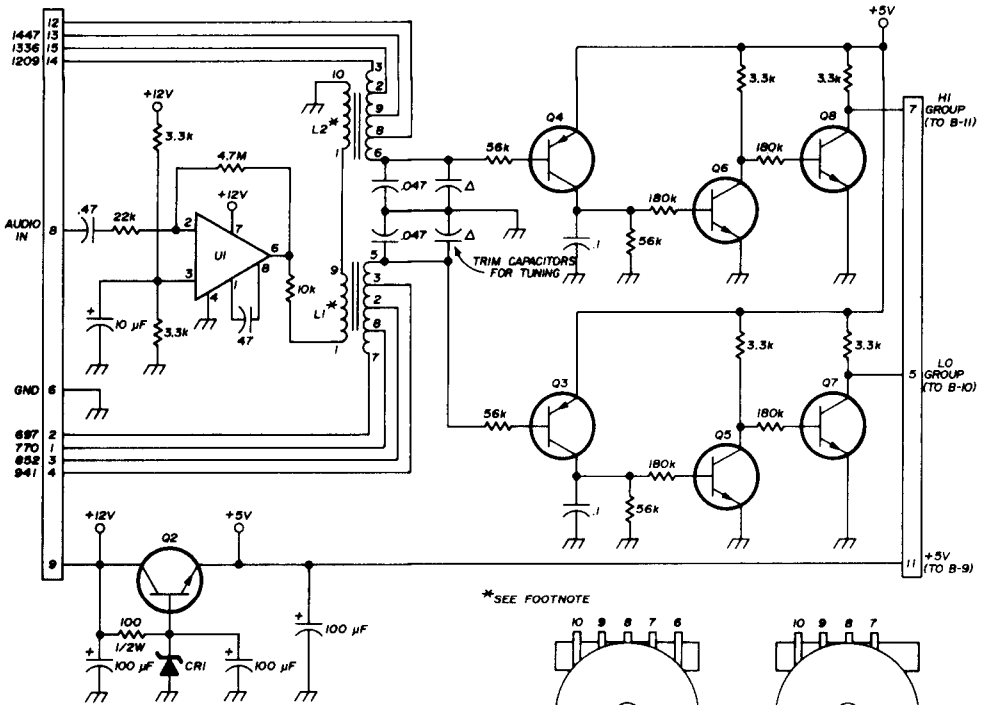
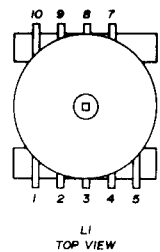
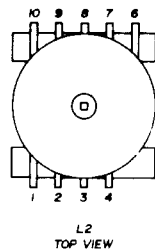


fig. 1. Touch-Tone decoder board A, which contains the preamplifier, tone decoders and voltage regulator. Transistor Q2 is an npn silicon in a TO-66 package without heatsink. Q2 and Q4 are 2N2907, 2N3638 or similar; Q5, Q6, Q7 and Q8 are 2N3568, 2N2222, 2N4400 or similar.

*SEE FOOTNOTE



decoder is tuned for the third digit tone pair. Upon receipt of the third tone pair the call latch is set and the decoder resets itself to the initial state; if only one or two of the three digits are received, the decoder will also reset.

The user may program the decoder for any three-digit number he wishes by rearranging the wiring between the two

amplifier, tone decoders and power supply. Board B contains the logic circuits to sequence digit recognition and provide the signalling output.

Audio is fed into board A (fig. 1) where it is amplified by U1 to drive the tone filters and decoders. L1 is the low group tone filter and L2 is the high group

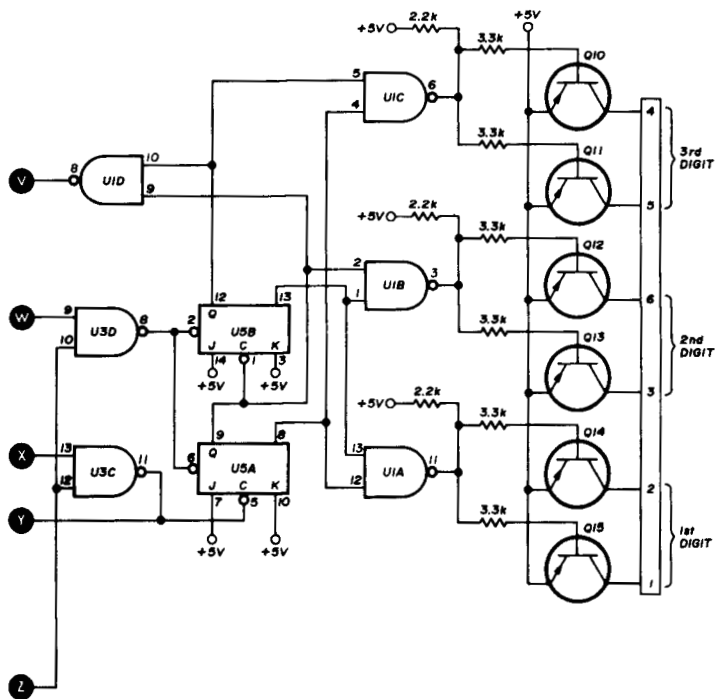
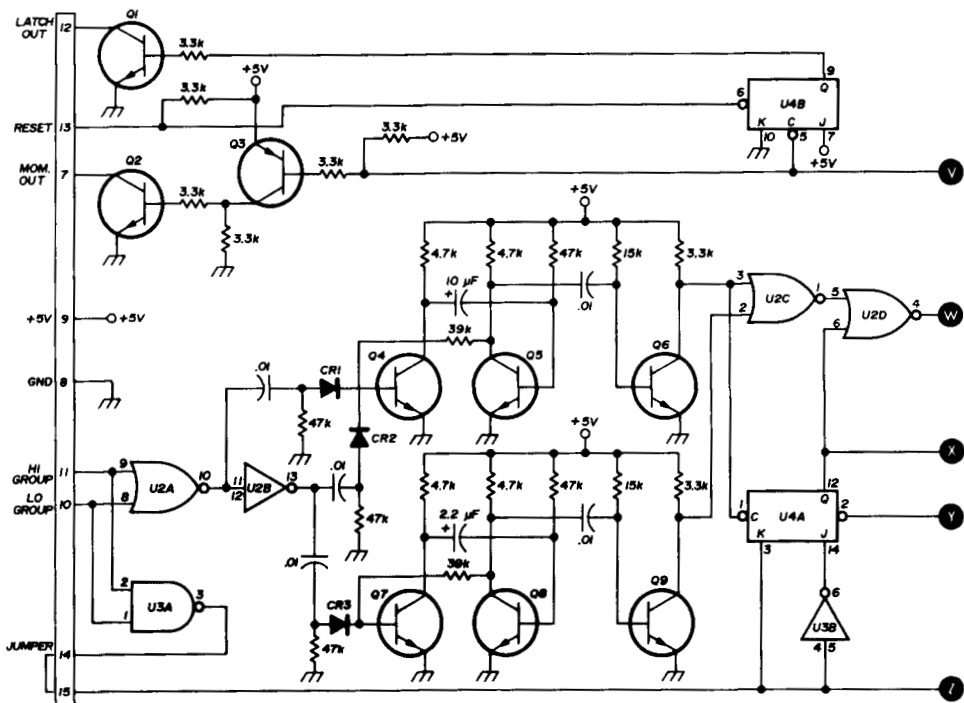


fig. 2. Touch-Tone decoder board B, which includes the logic circuits that sequence digit recognition, timing circuits and signal-activating output. Npn transistors are 2N3568, 2N2222, 2N4400 or similar; pnp devices are 2N2907, 2N3638, 2N4402 or similar.

ing the toroid filters convert the tones to standard logic levels. The power supply on board A (Q2) is a regulator to drop the 12-volt supply line down to 5 volts for the TTL logic.

The two logic signals, *hi group* and *low group*, are sent from board A to board B (fig. 2) where they are used to establish the sequencing of the decoder. The states

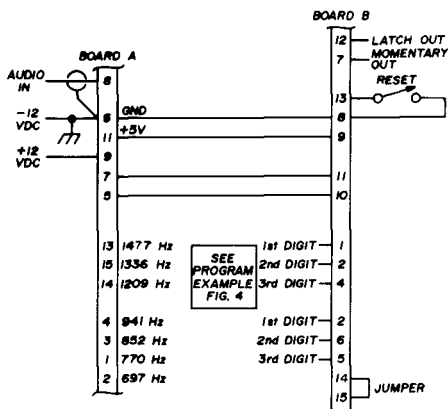


fig. 3. Interconnection wiring diagram between boards A and B. For programming example see fig. 4.

are sequenced by U5 which counts up from 00 as each digit is successively recognized. Gates U1A, U1B and U1C decode the output states of the counter and enable the transistor drivers (Q10-15) which pull the taps of the toroids to +5 volts. Transistors Q4-Q9 are time delays used to slow the circuit to a reasonable dialing rate and ensure the tones are legitimate before allowing the counter to sequence up. The upper time delay (Q4-Q6) is about 0.1 second and the lower time delay (Q7-Q9) is about 0.5 second in duration.

The output of gate U2A is true if either tone is present; the output of gate U3A is true only if both tones are present.

construction

The construction of the decoder is a matter of individual taste. I used two

3x3-inch (7.6x7.6-cm) printed-circuit cards which will plug into any standard edge connector. It is possible to use additional logic to reprogram the program wires connected between boards and change the selective call number remotely. This might prove handy for those who desire an extra command for some particular application.

To program a selective call number, six jumper wires are required. These wires are run between the open collector outputs of logic board B (fig. 2) and the open taps of the toroids on decoder board A (fig. 1). More than one collector will be connected to the same tap in cases where digits of the selective call number share the same row or column on the Touch-Tone keyboard. In effect, the collector outputs are logically being "ORed" by a parallel connection. This is permissible and will not affect the performance. A programming example is shown in fig. 4.

Fig. 3 shows the wiring for the connections between boards. The two outputs, *latch out* and *momentary out*, are open collectors which pull to ground in the true state. They are capable of sinking limited amounts of current (10 to 20 mA), so external drivers should be added if your particular application requires more current than that. The reset switch resets the entire decoder.

timing requirements

Each digit of the three-digit selective-

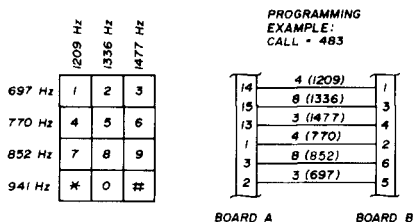


fig. 4. Touch-Tone tone matrix (left) and programming example. Note that common tones are used for different digits, and (for example) number 471 would have required that pins 1, 3 and 4 be strapped together on board B and connected to pin 14 of board A to provide response to a 1209-Hz tone for all three digits.

digit selective-call number must be transmitted for at least 0.5 seconds to be recognized by the decoder. Furthermore, there may not be a space between digits of more than 0.5 second or the decoder will reset. These requirements ensure good noise immunity and prevent triggering by voice or other signals on the channel.

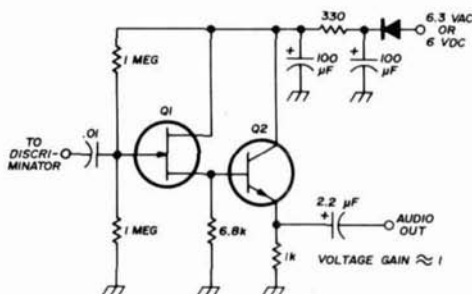


fig. 5. Circuit for simple discriminator amplifier, needed when receiver audio emphasis makes decoder response unreliable. Transistor Q2 is 2N3568, 2N2222, 2N4400 or similar.

other considerations

For best performance of a selective-call system the following factors must be considered. Poor frequency response in the audio sections of transmitters and receivers have been found to cause severe imbalance between the levels of the low and high tones in Touch-Tone systems. In some instances this difference could be great enough to create unreliable performance. If a stubborn case of *no workee* occurs, check out the audio response of the offending transmitter and receiver. A simple discriminator amplifier is shown in fig. 5 for those readers who would like to recover unprocessed audio from their receiver to operate the decoder without butchering the existing audio circuits.

For best results when transmitting Touch-Tone selective-call signals, acoustical coupling of the Touch-Tone audio into the live mike should be avoided, and the transmitter microphone should be disabled while transmitting the tones.

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how to convert your vtvm to an IC voltmeter

Simple solid-state
vtvm conversion
uses LM310H
voltage-follower IC,
costs less
than five dollars

The vacuum-tube voltmeter is probably the most common piece of test equipment used by amateurs. This article describes how to convert your vtvm into a battery-operated IC voltmeter (ICvm) at a total cost of about \$4.00. Input impedance of the ICvm is identical to your original vtvm, and accuracy on the dc and resistance scales is identical. On the ac scales there may be a slight error at the lower ranges, although I have not verified this.

the circuit

Fig. 1 is a complete schematic of the ICvm. While designed around the popular Heathkit IM-11 vtvm, the circuitry is applicable to virtually all vacuum-tube voltmeters. Components in fig. 1 with three-digit call outs (i.e., CR100) are new,

or are new applications for parts used in the original IM-11 vtvm (R133 for example, was R33 in the original circuit). The only new parts required are C100, CR100-CR103, S100, U100 and two 9-volt batteries (B100 and B101).

Begin the conversion by removing the pilot lamp, the ac line cord, the power supply transformer, capacitor and diode, the *ac balance* pot, the ac balance resistors, both vacuum tubes, tube bias components and all *zero adjust* components except the *zero adjust* pot itself. If you are modifying a Heathkit IM-11, the components to be removed are C1, R5, R10-R16, V1, V2, R24, C5, C6, R32-R35. Components R33, C5 and C6 will be used in the ICvm as will the circuit board and all the components remaining on it.

It is necessary to install a dpst toggle switch (S100) to operate as the new *on-off* switch. The vtvm switch wafer cannot be used as it has only a single pole. The new toggle switch (S100) may be installed on the front panel of the cabinet. Next, mount the two 9-volt transistor-radio batteries (B100 and B101). These batteries may be inserted into a battery holder, or they may simply be tied, with lacing cord, to the metal bracket holding the 1.5-volt battery. The 9-volt batteries may be connected to S100 at this time. Incidentally, rather than buy connectors for B100 and B101, make your own by removing the tops from two old 9-volt transistor-radio batteries and soldering a length of wire to each terminal.

Mike Kaufman, K6VCI, 3733 Meadville Drive, Sherman Oaks, California 91403

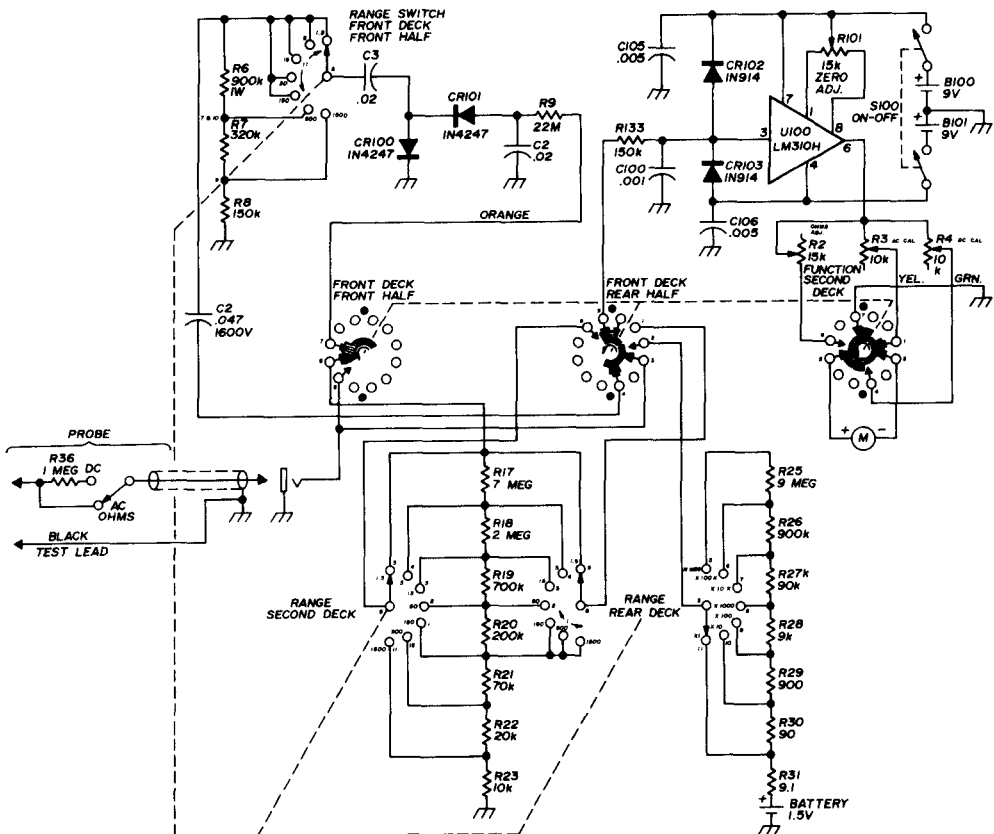


fig. 1. Basic IC voltmeter circuit may be easily adapted to any commercial vtvm although circuit shown here is the popular Heathkit IM-11. In this circuit two semiconductor diodes, CR100 and CR101, replace the original 6AL5 detector (see fig. 2). An LM310H high-impedance, unity-gain voltage follower, U100, replaces the original 12AU7 (see fig. 3).

Diodes CR100 and CR101 are solid-state replacements for the two diodes in the original vacuum-tube detector, V1, a 6AL5 (see fig. 2). Use the V1 tube socket to make the diode connections. Connect the cathode of CR100 to V1, pin 5, and the anode to V1, pin 2. Connect the cathode of CR101 to V1, pin 1 or pin 2, and the anode of CR101 to V1, pin 7.

Next wire in U100, the LM310H high input impedance (10^{10} ohms), unity-gain voltage follower.* This same IC may be used in virtually any vtvm (see fig. 3).

*The LM310H is available for \$1.45 postpaid from International Electronics Limited, Post Office Box 1708, Monterey, California 93940.

The LM310H may be wired into the remaining tube socket, but remember to break all printed-circuit connections going to the socket. Wiring is not especially critical.

Capacitors C105 and C106 act to bypass the battery power supply and should be connected right at U100. Diodes CR102 and CR103 provide over-voltage protection in the event a large voltage is probed while the ICvm is switched to a low-voltage range. Regardless of how large a voltage is probed, CR102 and CR103 will limit the voltage at pin 3 of U100 to ± 9 volts dc. Resistor R133 limits current into CR102 and CR103, and contributes to the protective circuitry.

Capacitor C100 is used to ensure that there is no ac at the input of U100. Although the value of C100 is not critical, increasing its value beyond .001 μF will introduce a noticeable time lag into your measurements. Resistor R101 is the original *zero adjust* pot.

Connect the *range* and *function* switches to the new circuitry, remembering to ground pin 7 of the second deck of the function switch. Your wiring should now be complete as shown in fig. 1. Install the batteries and the LM310H, and you are ready for calibration.

calibration

First ensure that the mechanical zero position of the meter pointer is correct. Then turn the IC *vm on* and adjust the *zero adjust* for either *dc-* or *dc+* zero reading with no probe input. There should be no appreciable change in the zero level when going from *dc-* to *dc+*. Next probe a known dc voltage and adjust the *dc cal* control to obtain the proper meter indication. Now put the function switch in the *ohms* position and

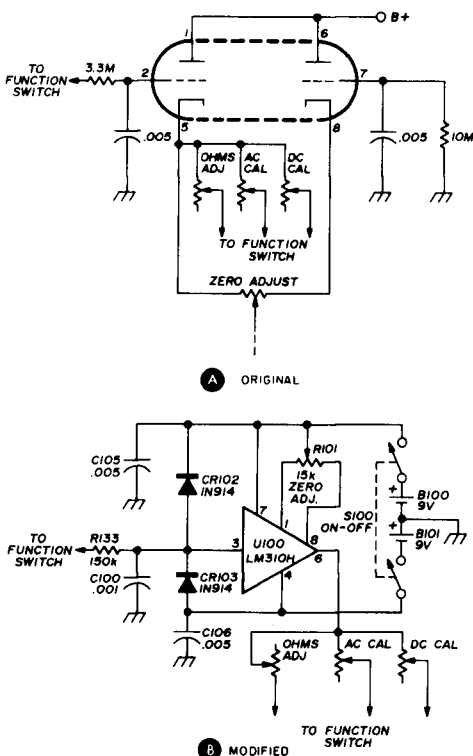


fig. 3. Solid-state replacement for the 12AU7 cathode follower uses a high-impedance, unity gain voltage-follower IC, the LM310H. The same circuit may be used to convert other dual-triode vtvm circuits.

set the *ohms adjust* control so that infinite resistance (probe open-circuited) registers full scale on the meter. Finally, put the function switch in the *ac* position and carefully adjust *ac cal* so that a known ac input (usually 117 Vac) registers properly on the meter. Unfortunately, it is rather difficult to obtain an accurate ac source voltage — nowadays the ac line is usually closer to 100 Vac than it is to 117 Vac.

The IC *vm* shown in fig. 1 has been in use for seven months with the original set of batteries. Since the LM310H draws about 4 mA from each 9-volt battery, it is well to remember to turn off the unit when it's not being used.

ham radio

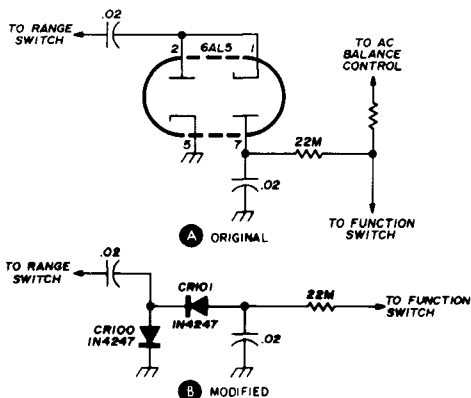


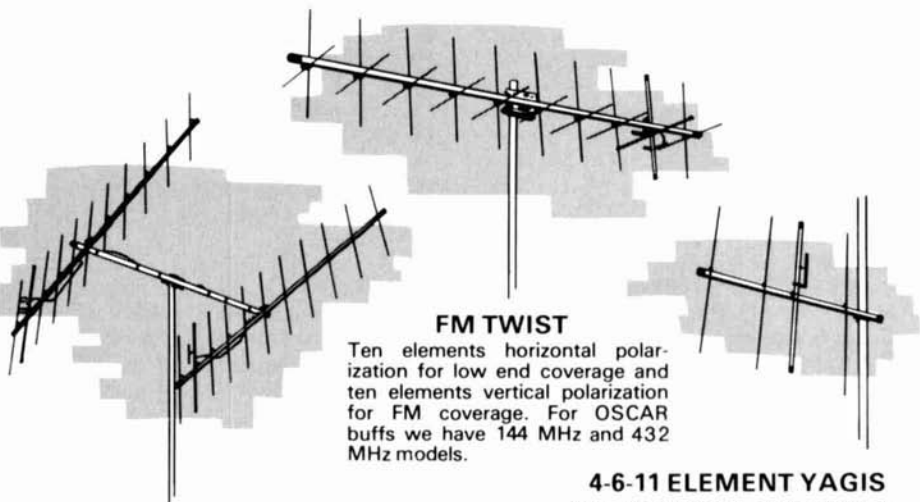
fig. 2. Conversion of the original vacuum-tube detector is simple and requires two diodes. Original ac balance control is not required in the solid-state version. Same circuit may be used with older instruments using 6H6 detectors as well.

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vhfer's view of Solar Cycle 20

A discussion of
Solar Cycle 20,
now on the wane,
and its effects
on long-distance
50-MHz propagation

As Solar Cycle 20 is finally, though somewhat unevenly, drawing to a close, it is appropriate to consider it and its effects on F_2 propagation in the spectrum above 30 MHz (and more particularly 6 meters). The following are the results of personal observations and data collection on both aspects.

Pat Dyer, WA5IYX, 5315 Silvertip Drive, San Antonio, Texas 78228

As far back as the peak of Solar Cycle 19 in 1957 I had casually noticed sunspots, but it was not until mid 1963 that regular plots were made and records kept. The whole period since has involved daily plot-counts, weather and other factors permitting, using a 3-inch reflecting telescope (f/10) with a 60-power eyepiece to produce a 5-inch diameter projected image of the solar disk. Only when sky conditions were deemed suitable would a record be made, thus avoiding the inherent inaccuracies of trying to observe the sun through even moderate cirrus clouds, etc. The only large lack of data was the period from June through September, 1971.

Fig. 1 shows the daily average sunspot count by month. As some months may have involved as many as 25 or more plots and others as few as 10 or less, the smoothed averages shown in fig. 2 are more meaningful. These smoothed averages are made by taking sunspot data for six months before and after a given month and then averaging it. The so-called Wolf numbers from my data (made by taking ten times the number of sunspot groups and adding to the spot count) show substantially the same features as those presented in figs. 1 and 2.

Unlike the official records made by the Swiss, this data shows a rather later

peak of Cycle 20 in 1970 vs the late 1968 or 1969 peak often cited elsewhere. A peak daily count occurred on November 17, 1970, with some 67 spots plotted in four groups. The Wolf-count peak for a given day was on February 1, 1968, with 53 spots in ten groups ($W = 153$). The results of this plot are shown in fig. 3.

The later stages of Solar Cycle 19 in 1963 are very evident in the graphs. This period was followed by a rather prolonged minimum running through 1964 and well into 1965. During these lean years the sun was spotless for many days at a time. A rebirth of activity was dramatic in 1966. In fact, the spotless sun of November, 3, 1966, was not dupli-

provide the necessary information. My method of projection viewing and plotting is the simplest and the most safe. Photographic setups provide the most accurate record but the cost factor there can be limiting. Regardless of the method you use, *do not observe the sun directly without adequate filtering devices*. Both visible and infrared, as well as ultraviolet rays, must be reduced to safe levels to prevent permanent eye damage (which can occur quickly and painlessly).

vhf propagation

The ionospheric effects of a solar cycle depend greatly on the location of the observer. My interest in vhf propagation

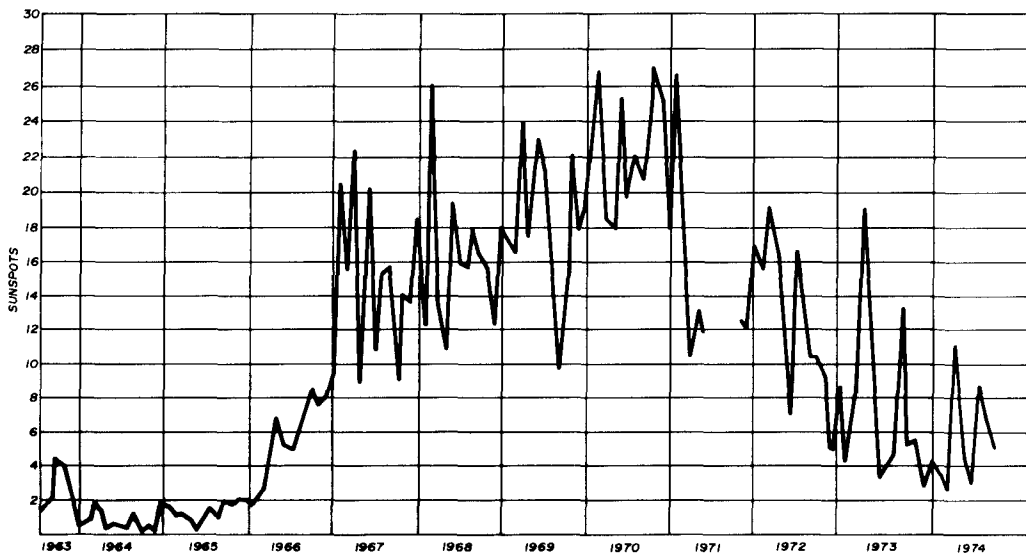


fig. 1. Raw daily average sunspot counts, 1963-1974.

cated until October 13, 1972. However, during the past year the incidences of zero counts have been becoming more and more frequent.

Lacking more sophisticated equipment, I was unable to view the other associated solar events such as prominences and flares.

For those readers who are interested in conducting their own solar observations just about any astronomy book will

came about in the early 1960s first in the realm of TV-DXing and sporadic-E. I became an amateur in late 1963, and the results of 50-MHz E_s observations made during the period from 1964 to 1970 have appeared elsewhere.^{1,2}

Much to my regret, suitable equipment for monitoring 30- through 50-MHz spectrum was not available until the fall of 1967. Even since then equipment has been on the simple side: a Radio Shack

Patrolman, and, in 1970, an Allied A-2586. Recently a Hallicrafters SX-62 has been revamped. Simple random-wire or whip antenna systems have been the rule.

On 50-MHz a low-power a-m transceiver and a five-element Yagi at 20 feet (6.1 meters) was used until the fall of 1968 when a higher power ssb rig was acquired.

Detailed records of F_2 MUFs in the 30- to 50-MHz region were not kept regularly until the fall of 1968. The late

with F_2 openings that would have otherwise passed, undetected. These graphs only include direct F_2 modes, and thus do not consider backscatter or trans-equatorial scatter (TE) propagation.

There was always a large difference in MUF behavior in the United States and Latin America, with little apparent relationship to one another. For instance, on many occasions South American signals were well above 45 MHz while in the United States even 10 meters was dead.

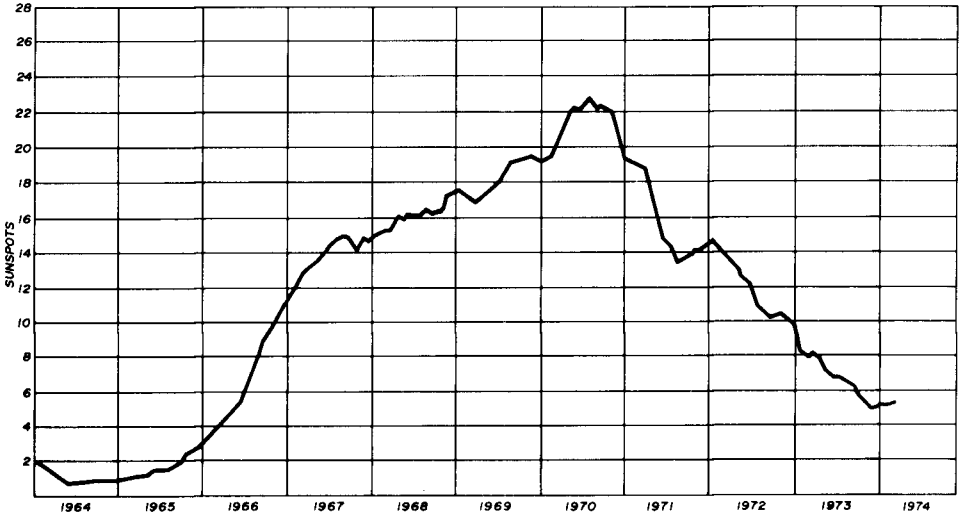


fig. 2. Smoothed sunspot counts, 1964-1973.

1969, early 1970 data has been cut due to various receiver-related problems. Actually, the term MUF (maximum useable frequency) in these cases should be taken as MOF (maximum observed frequency) as no method (e.g., backscatter radar) was available to determine if the band was "open" higher than the highest incoming signal frequency.

Figs. 4 and 5 show the number of days each month that F_2 signals were observed in the contiguous United States and from Latin America at the indicated frequencies. As most of the latter are unidentified signals, there is a possibility that E_s propagation was inadvertently included at times. However, as will be discussed in more detail later, E_s often played a big role in providing link-ups

But, on other occasions the MUFs in the United States almost seemed to be keeping pace with those to Latin America.

In figs. 4 and 5 the F_2 "season" has been limited to September through April, although occasionally during the summer Latin American signals reached the 40-MHz region. Both seasonal and solar epoch variations are easily found. For U.S. MUFs the best months were October-December; this in striking contrast to the Latin American peaks of March and April. Year-to-year changes, while not always smooth, show the decline of Solar Cycle 20.

I should mention a word about the seemingly arbitrary frequency divisions used in figs. 4 and 5. The selection is natural for the U.S. as FCC assignments

produce large groups at certain frequencies (i.e., fire departments at 33 MHz; pagers and mobile phones at 35 MHz; and law enforcement at 37 and 39 MHz). The Latin American situation is different as it is next to impossible to obtain station assignment information. Thus, no simple groupings are known which could make a more meaningful frequency division system than that used in figs. 4 and 5.

six meters

Since 50-MHz DX is of considerable interest to the vhf operator, it's worthwhile to take a more detailed look at Solar Cycle 20's F₂ effects on six meters. Table 1 gives a month-by-month summary of the number of days and minutes total open on 50 MHz by various modes. The mode determination is a rather simple process of considering the distances, peak antenna headings, fade rates, etc.

Fig. 6 shows the time of day of F₂ and TE openings on 50 MHz for the month of April summed over the period from 1967

table 1. Observed 50 MHz band openings.

		number of days (opening, total minutes)		
		F2	F2 bs	TE
1967	April	1 (85)	-	-
	September	1 (55)	-	-
	October	-	1 (15)	-
1968	March	3 (80)	-	-
	April	14 (635)	6 (530)	3 (40)
	May	2 (30)	-	1 (30)
	September	-	-	3 (255)
	October	-	1 (5)	1 (80)
1969	February	1 (40)	1 (30)	-
	March	1 (5)	3 (410)	-
	April	11 (290)	6 (655)	4 (60)
	September	-	-	1 (90)
1970	February	-	-	3 (150)
	March	3 (45)	1 (135)	-
	April	9 (340)	6 (265)	3 (200)
	May	2 (40)	-	-
	November	-	-	1 (10)
1971	March	1 (20)	2 (45)	-
1972	March	3 (60)	4 (170)	-
	April	8 (220)	3 (175)	-
	September	1 (10)	1 (45)	-
1973	April	1 (5)	1 (20)	-
	September	1 (15)	1 (20)	-
	October	1 (45)	-	-
	1974	March	2 (35)	-
	September	1 (15)	-	-

to 1973. The time to be on the air is clearly in the afternoon. Almost without exception, I suspect that all the trans-equatorial scatter openings made it this far north with the help of an E_s link. The use of beacons by CE3QG and OA4C in those years was a priceless asset.³ The lack of TE since 1970 is believed to be due, in large part, to the loss of activity from these two stations.

Backscatter, although not plotted in fig. 6, has much the same shape with earlier onset and later fadeout points. This is very consistent with the pattern of F₂ backscatter from the southeast, followed by direct F₂ from South America proper, ending with backscatter again from the South and Southwest.

The 50-MHz F₂ paths to South America's more remote end, namely Argentina, Uruguay and Chile, are very likely the result of what are known as F₂-F₂ paths, shown in fig. 7. These are sometimes called trapezoidal paths due to their shape, and they provide very strong signals since an intermediate ground reflection with signal loss is eliminated. The geomagnetic equator, with its attendant "bulges" of F₂ ionization on each side, is responsible for these tilted layers.

The geometry of the F₂-F₂ path is likely a rather ticklish affair requiring several different conditions to coincide. For example, if the ionization on the more northerly bulge of the path is not correct, the path is disrupted. Too low a level will cause the 50-MHz signal to overshoot the second bulge to the south, while the level which is too high may cause undershooting. This may explain the often observed oddity of six-meter stations from Argentina and Uruguay appearing when all the stations in Ecuador and Venezuela were at 44 to 46 MHz.

Sporadic-E, often seen as a friend in linking up with an F₂ or TE opening, can just as easily ruin, by topside reflection, what would otherwise be a good path as shown in fig. 8. Since E_s may be partially transparent, the effect is very likely quite variable.

Six-meter F₂ backscatter can be either single or double-hop in nature (perhaps

giving rise to a total path length of 9000 miles or more). The best earth reflection regions are over the oceans, or to the south and southwest of my station. This is ground backscatter and not direct backscatter from the ionized regions *per se*. E_s effects here are much the same as with the other two modes already discussed.

The following is an expansion with comments of the 50-MHz effects summarized in **table 1**. Suitable references are noted in the cases of major events.

1967 The month of April brought me my first meeting of 50-MHz F2 DX. It was more than five months before it was heard again.

1968 With some openings in March, April proved to be the best month of the Cycle, helped along by vast amounts of early season E_s, which also aided the first TE openings noted here. E_s also kept the F2 still alive well into May. The fall, though providing plenty of E_s-to-TE links, did not bring in the huge F2 openings that were anticipated by many operators.

1969 A very strong magnetic disturbance on February 2nd brought in backscatter here and several other modes elsewhere.⁴ An E_s-to-F2 link later in the month provided some 40 minutes of the ZK1AA beacon. March and April, in contrast to the previous spring, brought in much more backscatter than direct F2. The lack

of F2 was probably due to the poor E_s season.

1970 Good E_s in February permitted TE once again. Overall, April was better than expected, with many instances of the Cook Island beacon. However, the high-

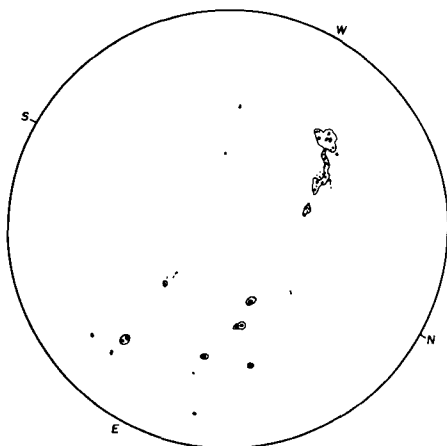


fig. 3. Sunspot diagram for February, 1968. Diagram shows 53 spots in 10 groups (Wolfenumber = 153).

light of the year and the Cycle was on March 8th where, in one 90-minute period 50-MHz F2 backscatter was noted in some 16 states as far north as Illinois, with direct paths to Puerto Rico. This was the largest magnetic storm of Cycle 20 and occurred during a time of year when it would do the F2 layer the most

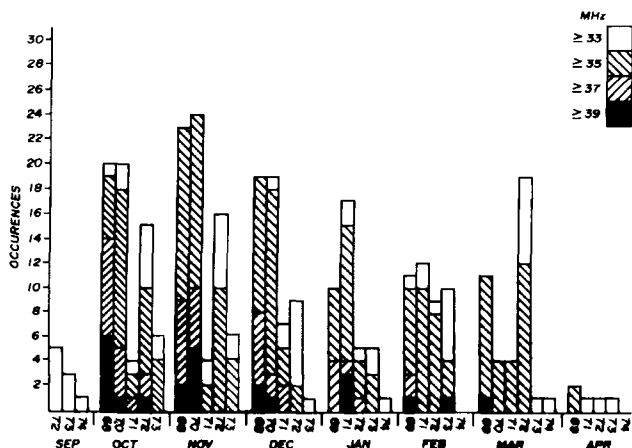


fig. 4. F2 MUFs for the United States plotted here were determined by noting the highest frequency incoming signal that originated within the 48 contiguous states. This meant the skip for a given frequency was down to 3000 km or less. When theoretical considerations are applied, the transcontinental MUF (e.g., W4-W6) was considerably higher than I could observe. Using the ITS maps, the 4000 Km MUF (nominal maximum 1-hop F2) can be extrapolated knowing how short the skip is on 35 MHz, etc.

good.⁵ The last incidence of TE here occurred during November, in the midst of an E_s opening to Guatemala.

1971 50-MHz propagation might be best described as a recession, with only very scarce F2 effects in March.

northwest region, while second-hand reports from the 10-meter nets raved about the coast-to-coast 6-meter opening in progress.

Also, being this far south geomagnetically, no direct evidence of any of the many auroral events appeared. The

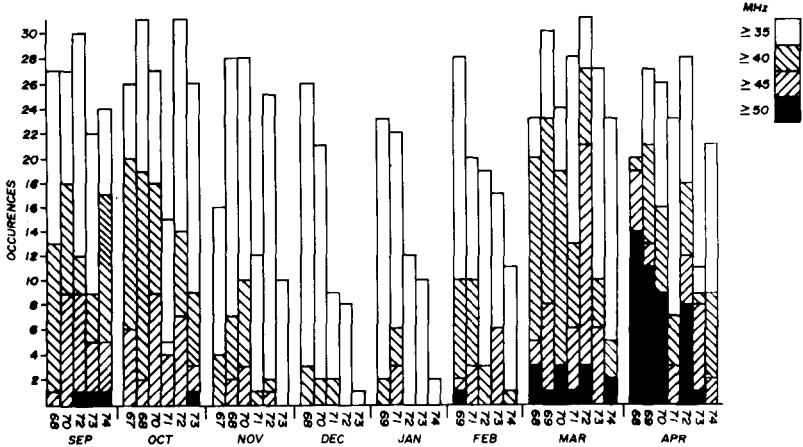


fig. 5. Latin American F2 MUFs.

1972 A rather unexpected upturn in solar activity in the spring provided the best spring March-April F2 in two years.

1973 Openings on 50 MHz, though very scarce, were amazing in that any occurred at all with such low solar levels.

Close followers of six-meter DX have probably noted by now a conspicuous absence of details on January 1, 1968.⁶ While this location is very good for Latin American F2 (though not as good as Florida), when it comes to transcontinental F2 on 50 MHz it is just too close to each coast to get any. On the date in question 46-MHz was in from the Pacific

closest incident was June 5, 1967, when a magnetic storm created extremely fluttery E_s (apparently) to Florida and perhaps either double-hop E_s or single-hop F2 to Puerto Rico. With so much E_s in June it is impossible to be sure of the modes without ionosonde evidence at hand. The prior week (May 25th) produced what were likely 49-MHz Latin American F2 signals while Florida had both visual and radio aurora.^{7,8}

Along other lines, solar activity introduced vhf noise bursts to me in July, 1967. Although the event observed was nothing extraordinary, having the 50-MHz background noise rise by 40 or

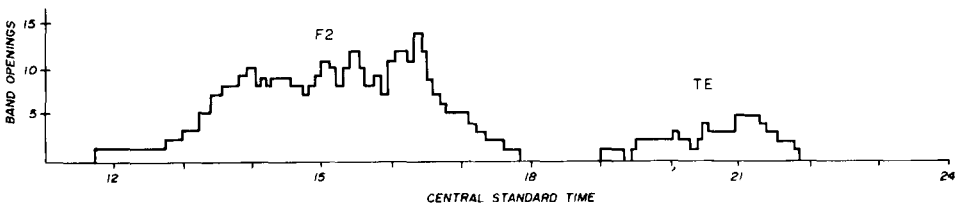


fig. 6. Graph showing 50-MHz F2 and TE openings during the month of April, 1967-1973.

50 dB for the first time was a memorable occurrence. During the ensuing years, while monitoring 30-50 MHz, numerous solar noise bursts have been logged incidental to MUF observations. A particular incident in April, 1973, when a solar noise burst was noted simultaneously with an increase in an F2 backscatter signal level, was vivid evidence of the association of flares, noise bursts and extra solar ionizing energy.

To step out of vhf for a moment, another equally dramatic trait of high solar levels is the high-frequency blackout (caused by extra D-layer ionization and consequent increase in collisions and absorption) when you are positive that your receiver has stopped working. Many of these blackouts were stumbled upon while attempting to get a WWV propagation forecast and the vhf E_s and F2 openings went along virtually unaffected.

future

While Solar Cycle 20 has not yet completely withered away, there is little doubt that it will be quite some time before the F2 effects on 50 MHz become as common as they were in 1968. However, devoted 50-MHz DXers might still be able to catch a few of the freak openings still left in the Cycle. For a better chance at catching the openings, the following suggestions are offered:

1. If you don't already have a receiver that will tune 30 to 50 MHz, by all means get one that does. While an SP-600 or one of its relatives is best, you can get by with a lot less.
2. Become familiar with the DX signals that frequent your area on the band. This can be helpful in looking for the more common E_s openings that might affect 6 meters.⁹ When the conditions appear

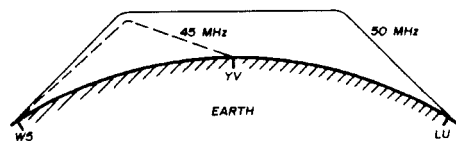


fig. 7. Propagation over an F2-F2 path from Texas to Argentina (not to scale).

favorable, don't just listen, call CQ. You may end up with a hoarse voice and not get a reply, but at least you tried. For those fortunate enough to have beacons, it will be a lot easier.

3. Obtain copies of the *Telecommunications Research and Engineering Report*

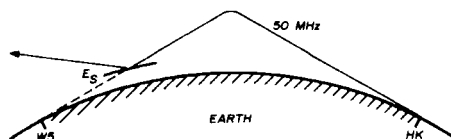


fig. 8. Sporadic-E shielding of a 50-MHz F2 path (not to scale).

13. This has ionospheric predictions for F2 median MUF (both at zero and 4000-km ranges) as well as normal E at various solar cycle levels (with interpolation methods) in the form of world maps at two-hour intervals for each month of the year.* While not all that useful in predicting the 50-MHz openings, they have supplanted the monthly bulletins that ITS (formerly CRPL) used to publish and are valuable in determining in which directions from your location the MUF is peaking at a given time of day, season, etc. The F2-F2 path can be inferred from the maps, but its MUF will be somewhat greater than the 4000-km MUF given on the maps for each "bulge" near the equator.

4. If you have high-frequency capabilities, do all you can with contacts in regions where 50 MHz might be likely to stir their interest in at least listening on that band, if not actually setting up a station. Innumerable openings have been lost due to lack of 50-MHz activity in Venezuela and other parts of northern South America — openings where all sorts of high-frequency harmonics were pouring

*Four volumes are available. Volume 1 is the instruction manual (\$.30), while Volumes 2, 3 and 4 are for smoothed sunspot levels of 10, 110 and 160, respectively (\$3.00 each). Order from the Superintendent, U.S. Government Printing Office, Washington, DC 20402.

through on or near 50 MHz. In addition, the use of beacons on 50 MHz should be encouraged in these DX spots.

The foregoing and suggestions elsewhere¹⁰ are a valid formula for getting into shape for the next solar cycle peak — you have plenty of time as it will not likely occur until the latter part of this decade. I'm afraid that a lot of plans for Solar Cycle 20 got going too late to be of much benefit, particularly the set-up of some 50-MHz beacons.

conclusion

I hope that this article will serve as a stimulus to others to undertake similar observations and recording of their data. This is only one of the ways amateurs can justify the portions of the spectrum we occupy — by contributing to the basic understanding of vhf propagation.

Over the years I have been indebted to several fellow amateurs for their encouragement and advice. Bob Cooper, W5KHT, deserves special acknowledgement for getting me to keep more accurate notes on the F2 DX conditions in the 30-50-MHz region. I wish that I had started earlier in the Cycle.

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improving the performance of low-frequency vertical antennas

Three basic ideas
for improving
the efficiency
of your
antenna system

This article discusses certain ideas and methods that improve the efficiency of vertical antennas. If these methods are followed the resulting antenna will perform as it should, approaching textbook levels of efficiency.

The first idea to consider is that radiation from the antenna is a *natural* phenomenon. It is created by the changing current, either ac or pulsating dc, that is flowing in an electronic circuit. It's that simple. As a matter of interest, all electronic circuits radiate to some degree but the amount of radiated energy is so small

it is ignored. An antenna is a special type of electronic circuit that maximizes radiation.

The second idea is the counterpart of the first: radiation can be suppressed only by mirror-image currents. This is the principle that is used in 300-ohm TV ribbon line to prevent radiation. Each conductor carries a current equal to the other in amplitude and frequency but 180° out of phase. The radiation from each conductor cancels that from the other, or very nearly so, thus for practical uses the line is considered non-radiating.

Considering the first and second ideas leads to the conclusion that antennas should not be built like a two-wire transmission line; they should be arranged so that there is no suppression of radiation by mirror-image currents. Fortunately there are two basic methods available to accomplish this goal. One is to spread the two conductors apart so that the radiated field from one conductor will not completely cancel that of the other. Examples of this type of antenna are loops, quads and some types of rhombics.

The other method is to use a single conductor in which current is maximized by tuning it to resonance at the operating frequency. This is possible because the current in the conductor is reflected from

Raymond H. Griese, K6FD, 405 Giannini Drive, Santa Clara, California 95051

the open end. The reflected current is in phase with the original current and its radiation adds to that of the original current. The familiar wire antennas — long-wires, Zepps, Windoms and so on — use this technique and differ only in method of feed. It will be assumed that you are familiar with loops and single wires so they will not be discussed further. The grounded vertical version of the wire antenna will be discussed, however, in terms of its equivalent electrical circuit.

The antenna, shown in the form of its equivalent electrical circuit in **fig. 1** consists of a power source, a two-wire line and a resistive load which represents the radiation and loss resistances of the antenna. **Fig. 2** shows another form of the antenna circuit. Here, however, it must be remembered that the antenna is self-resonant at the operating frequency and presents a 73-ohm load (or thereabouts) to the line. Although diagrams such as these are helpful in understanding antenna operation, the circuit of **fig. 3** is even more helpful.

In **fig. 3** the antenna is considered to be two quarter-wavelength antennas in series, the actual case. The connection between the ends of the antenna is fictitious, but this is actually the type of load the power source sees. At dc it will be an open circuit, but at radio frequencies it acts just exactly as if it were a

180°. This makes the two antenna currents in phase, maximizing radiation. *Line* currents, however, are 180° out of phase, minimizing radiation. This antenna is usually referred to as a half-wavelength, center-fed doublet or dipole. It is really two quarter-wavelength antennas operated in push-pull.

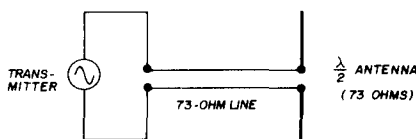


fig. 2. Common form of the antenna circuit.

Suppose the two quarter-wavelength antennas in push-pull are exchanged for one quarter-wavelength antenna and a ground connection. This circuit is usually drawn as shown in **fig. 4**. Redrawn in the ac closed-circuit form (**fig. 5**) it looks exactly like **fig. 3** except for the value of the ground resistance. The ground resistance will be from about 2 to 200 ohms, depending on the physical arrangement of the ground system. A 2-ohm ground resistance is typical of a broadcast station ground system composed of 120 radials; a 200-ohm ground is a typical value for a ground rod in sandy soil.

Applying series circuit power calculations to the antenna-ground circuit brings out some very useful and interesting information. Power delivered to the antenna-ground circuit divides proportionally according to the value of the resistances. With a 36.5-ohm quarter-wavelength antenna, a 2-ohm ground absorbs 5% of the power, a 36.5 resistance absorbs 50% and a 200-ohm resistance will absorb 85% of the power. This indicates that there are only two ways to improve efficiency. The first is to reduce the ground resistance to as low a value as possible. The second is to raise the antenna resistance to its highest possible value. Surprising as it may seem, this simple solution is a true engineering solution to the problem of achieving efficiency in grounded vertical antennas.

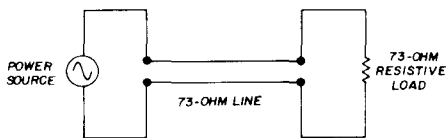


fig. 1. Equivalent electrical circuit of the antenna.

closed circuit. The standing wave of current in each quarter-wavelength antenna is responsible for this effect.

This circuit satisfies the dual requirements for the line and the antenna. The current into each quarter-wavelength antenna is 180° out of phase with the other, but one antenna is physically reversed

Reducing the ground resistance by using multiple ground rods is poor practice. Current distribution beneath the quarter-wavelength vertical is such that ground rods do not intercept much of it. Ground wires are much better, either on top of the ground or immediately below the surface, and should be roughly a quarter-wavelength long. One radial is roughly 40 ohms; two radials, 180° apart,

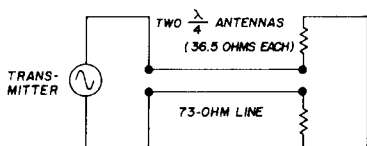


fig. 3. Ac equivalent of the antenna circuit.

are about 20 ohms; four radials get down to about 15 ohms. This is about the practical limit for amateur antennas — more radials are usually not worth the effort. It would, for example, take 116 more to get down to 2 ohms. Four radials should allow the antenna to operate at 70% efficiency — just 1.5 dB below maximum.

The radials don't have to be on or in the ground, they can be elevated above ground as well. This leads to the type of antenna known as the ground plane. One quarter-wavelength radial (antenna) exhibits a resistance of 36 ohms. If there was no interaction, two would be 18 ohms and four would be 9 ohms. However, the currents are 180° out of phase and the radiation is low, so the resistance is lower than you would suspect. I have not been able to determine the effective resistance of the ground plane itself, but suspect it is lower than 9 ohms.

Excellent results can be obtained with two or more radials on the ground-plane antenna. However, in emergencies only one radial will work. The advantage of the ground plane is that it can be elevated above ground, out of the vicinity of all neighborhood "hardware."

antenna resistance

Increasing the antenna resistance with respect to the ground system is also a

good technique for improving antenna efficiency. For example, the feedpoint resistance of half-wavelength verticals runs from 500 to 3000 ohms — 500 ohms for towers that are wide compared to height and 3000 ohms for a very thin wire such as you might use for a balloon-supported antenna. A TV pipe mast, when used for an antenna, exhibits about 1000 ohms resistance. Considering this antenna on the basis of the third idea, it can be seen that any type of ground system will work well, including that 200-ohm ground rod! The major difficulty with the half-wavelength antenna is that it is twice as high as the quarter-wavelength antenna and the 1000 ohms or so input resistance is harder to match to a 50-ohm transmission line. This is especially true if you are running high power.

Remember that it isn't mandatory to operate at the quarter- or half-wavelength points. The advantage is that these antennas are self-resonant and easier to match. Antennas that are not self-resonant can be resonated by the addition of tuning coils and capacitors which usually makes matching more difficult. Short antennas can be loaded with coils part way up the antenna, the tops can be folded over, and so on. All of these techniques are designed to raise the radiation resistance of the antenna so it will accept a higher percentage of the power delivered to the antenna-ground circuit.

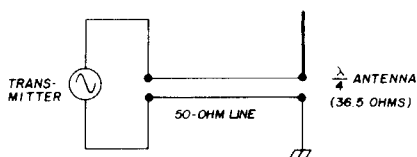


fig. 4. Common schematic for a vertical antenna.

Radials, too, can be loaded or tuned if space does not allow the use of radials a quarter-wavelength long. Radials can also be folded or bent quite severely without materially decreasing their effectiveness. Loading and folding are usually used on 1.8 and 3.5 MHz where full-size verticals

become physically large and difficult to erect on the normal city lot or apartment house roof. Many such arrangements are described in the textbooks that cover low-frequency radio engineering, and many of the old books from the spark era have a wealth of ideas for operating antennas on frequencies very much lower than the quarter-wavelength resonant frequency.

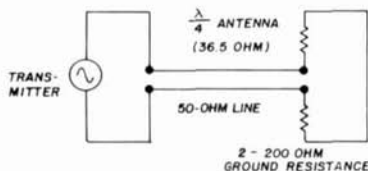


fig. 5. Ac equivalent of the vertical antenna circuit.

summary

To sum up the discussion for improving medium- and high-frequency vertical antennas, the following ideas should be thoroughly understood and put into practice:

1. Ac current flowing in a conductor radiates energy. This is a natural attribute and requires no special expertise.
2. Radiation can be suppressed only by mirror-image currents flowing in nearby conductors or structures. Hence, the antenna should be erected away from or above these obstructions if possible.
3. The antenna and ground resistances should be arranged to maximize antenna resistance and minimize ground resistance.

These ideas and rules are not new. They are sound engineering principles that have been in existence since radio first came into use. However, they seem to have been neglected in most recent antenna articles. There is an infinite variety of ways vertical antennas can be built, and if the construction meets the requirements embodied in these three basic rules, you can be assured the antenna will work properly.

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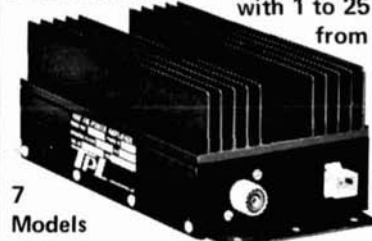
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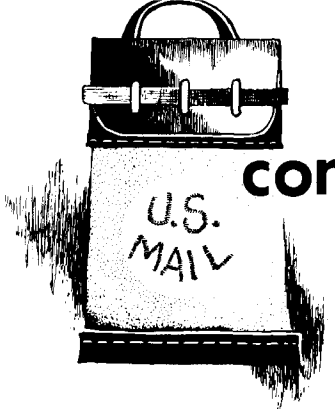
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comments

pi-network design aid

Dear HR:

My article on pi networks in the May, 1974, issue of *ham radio* (page 62) has caused some confusion because of an honest (but neglectful) error in the example using eq. 1 for tube plate-load resistance. When the values given are plugged into the equation, the answer is 5000 ohms, not the 1800 ohms indicated. Since the table for the B&W 850A coil is for $R_L = 1800$ ohms, the values should have been $E_B = 1900$ volts and $I_B = 0.525$ A, which works out to 998 watts input for a plate-load resistance of 1810

ohms. These values would be typical for, say, a pair of 813 or similar tubes. However, the newer tubes designed for linear amplifier service use plate voltages on the order of 3000 to 4000 volts.

The principles in the article are still valid, however. If the curves of inductance vs plate-load impedance are extrapolated to include the higher values (see fig. 1) it is clear that something must be done to the popular B&W 850A coil to obtain optimum inductance (assuming a nominal Q of 12).

Inductance for plate-load resistance, $R_L = 5000$ ohms

band	L (μ H)	B&W 850A (μ H)
3.5	20.0	13.50
7.0	10.0	6.50
14	5.0	1.75
21	3.3	1.00
28	2.5	0.80

The inductance values shown for the B&W 850A coil are those published in their data sheet. I have no axe to grind with B&W or their product, because the B&W 850A coil is well made and a pretty good bargain, even at today's prices. However, as I stated in the article, it is a design compromise, and to obtain optimum performance the coil must be modified to obtain the inductances shown.

Alf Wilson, W6NIF
Encinitas, California

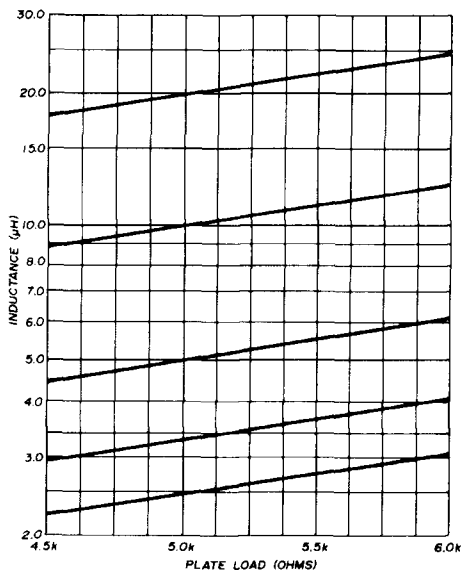


fig. 1. Curves of inductance vs plate load impedance for pi networks extrapolated to include values for high-power tubes.

memory keyer

Dear HR:

The electronic keyer with random-access memory described in the October, 1973, issue has generated considerable interest in this area. However, some operators have come to the conclusion that, "The (expletive deleted) thing doesn't work right." The first dot of a character following a character ending in a dash came out as a dash. Since the

keyer circuit is patterned essentially after the Micro-TO keyer, the problem isn't too difficult to solve — the toggle of the second J-K flip-flop should be connected to the Q output (pin 9) of the 7473, *not* the \bar{Q} output (pin 8) as shown in the schematic. (The Q output also goes to the 7402 NOR gate B.) With this simple change the keyer works perfectly.

The modification is easily made if the PC board is used. Simply bend pin 8 of the 7473 away from the IC so it will not short to the socket, and short pins 8 and 9 on the PC board.

Howard M. Berlin, K3NEZ
Edgewood Arsenal, Maryland

kilowatt linear modifications

Dear HR:

Regarding my five-band kilowatt linear amplifier which appeared in the January, 1974, issue of *ham radio*, following are two modifications which will improve its operation. The first, suggested by W1OR, provides monitoring of both plate *and* screen currents. By removing the ground from the plate meter and the positive screen supply, and connecting the plate- and screen-current meters as shown in fig. 2, both can be monitored.

The second modification provides better plate and screen efficiency when using the amplifier on CW. By adding a second zener diode in series with the one shown in the original circuit, the static plate current may be reduced to near zero for operation on CW. When this second zener diode is shorted out, the idling plate current returns to the proper level for linear ssb operation. Note, however, that the switch is at -300 volts with respect to ground so it must be insulated from its frame by at least that amount.

Some readers are apparently having difficulty in determining the proper connections for the zener diode. When using a volt-ohmmeter on the ohms scale, the polarity is sometimes reversed at the pin jacks (plus or red jack is minus and vice versa). This can only be checked with

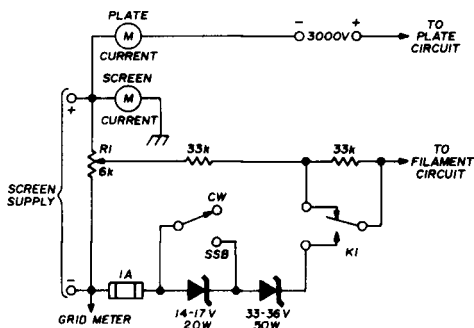


fig. 2. Improved metering and bias circuit for the five-band kilowatt linear. Zener diodes should be 50-volt units (50 watts) for CW and ssb operation.

another voltmeter or by checking a good diode that you know is properly marked. It's important to check zener diodes before installation because some manufacturers mark their product differently from others, and some diodes which appear on the surplus market are there because they were improperly marked in the first place.

John True, W40Q
Great Falls, Virginia

AFSK generator

Dear HR:

Having built and tested the AFSK generator described in the December, 1973, issue, I found that the oscillator was very sluggish in starting (delays up to two minutes). Once started however, the unit functions beautifully.

The problem appears to be in the feedback loop of the oscillator, namely the crystal and capacitor C1. The feedback gain (β) is dependent upon the ratio of C_x/C_1 where C_x is the capacitance of the crystal. This circuit seemed to need a little more feedback gain. Changing C1 to 510 pF cured the problem.

If the crystal is a type cut for parallel-resonant circuits (as are most of the military surplus crystals) the capacitance is different than that of a crystal cut for a series-resonant circuit, such as the circuit used in the AFSK generator.

David L. Chute, WA1NYL
Groton, Connecticut

the ham notebook

Heath HW-7 modifications

The Heath HW-7 QRP transceiver is a fine example of a compact rig for portable or home use. However, there are several minor modifications which will add to the ease of operations. These modifications are: an improved receiver blanking system, an adjustable sidetone volume level and the addition of a keyer.

The first modification is an improved circuit for cutting off the receiver during

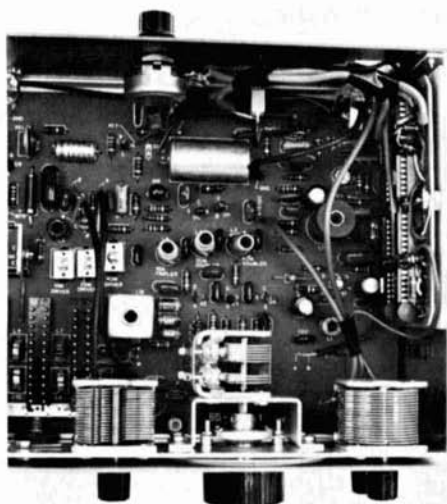


fig. 2. Location of the keyer board. Keyer controls are mounted on the rear panel. Note, at center, diode CR2 is removed from board. (Photo by WA5KV B)

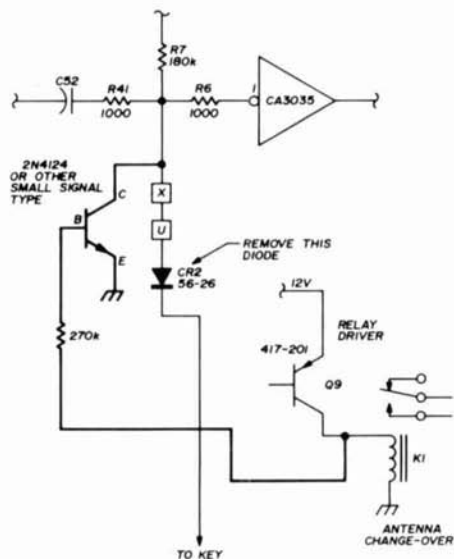


fig. 1. Schematic diagram of the HW-7 receiver blanking modification. The only two components needed, a small-signal transistor and a 270k resistor, are shown in bold.

the keydown time. As is, a diode, CR2, is used to ground the high-gain audio amplifier's input during the key-down mode (see fig. 1). However, the amplifier's input is grounded during the time of key-down only, and not during key-up. Thus, an annoying clicking sound is heard as code is sent.

An improved method of blanking the receiver during the transmit mode is to actually short the audio amplifier's input to ground during key-down and as long as the transceiver is in the transmit mode. The HW-7 has a time-delayed antenna transfer relay to switch between transmit and receive. By using the relay's coil

signal to switch a transistor gate, the receiver's audio amplifier's audio input will be grounded during the *total* transmit time.

The addition of a small signal transistor and a resistor is the only modification needed. Fig. 1 shows the placement of the transistor switch in the circuit diagram. During the transmit mode, relay coil K1 is energized by 12-volts. This same voltage is used to turn on the added transistor, thus shorting the receiver's input. Diode CR2 should be removed as it is not needed.

sidetone volume

The sidetone amplitude is fixed in the HW-7. The addition of a 500k variable resistor in *series* with C45 (0.05 μ F) will allow the adjustment of the sidetone's volume to a comfortable listening level. I used a miniature *Helipot* potentiometer, but the type is not critical. One lead of C45 is lifted from the foil; the potentiometer is connected in series with the capacitor. The sidetone volume is then easily adjusted by varying the added series resistor.

The addition of a keyer will be a welcome modification for the CW man. Rather than give a full description of the keyer design, the placement of the keyer in the HW-7 will be described (the keyer I used is a cmos version of the Accu-Keyer).¹ There is plenty of room inside the rig to allow for a great deal of flexibility. The keyer was placed in the rear, right-hand corner as shown in fig. 2. All of the keyer's controls were brought out to the rear panel since adjustments are seldom needed. A three-conductor phone jack replaces the phone jack originally used in the HW-7. This allows the use of a paddle-type key to be used externally. A tune pushbutton should also be mounted on the rear panel to facilitate tuning the rig. I recommend that a toggle switch not be used for the tuning control as the switch might be left on accidentally.

F.E. Hinkle, WA5KPG

1. James M. Garrett, WB4VVF, "The WB4VVF Accu-Keyer," *QST*, August, 1973, page 19.

sensitive rf probe

To detect the very low-level rf signals you may find in receivers or low-level transmitter stages, it's necessary to use a rectifier that will respond to small signals and yet give a respectable output. There are two tricks that will help get this done.

One is to hand pick the signal diodes. Most amateurs have the needed test equipment on hand. All it takes is a

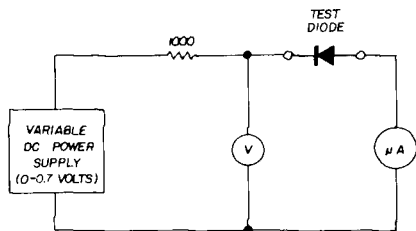


fig. 3. Circuit for testing diodes for use in the rf probe shown in fig. 4.

source of dc readily varied from zero to 0.7 volts, a voltmeter you can read accurately in that range, a current-limiting resistor and a microammeter. Hook them up as shown in fig. 3. Take a handful of diodes such as you get for just about zero cost on surplus circuit boards and test each for its forward-conduction voltage. Select the *germanium* diodes with the lowest forward-conduction voltage.

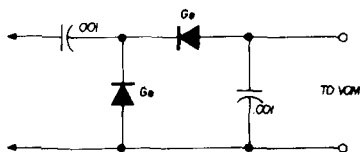


fig. 4. Sensitive rf probe uses selected germanium diodes in voltage-doubling circuit.

Then go back and rescreen that group for the ones with the least reverse-conduction current. Select two for use in the voltage-doubler rectifier shown in fig. 4.

This circuit, with selected germanium diodes, resulted in a change from zero to a full volt deflection on my fet-vom when used to pick up the output of a feeble rf signal generator.

Carl Drumeller, W5JJ

short circuits

L-network design

The radical sign in **equation 7** on page 27 of the February, 1974, issue should extend over the expression $(X^2 + R^2)$ at the end of the line. This also applies to the formula for the constant k in the practical example on page 28.

ssb transceiver

In the article on the 40-meter ssb transmitter and receiver in the March, 1974, issue of *ham radio* the author used the wrong nomenclature for the Collins mechanical filter by calling it an FA21-7102. The correct nomenclature for this filter is F455FA21 (where F indicates a mechanical filter, 455 indicates a 455-kHz center frequency, FA is the case style [FA is used in the S-line] and 21 indicates a nominal 6-dB bandwidth of 2.1 kHz). The "7102" on the author's filter is simply a date code used by the manufacturer.

lowpass filters

The construction data for the 40-meter lowpass filter described in **fig. 3** on page 39 of the March, 1974, issue is in error. L1 should be 15 turns number-16 on an Amidon T80-6 toroid (1.08 μ H). L2 is 13 turns number-16 on an Amidon T80-6 core (0.76 μ H). Insertion loss is approximately 0.14 dB.

two-meter transverter

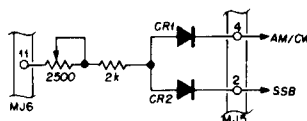
In the final amplifier schematic (**fig. 5**) for the two-meter transverter on page 12 of the February, 1974, issue of *ham radio* the symbol for the CTC byistor, BY1, is incorrect — the arrowhead should be at terminal S, the tail of the arrow at terminal I. Also, there should be a 68-ohm, 12-watt resistor in series with the line from terminal I of BY1 to the junction of the 0.1- μ F capacitor and L104.

Yaesu sideband switching

A serious flaw appeared in the article on Yaesu sideband switching which appeared in the *ham notebook* column on

page 57 of the December, 1973, issue. When the conversion is made as described, the USB and LSB are both on the same frequency on transmit and receive as claimed, but the tune and CW modes are shifted 3 kHz on receive but not changed on transmit, and the a-m mode is not changed on either transmit or receive! The problem is that pin 2 of MJ5 must be at ground potential to obtain the desired frequency shift — it is not in all cases with W2MUU's modification.

Fortunately, the solution is quite simple: simply add two silicon diodes as indicated in the schematic below.



The two diodes in this circuit operate as an OR gate so that whenever the emitter of Q6 (a-m/CW oscillator) or Q3 (USB oscillator) is grounded for operation, it also grounds the frequency-shift circuit.

cosmos electronic keyer

In the cosmos IC electronic keyer which was featured on page 6 of the June, 1974, issue, the circuit occasionally hangs up when first switched on. This can be corrected by removing pin 4 of U6A from ground and connecting it to pin 10 of U4B. Thus, when power is turned on, if the dot and dash generators both come on in the *on* state, the dash generator can now directly reset the dot generator, resulting in the emission of a single dash. After that the spurious state is permanently suppressed.

A second problem, where hang-up is induced by rapid deflection of the keyer paddle, is also eliminated by this modification. This problem is caused by the difference in propagation delays in the circuitry of the dot and dash generators (the delays in the dash generator are greater because the signal must travel through more gates). This problem is especially evident when going rapidly from dash to dot.

The Eitels comment on our *Triton*



William Eitel—WA7LRU/W6UF/W6AY
Laneil Eitel—WA7LUN/WB6MRW

Whatever your Amateur interests are on the HF bands, the TRITON will give you new operating convenience and pleasure. Fully solid state with the latest semi-conductor technology. Instant band change, high articulation SSB and a host of new and exciting features. Write for details.

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Eitel Ranch and Laboratory

DAYTON, NEVADA 89001

(702) 882-4187

August 24, 1974

Mr. Al Ka.
Ten Tec, Inc.
Sevierville, Tenn 37862

Dear Al:

I have been using a Triton II for about four months and I would like to comment on some of its features. As you know, my major interest on the HF bands is in high speed CW. After studying the features of the equipment available to serious CW operators, I decided the Triton II might meet my requirements. I had the opportunity to try a Triton II at the SAROC Convention in Las Vegas last January and I was indeed amazed at its performance on both SSB and CW. The Triton has better break-in performance than any separate receiver transmitter combination I have used and seems better than most of the stations I work. In a high speed roundtable, the first dot from the station wishing to break will usually break me. The CW filters are excellent and provide the selectivity necessary for practical CW operation. The offset tuning allows accurate zero beat with the station I wish to work. Yes, I am talking about a transceiver and not a receiver transmitter combination.

The XYL WA7LUN-WB6MRW is also a CW operator and she uses the Triton II at our summer location. She has decided to trade her present popular equipment for a Triton II. I am also considering replacing my home station exciter with a Triton. This will free my receiver for use for other purposes. I have used my receiver with the Triton II and the receiving antenna provision in the Triton is excellent and provides a very practical method of using a separate receiver to monitor other frequencies.

I would recommend the Triton to anyone interested in MODERN CW operation.

73,

Bill

Bill
WA7LRU/W6UF

WNE/eh



TRITON I 100 watts input \$579.00
TRITON II 200 watts input 669.00

TEN-TEC, INC.
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new products

portable general-coverage receiver



Barlow Wadley's new XCR-30 receiver is the first moderately-priced (around \$260.00) all solid-state portable to feature direct frequency readout. Using a multiple heterodyne circuit (interpolation and crystal oscillators), the XCR-30 is a high sensitivity receiver designed to provide precision no-gap tuning from 500 kHz to 30 MHz. A 1-MHz crystal — in conjunction with the famous Wadley Loop circuit found in expensive (\$2500 plus) Racal receivers — stabilizes the received frequency and eliminates drift. The tuned frequency is displayed mechanically as a composite function of two dials; the whole number (in MHz) is shown on one dial drum, and the decimal portion (in kHz) is shown on the second.

Reception modes include a-m, CW and switchable single sideband.

The XCR-30 is metal-cased with external padding, not the usual plastic, and measures less than 300x200x100mm. Access to internal parts is through removal of the front or rear panel. The receiver has a built-in loudspeaker, but has facilities for headphones, external speaker, and 9-12 volt dc power source. In addition to the built-in, collapsible whip, an external antenna can be attached.

For more information on this exciting new receiver from South Africa, write to the American distributor, Gilfer Associates, Inc., Post Office Box 239, Park Ridge, New Jersey 07656, or use *check-off* on page 136.

hand-held two-meter transceiver

A new portable solid-state two-meter fm transceiver, designed to provide radio amateurs with reliable commercial quality performance at low cost, is now available from the Clegg Division of International Signal and Control Corporation. The two-watt, 5-channel unit features a unique battery saver design that results in less than 5-mA standby current drain while the high reliability battery offers up to 4 or 5 years of life under normal use.

The new HT-146 also features a single-conversion receiver, a monolithic crystal filter, and solid state T/R switching. Plug-in crystals make channel change fast and easy. Jacks for external microphone, speaker, and earphone are included along with BNC antenna connector and heliflex antenna. Accessories available include a tone encoder/decoder, microphone, leather case, earphone and an automatic battery charger.

The HT-146 hand-held transceiver is priced at \$289.00. For additional information, write to Technical Literature Department, Clegg Division, International Signal and Control Corporation, 3050 Hempland Road, Lancaster, Pennsylvania 17601, or use *check-off* on page 136.

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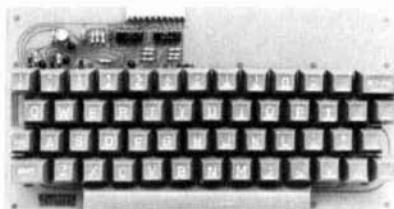
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So what does this have to do with the Atlas-180?

THE URC-87 and the Atlas-180 are what you might call 'first cousins.' Atlas Radio is licensed by SouthCom International, and thus has access to the advanced state-of-the-art circuit designs by Les Earnshaw, President of SouthCom. Les is widely recognized as one of the foremost solid state radio engineers in the world, and the URC-87 is an outstanding example of his work.



The Atlas-180 uses the same basic circuitry as the URC-87. There are some differences of course, such as a tuneable VFO in place of the frequency synthesizer, and we can't guarantee underwater operation. But the outstanding receiver and transmitter performance is there, and accomplished with far fewer components than any comparable equipment. Together the URC-87 and the Atlas-180 enjoy a reputation for performance and reliability that make them truly superior transceivers, the envy of competitors.

There are now over 1000 Atlas-180's on the air all over the world. Their growing reputation for excellent quality, receiver sensitivity, selectivity, and

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Modular construction with plug in circuit boards permits easy servicing, when required. However, built to top commercial specs, this isn't very often. But when service is needed, Atlas Radio backs every set with a service policy second to none. Your satisfaction is guaranteed.

73

Herb Johnson, W6QKI

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The easy-to-use 1550 keyer is your answer if you're looking for an electronic keyer that lets you send accurate CW effortlessly. Send from 8 to 60 WPM with conventional, iambic, and dot memory operation. Operates with dual or single lever keys. The optional 1550/ID automatically sends "DE" followed by your station call. For fast, accurate CW, order the HAL 1550/ID or 1550 today.

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A complete Morse keyboard. Code speed variable from 10-60 WPM with variable dot-to-space ratio (weight). All solid-state, featuring computer-grade components. Complete alphanumeric and punctuation keys, plus an optional "DE-call sign" key factory programmed for you. Includes built-in speaker/oscillator monitor.

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All solid-state. Type out CW at 8-60 WPM. Adjustable dot-to-space ratio (weight). Complete alphanumeric keys, plus 11 punctuation marks. Five standard two-character keys, 2 shift keys, break-for-tuning key, 2 three-character function keys, and a "DE-call sign" key. We'll program your call right into the DKB-2010. Plus complete RTTY capabilities. Built-in three-character buffer. Optional 64 or 128 key buffer also available.

Price: \$425 Assembled, \$325 Kit, ppd USA. 64 key buffer \$100, 128 key buffer \$150. Air shipment, \$10.



HAL Communications Corp.
Box 365, Urbana, Illinois 61801
Telephone: (217) 359-7373

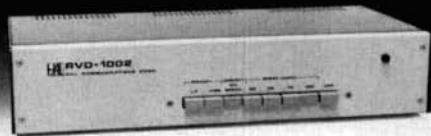
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Price: ST-6 \$310 Assembled, \$147.50 Kit, ppd USA.
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AK-1 AFSK \$40 Assembled, \$29 Kit, ppd USA.
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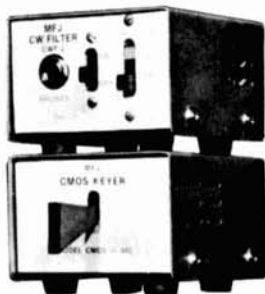
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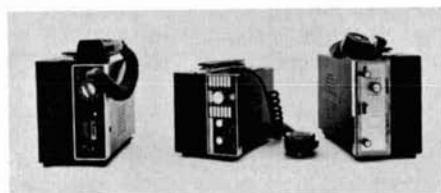
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AM-CW-SSB

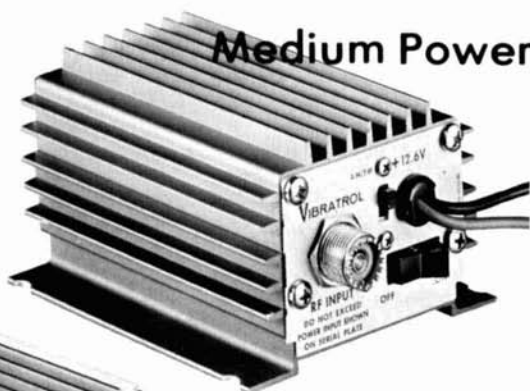
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Medium Power



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RFL-901*	10W	150W	199.95
RFL-1101*	25W	150W	229.95
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Maximum input sensitivity is 1 mV/cm over the entire vertical bandwidth. With a X10 probe and the 4510, you can read low-level waveforms to 10 mV/cm, not the 50 or 100 mV/cm found on other scopes.

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True X-Y operation is simple with the 4510. Channel 1 is used for horizontal deflection and Channel 2 for vertical deflection. Phase measurements can be made using the standard vertical inputs, not the horizontal input as other scopes require.

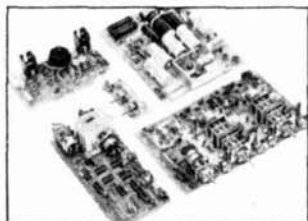
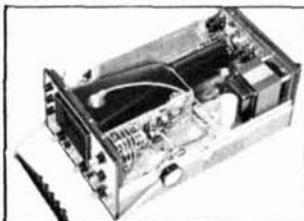
Servicing the 4510 is remarkably easy. All major circuitry is located on five circuit boards for easy troubleshooting. Push-on connectors permit fast removal of any board. Even the CRT can be removed and replaced in a matter of minutes.

The best feature of the 4510 is its low price. The SO-4510 comes completely factory assembled and calibrated for only \$750*. Or order the kit-form IO-4510 at \$549.95* and save by building it yourself. Shipping weight 34 lbs.

The 4510 was designed for easy access to all circuits and components.

All major circuitry is contained on five easily removed circuit boards.

The adjustable line voltage switch matches the power supply of the 4510 to any voltage from 100 to 280 VAC.



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A good low frequency generator is a necessity for every ham shack. And now Heath has the replacement for the traditional sine-square generator — the 1271 Function Generator. It offers a greater frequency range (0.1 Hz to 1 MHz), more waveforms (sine, square and triangle) and a usable low output impedance (50 ohms, not 600). Output is 10 volts p-p...attenuation is 0 to 50 dB in 10 dB steps with up to 20 dB additional variable attenuation for each step, for a total of 70 dB...triangle waveform non-linearity is 5% max., with waveform symmetry within 10%...square wave rise & fall times of 100 nsec max....adjustable handle for easy carrying and positioning. The kit IG-1271 is only \$99.95* and the as-

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Put away your slide rule and scratchpad. The Heathkit IC-2100 is the easy way to calculate those circuit impedances and phase angles. And it's easy to use — it's desk size, not a pocket calculator. It has contoured, finger-size keys and bright 1/2"-tall displays. To make it convenient to use, we built in cumulative memory and register changes that eliminate scratchpad work. Of course, it performs the functions you need — trig and arc trig in degrees or radians, common and natural logs, e^x , inverses, square roots, π and exponential functions. It can even be wired for 120 or 240 VAC. Assemble it easily in a few evenings. Kit IC-2100, only \$119.95*. Shipping weight 4 lbs.

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144-148 MHz

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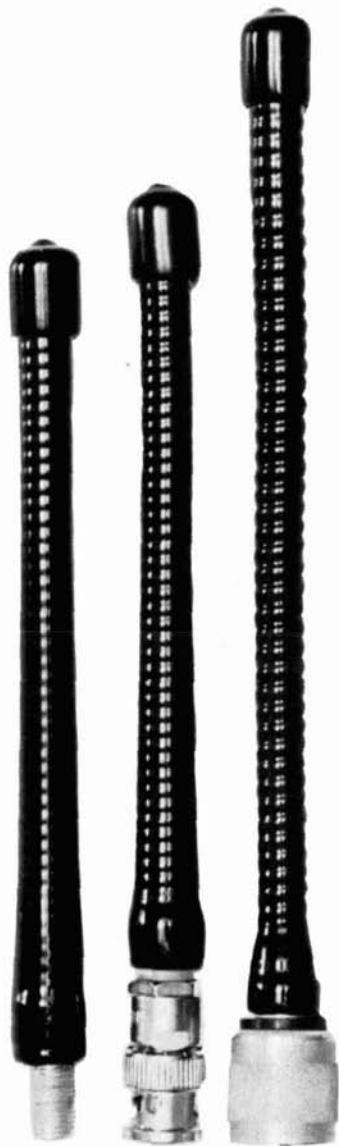
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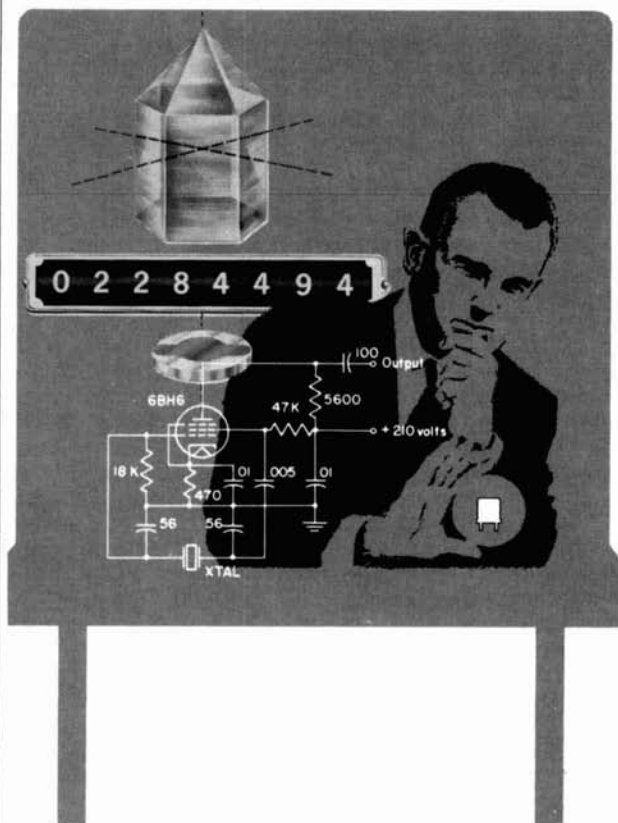


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222.34	223.90	146.10	146.52	52.525	52.525
222.38	223.94	146.12	146.61	52.70	52.60
223.14	223.98	146.16	146.70	52.76	52.64
223.26	224.74	146.19	146.72	52.82	52.68
223.30	224.86	146.22	146.76	52.88	52.72
223.34	224.90	146.25	146.79	52.92	52.79
223.50	224.94	146.28	146.82	52.96	52.80
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		146.52	146.88	53.25	53.08
		146.94	146.94	53.68	53.16

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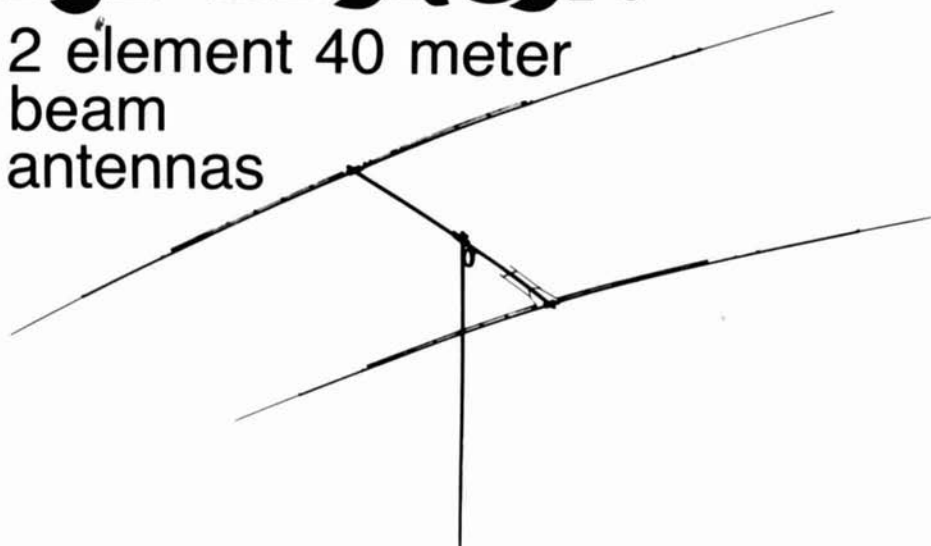
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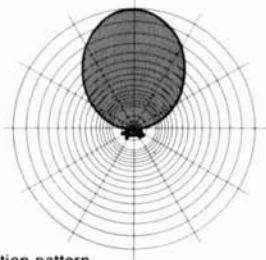


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ANNOUNCING

HCV-2A SSTV MONITOR



Now from the designer of the world famous HCV SSTV equipment, Dr. James Thomas, WB4HCV, we are proud to announce the new and improved HCV-2A SSTV Monitor. This monitor is similar to that produced by THOMAS ELECTRONICS only much improved. The special features have now been patented and carry U. S. Patent #DD-033468. Be watching for our HCV-3KB SSTV Keyboard and our Hard Copy SSTV copy machine. Call or write us for complete specifications on the HCV-2A. 24 hour telephone answering service and personal on the air technical assistance from WB4HCV if needed, to better serve you.

SPECIFICATIONS — HCV-2A SSTV MONITOR

- 6.25" Diagonal Screen.
 - Removable Picture Tube Filter for added viewing flexibility.
 - Manual Vertical Trigger Pushbutton allows re-start of scan at any time.
 - Tuning Meter, instead of LED, to aid tuning in of SSTV signal.
 - Noise immunity circuits and special filtering to allow for excellent "closed circuit" pictures under high noise conditions. Copy pictures with 3 db or less signal strength.
 - The only SSTV Monitor with Transistors, ICs and Op Amps mounted in plug-in sockets on a G-10 glass epoxy-gold flashed printed circuit board.
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 - 29 Transistors, 11 ICs, 30 Diodes, Special phosphor Mix CRT.
 - Optional Built In Fast Scan Viewfinder allows viewing of HCV-1B Camera or similar SSTV Camera fast scan sampling rate on the same CRT used for SSTV. By viewing the picture in real time, the camera can be focused and set-up instantly. Eliminates the need of a separate fast scan viewfinder monitor. Add \$95.00, to basic HCV-2A price for this optional feature, factory installed or purchase the HCV-70FSVFK modification kit for \$69.95, and install it yourself.
 - Built to rigid industrial specifications for long trouble free service. Full 1 year warranty — 90 days on CRT. Printed circuit board exchange program and complete service department available if ever needed. On the air technical assistance from designer, WB4HCV, plus 24 hour telephone answering service to better serve our customers.
 - Fully meets or exceeds all currently accepted SSTV standards — Worldwide.
 - Size: 15½" deep, 14" wide, 8½" high. Weight 26 lbs. Color: Black and White or optional 2 tone gray when specified — no extra charge. Aluminum Cabinet.
- Regular Price \$425.00. Special Introductory Cash With Order Price \$398.00. (Note: Credit Cards pay regular price \$425.00.) F.O.B. Hendersonville, Tennessee. 5 ways to purchase: Cash, C.O.D., Mastercharge, BankAmericard, SEEC financing plan (up to 36 months). HCV-2A Monitor with built-in fast scan viewfinder \$493.00. Regular Price \$520.00.

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Grey Scale Calibration Tape	\$ 5.00 Cassette \$4.00 Reel
Pre-Recorded, Call Sign, etc. — Specify	\$ 8.00 Cassette \$7.00 Reel
Blank Scotch Brand Tape:	
45 minute	\$ 2.00 Cassette \$3.75 5" RI.
60 minute	\$ 3.00 Cassette \$4.25 7" RI.
90 minute	\$ 4.00 Cassette \$6.00 7" RI.
120 minute	\$ 5.75 Cassette \$8.50 7" RI.
HCV70FSVFK Fast Scan Viewfinder Kit HCV-2A	\$ 69.95
Spare Printed Circuit Board HCV-2A	\$175.00

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TELEPHONE 615-824-3235

ANNOUNCING

HCV-1B

SSTV

CAMERA



Now from the designer of the world famous HCV SSTV equipment, Dr. James Thomas, WB4HCV, is proud to announce the new and improved HCV-1B SSTV Camera. This camera is similar to that produced by THOMAS ELECTRONICS only much improved. The special features have now been patented and carry U. S. Patent #DD-033471. Be watching for our HCV-3KB SSTV Keyboard and our Hard Copy copy machine for SSTV. Call or write us for complete specifications on the HCV-1B. 24 hour telephone answering service and personal on the air technical assistance if needed by WB4HCV, to better serve you.

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- $\frac{1}{4}$ - $\frac{1}{2}$ - $\frac{3}{4}$ Frame Rate Selector.
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- Normal-Reverse Horizontal Deflection Coil Switch (Mirror Image Reading).
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- The only SSTV Camera commercially made with a built-in power supply for 115/230 V 50/60 Hz, which does not produce 50/60Hz hum bars in the slow scan picture.
- F1.9-22 25MM Cosmicar TV Lens Supplied.
- Fast Scan (sampling rate — 5kHz horizontal, 15/30Hz vertical) R.F. or Video output for viewing fast scan on standard TV set — Channels 2-8 or on a video monitor to aid as a focusing aid only in camera setup, etc.
- Fast scan sampling rates also available for connection to HCV-2A equipped with fast scan viewfinder modification, which displays fast scan in the same format as on slow scan, except in real time, to allow for instant focus and set-up of scene.
- ALC Option. Automatic Light Control may be added if desired. This optional feature allows the operator to leave the iris of the lens at one F setting (all the way open if desired), as the camera will adjust itself to light changes automatically. The light can then be varied on the scene, thus eliminating adjustment of the lens opening or the camera Contrast control. Auto/Manual switch which allows the operator to return the camera to normal operation when ALC is not being used. Add \$40.00 to basic HCV-1B price for this optional feature.
- Fully meets or exceeds all currently accepted SSTV standards — Worldwide.
- Built to rigid industrial specifications for long trouble free service. Full 1 year warranty — 90 days on Vidicon Tube. Printed Circuit Board exchange program and complete service department available if ever needed. A separate lab facility is also available which is involved in making improvements and testing out new designs prior to production. Modifications, improvements, etc., are sent out as they are made. On the air technical assistance from designer, WB4HCV, plus a 24 hour telephone answering service to better serve our customers.
- Size: 6" wide, 8" high, 13 $\frac{1}{4}$ " long. Weight: 12 lbs. (with lens). Color: Black & White or Optional 2 tone Gray — No extra charge. Aluminum Cabinet.
- 48 Transistors, 14 ICs, 26 Diodes. Industrial Grade 7735A Vidicon. Regular Price \$475.00. Special Introductory Cash With Order Price \$452.00. (Note: Credit Cards pay regular price \$475.) F.O.B. Hendersonville, Tennessee. 5 ways to purchase: Cash, C.O.D., Mastercharge, BankAmericard, SEEC Financing Plan (up to 36 months). HCV-1B Camera with built-in ALC (Automatic Light Control) — Special Cash Price \$492.00., Regular Price \$515.00.

ACCESSORY LIST

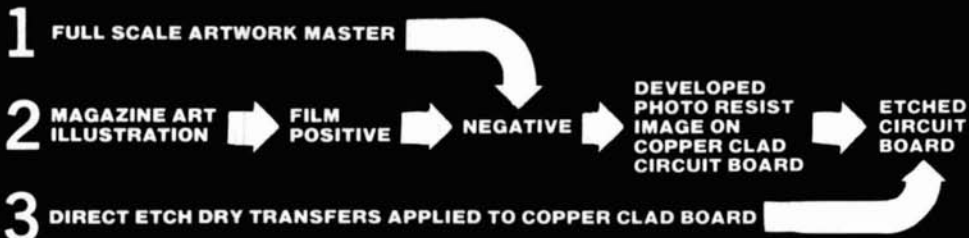
Heavy Duty Tripod		\$34.95
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#2519 25mm F1.9-22 C-Mount Standard		\$35.00
#1219 12.5mm F1.9-22 C-Mount Wide Angle		\$60.00
#Z-9015 22.5-90mm F1.5 C-Mount Zoom Lens		\$375.00
#504 75mm F1.4 C-Mount Telephoto		\$136.95
#2514DH 25mm F1.4-22 C-Mount Macro Close up		\$62.95
#EX-C6 Extension Tube (Close up) Kit C-Mount		\$15.95
Close Up Lens for 2514 and 2519 — Specify		\$14.95
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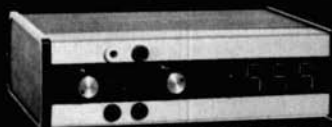
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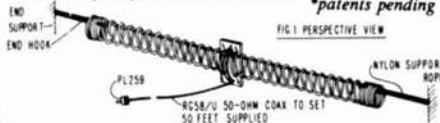
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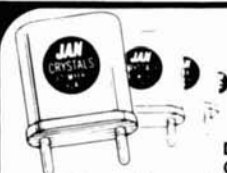
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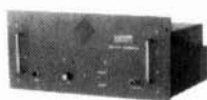
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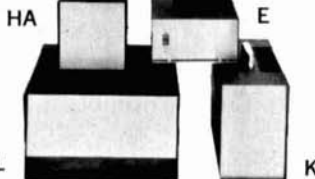


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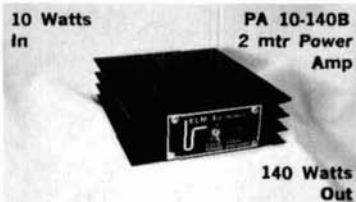




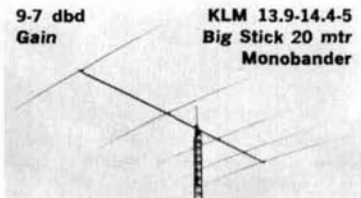
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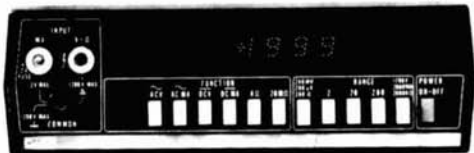
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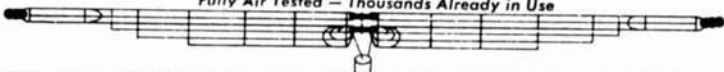


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NEED PARTS? We carry parts for R-388-390-390A-391-392-1051-51S1 - Nems Clark-Racal-Pack sets - PRC-25-41-47-62-70-71-73-74-77. If you need a part no matter what you have. If its U.S. government we have it or can get it. Also we want to buy or trade all aircraft communications. All ground radio communications. All plug-in modules control heads. No matter what cond. they are in - bent or busted ok. We will buy or trade. We have R-390-388-390A-392-1051-51S1 Nems Clark - Racal - and new ham gear for trade. D & R Electronics, R. D. #1, Box 56, Milton, Pa. 17847. Phone 1-717-742-4604 after 6:00 P.M.

LAMPKIN 105B, Very Good. \$45.00, includes shipping in USA. Money order only. Danny McMillan, POB 1042, Astoria, Oregon 97103.

SIGNAL ONE OWNERS, expert and prompt service by ex-Signal/One engineer. Also will purchase your functioning or not functioning unit or spare parts. Write or call for details. Larry Pace, K2IXP/7, 5717 Genematas, Tucson, AZ. 85704 (602-888-5234).

VHF-UHF EQUIPMENT. 432 MHz receive and transmit converters. We now have receive converters for 144 and 220 MHz bands. Pre-amps for all bands 28-450 MHz. Write for information. Carmichael Communications, P. O. Box 256, Carmichael, CA 95608.

WANTED - USED FM 2-way radio communications equipment and test equipment. Mot., GE and RCA etc. No doggies please, CAL-COM Systems, Inc., 701-51A Kings Row, San Jose, Calif. 95112, Tel. 408/998-4444.

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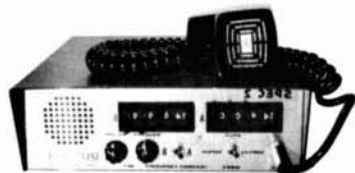
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HEATHKIT SB401, \$240; SB310, \$220; SB110A, \$280; SB630, \$70; SB510, \$70; Two SB620, \$110 each; SB600, \$15; HP23, \$45; HDP21A, \$15. All Heath aligned. Utica 650/VFO, \$70; Comdel speech processor, \$80; Clegg 6M conv., \$60. Richard Ravich, 15 West 72nd St., New York, N. Y. 10023.

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COLLECTORS: Sell Ham Radio April 68 thru Dec. 69 complete. Sell by year only, best offer. Bob Ghormley, WA0UVX, RR #2, Box 249-C, Panama City, Fla. 32401.

WANTED: tubes, transistors, equipment, what have you? Bernard Goldstein, W2MNP, Box 257, Canal Station, New York, N. Y. 10013.

STOLEN FROM MARS STATION, Fort Meade, Md. Five Collins Model KWM-2A transceivers, Serial Nos. 11359, 10731, 10095, 11218, and 16066. Two Collins Model 30L1 Amplifiers, Serial Nos. 10620 and 11012. Three Collins Model 312B-5 Controls, Serial Nos. 10016, 10394 and 59502. One Collins Model 516F2 Power Supply, Serial No. 18607. Three Power Supplies, Serial Nos. 12046, 12045 and 12015. Two Radio Receivers, Serial Nos. 2918 and 1168. One Multimeter, Serial No. 11065. Anyone having information concerning these items should contact their local FBI office and/or Fort Meade Field Office, USACIDC, Fort Meade, MD 20755, telephone 301-677-6446 or 677-6622.

CANADIAN JUMBO SURPLUS and Parts Catalogs. Bargains Galore. Send \$1. ETCO-HR, Box 741, Montreal "A" H3c 2V2.

CX7A REPLACEMENT PARTS, SASE for quote. Emerald, 8956 Swallow, Fountain Valley, CA 92708.

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10.7 MHz FILTERS

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N.F. (typical)	2.5dB	2.8dB	3.4dB	3.8dB	9.0dB
Nom. Gain	30dB	30dB	26dB	28dB	20dB
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1 1/4" x 2 1/2" x 4 1/2" + connectors

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20 watts max.

OUTPUT: 420-459 MHz

14 watts typ.

Size: 4 1/2" x 2 1/2" x 1 1/4" + connectors

High(er) Power units MMv432H and MMv1296H available.

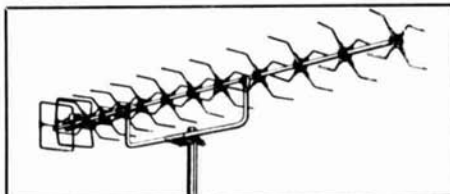
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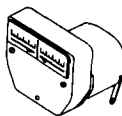
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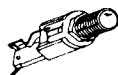
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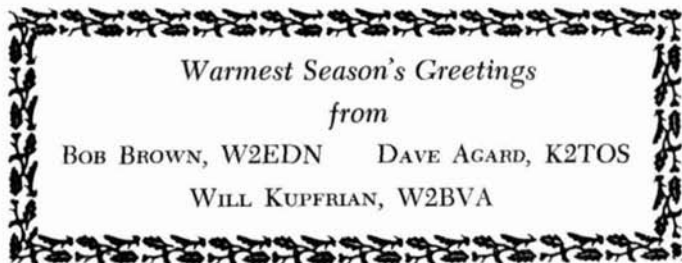
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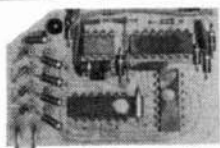
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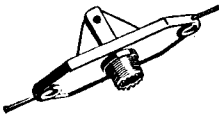
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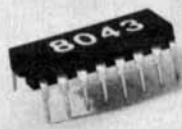
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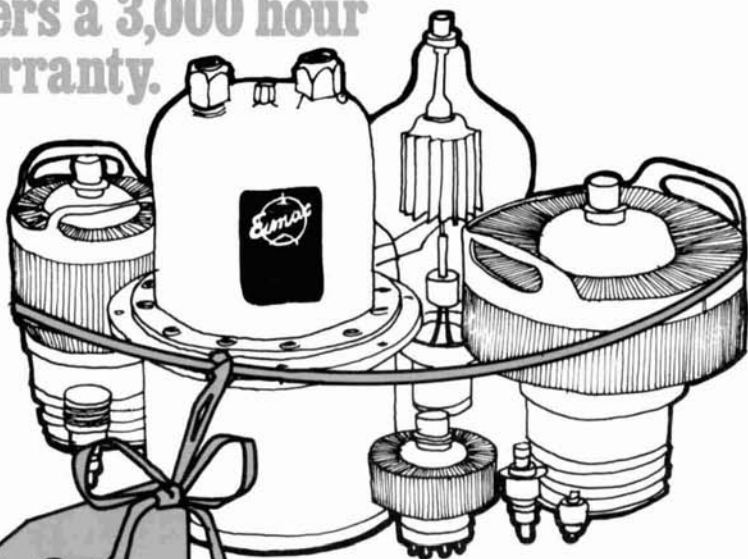
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