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# *ham radio*

*magazine*

AUGUST 1971



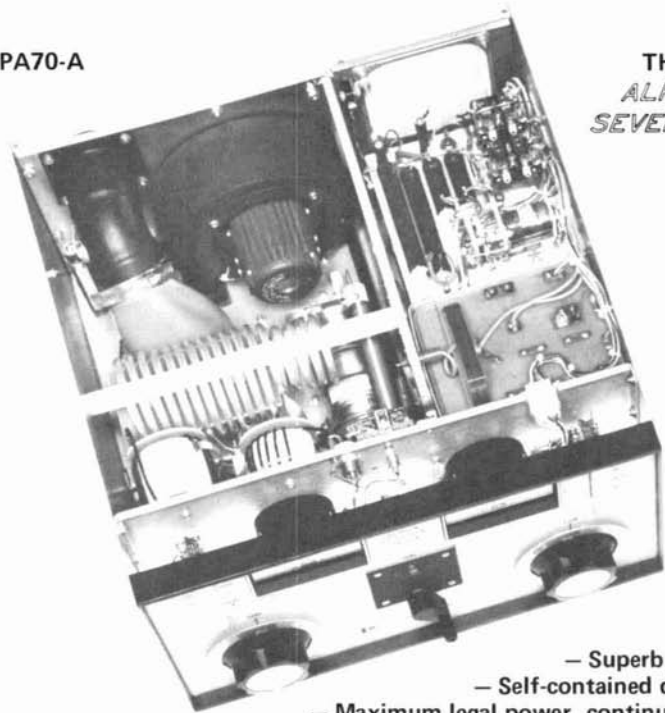
**frequency  
multipliers**

## *this month*

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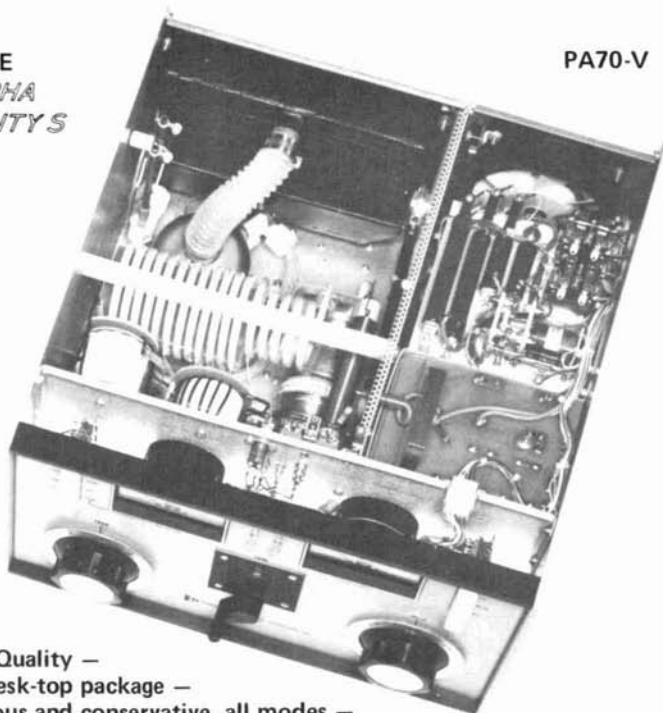
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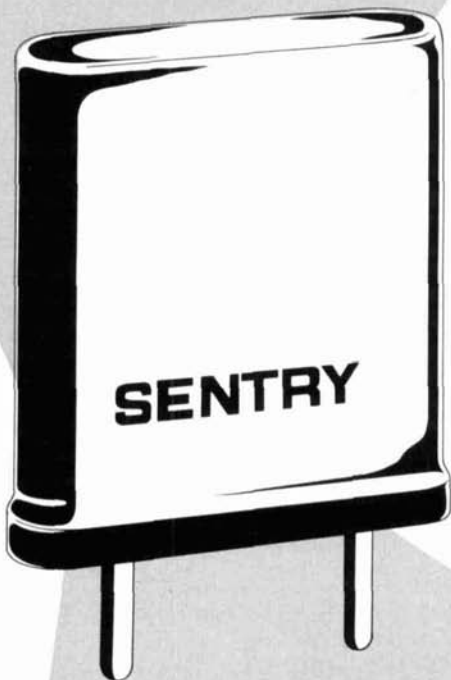
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## a second look

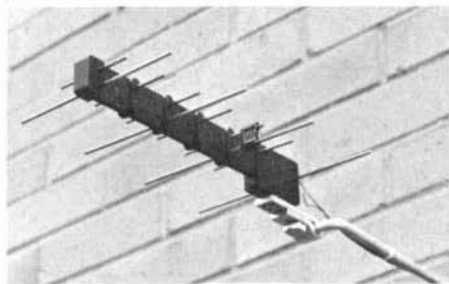
by Jim  
fisk

The latest application for radio is a new system developed by Sangamo Electric for automatically reading electric, gas and water meters from a cruising utility truck. The new system combines the functions of meter reading, communicating the data, and preprocessing the information on magnetic tape. The tape is used to prepare monthly bills.

The utility meters used in the automatic system are conventional watt-hour, gas and water meters which are equipped with an spdt switch on the numerical registers; such meters are commercially available today. The electrical pulse from the switch is accumulated in a digital counter; the output from the counter is fed into a transponder mounted on the side of the building.

The transponder is the heart of the system. It is a completely passive unit that radiates no rf energy except when interrogated once a month by a cruising utility truck. The transponder is activated by a 915-MHz signal from the truck. As long as the received signal is above a preset threshold, it re-radiates the second harmonic back to the truck's highly-directional receiving antenna.

Data transponder consists of harmonic generator and two Yagi antennas.



The 1830-MHz signal from the transponder is keyed on and off by the 4-kHz pulse train from the data accumulator. A complete message from up to 12 utility meters can be received within less than 30 feet when the truck is traveling at 20 mph.

The transponder consists of two Yagi antennas on a single boom as shown in the photograph. The 4-element 915-MHz antenna is mounted below the 6-element 1830-MHz unit. The radiators of the two antennas are connected through a harmonic generator; this is the small unit in the photograph located between the second elements of each antenna.

Pilot tests being conducted in Springfield, Illinois with a prototype system indicate that, on a one-shift basis, a cruising utility truck can automatically record data from 100,000 meters per month. This represents approximately one-tenth the cost of present meter-reading methods.

### sweepstakes

The prize drawings for the *ham radio* sweepstakes are taking place as this is being written. The grand prizes, a Signal/One transceiver and Delta Seventy linear amplifier, were won by W2ANB in Slingerlands, New York. W2CNB, W4YPC and WB8DUO are the proud new owners of Varitronics IC-2F fm transceivers. Fifty other winners will receive the famous RSGB "Radio Communications Handbook." We will have complete details in the September issue.

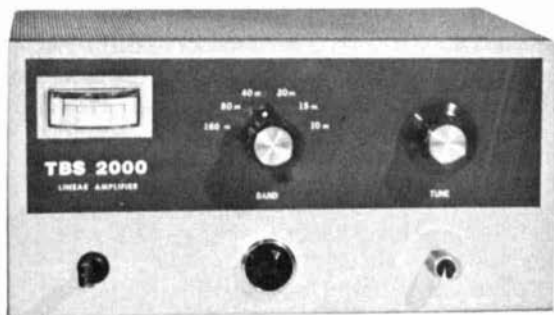
Jim Fisk, W1DTY  
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**DRIVING POWER:** 80-150 watts  
**OUTPUT IMPEDANCE:** 50 ohms nominally  
**TUBE COMPLEMENT:** six RCA 31LQ6  
**PLATE CURRENT METER:** 0-2 amperes, 5% move.  
**RELATIVE OUTPUT INDICATOR:** indicator light  
**RELAY:** built-in antenna change over relay  
**POWER SUPPLY REGULATION:** 3% key-up to key down  
**POWER SUPPLY FILTER CAPACITY:** total of 550 mfd  
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**POLARITY:** cord may be plugged into wall *without regard* to polarity  
**COLOR:** light gray cabinet with dark gray panel insert  
**DIMENSIONS:** cabinet is 11.25" wide, 5.75" high, 8.75" deep  
**WEIGHT:** net 10 lbs (4.6Kg); shipping weight 13 lbs (6 Kg)  
**PRICE:** TBS-2000 \$229.00, TBS-110 \$39.00; TBS-12 Price — To be announced.

**TOP BAND SYSTEMS, Dept. 3, 5349 Abbeyfield St., Long Beach, CA 90815**

# frequency multipliers

A complete discussion  
of frequency multiplier  
circuits,  
including vacuum tubes,  
bipolar transistors,  
field-effect transistors,  
diodes and  
integrated circuits

Hank Olson, W6GXN, Post Office Box 337, Menlo Park, California 94025

Radio amateurs have used frequency multipliers in receivers and transmitters for many years. The octave relationship of the originally designated amateur high-frequency and vhf bands (1.75, 3.5, 7.0, 14.0, 28.0, 56.0, 112.0, and 224 MHz) made doublers very popular in the era before World War II. Also, since the time when crystal control was first introduced frequency multipliers have been needed because of the maximum frequency limit of piezoelectric crystals at any given state of the art. In the 1930s crystals were limited to fundamental-mode types; crystals above 15 MHz were generally not available to radio amateurs. Therefore, amateurs who wanted to use crystal control on 28 MHz used a doubler from 14 MHz or two doublers from 7 MHz.

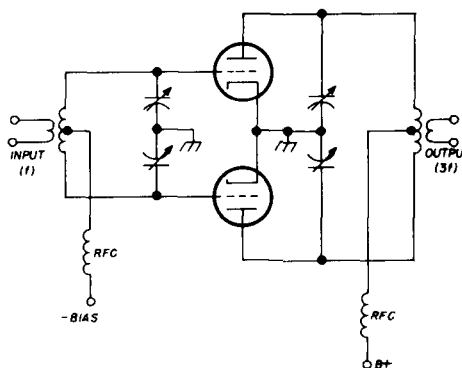


fig. 1. Vacuum-tube push-pull triple circuit.



**table 1. Vacuum-tube conduction angle for different frequency multiplication ratios.**

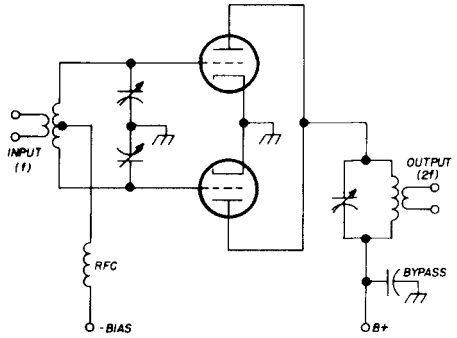
harmonic number	conduction angle
2	90-120°
3	80-120°
4	70-90°
5	60-72°

Today, 7th- or 9th-order overtone crystals are available for frequencies up to about 200 MHz. This makes frequency multiplication less imperative. However, variable crystal oscillators (vxo) work best with fundamental mode AT-cut crystals (generally available only up to about 22 MHz) so we will still find frequency multipliers in use. Also, multiplying up from a frequency standard, generally in the 1 to 5 MHz region, is often required to make calibrations at higher frequencies.

Until 20 years ago vacuum tubes and point-contact diodes were the only devices available as frequency-multipliers. For this application the vacuum tube was usually operated in class C with the cutoff bias set so the conduction angle was considerably less than 180°. This type of frequency multiplier is covered in detail by Terman.<sup>1</sup> The higher the multiplication factor, the narrower the conduction angle must be for best multiplication efficiency; this is shown in **table 1**.

Two variations of the vacuum-tube multiplier are available to improve performance; both use balanced tubes. The push-pull multiplier, **fig. 1**, cancels out even harmonics so is useful as a 3-, 5- or

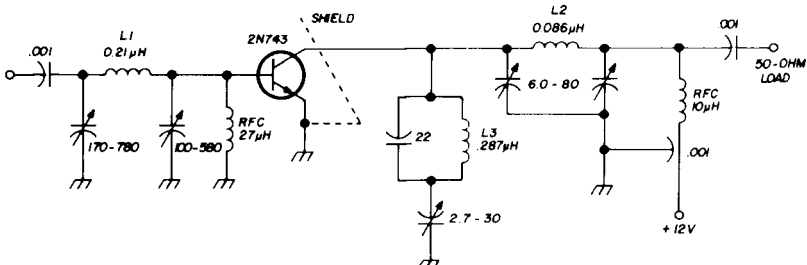
7-times multiplier. This circuit looks just like a push-pull class-C amplifier except that the cross-neutralization capacitors are removed since the output is on a different frequency than the input. The push-push multiplier, **fig. 2**, cancels the fundamental and odd harmonics so is useful as a doubler, quadrupler, 6-times multiplier, etc. Anyone who worked the vhf bands in the 1950s will remember the multi-stage push-push and push-pull 6J6 multipliers.



**Fig. 2. Vacuum-tube push-push doubler circuit.**

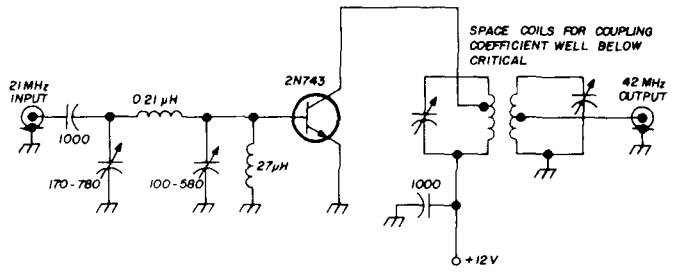
### transistor multipliers

With the development of the bipolar transistor a new type of multiplier became available — perhaps two new types. The most obvious way to use a transistor as a multiplier is to rely on the nonlinear characteristic of the base-emitter diode. The transistor doubler circuit in **fig. 3** has pi-networks on both input and output.<sup>2</sup>



**fig. 3. Bipolar-transistor 21- to 42-MHz doubler. L1 is 3 turns no. 516 Air Dux; L2 is 4 turns no. 416 Air Dux; L3 is 7 turns no. 416 Air Dux.**

fig. 4. Frequency doubler circuit using a bandpass output circuit.



Since the circuit is a frequency doubler and a pi network is a *lowpass* network, it is necessary to add a fundamental trap consisting of L<sub>3</sub>, C<sub>4</sub> and C<sub>5</sub>. (If it were a tripler circuit it would be necessary to have both fundamental and second-harmonic traps.) If you use a bandpass

coupling network such as a double-tuned circuit these traps may be eliminated. Such a circuit is shown in fig. 4. In fact, if you are not too fussy about the rejection of fundamental and unwanted adjacent harmonics the circuit of fig. 5 can be used. However, fig. 5 is best suited for doubling because frequency doubling gives the greatest spacing (percentage) of unwanted frequencies.

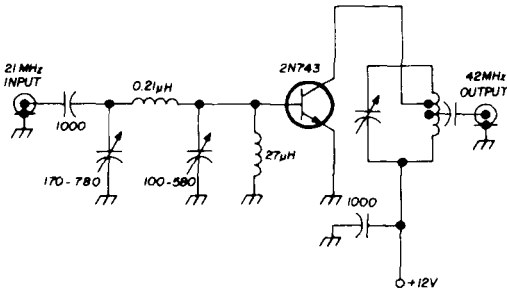
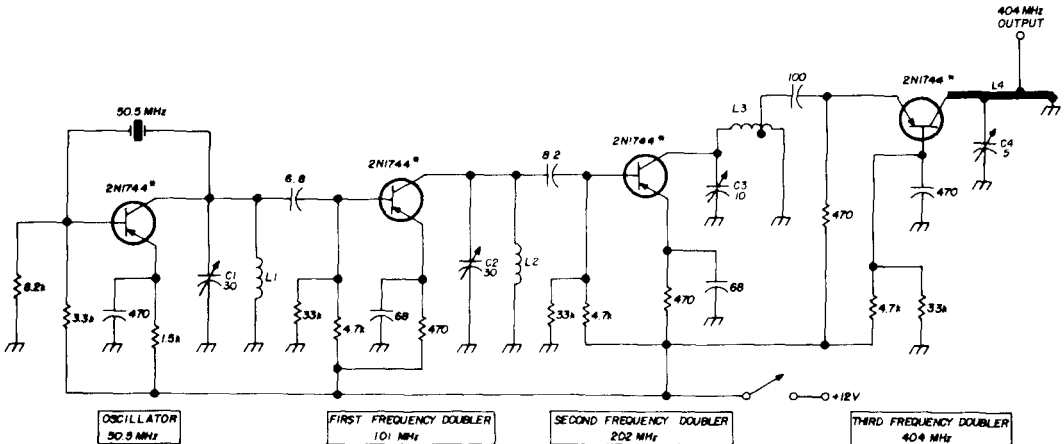


fig. 5. Frequency doubler circuit using a single parallel-tuned output circuit.

Since the transistor does not conduct current until the base-emitter junction is forward biased it is necessary to have at least a few tenths of a volt across this junction for appreciable multiplier action. For this reason, if the drive level is low, it is advisable to use a little dc forward bias to cause the transistor to conduct. However, forward bias and low drive voltage minimize the nonlinearity of the base-



\*CASES GROUNDED TO CHASSIS

L1 10 turns no. 18, 1/2" ID, 5/8" long

L2 3 turns no. 18, 1/2" ID, 1/2" long

L3 5 turns no. 18, 1/4" ID, 1/2" long, tap at 1 1/4 turn from ground

L4 1/2" wide copper trap, 2" long, spaced 1/2" from chassis, tapped 1/2" from ground

fig. 6. Three frequency doublers which use forward bias of the base-emitter junction because of low-level drive.

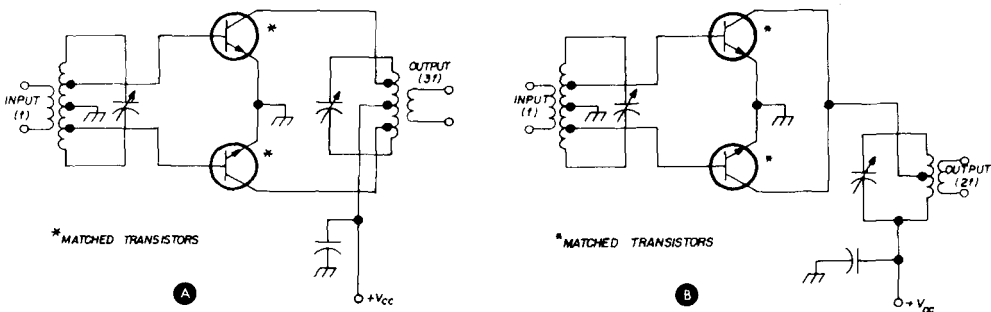


fig. 8. Push-pull tripler circuit is shown in (A). Circuit in (B) is a push-push doubler.

emitter junction and decrease the transistor's effectiveness as a multiplier. A transistorized crystal oscillator and multiplier chain using forward-biased frequency couplers is shown in fig. 6; it was originally designed as a local-oscillator source for a 432-MHz converter.<sup>3</sup> Of course, the base-emitter voltage required to forward-bias germanium transistors (as in fig. 3 through 6) is lower than that required for silicon transistors.

In a recent article on transistor multipliers W6AJF suggested a number of practical circuit innovations that make frequency multipliers more efficient.<sup>4</sup> One point is to reduce the affect of base-to-collector capacitance. He suggests a couple of ways of doing this: adding a series trap from the base to ground tuned to the output frequency, or using a capacitive divider in the input tuned circuit, making sure that C2 is no larger than -j10 ohms at the output frequency (see fig. 7B). W6AJF also suggests the use

of a "grid-leak" arrangement to reduce danger of transistor breakdown where the

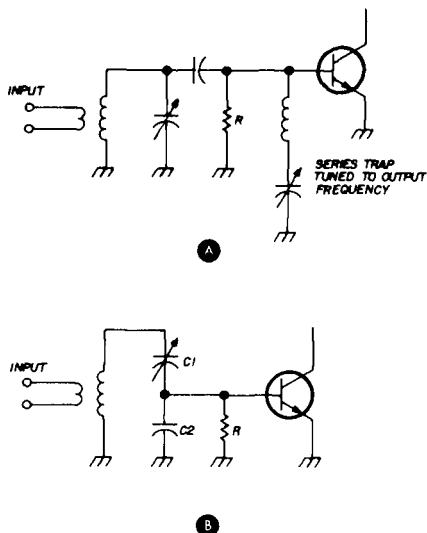


fig. 7. Improving multiplier efficiency: Input of circuit (A) uses a series trap tuned to the output frequency; circuit in (B) uses a large value at C2.

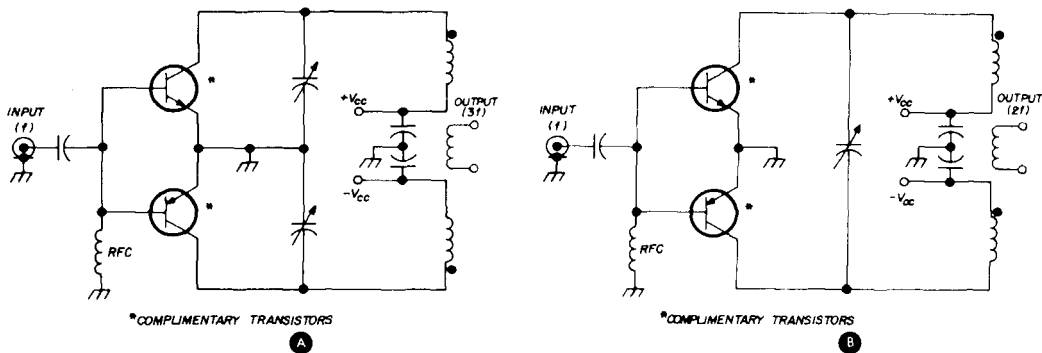
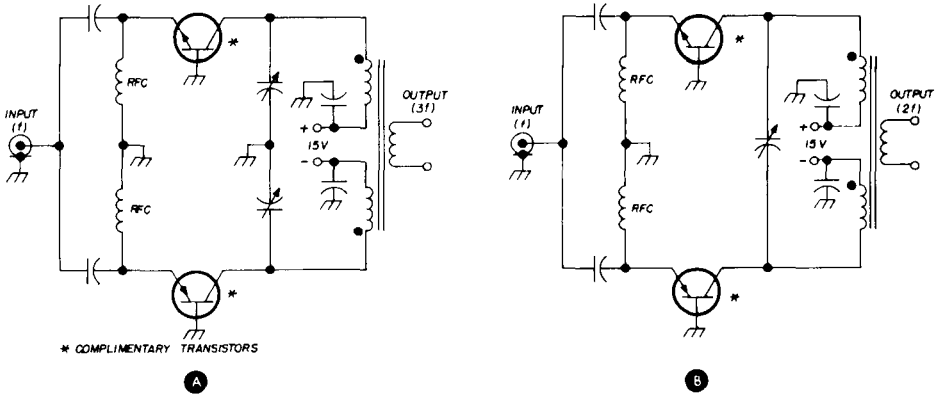


fig. 9. Complementary transistor frequency multipliers. Push-pull tripler circuit in (A); push-push doubler circuit in (B).

drive voltage exceeds the maximum base-emitter reverse breakdown rating.

As with tubes, it is possible to use push-pull transistor multipliers for odd-harmonic generation and the push-push

for the complimentary push-pull and push-push multipliers are shown in **fig. 10**. It should also be mentioned that transistor matching is desirable in both push-pull and push-push circuits. Anti-

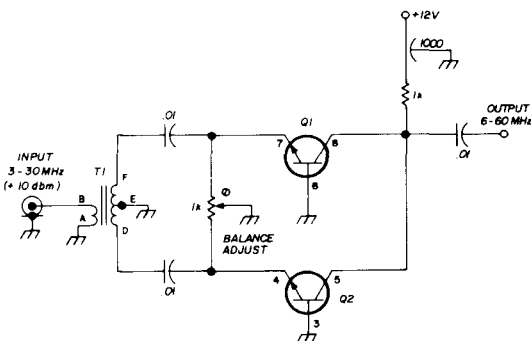


**fig. 10. Complimentary common-base multiplier circuits. (A) is push-pull tripler; (B) is push-push doubler.**

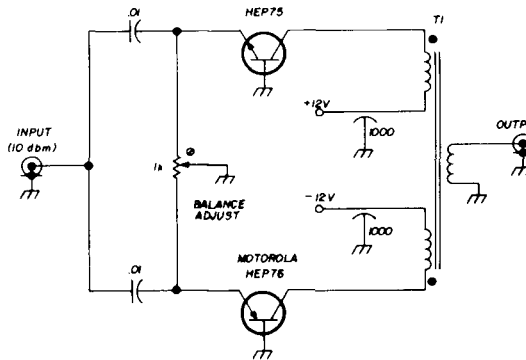
transistor multipliers for even-harmonic generation (circuits are shown in **fig. 8**). Unlike tubes, however, we can build complimentary circuits with transistors. Since both npn and pnp transistors are available it is possible to build both complimentary push-pull and complimentary push-push multipliers (typical circuits are shown in **fig. 9**).

Of course, you don't have to use the common emitter-configuration in transistor multipliers; common-base circuits

matching (finding pnp and npn transistors that have equal but opposite polarity characteristics) is desirable for the complimentary push-pull and push-push circuits. Dual npn and pnp silicon transistors are quite commonly available; also, many companies offer separate npn and pnp transistors which are intended for complimentary use (such as the Motorola 2N3903 and 2N3905). In the case of matched npn transistors it is often less expensive to buy an IC array, such as the



**fig. 11. Broadband push-push frequency doubler circuit uses two transistors of a CA3018 IC; numbers indicate IC pin numbers. T1 is a North Hills 50:400-ohm balanced transformer. Ground pin 10 of the CA3018.**



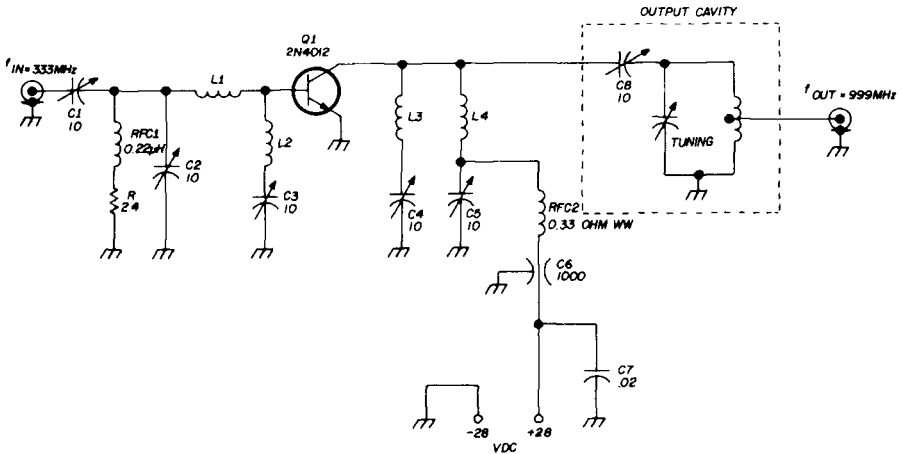
**fig. 12. Broadband push-pull complimentary tripler circuit. Primary of T1 is 28 bifilar turns no. 30 on Indiana General CF103-Q1 core; secondary is 2 turns no. 24.**

RCA CA3018, than to buy a commercial matched pair; the CA3018 contains 4 matched npn transistors (see fig. 11).\* A broadband complementary bipolar tripler is shown in fig. 12.

multiplier for tripling from 333 to 999 MHz is shown in fig. 13.

### fet multipliers

The field-effect transistor is a more



L1 2 turns no. 18, 1/4" diameter

L3 2 turns no. 18, 3/8" diameter

L2 1/16-inch wide copper strap, 4" long

L4 1 turn no. 18, 1/4" diameter

fig. 13. Uhf transistor parametric multiplier. RFC2 is 0.33-ohm wirewound resistor.

### parametric multiplication

A second mechanism that may be used for frequency multiplication with transistors uses the base-collector depletion capacitance.<sup>5, 6</sup> This is called parametric multiplication. As with parametric diode multipliers you must design carefully to obtain anything like optimum efficiency. The parametric effect is a high-level one and only becomes important when the rf voltage is swinging a significant percentage of the collector-to-base voltage. To make the most of the parametric effect the collector circuit must have a number of idler circuits which increase efficiency by reflecting undesired harmonics back to the collector-base capacitance. A typical parametric transistor

recent addition to the amateur's bag of semiconductor tricks. Fets have dropped in price with the availability of plastic packaging and modern production methods, and a number of respectable devices are available for a dollar or less. Fets can be grouped into two general types: Junction and insulated-gate. Both n- and p-channel fets are available in junction and insulated-gate versions.

The fet frequency multiplier can be treated in much the same way as the

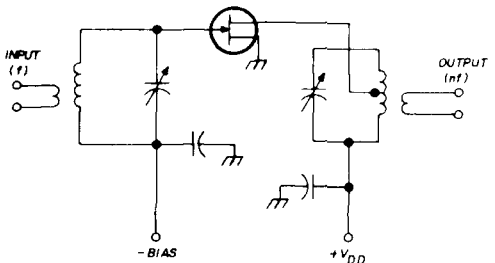


fig. 14. Simple fet frequency multiplier.

\*The broadband transformer used in fig. 11, as well as the one used in fig. 18, is available for \$5.50 postpaid from Hank Olson, Post Office Box 339, Menlo Park, California 94025.

vacuum-tube multiplier, with cutoff bias applied to the gate and rf drive voltage to set the conduction angle indicated in table 1. Two such circuits are shown in fig. 14. Both of the fets in fig. 14 are n-channel devices since most fets for rf are n-channel types, whether junction or insulated-gate types.

Since both n- and p-channel fets are available it is possible to build the complimentary push-pull and push-push multipliers in much the same way as with bipolar transistors. Circuits are shown in fig. 15. Conventional push-pull and push-push multipliers are feasible too; examples are shown in fig. 16. Matched fet pairs are commonly available, and push-pull and push-push circuits will work best with them. A complete 14-MHz crystal oscillator and fet push-push doubler with 28 MHz output is shown in fig. 17. The 28-MHz output is remarkably free of 14 MHz energy due in part to circuit balance, and in part to the resonant circuit, T2. Another fet push-push doubler, one that will work over the entire high-frequency spectrum, is shown in fig. 18. A broad-band complimentary fet doubler is in fig. 19.

### IC multipliers

Two similar devices that have recently been introduced to the IC market are the multiplier and the balanced modulator; either can serve as a frequency doubler. The Motorola MC1595 and MC1596, or their Fairchild equivalents,  $\mu A795$  and  $\mu A796$ , can be used as doublers by introducing rf drive into both inputs. Since the MC1595 and  $\mu A795$  are true multipliers the input signal is multiplied times itself, producing a  $\sin^2 \theta$  waveform. The  $\sin^2 \theta$  waveform looks very much like a full-wave rectified sine wave and contains only the second harmonic plus a dc component.\*

The MC1596 and  $\mu A796$  balanced modulators operate in much the same

\*If you are accustomed to trigonometric identities, the following equation provides an explanation for multiplier operation:

$$\sin^2 \theta = \frac{1}{2}(1 - \cos 2\theta)$$

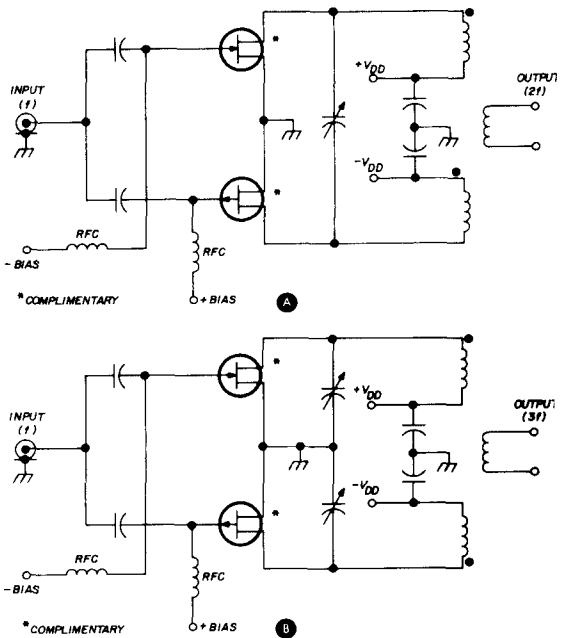


fig. 15. Complimentary fet multiplier circuits. (A) is doubler; (B) is tripler. Fets are matched complimentary pairs.

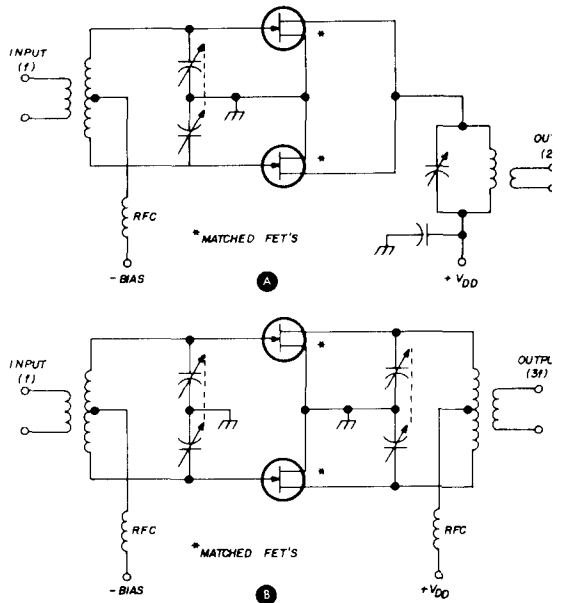


fig. 16. Push-push fet doubler (A), and push-pull fet tripler (B).

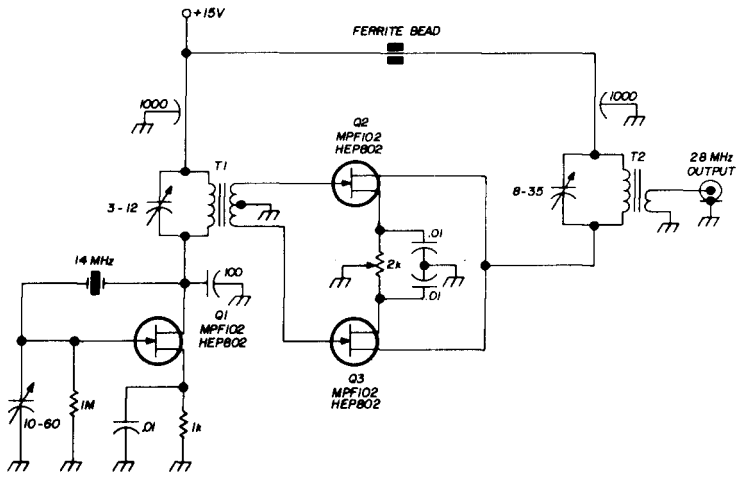


fig. 17. Fet 14-MHz crystal oscillator and push-push doubler. Primary of T1 is 20 turns no. 26 on Amidon T44-6 toroid core; secondary is 4 turns no. 22, center-tapped. Primary of T2 is 13 turns no. 20, on Amidon T44-6 core; secondary is 2 turns no. 20. Fets Q2 and Q3 are selected for approximately equal  $I_{DSS}$ .

way as the IC multipliers although they are not true multipliers. Frequency-multiplier circuits for the MC1595 and MC1596 are shown in fig. 20. Note that the circuit of fig. 20A does not depend on tuned circuits to suppress undesired harmonics but does so by circuit balance alone.

### diode multipliers

The point-contact diode has been used as a frequency multiplier since the first 1N34s became available, and possibly earlier than that.<sup>7</sup> These diodes were

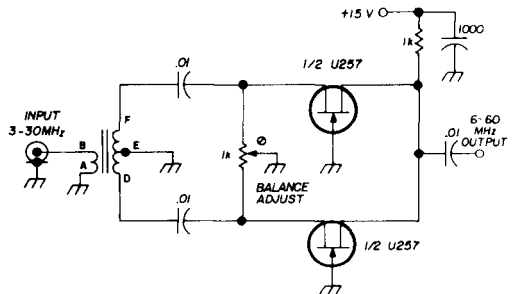


fig. 18. Broadband fet push-push doubler. T1 is broadband North Hills 50:400-ohm balanced transformer. U257 is dual matched Siliconix fet.

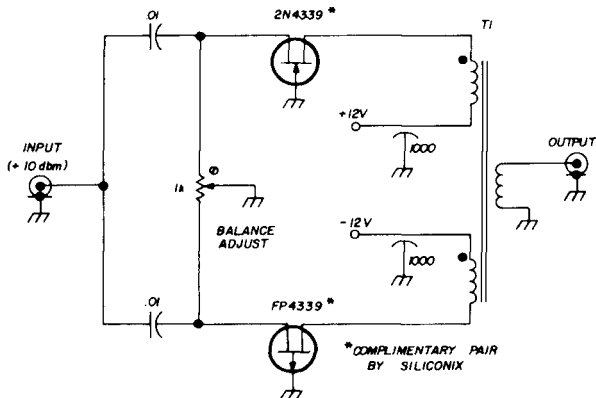


fig. 19. Complimentary fet broadband push-push doubler. Primary of T1 is 28 turns no. 30 bifilar wound on Indiana General CF103-Q1 core; secondary is 2 turns no. 24.

usually used to enhance the harmonics of 100-kHz crystal calibrators, so they cannot be considered to be multipliers of any significant efficiency. Modern ver-

built; a broadband doubler is shown in fig. 21. This circuit is very useful as a signal generator accessory.

In fact, broadband doublers are sold

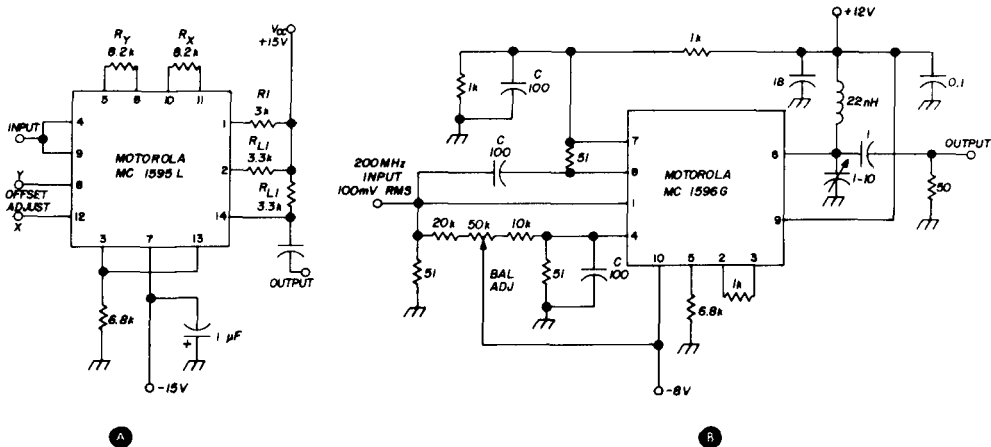


fig. 20 Broadband integrated-circuit frequency doubler is shown in (A). 200-MHz frequency doubler using the Motorola MC1596G in (B). Fairchild uA795/uA796 or Signetics S5995/S5596 may be used in these circuits.

sions of such a calibrator would probably still use a 1N100 or 1N270 germanium point-contact diode since these are superior even to good silicon computer diodes.

The hot-carrier or Schottky-barrier diode, such as the Hewlett-Packard HP 5082-2800, is better than either the point-contact germanium or the silicon junction diode. If you use two matched hot-carrier diodes, arranged as a full-wave rectifier, a fairly efficient doubler can be

by Hewlett-Packard and other test equipment manufacturers for doubling the high-frequency output range of their signal generators. The diode doublers put out 12 to 16 dB less second harmonic than input.

Another diode frequency multiplier is the parametric diode multiplier. Many circuits have been published. Like the parametric transistor multiplier, which they pre-date, operation of the parametric diode multiplier relies on the

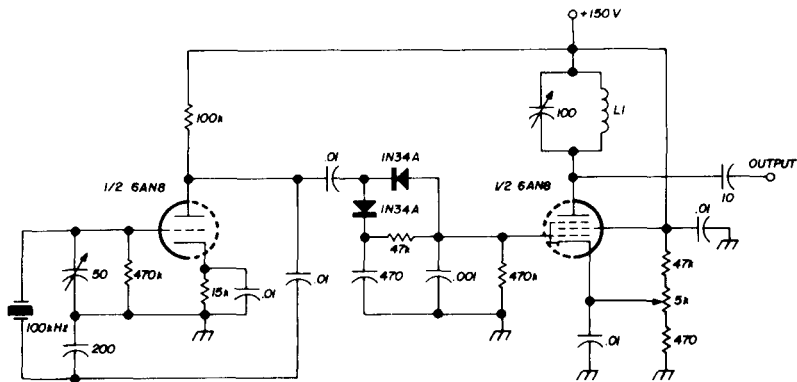
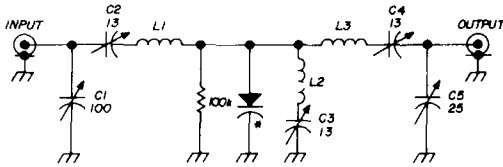


fig. 21. 100-kHz crystal calibrator using germanium point-contact diodes to enhance harmonics. L1 is tuned to the amateur band of interest.



variable capacitance of a reverse-biased junction. Idler circuits are required, and the design and tuneup procedures are extremely tedious. A typical 150 MHz to



\* AMPEREX H4A

- L1 6½ turns no. 16, 5/16" diameter, 9/16" long
- L2 2 turns no. 12, ¼" diameter, 5/16" long
- L3 ¼-inch wide copper strap, 1" long, spaced 9/16" from chassis

fig. 22. Medium-power 150- to 450-MHz tripler.

450 MHz diode parametric multiplier is shown in fig. 22. This single-ended design is the form most used in amateur equipment.

It is also possible to build a push-pull parametric multiplier which will have the same even-harmonic cancelling properties of the push-pull multipliers I've discussed previously (fig. 23). It follows, then, that a push-push parametric multiplier which cancels fundamental and odd harmonics could also be built. Such a circuit is shown in fig. 24.

A later development in the way of multiplier diodes is the step-recovery diode. Unlike the parametric diode or varactor, the step-recovery diode does not depend principally on the nonlinearity of its depletion capacitance for harmonic generation. Instead, it depends on the fact that when it is forward biased a charge is stored; when the diode is subsequently reverse biased the charge is dumped. In a properly designed circuit the step-recovery diode will be driven into forward conduction by positive excursions of the fundamental drive voltage; the stored charge will dump into a tuned circuit at the desired output frequency.

In a step-recovery frequency multiplier the harmonic power is proportional to  $1/n$ ; where  $n$  is the harmonic number. This is much better than the power falloff of a varactor multiplier where harmonic power is proportional to  $1/n^2$ . In a 144 MHz to 432 MHz tripler, for example, harmonic power would be 3 times greater with a step-recovery multiplier circuit. Fig. 25 shows efficiency vs harmonic number  $n$  for a typical step-recovery diode multiplier. Note that large values of  $n$  are quite feasible.<sup>8</sup>

There's another advantage, too: Only the desired output frequency is tuned in a step-recovery diode multiplier — no elaborate idler system is required.

Until recently step-recovery diodes

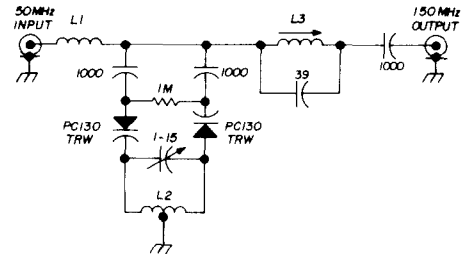


fig. 23. Balanced parametric diode 50- to 150-MHz tripler features conversion efficiency of 70%. L1 is 0.18  $\mu$ H choke. L2 is 7 turns no. 18, 5/16" diameter, 3/4" long, center-tapped. L3 is 8 turns no. 20 closewound on ½-inch form.

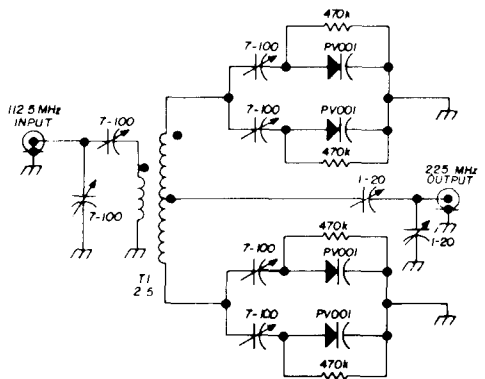


fig. 24. 112.5- to 225-MHz balanced parametric diode doubler. Primary of T1 is 2 turns no. 16, 3/8" diameter, 1-1/2" long, center-tapped; secondary is 2½ turns no. 16 on each side of primary. Conversion efficiency is 75%. Varactors are TRW types.

have been very high-priced and available only to industry. However, one low-cost step-recovery diode is available for amateur experiments. The Siliconix

Note the similarity between step-recovery diode multipliers and parametric diode multipliers. The circuits are quite similar, so it is also possible to build

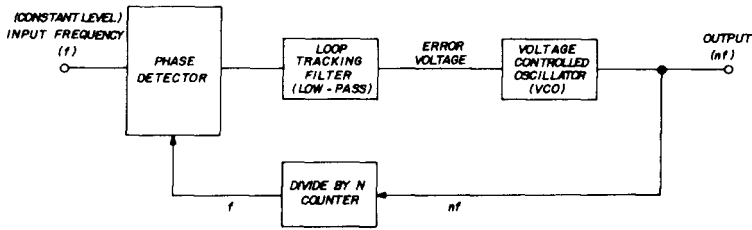


fig. 27. Basic elements of a phase-locked loop frequency multiplier.

SV110 is available in a standard axial-lead diode package for \$5.50.\*

Fig. 26 shows the general circuit ar-

balanced step-recovery diode multipliers which cancel either odd or even harmonics. However, the advantages of balanced step-recovery diode multipliers is decreased because no idler circuits are eliminated.

### phase-locked multipliers

In recent years another, a more complex method of frequency multiplication has been used for special purposes; this is the phase-locked loop frequency multiplier. Frequency synthesizers often make use of this technique because of its inherent signal cleanliness. The system effectively multiplies, but circuit operation is actually accomplished by frequency division. The general nature of the system is shown in fig. 27. To use this system you build the oscillator to the same frequency as the desired output, then phase lock it to a subharmonic. If

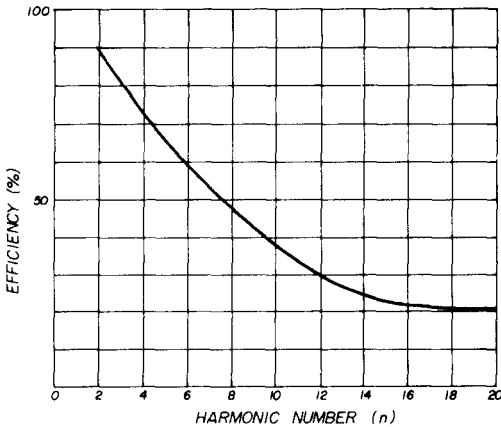


fig. 25. Typical output efficiency of a step-recovery diode multiplier as a function of the harmonic number, n.

range for a step-recovery diode frequency multiplier. With the Siliconix SV110 step-recovery diode conversion efficiency falls off as  $\frac{200\%}{n}$  up to 3000 MHz so you can expect maximum efficiency of about 22% in a 144 MHz to 1296 MHz times-9 multiplier. To realize anywhere near this theoretical efficiency, however, circuit losses must be low.

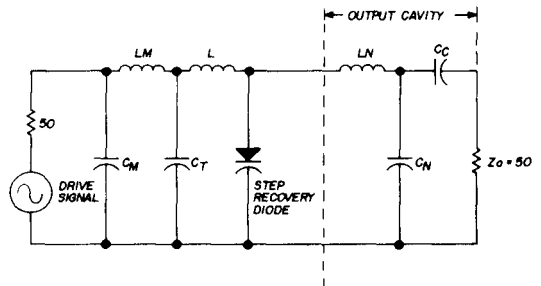


fig. 26. Generalized circuit of a step-recovery diode frequency multiplier.

\*\$5.50 from Siliconix Incorporated, 1140 West Evelyn Avenue, Sunnyvale, California 94086.

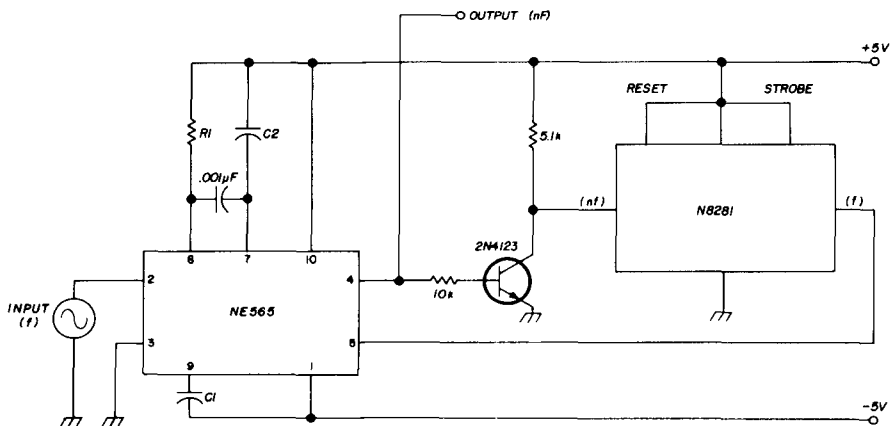


fig. 28. Phase-locked loop multiplier for output frequencies up to 500 kHz uses Signetics NE565.

the oscillator is voltage-controlled the only input to it is the dc error voltage, so the output can be made nearly perfectly clean (since no rf is fed into the vco).

Since the phase-locked loop technique is rather complex it has been used only in expensive electronic systems. However, now the phase-locked loop has been tucked into an IC (or two). Because of the advance of IC technology it is a fairly simple matter to build a phase-locked loop frequency multiplier. Fig. 28 shows

a Signetics NE565 phase-locked loop with a divide-by-n counter; in this case a four-stage binary counter, the Signetics N8281. It is not necessary to use this particular counter as nearly any TTL counter or combination of flip-flops will do. Since flip-flops may be connected in a variety of ways to divide by nearly any number almost any harmonic can be multiplied by this system. The Signetics NE565 has an upper frequency limit of 500 kHz, but the Signetics NE562 may be used to 60 MHz as shown in fig. 29.

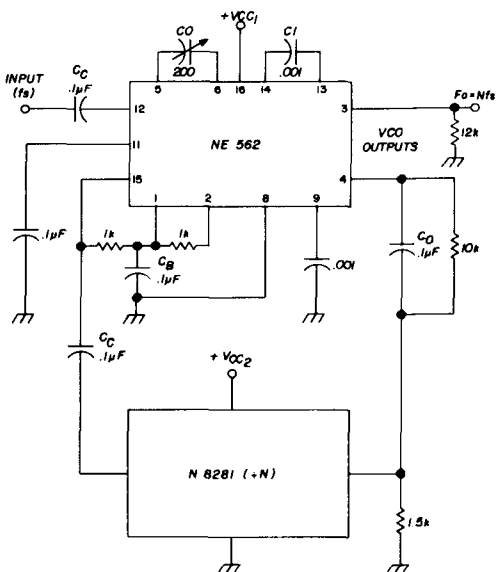


fig. 29. Signetics NE562 allows frequency multiplier operation up to 60 MHz (output). Capacitor C1 is a low-pass filter capacitor; C0 sets frequency of operation.

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ham radio

# rf clipper

## for the Collins S-line

This rf  
speech-processing  
circuit offers  
increased talk power  
without distortion  
or splatter —  
circuit can be adapted  
to other transmitters

Rf speech clipping is the most effective technique for increasing the average to peak power output of a ssb transmitter without increasing the transmitted bandwidth or in-band distortion products. The high effectiveness of rf clipping was dramatically illustrated by W6JES.<sup>1</sup> This article describes a highly effective rf speech clipper that is installed in a Collins 32S1 transmitter; the same circuit may also be used in the 32S3. The Collins S-line transmitter is one of the best rigs for added rf clipping circuitry because of

1. A beefy power supply, capable of supplying a high average current level.
2. The use of 6146 transmitting-type final-amplifier tubes coupled with an effective rf compression loop (alc) and negative feedback to the final ampli-

fier stage for reduction of intermodulation products.

3. A stable, effective balanced modulator capable of providing carrier suppression in excess of 50 dB for long periods of time.

Because of the highly effective alc loop very little additional performance improvement is gained through the use of audio processing techniques such as compressors and audio clipper/filters. The *apparent* improvement noticed with these devices usually comes with a sacrifice in overall intelligibility because the noise power of the processor-generated distortion products increases nearly as much as the voice power. The net result is a sloppy signal of poor overall intelligibility — exactly the thing we are trying to improve by using a signal processing device.

Quantitatively, an overall improvement of about 1-dB is all you can expect from an audio processor without adding appreciable distortion. Any S-meter reports to the contrary are due to noise and distortion components of the processor that hang the slow decay agc of the receiver and cause a higher average meter reading.

### rf clipping

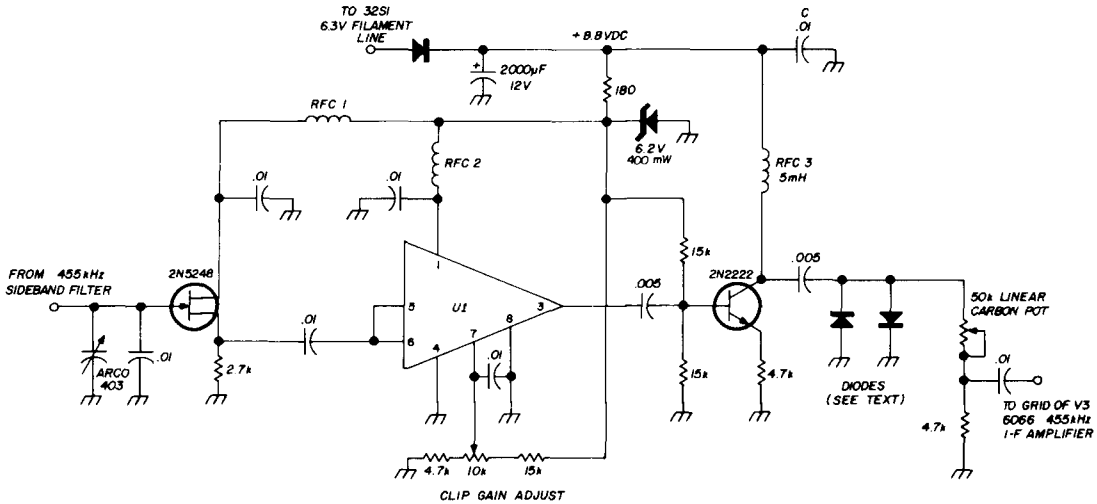
The answer to the signal processor question, at least for the Collins S-line\* is rf speech clipping. With rf speech clipping all processing takes place at the 455-kHz i-f. All harmonic distortion components are multiplied in frequency and are no longer close to their audio fundamentals; therefore, they can be removed easily by a bandpass filter. Intermodulation distortion products are still present, but they don't become objectionable at clipping levels up to 20 dB with the S-line transmitter.

Bruce Clark, K6JYO, 1019 El Dorado Drive, Fullerton, California 92632

## clipper circuit

The rf-clipper circuit shown in **fig. 1** is currently installed in my 32S1 transmitter. The circuit consists of an fet source follower, a variable gain IC amplifier, a

the clipper to be taken in and out of operation by merely turning the gain control. The clipping diodes are connected across the collector circuit of this amplifier.



C1	pF (Arco 403)	RFC1	7 turns no. 28 enameled on 0.060" diameter
CR1	6.2-volt, 1/2-watt zener diode	RFC2	Ferroxcube 3K2A ferrite core
CR2,CR3	Hot-carrier diodes, HP2800 (see text)	RFC3	5 mH (J. W. Miller 6304 or 70F-473A1)
CR4	silicon rectifier	U1	Plessey Microelectronics SL612C

**fig. 1.** Schematic for an rf signal clipper designed for the Collins S-line. Circuit can be adapted to other filter-type ssb transmitters which have sufficient power-supply reserve.

fier, a transistor driver and diode clipper. The 2N5248 input stage matches the high output impedance of the 455-kHz mechanical filter to the IC amplifier. The variable-gain IC amplifier is based on the Plessey SL612C.\* (A Motorola MC1590 IC should also work well in this circuit but one was not available when I built the clipper.)

The single transistor power-amplifier stage following the IC amplifier is necessary for maximum clipping level while providing enough surplus gain to allow

Several types of diodes were tried in this circuit including 1N914 silicon, 1N277 germanium and HP2800 hot-carrier diodes. As was expected at this frequency all types worked well. However, silicon devices have a higher conduction threshold in the forward direction, so require more clipper gain for a particular clipping level. The leakage of germanium diodes increases markedly with temperature, causing a noticeably lower level of clipping with a softness or rounding of the clipped peaks.

This leaves the hot-carrier diode as the best overall choice. The price of hot-carrier diodes is now less than \$1.00 from your local Hewlett-Packard regional of-

\*The SL612C integrated circuit is \$5.65 from Plessey Electronics Corporation, 170 Finn Court, Farmingdale, Long Island, New York 11735.

fice or from Hal Devices.\* Matched pairs and quads are also available from both sources. However at 455 kHz, the characteristics of individual devices are close enough for very symmetrical clipping of the ssb envelope. A resistive attenuator across the output of the clipper reduces the output level to a suitable value for the 6DC6 i-f amplifier stage. The adjustable attenuator compensates for gain variations in the devices.

The alternative approach is to use the original filter in the sideband filter location, and use the second filter for crud rejection. The second filter may have considerably wider bandwidth than the sideband filter without causing any serious increase in distortion products.<sup>2</sup>

## construction

My rf clipper is built on a 2x3-inch piece of copper-clad perforated Vector

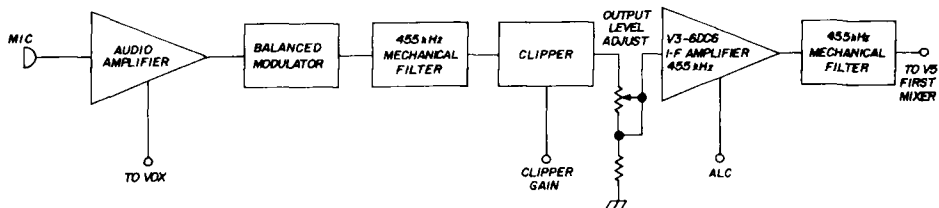


fig. 2. Rf clipper placement in the S-line transmitter. Circuit requires additional 455-kHz mechanical filter.

## installation

Fig. 2 shows the placement of the rf clipper circuit in the 32S1 transmitter. This arrangement was arrived at after much experimentation. It results in a stable unit with a minimum of wiring modifications to the 32S1 circuitry and no holes. Two mechanical filters are used. The first filter suppresses the unwanted side-band. The second filter blocks the unwanted harmonic distortion and out-of-band intermodulation-distortion products that are generated by the clipper.

I found it easiest to leave the original 455-kHz filter between the 6DC6 i-f amplifier (V3) and the 12AT7 first mixer (V5). This filter now serves as the crud rejection filter. I obtained a second 2.1-kHz filter for use as the sideband-suppression filter; I used a Collins F455FA21. The carrier crystal requirements were very close to those of the original ssb filter. This may be difficult to achieve if you buy a filter from a different manufacturer.

board. A Vector pad-cutting tool was used to insulate the holes needed for component mounting. Vector T-28 pins were used for component anchors and for circuit terminations to the power supply, input/output and gain-control pot.

The board is installed underneath the 32S1 chassis next to the existing mechanical filter. The wires for the remote gain control are routed through the PTO power cable hole to the pot which is mounted on an L-bracket at the rear of the PTO; the bracket is mounted with one of the PTO cover screws. The board is mounted with heavy no. 14 ground leads soldered to the copper-clad board; these leads are attached to solder lugs installed under existing screws in the immediate underchassis area.

## adjustment

Adjustment of the rf clipper is simple if you have a monitoroscope. If a monitoroscope isn't available, beg, borrow or steal one, at least for the initial setup. Using a single tone (32S1 in *tune*, then *lock-key*) tune and load the transmitter in the normal manner. Change the *mode* switch

\*HAL Devices, Box 365H, Urbana, Illinois 61801.

to either sideband and adjust the *mic* audio gain to the normal level. This should be between 8:30 and 10 o'clock, depending on the type of microphone you're using.

Change the *meter* switch to *alc* and check *alc* action. With the *rf* clipper turned off peaks should be between 4 and 8 dB. If required, adjust the output attenuator pot for this amount of average *alc* action. Now, advance the clipper gain

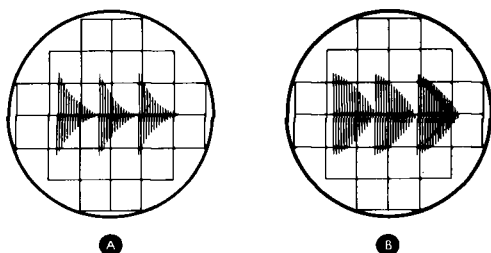


fig. 3. Typical *rf* envelope patterns. (A) shows unprocessed *ssb* speech; (B) shows processed speech envelope with about 15-dB clipping.

control while talking; the slope of the scope pattern should change markedly, flattening out as shown in fig. 3. The average wattmeter reading will also increase. No flat-topping of the *ssb* speech envelope should be detected. Nor should the vertical scope deflection increase beyond the value first noted under single-tone conditions when tuning up with the *function* switch in *lock-key*. The *alc* level now should increase to 10 to 12 dB on peaks; if it goes above this level reduce audio gain or increase the value of the output attenuator until the correct *alc* levels are obtained.

## performance

Performance of the *rf* clipper unit has been up to expectations. The results agree closely with those predicted in the *QST* article;<sup>1</sup> that is, an improvement of 8 to 9 dB in signal intelligibility along with a 10- to 11-dB gain in average-to-PEP output-power ratio.

When using *rf* clipping, several pre-

cautions must be observed, especially with regard to the additional strain placed on final amplifier and driver due to the large increase in average input power. The resultant higher temperatures can have a detrimental effect on tube and component life, particularly in the area of the final amplifier compartment.

I eliminated part of the problem by substituting 7212/6146W tubes in the final. I also added a Rotron Whisperfan on top of the transmitter cabinet that blows cooling air downward through the box; the fan is simply mounted on rubber grommets and sits on the cabinet top. Power for the fan is obtained from the 516F2 power supply by tapping into the switched ac line. A small 2-pin Jones plug connects the fan power cord to a short 2-inch line coming out of the 516F2 power supply.

You may consider installing 6146B/8298A tubes in the final amplifier. However, the modification necessary to increase the screen voltage is not recommended with the clipper as the power supply and tube dissipation ratings will be grossly exceeded.

I feel that *rf* clipping is a must for optimum *ssb* talk power in any transmitter with sufficient reserve power supply capability. For example, this circuit can be adapted easily for use in transmitters using crystal filters such as the Heath SB400; only minor changes in the crystal filter impedance-matching circuits should be required. Use of the unit for about six months has resulted in a marked reduction of TCIP — "time calling in pileups."

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ham radio



## high performance 144-MHz power amplifier

This efficient  
easy-to-tune  
grounded-grid  
8877 amplifier  
can be run  
at 2000 watts  
PEP ssb  
or 1000 watts cw

Robert I. Sutherland, W6UOV, EIMAC Division of Varian

The new Eimac 8877 is a ceramic/metal high- $\mu$  triode rated for use up to 250 MHz. Operation of this tube at 50 MHz proved to be so satisfactory<sup>1</sup> that other 8877 amplifiers have been designed and built for frequencies up to 350 MHz. Two of these amplifiers are of interest to the serious vhf operator. One amplifier is designed for the amateur 2-meter band and is described here. The other amplifier covers the range from 150 to 230 MHz, and is well suited for use on the amateur 220-MHz band; it will be described later.

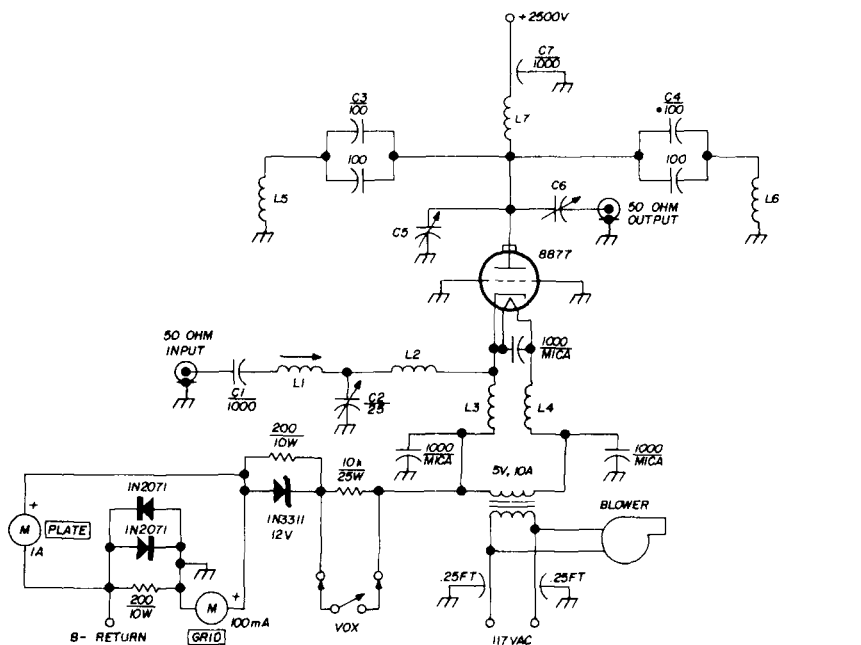
The 8877 triode has good division between plate and grid current and low intermodulation distortion. It has a plate dissipation rating of 1500 watts and  $\mu$  of approximately 200. The cathode is indirectly heated; filament requirements are 5.0 volts at 10 amperes. The tube base mates with a standard septar socket.

This 144-MHz 8877 linear amplifier is designed for the serious DXer who demands reliable service combined with



good linearity and efficiency. The compact grounded-grid design presented here uses a half-wave plate line<sup>2</sup> and a lumped T-network input circuit. The amplifier

reserve. For operation at 2000 watts PEP the plate voltage should be between 2500 and 3000 volts; under these conditions the amplifier will deliver 1240 watts



C1	1000 pF (Centralab 858S-1000)	L1	5 turns no. 14, 3/4" long on 1/2" diameter form with white tuning slug (CTC 1538-4-3)
C2	25 pF variable (Hammarlund HFA-25B)	L2	4 turns no. 14, air wound, 3/4" long
C3,C4	each consists of two parallel-connected 100-pF, 5000-V capacitors (Centralab 850S-100)	L3,L4	10 turns no. 12 enameled, bifilar wound, 5/8" diameter
C5	plate-tuning capacitor (see fig. 3)	L5,L6	plate resonators (see fig. 4)
C6	output loading capacitor (see fig. 2)	L7	7 turns no. 14 wire, 5/8" diameter, 1-3/8" long
C7	1000 pF, 4 kV feedthrough (Erie 2498)		

fig. 1. Schematic for the grounded-grid two-meter triode amplifier. Operating bias for the 8877 is supplied by a 12-volt zener diode in the cathode lead.

requires no neutralization, is completely stable and free of parasitics, and is very easy to operate.

This amplifier is designed for continuous duty operation at the 1000-watt dc input level, and can develop 2000 watts PEP input for ssb operation with ample

output. With the higher plate-voltage supply, up to 13.8-dB gain can be obtained with an amplifier efficiency of 62%.

### the circuit

In the amplifier circuit in fig. 1 the 8877 grid is operated at dc ground. The

grid ring at the base of the tube provides a low-inductance path between the grid element and the chassis. Plate and grid currents are measured in the cathode-return lead; a 12-volt, 50-watt zener diode in series with the negative return

ly burn open.

### input circuit

The cathode input matching circuit is a T-network which matches a 50 ohm termination to the input impedance of

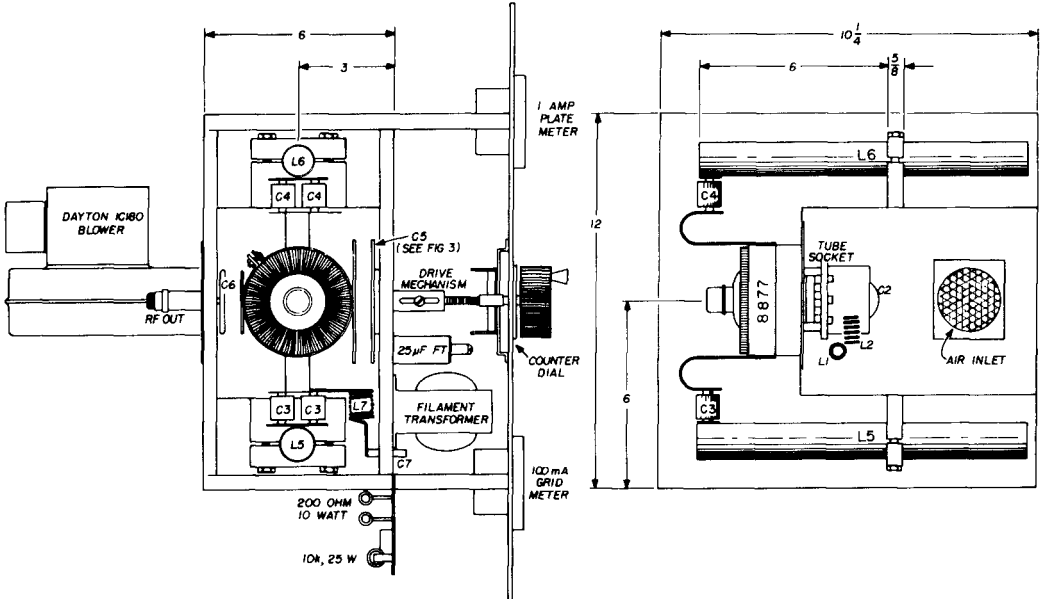


fig. 2. Structural details of the amplifier show the relative size and position of the various components. Assembly is made of aluminum panels.

sets the desired value of idling current. Two additional diodes are shunted across the meter circuit to protect the instruments.

Standby plate current of the 8877 is reduced to a very low value by the 10,000-ohm cathode resistor; this resistor is shorted out when the vox circuit is energized, permitting the tube to operate in normal fashion.

A 200-ohm safety resistor insures that the negative power circuit of the amplifier does not rise above ground potential if the positive side of the plate-voltage supply is accidentally grounded. A second safety resistor across the 1N3311 zener diode prevents the cathode potential from rising if the zener should accidental-

ly burn open. the tube (about 54 ohms in parallel with 26 pF). The network consists of two series-connected inductors and a shunt capacitor. One inductor and the capacitor are variable so the network is able to cover a wide range of impedance transformations.

The variable inductor (L1) is mounted on the rear wall of the chassis and may be adjusted from the rear of the amplifier. The input tuning capacitor (C2) is adjustable from the front panel. When the network has been properly tuned no adjustment is required over the 4-MHz range of the 2-meter band.

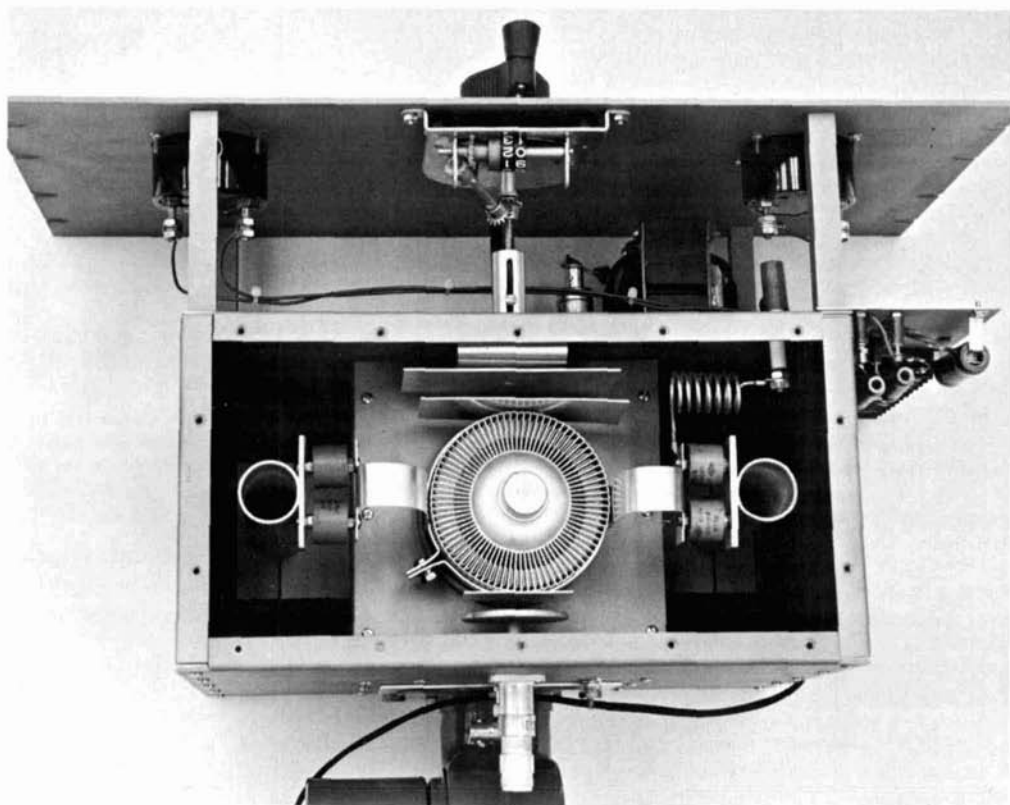
Underchassis layout of components is shown in the photograph. The cathode input circuit is in center compartment.

The slug-tuned coil in the input matching circuit is mounted on the rear wall. Air-wound filament chokes are placed in front of the socket. The cathode-heater rf choke is near the top edge of the enclosure. All of the cathode leads of the

mechanism are placed in the area between inclosure and panel.

### plate circuit

The plate circuit of the amplifier is a transmission-line type resonator. The line



Top view of amplifier showing plate compartment. 8877 tube is at center with plate lines on each side.

socket, plus one heater pin (pin 5) are connected in parallel and driven by the input matching network.

The ceramic socket for the 8877 is mounted one-half inch below chassis level by spacers. Four pieces of brass shim stock (or beryllium copper) are formed into grounding clips to make contact to the control grid ring. The clips are mounted between the spacers and the chassis. The aluminum clamps holding ends of plate lines are visible in the side compartments. The filament transformer and dial

(L5 plus L6) is one half-wavelength long with the tube placed at the center (fig. 2). This type of tuned circuit has several advantages. A quarter-wave circuit would normally be preferred because of its greater bandwidth, but I wanted to use easily obtainable standard copper water pipe as the center conductor of the transmissionline tank circuit. The resulting high-impedance transmission line would make a quarter-wave plate tank circuit physically short and difficult to handle.

In addition, the heavy rf current that flows on the tube seals and control grid would, in the process of charging up the output capacitance to the plate voltage

this type of cavity is complex and difficult to build.

A practical compromise is to use two quarter-wave lines connecting to opposite

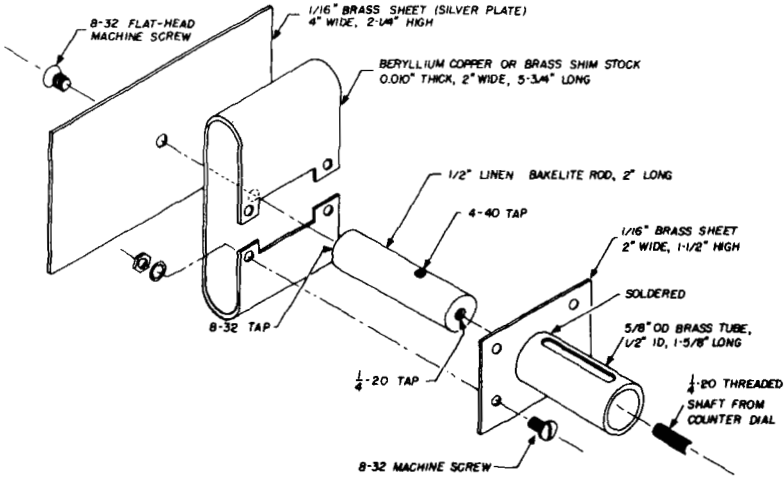


fig. 3. Variable plate portion of plate-tuning capacitor C3. This arrangement permits the capacitor to be adjusted under full power without "jumpy" tuning as there are no moving or sliding contacts which carry heavy rf current.

swing, tend to concentrate on one side of the tube if a single-ended quarter-wave circuit were used. This current concentra-

sides of the tube. It is interesting to note that each of the two quarter-wave lines is physically longer than if only one quar-

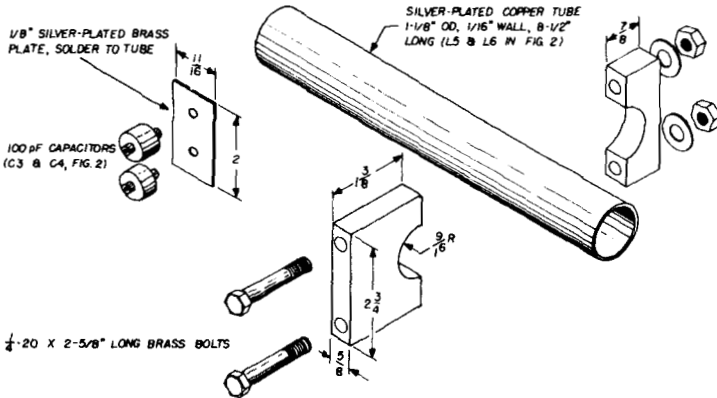


fig. 4. Details of plate lines L5 and L6. Copper tubes are standard copper water pipe.

tion would cause localized heating of the tube. The best tuned circuit configuration to minimize this effect is a symmetrical cylindrical coaxial cavity. Unfortunately,

ter-wave line were used. This is because only one-half of the tube output capacitance loads each of the two lines.

Resonance is established by a moving

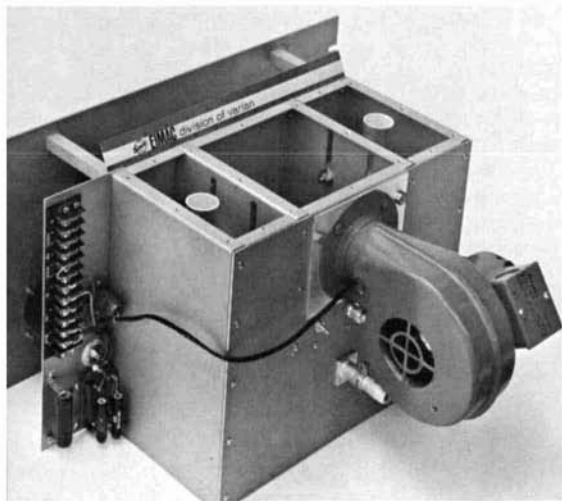
plate capacitor (C5); antenna loading is accomplished by a second capacitor (C6) placed at the anode of the 8877. Output power is coupled from the plate circuit through the series capacitor into a 50-ohm output. In the top-view photo tuning capacitor C5 is at the front of the compartment; variable loading capacitor C6 is at the rear. The plate choke is visible in the front corner.

### construction

The two-meter amplifier is built in an enclosure measuring  $10\frac{1}{4} \times 12 \times 6\frac{1}{4}$  inches. The 8877 socket is centered on a  $6 \times 6$  subchassis plate. A centrifugal blower forces cooling air into the under-chassis area; the air escapes through the  $2\text{-}5/8$ -inch diameter socket hole.

The plate tuning mechanism is shown in fig. 3. This simple apparatus will operate with any variable plate capacitor, providing a back and forth movement of about one inch. It is driven by a counter

Rear of amplifier showing blower and coaxial output connector. Amplifier is upside down in this photograph.



dial and provides a quick inexpensive and easy means of driving a vhf capacitor. The ground return path for the grounded capacitor plate is through a wide low-

inductance beryllium-copper or brass shim stock which provides spring tension for the drive mechanism.

The variable output coupling capacitor

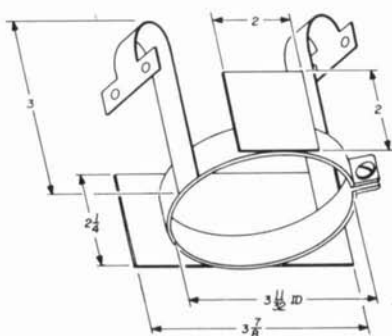


fig. 5. Anode clamp assembly for the two-meter linear amplifier.

is located at the side of the 8877 anode. The type-N coaxial fitting is connected to the moveable plate of the coupling capacitor. The fitting is centered in a special tubular assembly which allows the whole connector to slide in and out of the chassis, allowing the variable plate of the coupling capacitor to move with respect to the fixed plate mounted on the tube anode clamp. When the final loading adjustment has been set the sliding fitting is clamped by an arrangement similar to the slider on a variable wire-wound resistor.

The length of the plate-line inductors (L5 and L6) is adjusted by means of dural blocks placed at the shorted end of the line (fig. 4). The position of the blocks is determined by setting capacitor C5 at its lowest value and adjusting line lengths so that that plate circuit resonates at 148 MHz with the 8877 in the socket.

The plate rf choke is mounted between the junction of one plate strap and a pair of the dual blocking capacitors; the high-voltage feed-through capacitor is mounted to the front wall of the plate compartment. The blocking capacitors are rated for rf service, and inexpensive tv-type capacitors are not recommended for this amplifier. A short chimney to

direct cooling air from the socket through the anode of the 8877 is made from Teflon and clamped between the chassis deck and the anode strap.\*

### operation

Amplifier operation is completely stable with no parasitics. The unit tunes up exactly as if it were on the "dc bands." As with all grounded-grid amplifiers excitation should never be applied when plate voltage is removed from the amplifier.

The first step is to grid-dip the input and output circuits to near-resonance with the 8877 in the socket. A swr meter should be placed in series with the input line so the input network may be adjusted for lowest swr.

Tuning and loading follows the same sequence as any standard grounded-grid

amplifier. Connect a swr indicator at the output and apply a small amount of rf drive. Quickly tune the plate circuit to resonance. The cathode circuit should now be resonated. The swr between the exciter and the amplifier will not neces-

**table 1. Performance data for the 144-MHz power amplifier under the conditions most suitable for amateur ssb (2000 watts PEP) and cw (1000 watts).**

Plate voltage	3000 V	2500 V	2500 V
Plate current (single tone)	667 mA	800 mA	400 mA
Plate current (idling)	54 mA	44 mA	44 mA
Grid voltage	-12 V	-12 V	-12 V
Grid current (single tone)	46 mA	50 mA	28 mA
Power input	2000 W	2000 W	1000 W
Power output	1240 W	1230 W	680 W
Efficiency (apparent)	62 %	62 %	68 %
Drive power	47 W	67 W	19 W
Power gain	13.8 dB	12.6 dB	15.5 dB

sarily be optimum. Final adjustment of the cathode circuit for minimum swr should be done at full power because the input impedance of a cathode-driven amplifier is a function of the plate current of the tube.

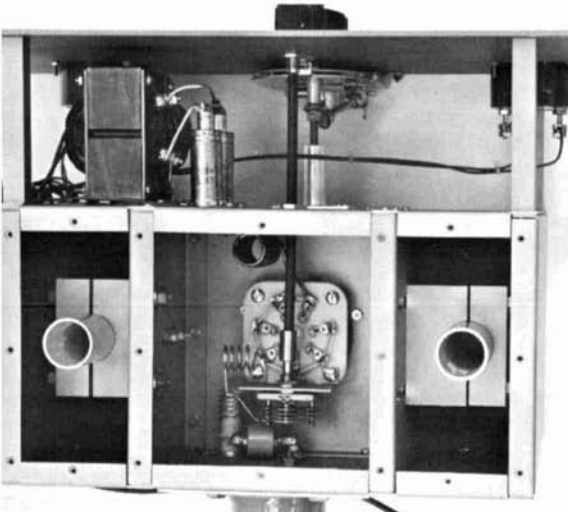
Increase the rf drive in small increments along with output coupling until the desired power level is reached. By adjusting the drive and loading together it will be possible to attain the operating conditions given in the performance chart in **table 1**. Always tune for maximum plate efficiency: maximum output power for minimum input power. It is quite easy to load heavily and underdrive to get the desired power input but power output will be down if this is done.

I would like to thank K6DC for his help in adjusting and determining the operating conditions for this two-meter amplifier.

### references

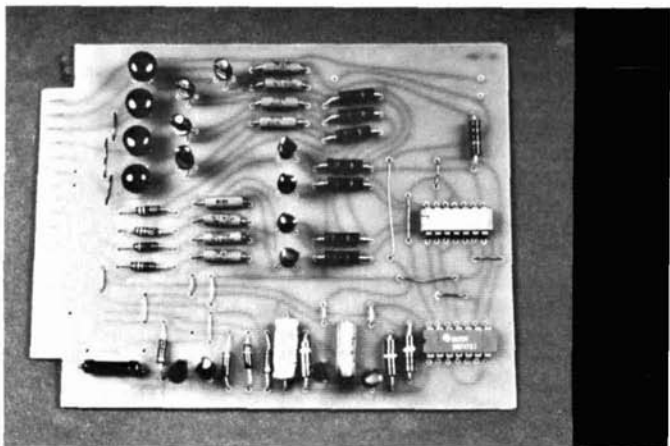
1. R. Sutherland, W6UOV, "Two Kilowatt Linear Amplifier for Six Meters," *ham radio*, February, 1971, page 16.
2. R. Barber, R. Rinaudo, W. Orr, R. Sutherland, "Modern Circuit Design for VHF Transmitters," *CQ*, November, December, 1965.

ham radio



Underchassis view of the two-meter amplifier. The cathode input circuit is in the center compartment. Plate lines are visible in the side compartments.

\*Detailed drawings of the anode clamp, plate resonator and blocking capacitor assembly, and variable plate tuning capacitor (C5) are available from R. Sutherland, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070. Ask for drawing numbers 168658, 168648 and 168647.



## vhf fm channel scanner

With this low-cost  
solid-state  
fm channel scanner  
you can monitor  
up to four  
vhf fm channels  
at one time

George R. Allen, W2FPP, 4059 Bay Park Drive, Liverpool, New York 13088

Fixed-frequency amateur operation has become very popular during the last few years. One reason is the availability of commercial fm gear which can be converted easily to the vhf amateur bands. When using this equipment it's customary to pick a popular channel and monitor it for activity. This has the advantage that at any one time there will usually be a large number of local hams listening to the channel; to establish contact it is only necessary to give a short call.

While this type of fm operation may seem ideal it presents some problems. For example, a channel that is popular in one area may not be popular in another area. A mobile operator who is active on one channel has little chance of making contacts in another area where another channel is normally used. Furthermore, a channel which is popular one month may not be in vogue next month. Also, in a particular area you may find fm activity on a number of different channels. Without a large number of receivers, or a channel scanner, it's practically impossible to keep track of all the activity.

The four channel scanner described here can be used to monitor up to four channels in sequence. The scanner looks at each channel individually for 100 milliseconds. If there is no activity the scanner goes on to the next channel. This process continues until activity is encountered, at which time the scanner locks onto the active channel. It remains

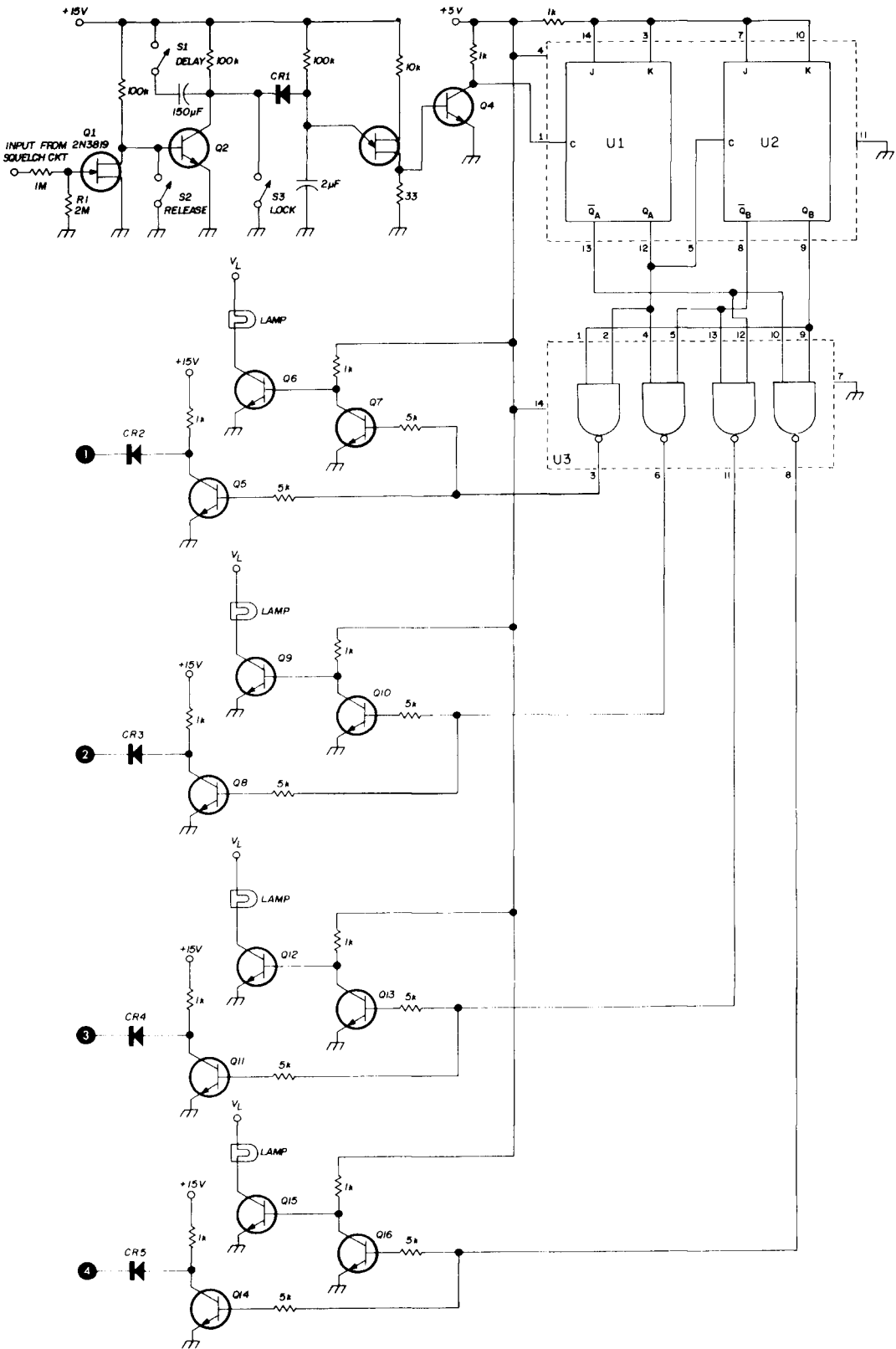




table 1. Parts list for CS-4 channel scanner.

qty	item	price	source
1	printed-circuit board	\$3.50 (undrilled) 4.50 (drilled)	Alton Industries, 7471 Thunderblrd Rd., Liverpool, New York 13088
1	SN7473 IC	1.00	Gateway Electronics, 6150 Delmar Blvd., St. Louis, Mo. 63112
1	SN7400 IC	.50	same as SN7473
1	unijunction transistor	.30	Radio Shack, 4 for \$1.19
1	2N3819 fet	.50	Poly Paks, P. O. Box 942, South Lynnfield Mass. 01940, 2 for \$1.00
10	npn small-signal silicon transistors	2.38	Radio Shack, 15 for \$1.19
4	2N3641	1.19	Radio Shack, 4 for \$1.19
5	small-signal silicon diodes	.02	Poly Paks, 40 for \$1.00
24	resistors	2.40	Radio Shack, etc.
1	2- $\mu$ F capacitor	.40	Radio Shack, etc.
1	150- $\mu$ F capacitor	.60	Radio Shack, etc.
		<u>        </u> \$12.79	

locked on the active channel until manually released, or activity stops.

When designing the scanner I wanted to develop a reliable unit which could be built easily at low cost. These goals have been met; the scanner can be built for less than \$13 if all parts, including the

printed-circuit board, are purchased new. The unit can be completely assembled in 3 or 4 hours. In addition, the channel scanner, which I call the CS-4, can be connected to many of the fm transceivers on the market without making major modifications.

fig. 1. (Left) Vhf fm channel scanner. Lamps are 6, 12 or 24-volt, 200 mA maximum; voltage  $V_L$  is proper voltage for selected indicator lamps.

Q2,Q4,Q5,Q7, Q8,Q10,Q11, Q13,Q14,Q16	npn small-signal transistor (Radio Shack 276B590)
Q3	unijunction transistor (Radio Shack 276B111)
R1	optional 2-meg resistor (see text)
U1,U2	part of Texas Instruments SN7473 dual J-K flip-flop
U3	Texas Instruments SN7400 quad dual-input gate

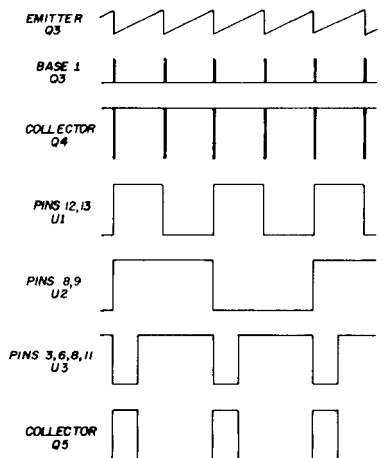


fig. 2. Typical waveforms of the channel scanner.

The CS-4 is built around two inexpensive integrated circuits: the Texas Instruments SN7473 dual JK flip-flop and SN7400 quad dual-input AND gate. The dual JK flip-flop counts to four using two

the scanning rate is about 100 ms per channel. This rate seems adequate. However, if you want a different scanning rate the 2  $\mu$ F capacitor may be changed; lowering the value will increase the scan-

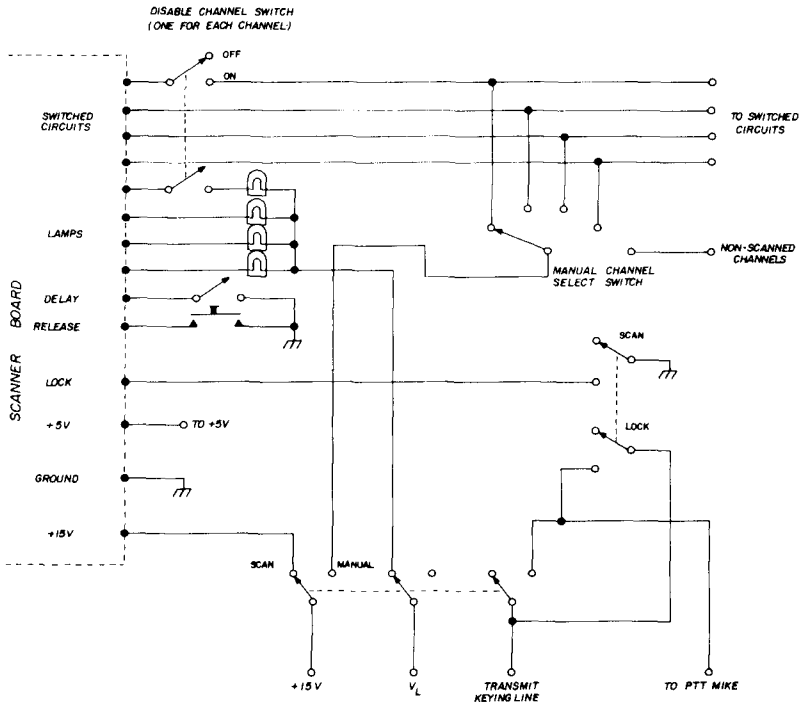


fig. 3. Channel scanner installation at W2FPP's station.

binary bits for the count. The quad dual-input gate separates the counts of the two binary bits into four separate outputs. The four separate outputs drive discrete transistors which in turn drive the lamps and the diode or transistor switches for each channel. Lamp drivers and diode or oscillator drivers must be used since the SN7400 will not handle the required voltage or current. Although an additional IC could have been used, one designed for output driving, discrete components were chosen to keep cost to a minimum.

Since the scanner is built around a counting circuit it's necessary to provide a source of pulses to be counted. A variety of circuits were tried, and most of them worked well; the unijunction circuit as shown in fig. 1 proved to be the least expensive. With the components specified

ning rate. If the scanning rate is too fast, however, the scanner will not lock since signal detection in the receiver may not occur rapidly enough.

The output of the unijunction clock circuit is fed into an npn transistor operating in the saturated mode. This transistor produces a large-amplitude negative-going pulse. The large negative-going pulse drives the flip-flops.

The channel-locking circuit was the result of considerable experimentation. Several problems were encountered: first was the problem of stopping the oscillator quickly; the second was how to get the receiver to stop it. One of the first approaches used an npn transistor with the emitter grounded and the collector connected directly to the emitter of the unijunction. A positive voltage caused the transistor to conduct, shorting the

emitter of the unijunction to ground, stopping the oscillator. However, this circuit had too much lag.

With scanning rates less than one channel per second the lock circuit did

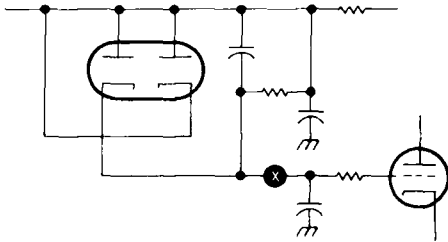


fig. 4. In a typical tube-type squelch circuit the channel scanner is connected at point X.

not react fast enough, so the scanner never locked. Although one channel per second may sound like a reasonable rate, it resulted in parts of a transmission being missed before lock occurred. This problem was corrected by using a small silicon diode, CR1, to isolate the emitter of the unijunction from Q2. This transistor switches the unijunction emitter from ground to +15 volts.

Solving the problem of locking the receiver turned out to be fairly simple. It was only necessary to find a point in the receiver that had a marked voltage change between signal and no-signal. Two points used successfully were the grid of the first limiter and the derived squelch-voltage output. It is preferable to use the squelch-voltage output since it is immune to noise. The first limiter voltage fluctuates with noise and will cause the scanner to lock in the presence of noise; this can be quite annoying.

Although the input locking circuit in fig. 1 is designed to operate with a tube-type receiver that has a squelch voltage that ranges from slightly positive to several volts negative (with signal) the scanner can also be used with transis-

torized rigs that have positive squelch voltage or current.

## construction

Construction of the scanner is simplified if you use the commercially-available printed-circuit board.\* If you use the components shown in the table the scanner can be built for less than \$13. The npn transistors are not critical and virtually any small signal silicon types in your junk box will work. The integrated circuits are not critical either. The only criteria is that they be of the TTL variety, designed for a 5-volt power supply. If other ICs are used it will probably not be

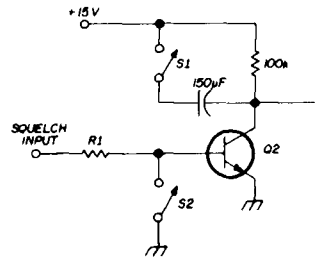


fig. 5. Channel scanner modification for use in solid-state fm receiver where signal voltage goes positive with signal. Q1, the 2N3819 fet input stage, is omitted. For value of isolation resistor R1 see text.

possible to use the commercial printed-circuit board since the pin connections will probably be different.

I recommend that you build one stage at a time and check it out before going further. With this step-by-step construction procedure it is easy to uncover possible problems. The unijunction oscillator stage should be built first. This circuit can be checked with an oscilloscope. The waveforms in fig. 2 will help if you run into problems. If you don't have these waveforms check to see that all parts are wired correctly; then try parts substitution.

After the oscillator is working properly build the locking stages, Q1 and Q2. When a negative voltage of several volts is applied to the input of Q1 the oscillator should stop. Since the gate of Q1 will hold a charge for some time it may be

\*Printed-circuit boards are available from Alton Industries, 7471 Thunderbird Road, Liverpool, New York 13088. Drilled boards are \$4.50; undrilled boards, \$3.50. Completely wired and tested channel scanners are \$33.50.

necessary to wire an external 2.2 meg resistor from the squelch input to ground when testing the unit on the bench. After the locking stages are working the remaining portions of the scanner can be built. The waveforms in **fig. 2** should help in diagnosing any problems.

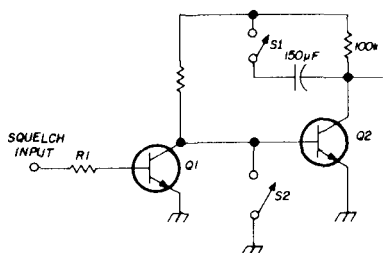
## installation

The scanner installation at my station is shown in **fig. 3**. This circuit permits either manual or automatic operation by merely throwing a switch.

The squelch input to the scanner can be obtained from a typical tube-type transceiver as shown in **fig. 4**. If this is not possible the scanner squelch input should be connected to the grid of the first limiter stage. The 2-megohm resistor from the gate of Q1 is needed only if the scanner lock signal is taken from the first limiter.

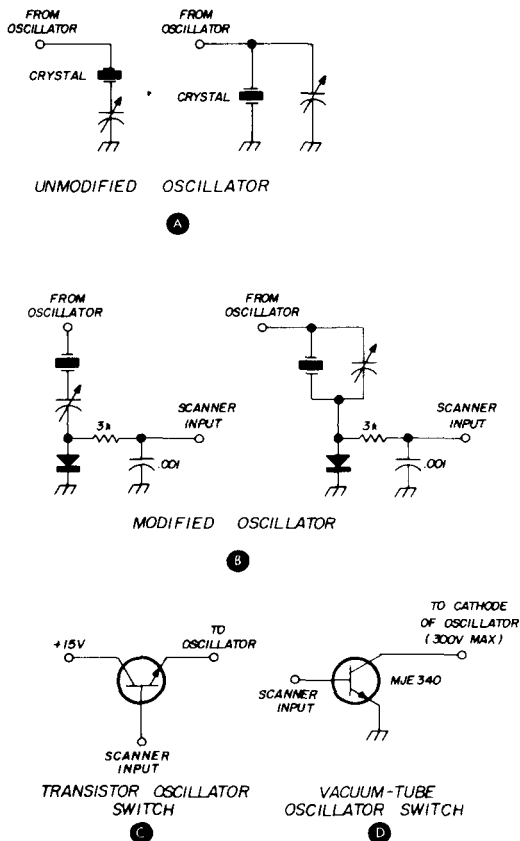
If the fm receiver is a transistorized unit that does not have a voltage that goes from zero to at least 2 volts negative, the scanner must be modified slightly. Using a vtvm, find a spot in the receiver squelch circuit which shows a marked voltage change with the presence of a signal. If the voltage goes from zero to positive from no signal to signal, apply this voltage directly to the base of Q2 through an isolation resistor (**fig. 5**).

If the voltage goes from positive to zero from no signal to signal, then the input to the scanner should be modified as shown in **fig. 6**. In this case, Q1 is



**fig. 6.** Channel scanner modification for use with solid-state fm receiver where signal voltage goes from positive to zero with signal. The fet input stage is replaced with an npn small-signal transistor. For value of isolation resistor R1 see text.

replaced by a junkbox npn silicon bipolar. The isolation resistor R1 is determined experimentally by selecting a value which will lock the scanner, but not affect receiver operation.



**fig. 7.** Methods of connecting the channel scanner to the receiver local oscillator stages. Typical modified and unmodified oscillator stages are shown in (A) and (B). Circuit for switching transistor oscillators is shown in (C); (D) is circuit for switching cathodes of vacuum-tube oscillator stages. Diodes in (B) are small-signal silicon.

To connect the scanner to the oscillator stages in the fm receiver the circuits must be modified slightly. One of the oscillator circuit modifications in **fig. 7** should work with your receiver.

Two supply voltages are required for the scanner, +5 volts and +15 volts (nominal). The +5-volt supply is critical

and should be obtained from a regulated source. The nominal +15 volts may be anywhere from 12 to 18 volts.

### using the scanner

To start scanning, all channel switches should be *on*, the scan-auto switch should be to *scan* and the delay switch to *out*. The channel scanner should begin scanning immediately. As soon as a signal appears on one of the four channels the scanner will lock. With the delay switch out, the scanner will start scanning again as soon as the signal on the channel disappears. In this mode you can keep track of activity on other channels during transmission breaks.


If you want to monitor both sides of a QSO turn the delay switch *on*. In this mode the scanner will remain on a given channel for several seconds after the activity ceases. This prevents switching and locking on another active channel during transmission breaks.

With the delay switch *out* the scanner will resume scanning for one scan if the release button is pressed when the scanner is locked to a channel. To transmit the scanner lock switch must be turned on. This locks the scanner on the active channel and the push-to-talk line is connected to the mike. You can get the same results by switching to *manual*. The manual position is used so that more than four channels may be used. At my station the transmit and receive oscillators for a given channel are tied to a single control line. When the scanner locks I am ready to transmit after setting the lock switch. By running the push-to-talk line through this switch the transmitter cannot be activated while scanning. If you operate the scanner while transmitting you'll get 100-ms pulsed signals on four channels.

### summary


The CS-4 channel scanner was designed to provide a simple, low-cost fm scanner that could be installed with little difficulty. Many of these units are now in operation in central New York State with excellent results.

ham radio




# DIODES

PIV	TOP-HAT	EPOXY	STUD-MOUNT	
	1.5 AMP	1.5 AMP	3 AMP	6 AMP
50	.04	.06	.12	.15
100	.06	.08	.16	.20
200	.08	.10	.20	.25
400	.12	.14	.28	.50
600	.14	.16	.32	.58
800		.20	.40	.65
1000		.24	.48	.75



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**TI 1N914 Silicon Diodes. 16 for \$1.00 ppd.**

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Your Choice 20 for \$1.00

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# vhf coaxial filter

A dual-stub system  
providing  
32-dB attenuation  
at the design  
center frequency  
and more than  
25-dB attenuation  
for a 1%  
frequency change

More often than not, a good vhf receiving system is determined not by what it receives, but by what it rejects. The congestion of radar, radio positioning, and mobile services near amateur vhf bands often leads to distressing image problems. Many low-noise, transistorized receiving systems can be rendered near-useless because of a strong image signal from a station far removed from the amateur band.

On the other hand, spurious signals from improperly adjusted or poorly designed amateur transmitters can, and do, cause interference to other vhf services. Unwanted signals are everybody's problem. Such signals in the coaxial transmission line can be attenuated more than 30 dB by using dual stubs, one for unwanted signal rejection and the other to correct line impedance. These stubs are well worth trying, as they are inexpensive and they work! When interference is confined to a discrete range of frequencies, this high-Q coaxial filter will do an outstanding job of interference rejection.

## the dual coaxial filter

The dual coaxial filter is shown in **fig. 1**. It works well between 20 – 250 MHz and has often been used in commercial mobile and point-to-point equipments.<sup>1,2</sup> Two stubs are used. One,  $l_1$ , is for signal rejection at the unwanted frequency; and another,  $l_2$ , is for impedance correction at the operating frequency.

The stubs are made from lengths of coaxial line. For low power (under 100

William I. Orr, W6SAI, Eimac Division of Varian, San Carlos, California 94070

watts) and for receiving systems, RG-58A/U may be used. Transmitting systems should use the heavier RG-8A/U line. These two lengths of coaxial line,  $l_1$  and  $l_2$ , properly adjusted, provide good filtering as shown by the unwanted-signal rejection plot of fig. 2. For a frequency change from the design frequency of one percent (1.4 MHz at 144 MHz), the dual filter offers better than 25-dB rejection to the unwanted signal. Tuned "on the nose," filter rejection is somewhat better than 32 dB.

### operation

The rejection stub,  $l_1$ , is an electrical half wavelength at the rejection frequency. The impedance-correction-stub length,  $l_2$ , may vary from near-zero to an approximate electrical half wavelength at the operating frequency, as discussed later. Both stubs are placed in parallel across the coaxial transmission line at one point (preferably near the equipment) and are shorted at the far ends.

Since the rejection stub is one-half wavelength at the rejection frequency, its impedance across the coaxial line at this frequency is close to zero, effectively

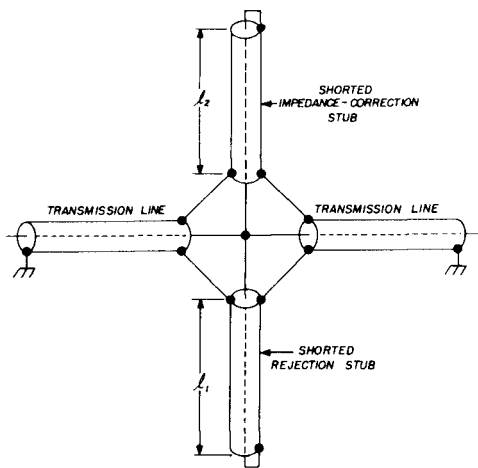


fig. 1. Dual coaxial stub filter made of shorted segments of transmission line shunted across regular transmission line. Presence of rejection stub is neutralized by impedance-correction stub.

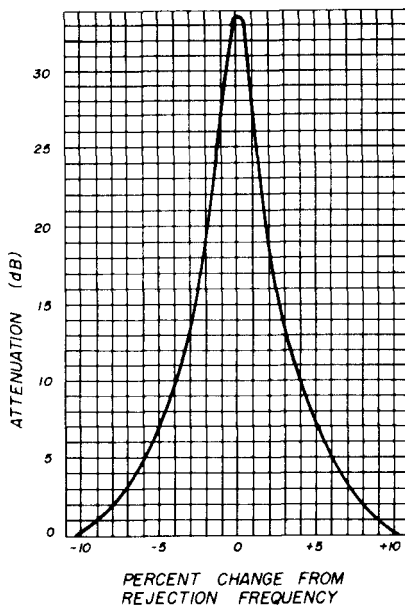


fig. 2. Attenuation characteristic of the dual coaxial stub filter. A single unwanted frequency may be attenuated as much as 33 dB by this simple filter, which offers over 25 dB attenuation at a frequency one percent removed from center frequency.

bypassing this frequency to ground. However, at the operating frequency, the rejection stub is not a shorted half-wavelength section and therefore presents either capacitive or inductive reactance to the transmission line. The unwanted reactance is compensated by adding the impedance-correction stub, which presents an equal and opposite reactance at the operating frequency.

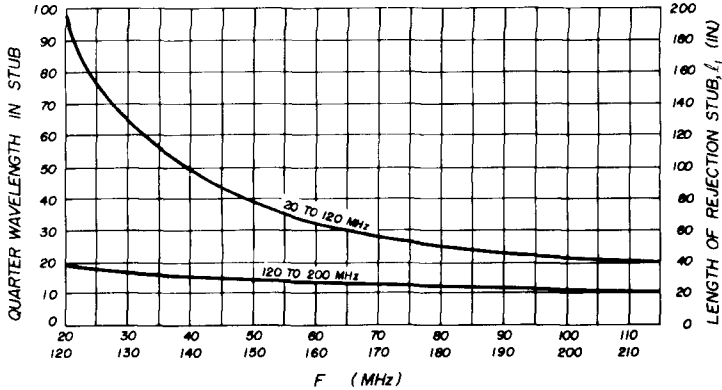
The length of both stubs depends upon the operating frequency and the relationship between this frequency and the rejection frequency, as illustrated in fig. 3. For example, assume the operating frequency,  $f_o$ , is 146 MHz and the rejection frequency,  $f_r$ , is 118 MHz, a not uncommon relationship. The ratio  $118/146$  is  $0.81f$ . This falls on the x-axis of the lower chart between  $0.75f$  and  $1f$ . The curve shows that, in this example, the reactance presented by the rejection stub to the line is inductive; and the upper curve shows that the impedance-

correction stub should present a capacitive reactance at the operating frequency, thus balancing the effect of the rejection stub at the operating frequency.

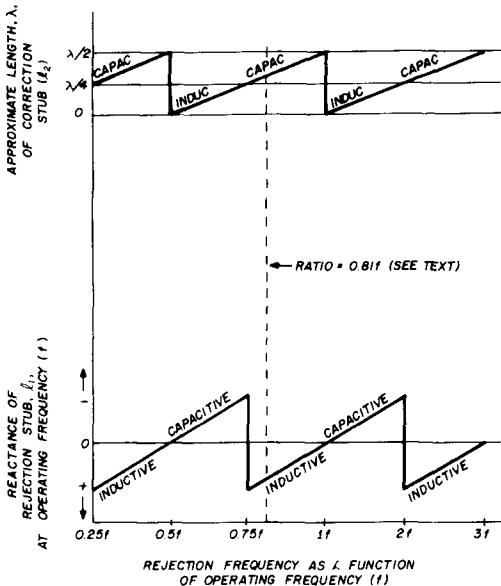
### adjustment

Shown in **fig. 4** are approximate

lengths for the stubs, as computed for solid dielectric cable having a velocity factor of 0.66. For the example, the rejection stub,  $l_1$ , is an electrical half wavelength at the rejection frequency of 118 MHz, or a little less than 40 inches long. A length of line a few inches longer



**fig. 4.** Correction and rejection stub lengths. Left-hand scale is used with **fig. 3** to approximate the length of correction stub, since the stub is longer or shorter than a quarter wavelength at some frequencies. Right-hand scale is used for rejection-stub length.



**fig. 3.** Reactance of rejection and correction filters as the ratio of rejection-to-operation frequency is varied. Net reactance of both filters at the operating frequency is zero. Sample filter for a rejection ratio of 0.81f is discussed in the text.

than this should be connected across the transmission line as shown in **fig. 1**. The stub may be adjusted to the rejection frequency with a grid-dip oscillator by placing a small loop at the unshorted end and trimming the shorted end for resonance.

Even easier, a signal at the unwanted frequency may be injected into the existing transmission line. Using a needle, the inner conductor of the stub is shorted to the outer conductor at various points, starting from the end of the stub and working toward the transmission line. The short is advanced about one-half inch at a time until the position of greatest attenuation of the unwanted signal is found. The line is permanently shorted at this point. This is best done by removing a short slug of the inner insulation and collapsing the outer shield around the center conductor and soldering it all around.

The impedance-correction stub,  $l_2$ , is now added. For various ratios of rejec-



tion-to-operating frequency, the length of this stub may vary from near-zero to about one-half wavelength. For an operating frequency of 146 MHz, a quarter wavelength in the coaxial stub is about 17 inches or less. If this stub were this length, it would present a very high

present a near-short to the operating frequency as well as to the rejection frequency. On the other hand, if the undesired frequency happens to be twice or 3/4 the operating frequency, a correction stub will not be necessary since the rejection stub will be a quarter wavelength (or three-quarter wavelengths) at the operating frequency and will present a high impedance at this point.

### construction

As any wise vhf enthusiast knows, rf has a disconcerting habit of running wild and free in the vhf spectrum. Unless properly contained, the unwanted signals can pass freely around the dual coaxial filter, rendering it useless. This means that no antenna currents should flow on the outer surface of the shield of the coaxial line and the shield should not be broken at the junction of the filters and line. The best way of attaching the two coaxial stubs to the transmission line, therefore, is to make up a small box of brass stock and mount a coaxial hood on the box for each cable, as shown in fig. 5. This makes an rf tight enclosure and helps keep the rf where it belongs.

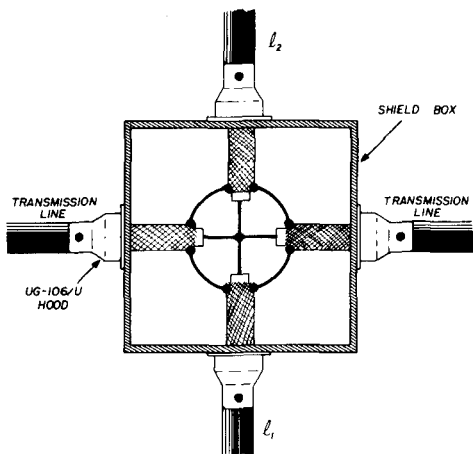


fig. 5. Typical assembly of vhf coaxial filter. Ends of coaxial lines are tinned and passed into brass box through UG-106/U hoods. Cable braid is soldered through holes in hood. The ends of the braid are jumpered together in the box with thin copper shim stock.

impedance to the desired signal. However, according to fig. 3, the correction stub should present a capacitive reactance and must therefore be longer than one-quarter wavelength. As a starter, the stub is cut to one-half wavelength and progressively shorted with a needle as outlined for the rejection stub. In this case, however, tuning is done to produce the least attenuation of the desired signal; or in the case of the transmitting stub, the least value of swr on the transmission line.

### filter limitations

If the rejection frequency happens to be 1/2, 1/4, or 1/8 the operating frequency, the dual-stub filter cannot be used, as the rejection stub will be a full wave-length (or multiple thereof) at the operating frequency and will, therefore,

### references

1. Ramo and Whinnery, "Fields and Waves in Modern Radio," Section 10.11, Wiley & Sons, Inc., New York.
2. Craig, "A Coaxial Stub Filter," *Electronics*, June, 1951.

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# easy-to-build integrated-circuit function generator

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square and  
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A **function generator** is a specialized signal generator normally used for testing complex electronic equipment; output signals include sine, cosine, square and triangular waveforms. As you might imagine, the electronic components necessary to generate this array of waveforms is rather complex. However, there is now an integrated circuit available that generates both square and triangular waves.

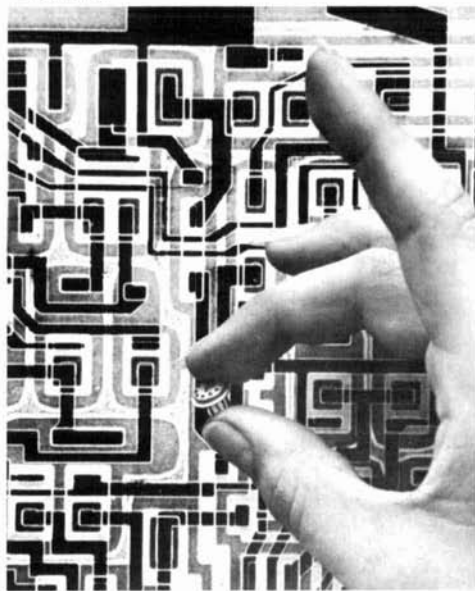
The new Signetics NE566 IC is a voltage-controlled oscillator that produces a highly accurate square wave and a very linear triangular wave up to 1 MHz. It can be used in tone generators, fre-

quency-shift keyers, fm modulators, clock generators and signal generators. The output frequency is extremely stable.

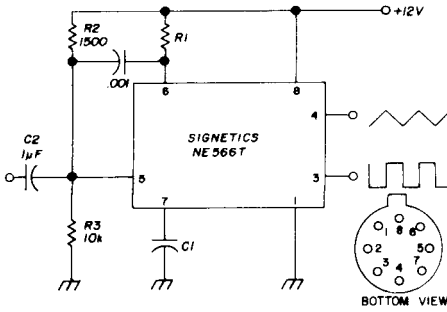
## frequency

The oscillation frequency is determined by the bias voltage on the control terminal (pin 5) and two external components, R1 and C1 (see **fig. 1**). The voltage at pin 5, as referenced to the positive

The Signetics NE566 function-generator IC contains 21 transistors, 10 diodes and 16 resistors.



Jim Fisk, W1DTY, editor



C1 (uF)	frequency range (Hz)
1	14 — 125
0.1	125 — 1250
0.01	1250 — 12500
0.001	12500 — 125k
100 pF	125k — 1MHz

fig. 1. Basic function generator using the Signetics NE566T. Frequency is determined by R1, C1, and the bias voltage on pin 5.

voltage supply at pin 8, must be greater than 0.75 volt, but less than the positive supply (24 volts maximum). In fig. 1 the control voltage is set by the voltage-divider resistors, R2 and R3.

Output frequency vs control voltage is plotted in fig. 2. Normalized frequency is used on the vertical scale to provide

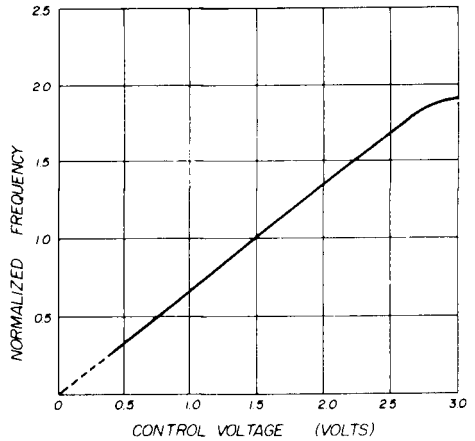


fig. 2. Normalized frequency output as a function of control voltage (control voltage is measured between pin 5 and pin 8).

maximum usefulness. This means simply, that, if the oscillator frequency is 1000 Hz (with 1.5 volts bias), with 3 volts bias the output frequency will be approximately 1800 Hz. As you can see from this graph the integrated circuit can be modulated by the control voltage over a wide range with excellent linearity. A modu-

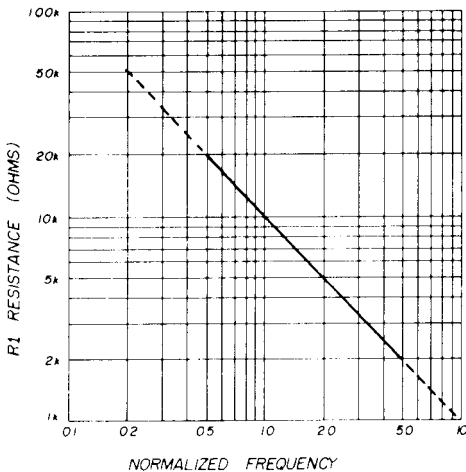


fig. 3. Normalized frequency output as a function of resistor R1 (with control voltage = 2 volts).

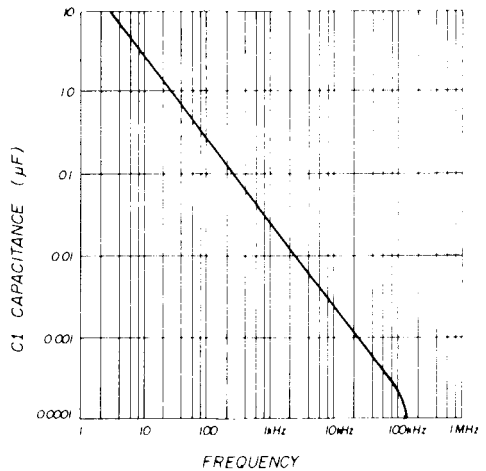


fig. 4. Frequency as a function of capacitor C1 (with R1 = 10k, control voltage = 2 volts).

lating signal can be ac coupled to the device through capacitor C2 in fig. 1.

Resistor R1 and capacitor C1 also determine output frequency. By proper selection of these two components the frequency may be set at any point up to 1 MHz. Once set, frequency drift is negligible at room temperature. Resistor R1 should be in the range between 2000 and 20k ohms. Its affect on output frequency is plotted in fig. 3. Note that *normalized* frequency is again used in this graph, with a normalized value of 1.0 when R1 = 10k. The value of C1 vs frequency is shown in fig. 4; this graph is based on 10k resistance at R1.

To show the use of figs. 3 and 4 let's choose values for R1 and C1 that will provide an output of 3000 Hz. First go to fig. 4 — 3000 Hz coincides with about 0.007  $\mu$ F capacitance, a rather unordinary value. Choose the closest standard value, 0.01  $\mu$ F. This moves the frequency down to about 2200 Hz.

If you read the fine print in the caption of fig. 4 you'll see that this capacitor is based on a 10k resistance at R1. To bring the frequency up to 3000

Hz you find the required resistance value to set the output frequency at 3000 Hz; approximately 8000 ohms.

### practical circuits

If the output frequency is off slightly when you build the circuit, you can add parallel trimming resistors to set the

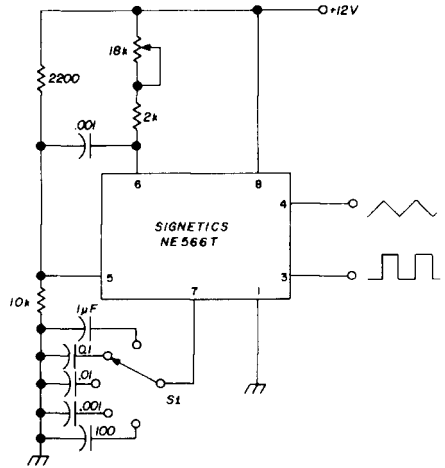


fig. 5. Variable-frequency function generator covers the frequency range up to 1 MHz.

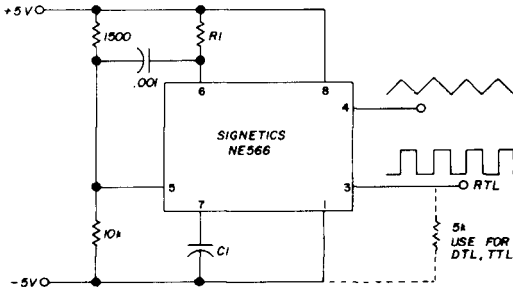


fig. 6. Plus and minus supply voltages put the square wave output at the proper dc level for driving logic circuitry. RTL logic may be driven directly; DTL and TTL logic require 5000-ohm resistor connected to the negative supply.

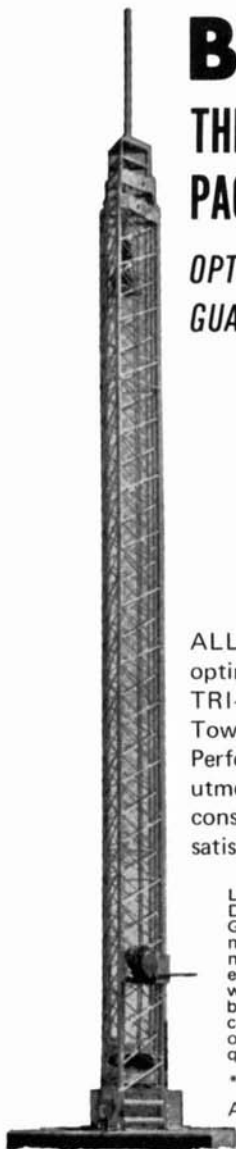
Hz use a slightly lower resistance as shown in fig. 3. To find the necessary multiplication factor, divide 2200 into 3000; this gives a factor of 1.35. Entering fig. 3 at 1.35 on the normalized fre-

output frequency exactly. Or, if you want a variable frequency output, you can replace R1 with a potentiometer. A typical circuit is shown in Fig. 5. In this circuit capacitor C1 is selected by switch S1. Five capacitors will provide nearly complete coverage from about 20 Hz to 1 MHz.

When building this unit be sure to include the 0.001 capacitor between pins 5 and 6 of the integrated circuit (with short leads). This prevents oscillation of the internal IC circuits.

The NE566T is a natural choice for driving standard IC logic circuitry. If you use the dual  $\pm$ 5-volt power supply as in fig. 6 the square-wave output will have the proper dc level for driving directly RTL logic. For DTL or TTL logic connect a 5000-ohm resistor between pin 3 and the negative supply voltage.

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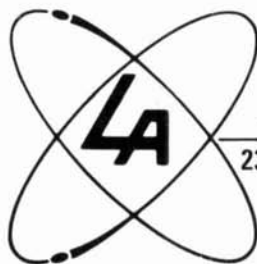
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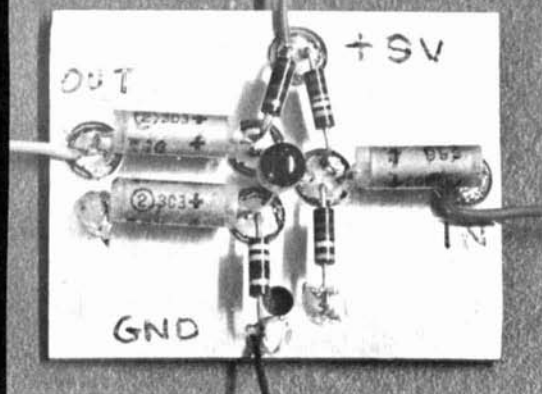


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Instant tie points can solve most of these problems. By cutting a small ring through the copper surface of the copper-clad circuit board a small disc of copper remains which is firmly attached to the board but is electrically insulated from the rest of the sheet. These insulated discs make excellent tie points for connecting two or more component leads together. The tie points are very strong and, therefore, well suited for mounting components that can be supported with their own leads. Transistors, resistors, fixed or variable capacitors, inductors, crystal sockets, wire leads to external components and many other items can be soldered to these insulated discs. For example, three insulated discs, grouped close together, provide an excellent mounting base for a transistor and resistor, capacitor or other component. Terminals or pigtailed that connect to ground are soldered to the copper surface of the circuit board *without* cutting a circular groove.

Ted Swift, W6CMO, 1069 Savoy Street, San Diego, California 92107

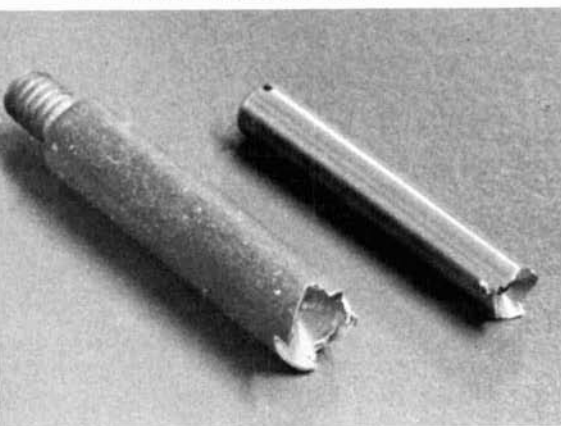
## cutting tool

The best part of this construction technique is that the saw that cuts the ring in the copper surface can easily be made at home. Several different sizes, for producing large or small insulated discs, are handy. However, a description of the saw I use most often will serve as a guide for making other sizes.

A 2- or 3-inch length of mild steel rod, 1/4-inch in diameter, is the only material required. If necessary, true up one end of the rod by turning it in a lathe. If a lathe is not available, careful work with a hand file is an acceptable substitute. Bore a shallow hole in the end of the rod using a number 3 drill. This forms a cup in the end of the rod with a narrow rim. Now make two hacksaw cuts across the face of the cup, 90 degrees apart. File away the metal between adjacent saw cuts on a slant to form saw teeth; be sure the slant is in the direction that results in the cutting edge of each tooth being headed in the right direction when the tool is rotated in a drill press.

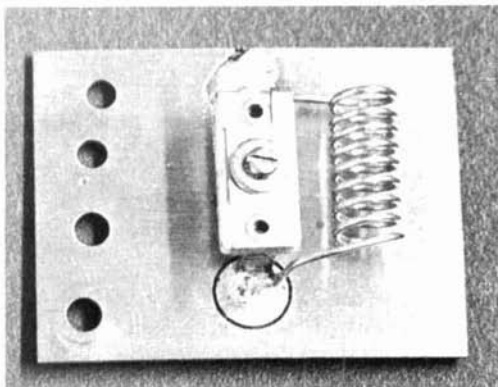
To use the cutting tool, chuck it in a drill press. Center the saw over the spot on the circuit board where the tie point is required. Cut through the copper surface and slightly into the insulating material of the board. Practice using the tool on scrap material to get the feel of it before attacking a project. If your saw is not too

Insulated printed-circuit pads are cut with small saws made from mild steel rod.



sharp it may leave a small burr on the copper surface. This may be smoothed out by rubbing the side of a round glass jar over the surface of the disc.

This tie-point technique is very flexible. Where practical it pays to plan the layout of all components on the circuit board in advance of construction. The required tie points can then be located and cut before parts are mounted, thus speeding the assembly job. However, if a tie point is forgotten, or if you need more of them, insulated discs can be added at any stage of construction without disturbing already installed parts.



Larger pads are useful for big components. This printed-circuit board is the same size as the transistor amplifier.

Furthermore, the tie point technique has an unexpected advantage. Since the tie points can be located any place on the circuit board it is practical to mount components salvaged from surplus printed circuit boards. Such salvaged components usually have pigtails too short for reuse by other mounting methods.

One other circuit board hint: After the circuit board is cut to size and its copper surface is cleaned and polished with steel wool or household cleanser, spray the surface with a thin coat of *Krylon*. The copper surface will stay bright for life and solder will still wet the board as if the *Krylon* were not there.

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## ac power-line monitor

Simple  
high performance circuit  
provides highly accurate  
line-voltage monitor  
that requires  
no calibration

During the hot weather that persisted from last summer through early fall, the locality where I live experienced several power brownouts. Not blackouts, but a lowering of the nominal 117 volts ac in order to supply badly needed kilowatts to the adjoining metropolitan area. The measured line voltage dipped from its usual value of 120 volts to the vicinity of 110 to 112 volts. Air conditioners ran at reduced efficiency, lights dimmed somewhat and the automatic pin-spotter at the local bowling alley refused to function. Although some electrical appliances may not suffer from this sort of undervoltage it is a good idea to be able to read the line voltage with a higher level of accuracy

than is possible with the average multimeter, which may be off as much as 6 volts (at 120 volts) and still be within tolerance.

There are several commercial ac voltmeters available for this purpose; most common is the iron-vane type. The better instruments are generally accurate to 2% of full scale. On a meter that reads 150 volts full scale this implies an inaccuracy of 3 volts at a line voltage of 120 volts ac. Since most of these instruments are not easy to read at a glance some commercial users and laboratories have changed over to the *expanded-scale* voltmeter. Simpson makes a fine segmental voltmeter with a mid-scale accuracy of 1/2%, but the high cost puts it beyond the reach of most amateurs and experimenters.

There are several electronic voltmeter circuits where the indicating meter reads all over-voltage above a certain standard. This standard or comparison voltage is a voltage-reference tube or zener diode. When properly calibrated the accuracy of such devices is in the neighborhood of 3%. There are two drawbacks, however: most voltage-reference sources are temperature dependent, and for reasonable accuracy the instrument should be calibrated with a laboratory standard.

The ac line monitor shown in **fig. 1** neatly skirts these obstacles. It is simple and requires no calibration. In addition, the cost is lower than you might pay for an equivalent meter.

Basic to this ac voltmeter is the use of a segmental scale voltmeter that reads from 18 to 36 volts dc. My meter, a Marion Electric type HS2 was purchased

Neil Johnson, W20LU, 74 Pine Tree Lane, Tappan, New York 10983



new at a surplus store for slightly under \$4.00.\* An ordinary silicon rectifier diode is used to furnish approximately 54 volts dc from the 120 volt line. Since the hermetically sealed Marion meter does not lend itself to easy modification I chose to use the 30-volt reading on the scale to correspond to 120 volts ac line voltage. The current drain at the 30-volt mark is  $833 \mu\text{A}$ . (The 30-volt mark is  $5/6$  of full scale or 83.3%; since the meter has a 1-mA meter (the usual type) current flow at  $5/6$  full scale is  $833 \mu\text{A}$ .)

The value of multiplier resistor is determined with Ohm's law. Dropping 54 volts dc (from the rectifier) to 30 volts requires 28.8 kilohms for a current of

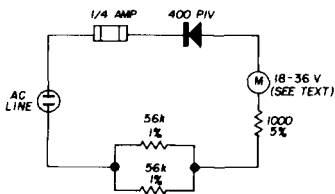


fig. 1. Circuit of the high accuracy ac line monitor.

$833 \mu\text{A}$ . I used two parallel-connected 1% 56k resistors in series with an ordinary 1000-ohm resistor. The total resistance is very close to the desired value of 28.8k.

### accuracy

Before talking about the performance of this simple instrument I'd like to explain some of the techniques used to insure that it will provide 1% accuracy without comparison to a lab standard.

First the dc meter was connected in series with four other 1,000-ohms-per-volt dc meters. One of these was a Weston 741 mirror-scale meter, rated at 1% ac-

curacy. Readings were taken at 3-volt intervals; then an identical run was made backward from full scale deflection of 36 volts to 18 volts. Averages of the four other meters were tabulated; the readings of the expanded-scale Marion meter compared closely to the other instruments. The maximum error was 1.25% of full scale and the average error was less than 1%. After the instrument was completed ac accuracy was checked. A mirror-scale Simpson 261 vom was checked at 6.7 volts against a meter of known accuracy, a precision mirror-scale laboratory type ac voltmeter (Weston 433). Since the two readings were in agreement the Simpson 261 readings on the 0 to 10-volt ac scale were trustworthy. When switching to the 250-volt ac range additional precision multipliers are used; however, the basic ac circuitry and accuracy remain essentially the same. When my meter was compared to the Simpson 261, it read 119 volts as opposed to the Simpson's 119.5 volts.

You may wonder how such high accuracy may be obtained from such a simple circuit. Through segmentation, it is possible to increase the absolute accuracy of the original movement.<sup>1</sup> Proper selection of the multiplier resistors will contribute to the retention of this enhanced accuracy. As with any homemade device care and forethought are important ingredients that will pay off in increased accuracy and dependability.

The Marion meter movement is not highly damped. This allows a very slight flickering of the pointer but it is hardly noticeable. However, it has one definite advantage: Rapid excursions of the ac line voltage, not fully discernible with ordinary voltmeters, can be easily followed. I first noticed this effect when I hooked the ac line monitor to the wall socket where a small air conditioner was plugged in. When the compressor first started up, the ac line dipped — for an instant — to below 100 volts ac!

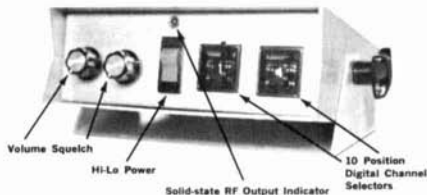
### reference

1. C. E. Miller, W1ISI, "Blow Up That Meter," 73, October, 1964, page 56.

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\*The Marion Electric HS2, 2-1/2-inch round, 18- to 36-volt dc meter is available for \$3.95 from Fair Radio Sales, Post Office Box 1105, Lima, Ohio 45802. A similar 18 to 36-volt Roller-Smith meter is available for \$4 from Jeff-Tronics, 4252 Pearl Road, Cleveland, Ohio 44109.

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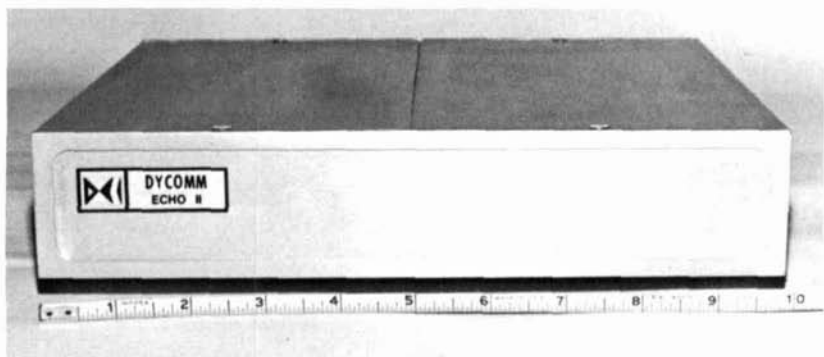


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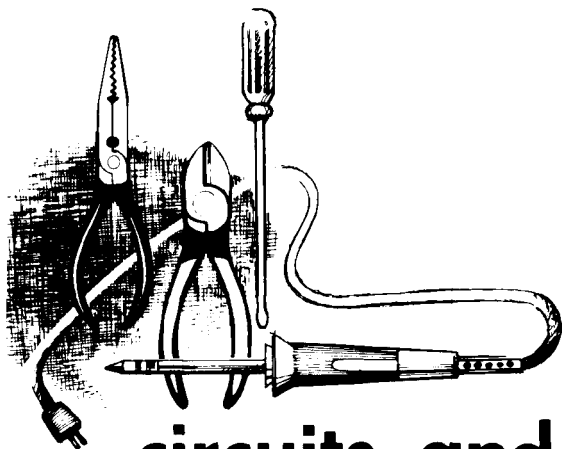
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# circuits and techniques

ed noll, W3FQJ

## integrated circuits

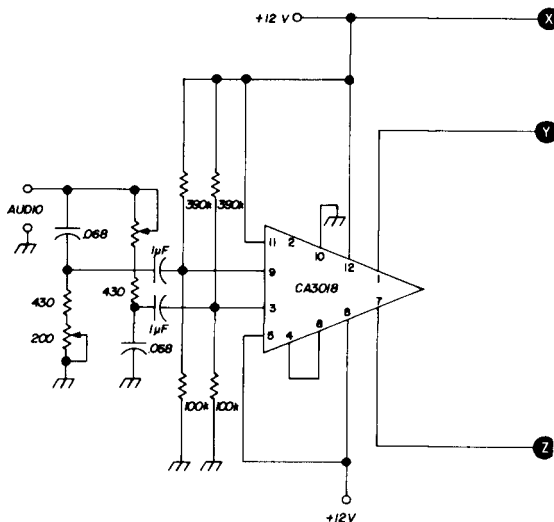
Integrated circuits hold great promise for modulation and demodulation applications. The modern transmission modes of single sideband, double sideband, suppressed carrier and frequency modulation, plus phaselock receiving systems, depend a great deal on balanced circuits. This is the forte of integrated circuits with their arrays of identical diodes and identical transistors.

### modulators

The diode balanced modulator is widely used in transmitters. IC diode-arrays provide the experimenter with small, well balanced diode assemblies. One example is the RCA CA3019, fig. 1. The CA3019 consists of four bridge-connected diodes plus two additional diodes, all in a miniature 10-pin TO-5 case. Conventional balanced modulator and ring modulator circuits are shown in fig. 2. In fig. 2B the diode between points X and Y consists of CA3019 diodes D1 and D2 in parallel; pin 5 is connected to Y, pins 6 and 2 are connected to X. Similarly, the diode between points X

and Z consists of CA3019 diodes D3 and D4 in parallel; pin 8 is connected to Z.

Phasing-type single sideband generation may not disappear from the scene with the advent of integrated circuits. The balance complexities of the phasing system are reduced by the unusual uniformity that can be obtained in integrated-circuit construction. As shown in fig. 3, a combination of CA3018 and



CA3050 integrated circuits provide a packaged phase-shift single-sideband modulator.

The RCA CA3018 is a four-transistor IC that can be connected as two Darling-

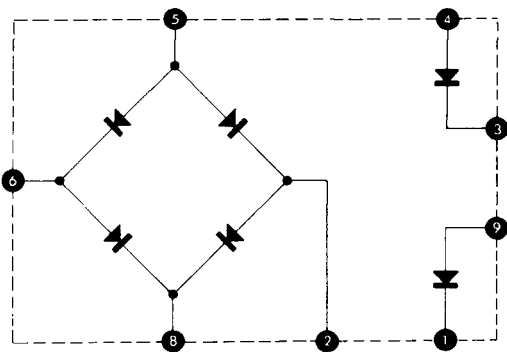
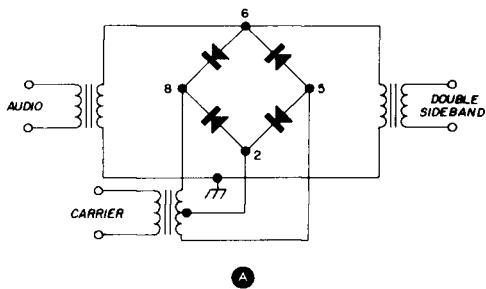


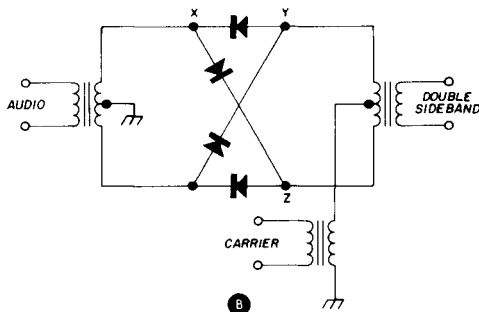
fig. 1. The RCA CA3019 diode array.

ton pairs. The audio phase-shift network is connected externally, supplying 90°-related components to the separate inputs of the Darlington pairs; two low-impedance 90°-related outputs are made available. The Barker & Williamson 2Q4 is a good choice for the audio phase shift network.

The RCA CA3050 consists of two



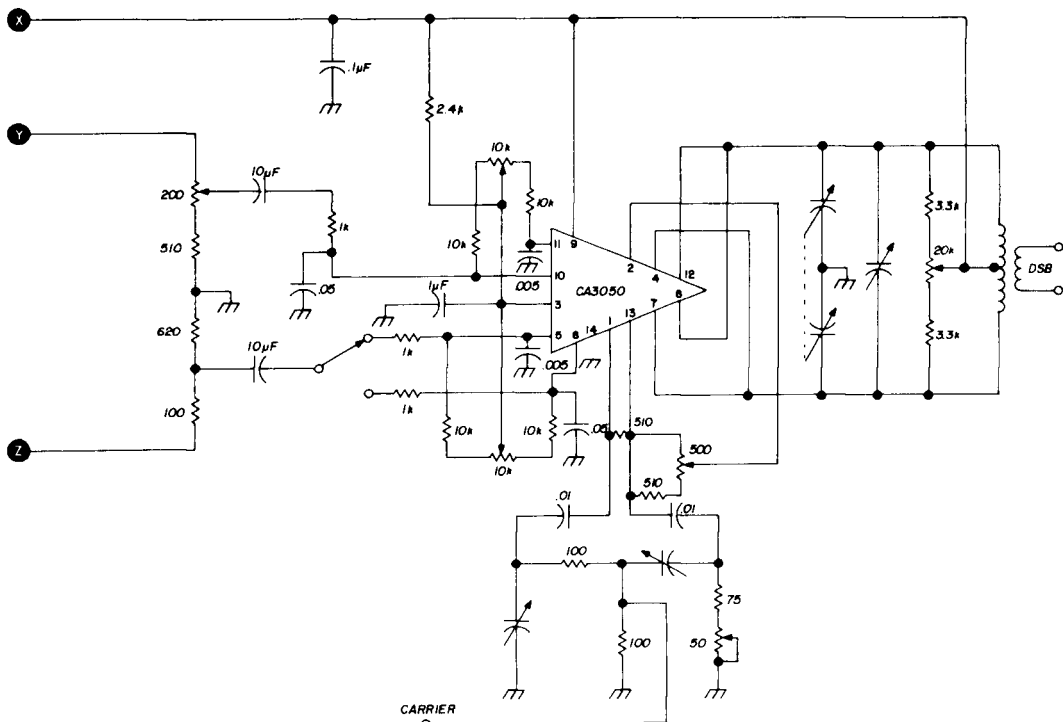
(A)



(B)

fig. 2. Balanced modulator (A) and ring demodulator (B) using the RCA CA3019.

fig. 3. Phasing-type ssb generator based on the RCA CA3018 and CA3050 integrated circuits.



independent differential amplifier arrays. Each array is made up of two Darlington pairs connected as differential amplifiers. Audio signals from the phase-shift IC are

ssb i-f strip. Simple external connections can switch the IC from one mode to another. Bandpass shaping may be accomplished externally over a frequency range

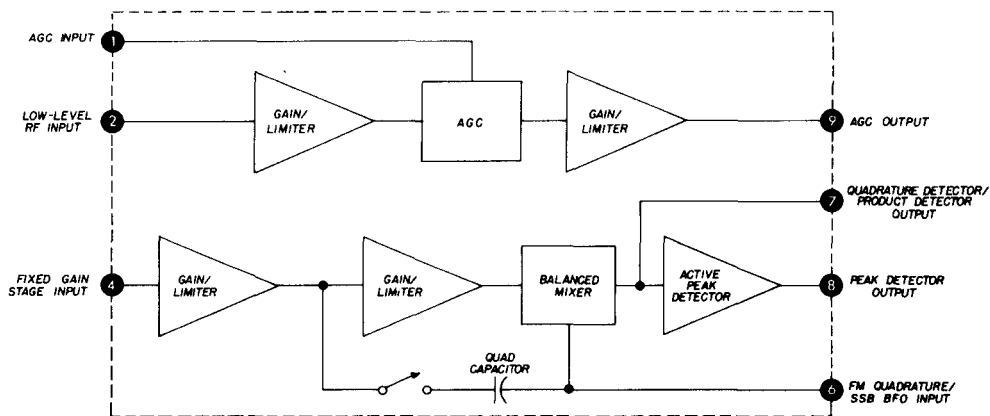


fig. 4. Block diagram of the National Semiconductor LM373 integrated-circuit a-m/fm/ssb i-f strip.

applied to their bases. A switch permits the selection of upper or lower sideband.

Additional transistors provide carrier input so the  $90^\circ$ -related carrier components can be applied to the emitter circuits of the independent dual differential amplifiers. The appropriate  $90^\circ$  phase shift networks are connected across the inputs of these transistors. One input consists of series resistor and shunt capacitor; the other, a series capacitor and shunt resistor. If each network provides  $45^\circ$  phase shift, the total phase shift of the two carrier components is  $90^\circ$ . The single-sideband signal is developed across the tuned output transformer.

## demodulators

Some of the most intriguing ICs are those that contain an i-f amplifier plus capability for various demodulation modes. They lend themselves to the construction of small and versatile receiving systems.<sup>1</sup> With such IC versatility I wonder if a compact all-band (1.8 MHz to 144 MHz) all-mode, cw, a-m, fm and ssb receiver is a real possibility?

One particularly interesting IC is the National Semiconductor LM373 a-m/fm/

from audio to 15 MHz. Agc is also included.

A functional block diagram of the LM373 is shown in fig. 4. The row of stages at the top include an amplifier/limiter, agc and second gain circuit. The signal to be demodulated is applied to pin 2. Output is taken at pin 9, and in most applications, re-introduced at pin 4, passing through an external filter circuit on the way. More gain stages are followed by a balanced mixer and peak detector. With proper external circuitry the latter two circuits can be switched for a-m, fm or ssb. Output voltage ranges from 50 and 120 millivolts rms depending upon mode.

Test circuit connections for a-m, fm and ssb are given in fig. 5. An a-m i-f signal is applied to pin 2, removed at pin 9 and re-introduced at pin 4. Demodulated output is taken from the peak detector at pin 8.

The fm detector uses a quadrature demodulator. The fm i-f signal is applied to pin 2, picked up at pin 9, and through transformer T1 is re-applied at pin 4. The quadrature LC circuit is connected at pin 6; demodulated audio is removed at the output of the balanced mixer at pin 7.

For ssb and cw operation the signal is sent through the amplifier/agc system, pin 2 to pin 9, and is re-inserted at pin 4. The balanced mixer is now used as a

adapt these unusual devices for amateur applications and experimentation to make the ideas work. G3VJN points out in Technical Topics<sup>2</sup> that an amateur can

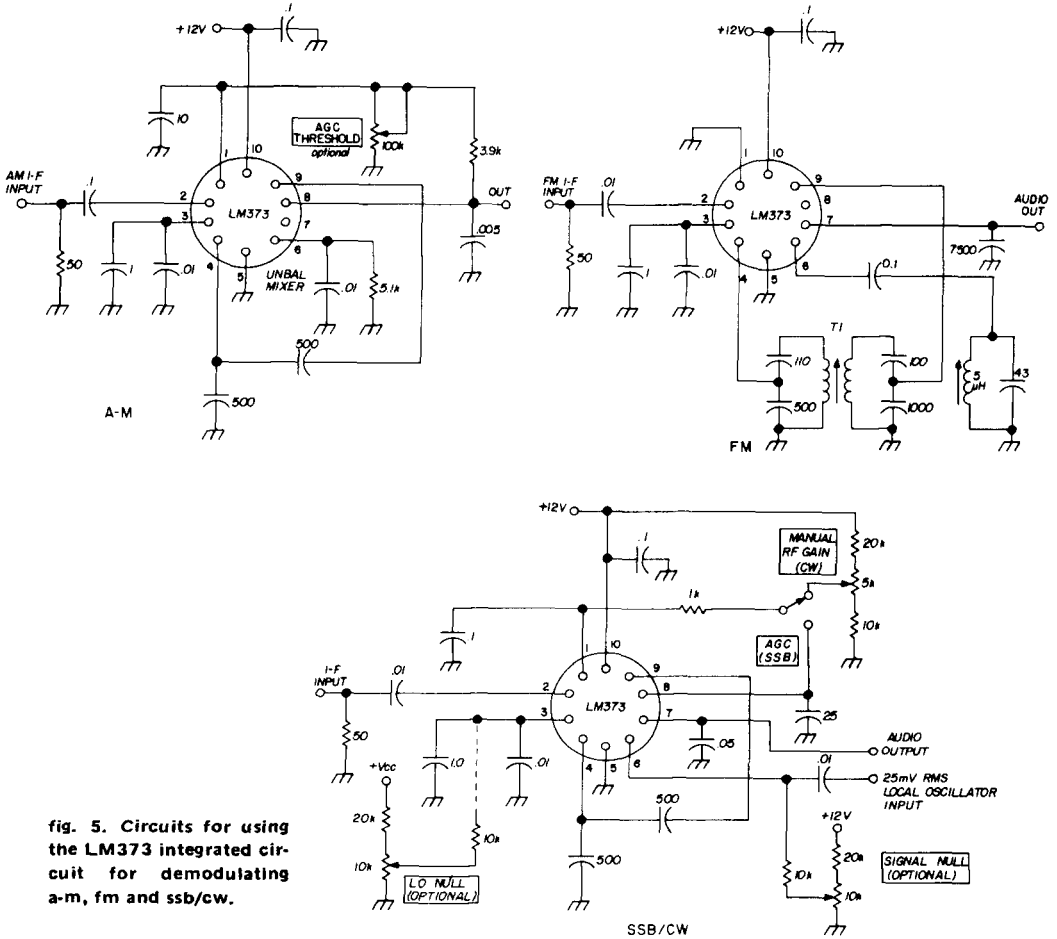


fig. 5. Circuits for using the LM373 integrated circuit for demodulating a-m, fm and ssb/cw.

product detector with carrier applied to pin 6. Ssb output is again taken at pin 7. An appropriate switch permits selection of agc action for single sideband or manual gain control for CW.

### rf amplifier

Integrated circuits are not the monsters that you may have been led to believe. That they destroy ingenuity and the yen for experimentation is more evasion than fact. Ingenuity is required to

often adapt some of these newer devices for applications very different from the manufacturer's intended use. To prove the point he built an rf linear amplifier for 80 meters using the popular RCA CA3020 audio power amplifier (fig. 6). A close check of CA3030A specs indicates operation to 8 MHz.

A diagram of the CA3020, fig. 7, shows the isolating input stage (Q1), differential amplifier (Q2 and Q3), driver (Q4 and Q5) and power output stage (Q6

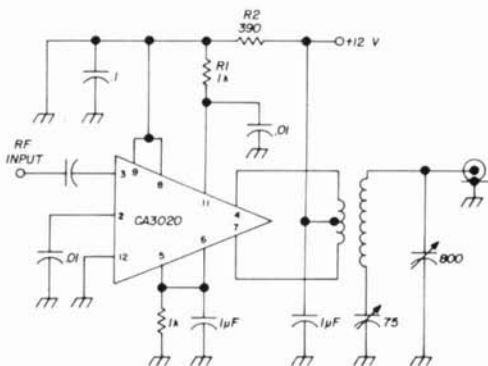
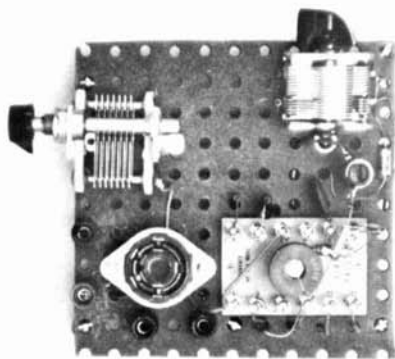


fig. 6. Integrated-circuit 80-meter linear amplifier designed by G3VJN.



Breadboard layout of the RCA CA3020 linear amplifier.

and Q7). The IC also includes a built-in voltage regulator.

We can now look at G3VJN's circuit in fig. 6 and understand its operation. First of all, input transistor Q1 is not used; signal is applied to pin 3 which is the input to the differential amplifier. Supply voltage is applied to this stage through

resistors R1 and R2 to terminal 11.

Push-pull output is taken from the final amplifier at terminals 4 and 7 which connect directly to the collectors of the output transistors. Supply voltage is applied through the coil center tap. The circuit is simple and easily understandable.

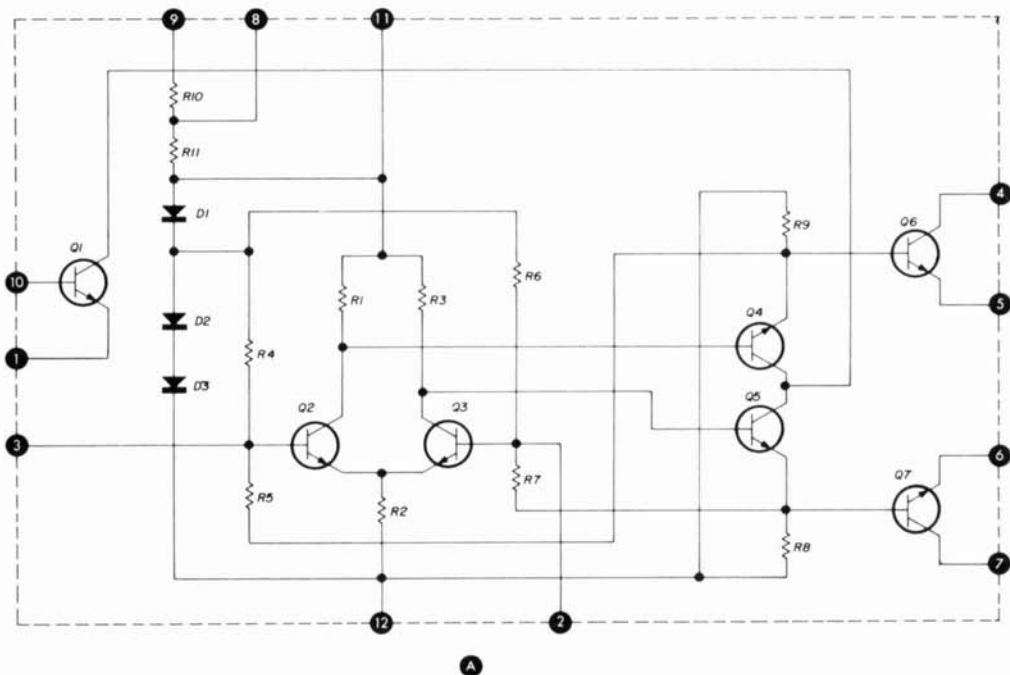
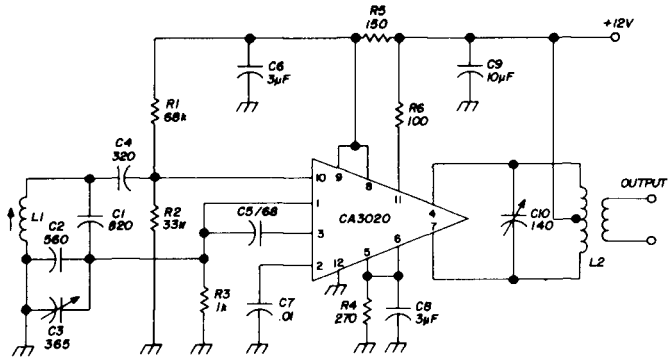


fig. 7. Block diagram and internal circuit of the RCA CA3020.



fig. 8. Seiler vfo and output amplifier using the RCA CA3020.



### vfo

With the CA3020 you also have the makings of an integrated-circuit vfo, using the input transistor in a Seiler-type vfo. The circuit shown in fig. 8 performs well on 160, 80 and 40 meters. Since linear operation is not required for vfo operation G3VJN's basic circuit can be modified somewhat to obtain slightly more output.

The oscillator is built around pins 1 and 10 which connect to the base and emitter of the input transistor (fig. 7). The emitter output of the Seiler oscillator, pin 1, is connected to the input of the differential amplifier, pin 3, through capacitor C5. Some adjustment of C5 may be needed to obtain optimum output and minimum turn-on drift. Pins 4 and 7 connect to the push-pull rf output transformer. This is a center-tapped primary winding with secondary wound between the two halves of the primary.

A breadboard test unit of this circuit is shown in the photo. To facilitate circuit changes I used a Vector 570-F IC test socket. With this test socket the IC pins are brought out to 12 pressure spring terminals, a real blessing for experimental work.

The RCA CA3020 can also be used as an oscillator and frequency doubler to provide even greater isolation between the output and the oscillator. The circuit of fig. 8 frequency doubles by tuning the output circuit to twice the oscillator frequency.

Greater output can be obtained from the circuit of fig. 9. In this circuit the

output transistors are connected in a push-push frequency doubler circuit. The bases are connected internally in a push-pull circuit that cannot be altered. The

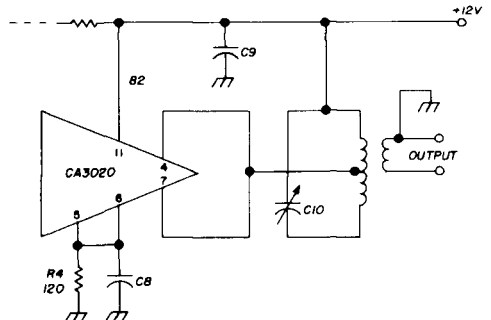


fig. 9. Modifying the output circuit of fig. 8 for frequency doubling.

push-push doubler circuit requires that the collectors of the output transistors be connected in parallel as in fig. 9. A single-ended output circuit is used with

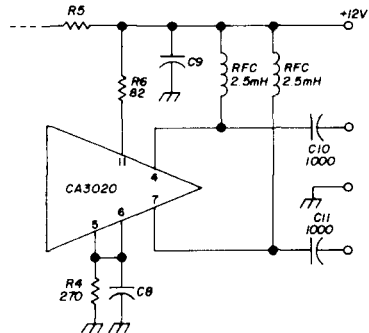


fig. 10. Modifications to the output circuit of fig. 9 for balanced voltage drive to succeeding high-impedance stages.

the collectors connected to the primary tap. Several hundred milliwatts rf output is possible.

The CA3020 circuit arrangement in fig. 10 is ideal for driving a succeeding high-impedance amplifier such as the push-pull input to a vacuum tube or fet. The primary objective of this circuit is to provide good voltage drive to the next stage.

### triangle antennas

The full-wave triangle antenna seems like the best "hunk-of-wire" antenna ever; performance-per-penny-spent is exceptional. Only a single mast or other high support point is needed. Since it is fed at the bottom the triangle can be trimmed to resonance with ease.

The basic triangle is a closed full-wave-length antenna, fig. 11, with three equal-length sides. However, within reason, good performance is maintained if the

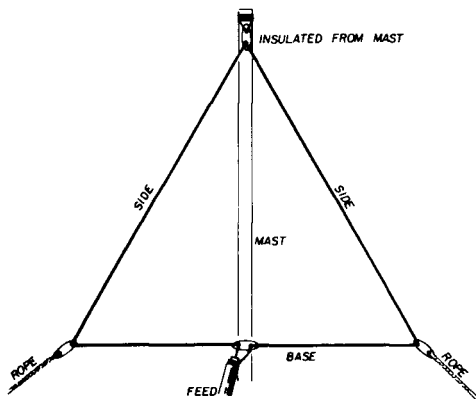


fig. 11. Basic triangle antenna layout for 40, 80 and 160 meters. Total length of wire is 1-wave-length on the band of interest.

base is longer than the two sides. Conversely, the sides can be longer than the base, within limits, as long as the overall length is one wavelength. The relative length of sides and base influence radiation resistance, therefore simplifying impedance-matching problems.

On 40, 80 and 160 meters you can use coaxial feedline without any supplement

tal matching system. Simply make certain that the base of the triangle is 8 to 12 feet above ground; at this level the antenna is easy to trim for proper reson-

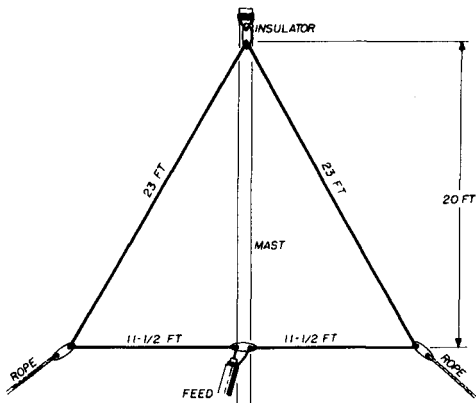


fig. 12. Triangle antenna for 10, 15 or 20 meters is mounted above ground on a single supporting mast.

ance and matching to a given transmission line.

### construction

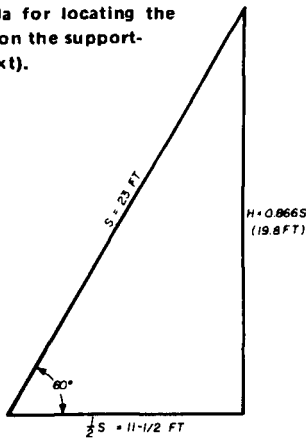
The mounting arrangement consists of a single support mast and a pair of ground stakes. The antenna wire is fed through an insulator at each end of the base and is supported by an insulator at the top of the mast. I use insulated wire such as plastic-covered no. 12, no. 14 or no. 16. The insulation is removed only where the antenna is connected to the transmission line at the center of the base. Nylon rope or plastic clothesline (non-metallic core) is attached to each of the base insulators; the triangle is pulled open and held in position by the two ground stakes.

On the higher bands, 10, 15, 20 meters, a single triangle antenna element can be supported in about the same manner, fig. 12. On these bands use coaxial line or open-wire transmission line and an antenna tuning unit. This provides good performance over the entire band for which the triangle is designed.

To build the high-band triangle measure off three equal sides. Attach the

two base insulators so they cannot slide along the antenna wire. Locate the exact position of the feed point. This can be done with the simple equation in **fig. 13**.

**fig. 13. Formula for locating the base feedpoint on the supporting mast (see text).**



For example, a full wavelength at 20 meters is:

$$\lambda = \frac{984}{f_o} = \frac{984}{14.2} = 69 \text{ feet}$$

Each side, *S*, will be one-third this value or 23 feet.

To set up an equilateral triangle, the separation between the apex and the center feedpoint of the base must be:

$$h = 0.866S = 0.866 \times 23 = 19.8 \text{ feet}$$

A twenty foot separation between apex and feedpoint is fine.

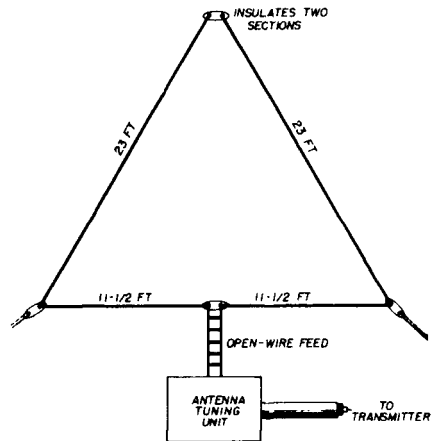
In erecting the antenna the apex and center feedpoint are attached to the mast. Then the mast is raised. Finally, the ropes attached to the base insulators are used to pull the wire into a triangle.

The triangle antenna has a bi-directional pattern and provides good performance at reasonably low mounting heights. Cost is low; what do you pay for a 69-foot piece of wire and four insulators? On the lower bands the triangle antenna has favorable low-angle directivity. It also operates well with parasitic reflectors and directors and can be used as elements of a phased antenna system.

## open triangle

The closed triangle, like the closed quad or delta loop, is a single-band antenna. Operation on other bands is possible using concentric mountings as for three-band cubical quads. The open triangle antenna, when cut for 20 meters provides good bi-directional performance on 10, 15 and 20 meters (see **fig. 14**). Note that the insulator at the apex of the triangle divides the antenna into two half-wave 20-meter sections. The feed-point impedance is high and requires an antenna tuning unit with both series and parallel tuning.

The open triangle also loads well and gives reasonable performance on 40 meters. On this band each segment, at 34.5 feet, is a bit longer than a quarter wavelength. Although there is a lot of experimentation to be done with the triangle, it is a good base for high-performance, low-budget antennas.



**fig. 14. Open triangle antenna cut for 20 meters operates successfully on 10, 15 and 40 meters. The antenna wire is broken at the apex of the triangle.**

## references

1. Paul Hrivnak, VE3ELP, "Integrated-Circuit Communications Receiver," *ham radio*, July, 1971, page 6.
2. Pat Hawker, G3VA, "An Integrated-Circuit Linear Amplifier," *Radio Communication*, November, 1970, page 761.

ham radio

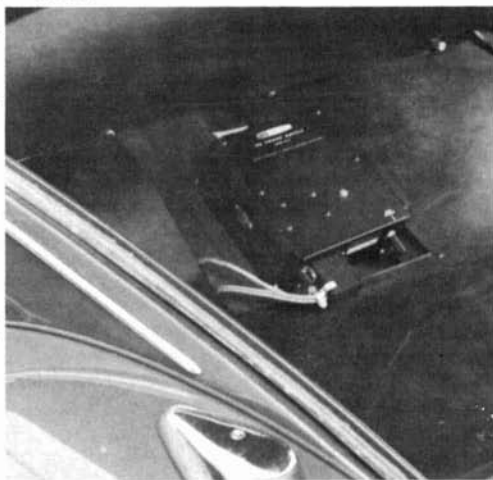


## mini-mobile

It is possible  
to operate mobile  
from a small  
foreign car —  
this VW mobile  
is a good example

When my wife first suggested buying a Volkswagen for our first car I was somewhat stunned — knowing it would never materialize into the mobile station I always dreamed of. Going against the odds of placing all my mobile gear in the small Beetle I began to change the VW into a rolling radio station. I hope this article will provide incentive to all hams who own small cars to try mobile operation.

The dc power supply is installed up front in the VW trunk.

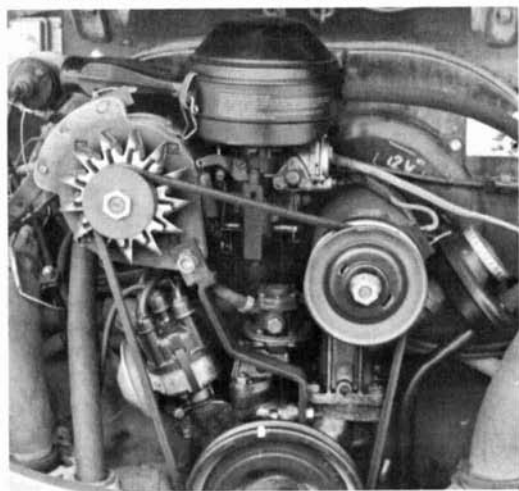


Donald Backys, K9UQN, 138 Valley Lane, Apartment 205, Hoffman Estates, Illinois

In my mobile radio station a Heath ssb transceiver is mounted under the dash on the passenger's side. It requires some ingenuity in fabricating mounting hardware; however, no special tools are necessary. A standard magnetic mobile microphone holder is mounted on the glove compartment to allow easy access to the microphone with minimum distraction from driving chores. The mobile speaker is mounted next to the microphone. If you wish, the car broadcast radio speaker may be used by placing a toggle switch under the dash that switches the speaker from the car radio to the mobile radio. This is an added advantage in the VW since the speaker is directly in front of the driver.

The dc power supply was mounted in the trunk by cutting an access hole in the trunk liner and fabricating mounting hardware to compensate for the contours of the trunk base. You may question the mounting position of the power supply; however, no problems have been encountered with overheating; even on hot summer days.

**A 35-amp alternator takes the load off the VW electrical system.**



The heart of the VW mobile, and the key to its success, is its 12-volt power plant. A separate 35-amp alternator system was installed to eliminate the possibility of overtaxing the VW electrical system.\* The regulator was installed in the upper left corner of the engine compartment. A separate battery was



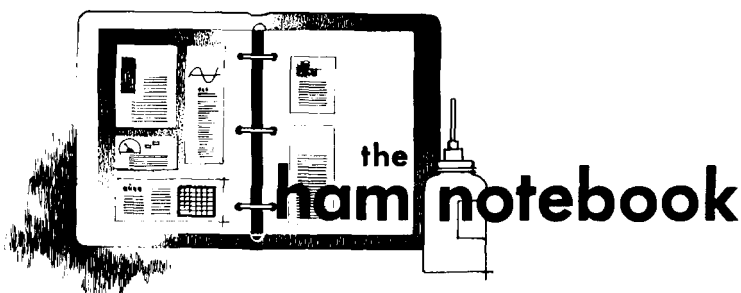
**Heavy-duty battery under the rear seat is used exclusively for the radio gear (can also be used for starting the car on cold winter mornings).**

installed under the rear seat with battery cables running to the power supply in the trunk.

When I work fellow VW owners on the air they invariably ask me how it was done. It is hoped the ideas presented here will make it possible for other VW owners to have a mobile radio station. For those of you who are wondering about the added drag of the alternator, I found that approximately 3 to 5 mph was knocked off the top speed; however, there was no noticeable decrease in gas mileage.

\*Alternator, part number RM 12V PAK, available from 767 Minot Avenue, Auburn, Maine 04210.

ham radio



## motorola fm receiver mods

During the past year I have returned several 43G and 43GGV Motorola Sensicon transceivers for amateur use on two meters. In some of the units I discovered that the squelch control had to be advanced almost fully clockwise to quiet the channel. After checking tubes, components and voltages and a careful alignment I still could not find the problem.

Checking through a number of manuals, I found some resistor changes in the schematic for a late T-Power receiver strip. When these resistor values were incorporated in an otherwise identical older version of the receiver the result was vastly improved squelch-control action. The new resistor values are shown in table 1.

To provide a measure of protection to the 6AQ5 audio output stage I installed a 120-ohm, 1-watt resistor between the cathode (pin 2) and ground, bypassed with a 50- $\mu$ F, 25-V capacitor. Gain of the stage is not greatly affected, and the tube will be protected by self-bias.

table 1. New resistor values for the Motorola Sensicon G fm receivers.

resistor	old value	new value	
		wide band	narrow band
R139	-	56k	180k
R140	-	56k	180k
R145	150k	330k	330k
R146	-	680	220
R152	560k	820k	1.5M

table 2. Squelch and audio-voltage readings are helpful in troubleshooting Motorola Sensicon G fm receivers. (Vrms readings are noise voltage measurements made with ac vtvm.)

test point	unsquelched	squelched
V112, pin 1	3 V rms	3 V rms
V112, pin 2	7 Vdc	2 Vdc
V112, pin 5	50 V rms	50 V rms
	190 Vdc	100 Vdc
V112, pin 6	100 Vdc	60 Vdc
V113, pin 6	12 Vrms	12 Vrms
V114, pin 1	45 Vdc	25 Vdc
V114, pin 2	-8 Vdc	2 Vdc
V114, pin 3	3 Vdc	3 Vdc
V114, pin 6	180 Vdc	190 Vdc
V114, pin 8	50 Vdc	50 Vdc

Table 2 lists a number of dc voltage readings at various points in the squelch and audio stages. These should be helpful in tracking down circuit ailments.

Murray Ronald, VE4RE

## multiple tubes in parallel grounded grid

The use of four parallel tubes in grounded-grid dates back many years. If the tubes are honest-to-goodness triodes like the 811A they work pretty well. However, if you use tv-type horizontal-amplifier tetrodes or pentodes, tie all of the grids together and ground them, the picture is a little different. When you get that much grounded hardware in close proximity to the plate of the tubes the plate-to-ground capacitance becomes formidable, particularly when you have four tubes in parallel.

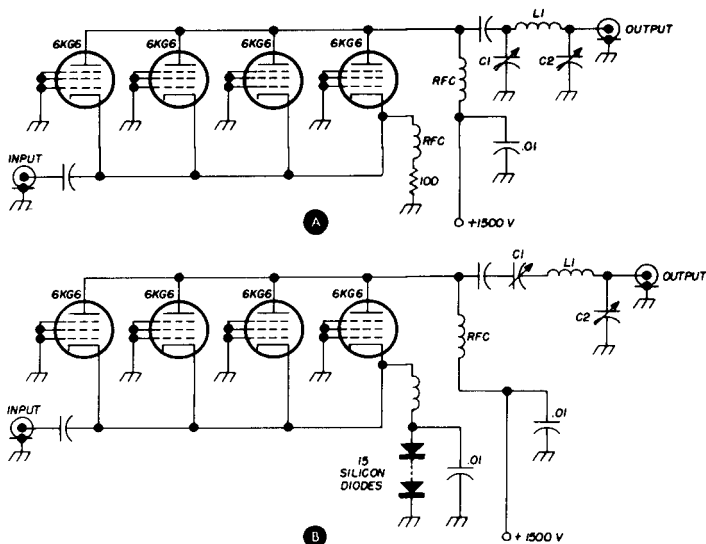


fig. 1. High capacitance of parallel-connected tv sweep tubes limits upper frequency capability of the amplifier circuit in (A). Series capacitor C1 in (B) improves L/C ratio of the circuit and provides increased high-frequency efficiency.

Several years ago I built such an amplifier using four 6KG6 Amperex tubes. These tubes are somewhat huskier than the 6LQ6 and harder to come by, but they will take a lot of abuse. I have run the four of them to a full 1000 watts dc. One tube finally blew so power was dropped to a conservative 500 watts dc (1000 watts PEP).

At the lower frequencies the standard grounded-grid circuit shown in fig. 1A worked fine. However, at the higher frequencies the plate-to-ground capacitance is on the same order of the tuning capacitor and in parallel with it. Result: poor efficiency on 15 meters and impractical on 10 meters.

Recently I decided that I wanted to use this amplifier on 10 and 15 meters, but first I had to solve the high-C dilemma. The solution is shown in fig. 1B. In 1B the input pi-network capacitor C1 is placed in series with the plate-to-ground capacitance. With this arrangement capacitor C1 becomes the series combination of the plate-to-ground capacitance of the four tubes and the variable tuning capacitor. You have to insulate both sides of the tuning capacitor

from ground now but this is no big problem.

With circuit 1A on 15 meters the tank coil consisted of two very hot turns; with fig. 1B the tank circuit has 6 turns and everything runs cool, as it should. I drive the amplifier with an SB-34 transceiver.

One other major improvement was incorporated into the rebuilt amplifier. The original circuit used a 100-ohm cathode-bias resistor (fig. 1A). This is a poor way to bias a variable-plate-current power amplifier. The bias circuit in fig. 1B uses fifteen series-connected silicon rectifiers to obtain a 10-volt drop which is constant and limits the resting current to about 60 mA. The cost of this arrangement was kept down by using surplus 100 PIV 1500 mA silicon diodes that are available from Poly-Paks for less than a dime apiece. A more expensive approach to the bias problem is a 10-volt, 20-watt zener diode.

The rebuilt linear delivers a very clean signal. Although I used 6KG6 tubes the same technique may be used to solve the high plate-to-ground capacitance of any parallel-connected tv sweep tubes.

Bob Baird, W7CSD

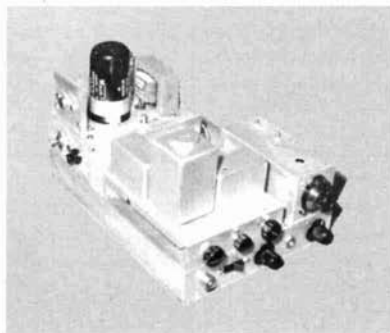


## comments

### solid-state ssb exciter

Dear HR:

I just wanted to let you know that some of us actually build equipment described in *ham radio*. I'm enclosing a photo of a ssb exciter I came up with after reading W9KIT's article in the December issue. The basic 9-MHz section is basically the same as that described in the article, although I haven't put the crystal filter in yet.



In correspondence with the author I got the dope on his entire ssb exciter, and followed his heterodyning scheme pretty much, although I used transistors and he used vacuum tubes. The double-balanced mixers work out nicely; although this is my first experience with them I remember an article you ran on these gadgets some time ago.

It sure is a kick to work somebody on

phone and tell them I'm using a homebrew rig. Most of the guys are never aware that I'm using double sideband unless I tell them, so I may never get around to putting in the crystal filter as I'm primarily interested in cw anyway! This little rig drives my 6146 final to about 60 watts PEP input which seems to be plenty to make contacts on 40-meter ssb.

Cal Sondgeroth, W9ZTK  
Mendota, Illinois

### fire protection

Dear HR:

In the article "Fire Protection in the Ham Shack" in the January 1971 issue, Freon is listed as being a good fire extinguisher. Possibly it would be good for putting out the fire, but might hospitalize the fireman. When subjected to temperatures corresponding to that of red-hot metal, Freon breaks down, forming Phosgene gas, which my dictionary describes as a colorless, highly toxic gas; one use of which is chemical warfare. As personal experience followed by research has taught me, phosgene is a lung irritant, also an eye irritant and very good for rusting tools. The authors are not to be blamed too harshly. Freon is non-toxic, stable and non-inflammable — but only at ordinary temperatures.

Frank Knottingham, K7QCM  
Gold Beach, Oregon

A set of schematics for W9ZTK's solid-state ssb exciter for 80, 40 and 20 meters is available for 25c from *ham radio*. The circuit includes a 9-MHz sideband generator, speech amplifier, vfo, double-balanced mixers for 80, 40 and 20 meters plus an fet output amplifier. *editor*



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with "fixed station reports from the mobile"

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Model RM-80S . . . . .	80 meter resonator . . . . .	24.50

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# new products

## frequency standard



A zero adjustment allows the frequency to be set precisely to WWV or other frequency standard. The accuracy holds for all outputs of the frequency standard. Applications include calibration of receivers, signal generators, vfos, oscilloscopes and general use in the lab or ham shack. The unit is priced at \$32.50 postpaid from Palomar Engineers, Box 455, Escondido, California 92025. For more information use *check-off* on page 94.

The new Palomar Engineers frequency standard contains a crystal-controlled oscillator that is based on a precision 100-kHz crystal. A front-panel switch controls the operation of three frequency dividers driven by the 100-kHz oscillator. They provide outputs at 100, 50, 25, 10 and 5 kHz, depending on the switch setting. The output is a square wave with rich harmonic content; thus the signal can be heard at every 100 kHz (or every 50 kHz, or every 25 kHz, etc.) throughout the shortwave bands to 50 MHz and above.

## afsk generator

The new J&J solid-state afsk generator provides short-term stability of  $\pm 1$  Hz. The basic oscillator uses a unijunction transistor in an RC circuit with precision resistors. The internal 5-pole butterworth filter with cutoff above 3000 Hz removes harmonics and assures sinusoidal output.

The J&J afsk generator features high output with more than ample transmitter drive. The high level line output may be used to test TUs or other RTTY equipment. The generator may be triggered by any positive voltage greater than 2 volts. A keyboard can be connected to the input of the generator with a power supply up to 20 volts to cause the unit to conduct on *space*. The afsk generator can also be operated directly from any of the TT/L or equivalent keying circuits which supply a positive voltage on *space*.

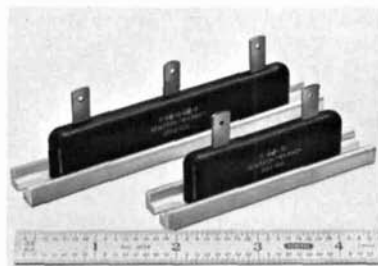
The J&J afsk generator is furnished with standard tones 2125, 2295 and 2975 Hz unless otherwise specified. Price, in modern desk-top cabinet, is \$90.00; \$99.00 for rack-mounted model (3 1/2" panel). Also available with low tones of 1275, 1445 and 2125 Hz at \$99.00. Order from J&J Electronics, Windham Road, Canterbury, Connecticut 06331. For more information use *check-off* on page 94.

## broadband rf amplifiers



The new broadband rf amplifiers introduced by Radiation Devices Company span the region from 10 to 500 MHz for state-of-the-art performance for laboratory or field use. Gain is 30-dB minimum from 10 to 150 MHz; gain from 3 to 500 MHz is 10 dB for the model BBA-1 and 15 dB for the BBA-1P. Noise figure, from 10 to 500 MHz, is 6 dB maximum for the BBA-1, and 3 dB maximum for the BBA-1P. The broadband amplifiers require a supply voltage of 12 volts,  $\pm 1$  volt. Input and output connectors are type BNC (other connectors available). The BBA-1 is priced at \$30; the BBA-1P is priced at \$45. For more information, use *check-off* on page 94, or write to Radiation Devices Company, Post Office Box 8450, Baltimore, Maryland 21234.

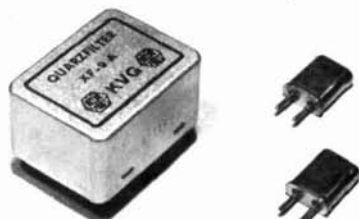
## high-voltage silicon rectifiers



Semtech has announced the development of a unique high-voltage silicon rectifier device, called the KV-PAC, with peak inverse voltages up to 15 kV. The KV-PAC offers a rugged functional pack-

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XF 9E	12.0 kHz	\$32.45
XF 9M	0.5 kHz	\$23.00
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### 10.7 MHz FILTERS

XF 107A	14 kHz	\$30.25
XF 107B	16 kHz	\$30.25
XF 107C	32 kHz	\$30.25
XF 107D	38 kHz	\$30.25

### 9.0 MHz DISCRIMINATORS

XD9-01	$\pm 1.5$ kHz	\$16.95
XD9-02	$\pm 3.0$ kHz	\$16.95
XD9-03	$\pm 8.0$ kHz	\$16.95

### 10.7 MHz DISCRIMINATORS

XD107-01	$\pm 10$ kHz	\$14.95
XD107-02	$\pm 20$ kHz	\$14.95

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XF 900	9000.0 kHz	\$2.75
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## New 3 Digit Counter



• The model fm-36 3-digit frequency meter has the same features that has made the 2 digit model so popular with Hams — low price, small size (smaller than a QSL card), 35 Mhz top frequency, simple connection to your transmitter, +0 -0.1 Khz readout — PLUS the added convenience of a third digit to provide a 6 digit capability. Kit or Assembled.

Example: 28,649,800 Hz reads 28.6 MHz or 49.8 Khz. (Add the 10 Hz module to read 9.80.)

• A divide-by-ten prescaler is also available that operates up to 170 Mhz. Extend the range of any frequency counter — or use with the fm-36 for 6 meter or 2 meter use.

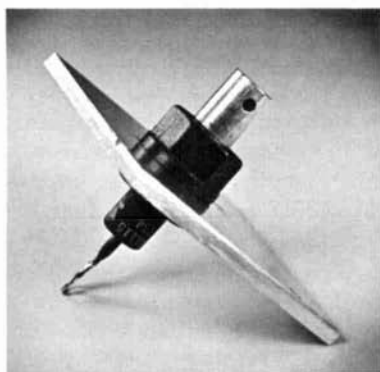
FM-36 KIT \$134.50  
FM-36 ASSEMBLED \$164.50

**Micro-Z Co.**

Box 2426 Rolling Hills, Calif. 90274

age that is corona free. Mounting slots are designed for easy installation. Universal 3-watt electrical terminals accommodate fast-disconnect fittings, wire wrap or solder connections. The devices are rated at 5 to 15 kV PIV per leg. Average rectified current is 0.4 amp; one-cycle surge current is 50 amps. Reverse current at the rated PIV is 10  $\mu$ A. For more information, use *check-off* on page 94, or write to Semtech Corporation, Newbury Park, California 91320.

## stud-nut



The *Stud-Nut* is a new unitized fastener which eliminates five separate pieces of hardware now required to mount stud-type solid-state devices. It replaces an insulating bushing, mica washer, metal washer, solder lug and hex nut; it provides rapid, secure mounting of SCRs, power transistors, rectifiers and zener diodes with 10-32 threaded studs. It can be used with DO-4, TO-36, TO-59, TO-60 and TO-64 case types.

The threaded metal insert is molded into an insulated hex base and contains through holes to provide solder connections for external leads. Due to the unique design of the *Stud-Nut* the contact resistance between the stud-mounted device and external lead is extremely low. Continuous current rating is 30 amperes. For more information, use *check-off* on page 94. A package of four *Stud-Nuts* is available for \$1.00 postpaid from the SCF Corporation, Post Office Box 999, Hightstown, New Jersey 08520.

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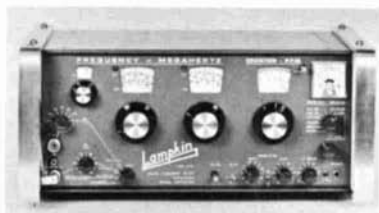


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## digital frequency meter/ signal generator



The recently announced type 107A digital frequency meter/signal generator/synthesizer from Lampkin Laboratories is an extremely versatile instrument that is aimed primarily at the mobile-radio maintenance field. The instrument has many applications in educational, aerospace and industrial laboratories; in manufacturing, research, and production operations; in a-m, fm, and tv broadcast engineering and receiver servicing; in commercial frequency-measurement services and in many other applications. It is completely solid-state, operates from either 12 Vdc or 115 Vac and weighs 22 pounds.

As a heterodyne frequency meter, the 107A will measure carrier frequencies of nearby transmitters or signals picked up on a receiver. Coverage on FCC-assigned frequencies is continuous from 10 kHz to above 500 MHz. Guaranteed accuracy in the field, independent of WWV, is considerably better than 0.0001% (1 part per million).

As a synthesizer any frequency from below 1,000 Hz to 9,999.9 Hz, can be generated, in steps of 100 Hz, phase-locked to the internal crystal standard. Voltage output level is 1.0-volt rms down to 0.0005-volt, continuous and calibrated, into 50-ohm load or greater. As a signal generator the 107A provides cw, amplitude or frequency-modulated signals on fundamental frequencies up to 10 MHz; from 10 MHz to above 500 MHz harmonics are employed, but no arithmetic is needed — the dials are direct reading in MHz and kHz. An external variable attenuator (supplied) will bring the signal below the noise level of receivers.

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Price of the Lampkin 107A is \$2150.00. For further information, write Lampkin Laboratories, Inc., Dept. 243, 8400 Ninth Avenue N.W., Bradenton, Florida 33505.

## vhf marine radio



Every marina or yacht club, or any marine service company, can now afford its own VHF Limited Coast Station with the Ensign II produced by RF Communications. Ideal for marine sales and service dealers to have as a unit to show, demonstrate and use, all at the same time, the Ensign II provides full 25-watt output. Transceiver weight is under 7 pounds, and the unit includes crystals aligned for channel 16 and a working channel ready for use. Capable of being mounted in any position, the Ensign II is housed in a vinyl painted cabinet with drip-proof and dust-tight construction. List price is \$578.

A complete line of antennas and accessories is also available. For literature with full specifications and further information use *check-off* on page 94, or contact National Sales, RF Communications, Inc., a subsidiary of Harris-Inter-type Corp., 1680 University Avenue, Rochester, New York 14610.

## www changes

When you tune in WWV (or WWVH) for time signals or propagation information after 0000 hours gmt, 1 July 1971, you will hear a different format than you've been accustomed to over the last few years. The Morse code transmissions will be gone and the announcements of time and other information will be made in voice. The time will be announced

every minute instead of every five minutes; a male voice will be used by WWV and a female voice by WWVH to distinguish between them. The carrier frequencies will remain the same: 2.5, 5.0, 10.0, 15.0, 20.0 and 25.0 MHz. The frequency accuracy of the two stations is controlled by the NBS Atomic Frequency Standard at Boulder, Colorado.

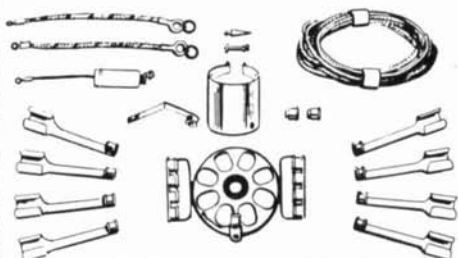
The format of the broadcasts from the two stations will be similar, but to avoid confusion they will use alternate time slots for the transmission of tones, announcements, etc. The standard time tick each second will remain.

Each hour will be divided into 1-minute slots. Each minute (except the first) will begin with an 0.8-second 1000-Hz tone on WWV (1200 Hz at WWVH). The first minute of each hour will begin with a 1500-Hz tone at both stations. The one minute slots will be divided into a 45-second segment and two 7.5-second segments. On alternate minutes the 45-second segment will contain either a standard tone or an announcement. The first 7.5-second segment following the 45-second segment will be used by WWVH to announce time while WWV will be silent. The second 7.5-second segment will be used by WWV to announce time, WWVH being silent.

Each station will omit for 5 minutes of each hour all tones and announcements during the 45 second segments. This period will begin for WWV at 45 minutes past the hour and for WWVH at 15 minutes past the hour. A special 440-Hz tone will be broadcast by WWV for 45 seconds beginning one minute past the hour and by WWVH two minutes past the hour. This tone can be used to mark the hours on strip-chart recorders or other instruments. The tone will be omitted during the zero hour (gmt) of each day.

It is interesting to note that announcement slots will be available to Government agencies to use for their own purposes. The slots not used will be filled by a standard tone, probably 500 Hz. To prevent interference between the two stations one station's announcements will coincide with the other's tone.

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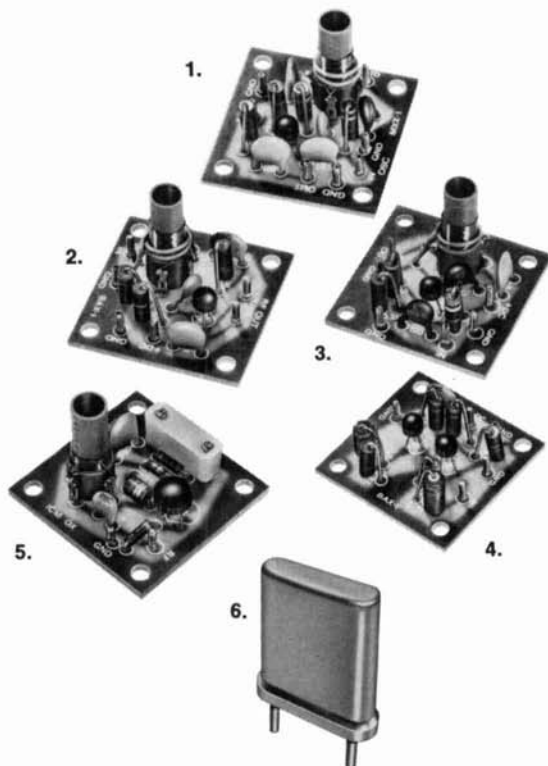
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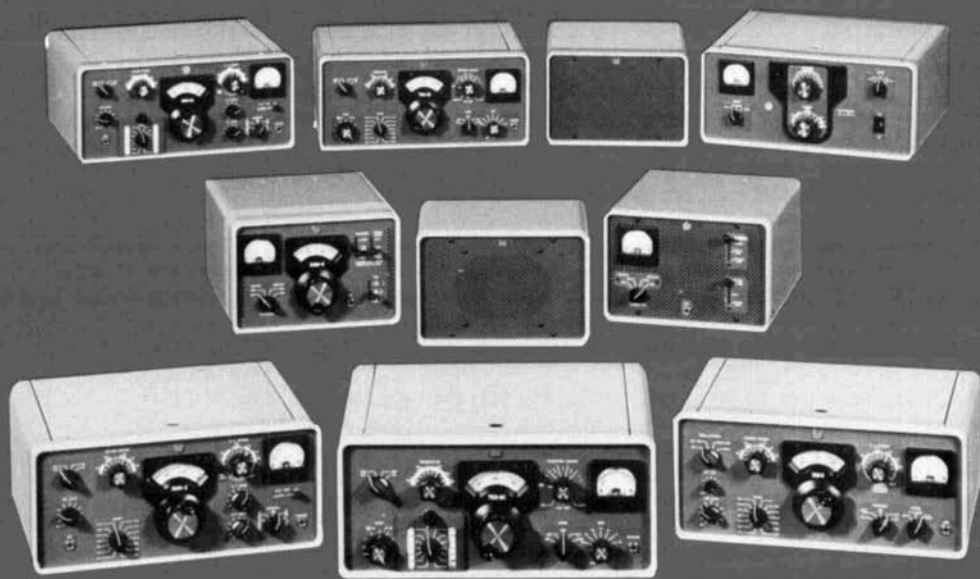


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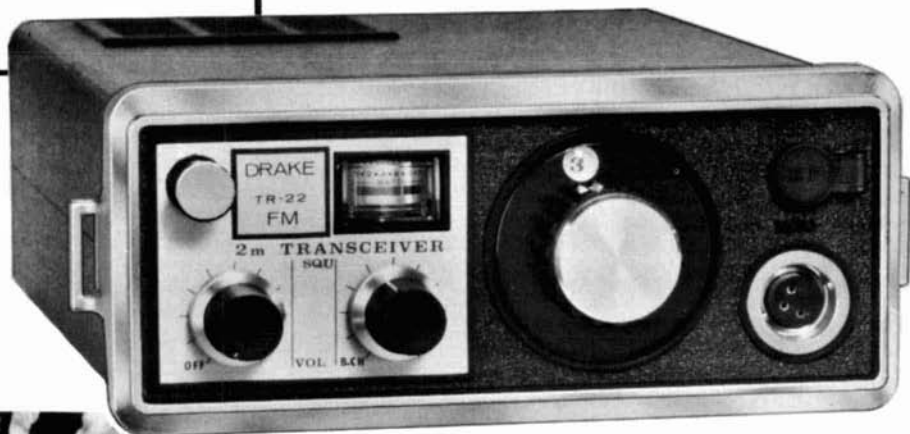
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# TO TROUBLESHOOT FAST & EASY

USE:

## SERVISSET Model E-C

PATENTED



INTRODUCTORY PRICE JUST

**\$29.95**

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FREE INFORMATION

### COMPARE!

Functions  
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Size  
Weight  
Cost

SERVISSET MODEL E-C will outperform any tester of its size, weight, & price ANYTIME-ANYWHERE.

A precision engineered, professional quality electronic test instrument ideally suited to field or bench servicing of: Radio, Television, Audio, Appliance, and Allied Equipment.

### COMES COMPLETE

- Servisette Model E-C
- Special ALNICO phone
- Phone Extension
- KLIPZON Adapter
- Hi-Voltage Adapter
- Long KINKLESS Test Lead
- Short "mini" Test Lead
- 30 Page Instruction Manual
- Special Hi-Quality carrying pouch
- Battery (1.5 volt)

### SPECIFICATIONS:

RF & AF Signal Tracer  
DC Polarity Indicator 60/550/20,000 volts  
AC & DC Voltage Indicator 0/60/550/20,000  
Lo ohms 0-5, Hi ohms 0-500k-20 megohms  
Tests Condensers .00025 - 12mfd.  
Tests Resistors 2 ohms - 20 megohms  
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3 Resistance Sub ranges 50-500 ohms, 5k-25k, 100k-1 meg.

IDEAL for: Professionals, Amateur Repair men, Ham Radio Operators, STUDENTS, appliance repairmen, etc.

Will complement your existing equipment and will outperform other testers costing many times more.

30-DAY UNCONDITIONAL MONEY BACK GUARANTEE, 90 DAY PARTS WARRANTY

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# KENWOOD

...the value  
line of the  
70's

**R-599 SOLID STATE RECEIVER AND T-599 HYBRID TRANSMITTER OFFERS UNIQUE FEATURES, SUPERB PERFORMANCE, HIGH STYLE...THE ULTIMATE IN VALUE**

THE R-599 RECEIVER: 1.8 to 29.7 MHz (amateur bands) • .5 microvolt sensitivity nominal • Dial readout to 1/2 kilocycle • Special detectors for SSB, AM, and FM • Transceive operation with T-599 • Built-in 100 kc and 25 kc crystal calibrator • Built-in 500 cycle CW filter • Provision for 2 and 6 meter coverage with optional accessory self-contained converters • Adjustable threshold squelch • The price... only \$298.00

S-599 speaker \$14.50 • CC-29 2 meter converter \$29.50 • CC-69 6 meter converter \$29.50. •

THE T-599 TRANSMITTER: Clear, stable, selectable sideband, AM and CW • 4-way VFO Flexibility plus Receiver Incremental Tuning (RIT) when used with the R-599 • Amplified ALC • Built-in VOX • Full metering, including cathode current, plate voltage, ALC and relative Power Output • Built-in CW Sidetone monitor and semi-automatic break-in CW • Built-in power supply • Maximum TVI protection • Employs only 3 vacuum tubes • The price... \$345.00

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**AMATEUR RADIO CENTER** 2805 N.E. 2nd St., Miami, Florida 33137 374-4101

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**STAN BURGHARDT** 315 10th Ave. N.W., Watertown, S.D. 57201 886-3767

**COMMUNICATIONS WORLD** 4788 State Road, Cleveland, Ohio 44109 398-6363

**DERRICK ELECTRONICS** 108 E. El Paso, Broken Arrow, Okla. 74012 251-9923

**DOUGLAS ELECTRONICS** 1118 S. Staples, Corpus Christi, Texas 78404 883-5103

**ELECTRONIC CENTER** 107 3rd Ave. N., Minneapolis, Minn. 55401 338-8461

**ELECTRONIC DISTRIBUTORS** 1960 Peck St., Muskegon, Mich. 49441 726-3196

**ERICKSON COMMUNICATIONS** 4657 N. Ravenswood, Chicago, Ill. 60640 334-3200

**FRECK RADIO & SUPPLY** 38 Biltmore Ave., Asheville, N.C. 28801 254-9551

**HARRISON Rt. 110 at Smith, Farmingdale, N.Y. 11735 293-7990 8 Barclay St., N.Y. City 227-7922**

**HAM RADIO CENTER** 8342 Olive Blvd., St. Louis, Mo. 63132 993-6060

**HAM RADIO OUTLET** 999 Howard Ave., Burlingame, Ca. 94010 342-5757

**INDUSTRIAL DISTRIBUTORS** 1209 S. Industrial Ave., Dallas, Texas 75207 742-8570

**JRS DISTRIBUTORS** 646 W. Market St., York, Penn. 17404 854-8624

**KASS ELECTRONICS** 2502 Township Line Rd., Drexel Hill, Penn. 19026 449-2300

**MADISON ELECTRONICS** 1508 McKinney Ave., Houston, Texas 77002 224-2668

**PORTLAND RADIO SUPPLY** 1234 S.W. Stark St., Portland, Or. 97205 228-8647

**RADIO DISTRIBUTING CO., INC.** 1212 High St., South Bend, Indiana 46624 288-4666

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**WESTERN RADIO** 1415 India St., San Diego, Calif. 92101 239-0361

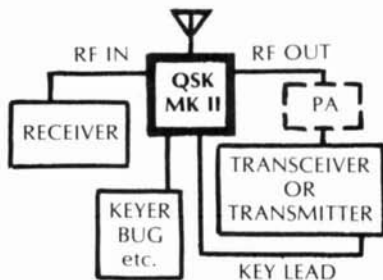
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... for the **ULTIMATE** in CW OPERATION

The **QSK Mk II** is a station control system that will permit you to hear other stations between your transmitted dots and dashes at speeds up to 60 wpm . . . **full break-in cw!**

- \* Provides high speed antenna switching, exciter keying and receiver isolation
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- \* Use with virtually any exciter/PA and receiver combination
- \* Proven in traffic, contest and DX work. Changes ordinary QSO's into a mode that is as effective as a telephone conversation!



8 transistor 9 diode printed timing and sequencing circuit assures cold switching of vacuum relay. 5 kw rating. Negligible losses. 110vac internal power supply. 4 x 5 x 6 inch metal enclosure. UHF and phono connectors. See your dealer or factory direct. Allow two weeks for shipping. N.J. residents add 5% tax.

**\$119<sup>95</sup>** Post Paid U.S.A.

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## The **STANDARD**, by Heights

Light, permanently beautiful **ALUMINUM** towers

THE MOST IMPORTANT FEATURE OF YOUR ANTENNA IS PUTTING IT UP WHERE IT CAN DO WHAT YOU EXPECT.

RELIABLE DX — SIGNALS EARLIEST IN AND LAST OUT.



### **ALUMINUM Towers**

And now, with motorized options, you can crank it up or down, or fold it over, from the operating position in the house.

The "Standard" can be assembled on the ground with nothing more than a wrench and a spade. No guys, no climbing necessary. Strong and beautiful.

See your local distributor, or write for 12-page brochure giving dozens of combinations of height, weight and wind load.

NOW In New Larger Facilities  
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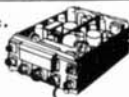
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4516 North Van Dyke, Almont, Michigan 48003

# NEW G&G CATALOG! MILITARY ELECTRONICS

24 PAGES, crammed with Gov't Surplus Electronic Gear - the Biggest Bargain Buys in America! It will pay you to **SEND 25¢** for your copy - Refunded with your first order.

**BC-645 TRANSCEIVER** 15 tubes, 435 to 500 Mc. Easily adapted for 2 way voice or code on Ham, Mobile, Television Experimental, and Citizens Bands. With tubes, less power supply in factory carton, BRAND NEW..... **\$16.95**



**TRANSMITTER** has 4 tubes: WE-316A, 2-6F6, 7F7  
**RECEIVER** has 11 tubes: 2-955, 4-7H7, 2-7E6, 3-7F7  
**RECEIVER I.F.:** 40 Megacycles  
**SIZE:** 10-1/2" x 13-1/2" x 4-1/2". Shpg wt 25 lbs.

**SPECIAL PACKAGE OFFER:** BC-645 Transceiver, Dynamotor and all accessories, including mounting, UHF Antenna Assemblies, control box, complete set of connectors and plugs.  
Brand New ..... **\$26.95**

**HEADSET** Low impedance. With large chamois ear cushions. 4-ft cord and plug. Reg. \$12.50. Our Special Price **\$2.95**  
Less ear cushions..... \$1.95  
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## SCR-274-N, ARC-5 COMMAND SET HQ!

Freq. Range RECEIVERS.	Type Complete with Tubes	Exc. Used	Like New	BRAND NEW
190 - 550 Kc	BC-453	\$16.95	.. \$23.50	.. \$27.50
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1.5 - 3 Mc	R-25	.. ..	.. \$19.50	.. \$21.50
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4 - 5.3 Mc	.. ..	BC-457	\$8.95	.. .. \$11.95
5.3 - 7 Mc	.. ..	BC-458	\$8.95	.. .. \$11.95

**TG-34A CODE KEYER**, self-contained, automatic, reproduces code practice signals from paper tape. 5 to 12 WPM Built-in speaker. Brand new with tech manual. Takeup reel and AC line cord. ... **\$24.50**  
Code practice tapes for above P.U.R.



**BC-1206-C RECEIVER** Aircraft Beacon Receiver 200 to 400 Kc. Operates from 24V DC 1.5A. Continuous tuning, vol control, on-off switch and phone jack. Very sensitive. Compact.  
Complete with tubes, NEW..... **\$12.50**



**BC-604 FM TRANSMITTER** 20 to 27.9 Mc. Output approx 30 watts. 10 crystal controlled channels. Complete with tubes.  
NEW..... **\$12.50**



ARC-R11A Modern Q-5 Receiver 190 - 550 KHz ..... **\$10.95**  
ARC-R22 540 - 1600 KHz Receiver with tuning graph ..... **\$15.95**  
R-4/ARR-2 Receiver 234-258 Mhz, 11 tubes, NEW ..... **\$8.95**

BC-605 INTERPHONE AMPLIFIER, NEW \$3.45 EXC. USED..... \$1.95  
TELEPHONE HANDSET, W.E. type..... LIKE NEW \$2.95  
SCR-522 TRANSMITTER-RECEIVER, with 18 tubes, LIKE NEW \$32.50

**AM-300/AIC PUSH/PULL AMPLIFIER**  
4-tube PP power amplifier with dynamotor, works on 28 VDC. Automatic gain control.  
Shpg wt 15 lbs. LIKE NEW..... **\$3.95**



**DUAL AMPLIFIER** has two input circuits each feeding a single 6SN7GT twin triode amplifier. Complete with 115V 60 cy. power supply using 6X5GT rectifier. NEW..... **\$5.95**



**IP-69A/ALA-2 INDICATOR** 3" scope. Front panel controls: Vertical Pos., horizontal pos. Intensity, focus, gain, width, center freq. Pan. Operates on 115 V 380 to 1000 cps.  
Complete with tubes. LIKE NEW..... **\$27.50**



**TG-5B TELEGRAPH SET** for code communications or code practice. Portable, with hinged lid. Two or more units operate up to 25 miles apart. Bell call system, 1000 cycle howler, key, headpiece, canvas case, book.  
Size 5-1/2x5-1/2x10". NEW..... **\$8.95**



**TELEPHONE TYPE RELAY**  
Made by J.H. Bunnell, has adjustable sensitivity. 150 ohm coil. NEW..... **\$3.45**



## AN/APR - 4Y FM & AM RECEIVER "FB" for Satellite Tracking!

High precision lab instrument, for monitoring and measuring frequency and relative signal strength, 38 to 4000 Mc. in 5 tuning ranges. For 110 v 60 cycle AC. Built-in power supply. Original circuit diagram included. Checked out, Perfect. LIKE NEW..... **\$88.50**  
All tuning units available for above. P.U.R.



**R48/TRC-8 UHF FM RECEIVER** 230 to 250 Mc. Variable tuning, one band. 115/230 V 60 cy. Complete with speaker, phone jack, squelch circuit 2-1/2" meter for circuit testing; includes 15 tubes: 8/6A67, 9002, 5U4, 6V6, VR-150, 6N7, 6SN7, 6AL7. Size 20 x 19 x 16". Weight 75 lbs.  
NEW..... **\$44.50**



**TV-10 UHF TRANSVERTER** 28V DC  
Made by Aircraft Radio Corp. Couples UHF Antenna to VHF transmitter and VHF receiver. Uses 6 tubes: 4/5763 and 2/6201. Includes 8 crystals ranging from 233.8 Mc to 257.8 Mc. Size: 11x 4-1/2x4-5/8". Wt 5-1/2 lbs.  
LIKE NEW, with tubes and crystals..... **\$9.95**



## R-20 RECEIVER

Made by Aircraft Radio Corp, works on 28 V, includes 4 tubes: 2/12AW6, 12AX7, 12AT7. Size: 6-1/2x4-1/2x4-5/8".  
LIKE NEW..... **\$7.50**



## HANDMIKE

Rugged, heavy-duty carbon hand mike with press-to-talk switch. Equipped with 4-ft cord & phone plug. SPECIAL  
NEW, boxed..... Each **\$1.88** 2 for \$3.25



## 2" DC VOLTMETER

Mounts in 2-1/8" hole. Flange diameter 2-5/8" Two scales: 0-15 and 0-600. Calibrated for use on steel panel. Standard brand. SPECIAL  
NEW, boxed..... Each \$1.75 2 for \$3.00



**BC-733 RECEIVER** Receives radio signals being transmitted by US satellite on approx. 108 Mc. AM, crystal-controlled on 6 preset freq. in 108.3 to 110.3 Mc range. Operates on 12/24 V DC & 220 VDC 80 Ma. Complete with 10 tubes. Can be converted to FM Receiver  
80 to 108 Mc. Exc. Used..... **\$5.95**  
BC-732A Control Box for above, NEW... 1.75



## T-41 / APS - 1B TRANSMITTER

**ANTENNA UNI** designed for 115 V 800 to 1400 cps. Tubes included are two 15E and one 15R. Complete with shock mounts and blower motor. 7x8x18", NEW.... **\$8.95**



**BC-223AX TRANSMITTER** 25 Watt, CW, MCW, Voice, Crystal control on 4 pre-selected channels, range 2000 to 5200 Kc by use of 3 plugin units, included. Complete.  
BRAND NEW..... **\$27.50**



**APN-1 FM TRANSCEIVER** 400-450 Mc. Freq. modulated by moving coil transducer. Easily converted for radio control or 70 cms. Complete with 14 tubes, dyn.  
BRAND NEW..... **\$9.95**



**AM-26/AIC PHASE INVERTER AMP.**  
4-tube pushpull power amplifier, Carbon mike input, hi-lo imp. output. Works on 24VDC. Easily converted to dandy 9-watt amplifier. Complete with tubes and dynamotor  
LIKE NEW..... **\$5.95**



**WILLARD 2-VOLT STORAGE BATTERY**  
Rated at 20 Amp.-Hours. Model 20-2. Rechargeable. Compact nonspill construction. Lightweight polystyrene container, 3x4x5 1/2". Shipped dry, uses standard electrolyte. Shipping Weight 3 lbs. NEW, each..... **\$2.79**



TERMS: 25% Deposit with order, balance C.O.D. - or - Remittance in full. Minimum order \$5.00 F.O.B. NYC. Subject to prior sale and price change

**G&G RADIO ELECTRONICS COMPANY**  
45-47 Warren St. (2nd Fl.) New York, N.Y. 10007 Ph. 212-267-4605

# HAL DEVICES



**HAL 311BC  
ELECTRONIC  
KEYER  
\$53.00**

THE most versatile keyer available. Send for full details on the HAL 311BC and the complete line of HAL electronic keyers. There is a model to fit your requirement and budget from \$16.50 to \$53.00. Shipping extra. Available in kit form for even greater value.



**HAL  
TOUCHCODER II  
KIT  
\$55.00**

### HAL TOUCHCODER II KIT \$55.00

Complete parts kit, excluding keyboard, for the W4UX CW code typer. All circuitry on one 3 x 6" G10 glass PC board. Plug-in IC sockets. Optional contest ID and RTTY features available. New keyboard under development.

### HAL DIP BREADBOARD CARD

Drilled G10 glass PC board accepts 6 16 pin DIP IC's in plug-in sockets. Each IC pin fanned out to two pads. Plugs into standard 22 pin edge connector (.156" finger spacing). \$5.50

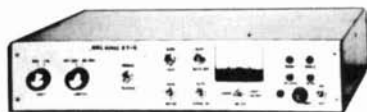
### DOUBLE BALANCED MODULATOR KIT

For the DBM in March 1970 Ham Radio 7/8 x 2" drilled G10 glass PC board  
4 HP-2800 hot carrier diodes matched by HAL.  
2 Indiana General CF102-Q1 toroids.  
Wire and instructions included. \$6.50

### HAL 25KHz MARKER GENERATOR

Generates 50 KHz or 25KHz markers from 100 KHz oscillator (not supplied)  
Drilled 1 x 2" G10 glass PC board  
Strong markers to 148 MHz. Divides any signal up to 2MHz by 2 or 4. \$4.25 kit form.

Hot Carrier Diodes: HP210J . . . . . 90¢	12/510.00	Matched by HAL: 4/84.25
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MC1496G . . . . . \$3.25	MC15900 . . . . . \$5.00	JUL 923 . . . . . 90¢
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MRTL . . . . . MC980P . . . . . \$2.00	MC724P . . . . . \$5.45	MC771P . . . . . \$1.75
MC725P . . . . . \$5.45	MC789P . . . . . \$1.75	MC970AP . . . . . \$3.30
MC724P . . . . . \$5.45	MC771P . . . . . \$1.75	MC970AP . . . . . \$3.30
MC970AP . . . . . \$3.30	MC970AP . . . . . \$3.30	MC970AP . . . . . \$3.30
TTL: 7400P . . . . . \$1.00	7401P . . . . . \$1.00	7402P . . . . . \$1.00
7403P . . . . . \$1.00	7404P . . . . . \$1.00	7405P . . . . . \$1.00
7406P . . . . . \$1.00	7407P . . . . . \$1.00	7408P . . . . . \$1.00
7409P . . . . . \$1.00	7410P . . . . . \$1.00	7411P . . . . . \$1.00
7412P . . . . . \$1.00	7413P . . . . . \$1.00	7414P . . . . . \$1.00
7415P . . . . . \$1.00	7416P . . . . . \$1.00	7417P . . . . . \$1.00
7418P . . . . . \$1.00	7419P . . . . . \$1.00	7420P . . . . . \$1.00
FETS: 40073 MOSFET . . . . . \$1.60	MPF102 JFET . . . . . 50¢	2N3819 JFET . . . . . 50¢
TORIODS: Indiana General CF102-Q1 . . . . . 50¢	CF102-Q2 . . . . . 50¢	CF102-Q3 . . . . . 50¢
CF102-Q3 . . . . . \$1.25	FERROXUBE FERRITE BEADS . . . . . 10/51.25	16-DIP . . . . . 75¢
CINCH IC SOCKETS . . . . . 8/1CS, 14/DIP . . . . . 80¢	16-DIP . . . . . 75¢	



**HAL MAINLINE ST-6 RTTY TU**

Complete parts kit for the W6FFC ST-6 now includes all parts except cabinet. Only 7 HAL circuit boards (drilled G10 glass) for all features. Plug-in IC sockets. Custom transformer by Thordarson for both supplies, 115/230V, 50-60Hz. \$135.00 kit. Wired units available.

Shipping extra. Write for full details.



**HAL RT-1  
TU/AFSK  
KIT  
\$51.50**

All TU and AFSK generator circuitry, including PS, on 3x6" G10 PC board. 850, 170, and CW ID shifts. Zener protected transistor loop switch. High and low impedance audio output. Price \$45.00. Shipping extra. Write for full details. HAL Designer Cabinet for the above \$6.50. 3 pole Butterworth filter drilled PC board \$3.00.

### HAL MAINLINE ST-5 RTTY TU

ST-5 kit now includes drilled G10 glass boards, custom Thordarson transformer, meter and metering components. Boards accept both round and DIP 709 IC's. \$50.00. Less boards, meter & meter components \$37.50. Boards only \$6.00. Shipping extra.

### HAL MAINLINE AK-1 AFSK OSC

HAL now offers a parts kit for the AK-1 AFSK osc. Drilled G10 glass PC board plugs into 12 pin edge connector for compatibility with the HAL ST-6, or for ease of use alone. Requires 12vdc. \$27.50. Board only \$4.00. Shipping extra.

### HAL ID-1 REPEATER IDENTIFIER

TTI logic. Power line frequency counter for 3 minute or less timing and control. Easily reprogrammable diode ROM uses only 27 diodes (depending on call) to send DE "any call". Low impedance audio with volume and tone control. All circuitry including PS on small G10 glass PC board. Write for full details..... \$75.00 Wired.

### ORDERING INFORMATION

Postage is not included in the prices of HAL products. Please add 75¢ on small parts orders, and \$2.00 on larger kits. Shipping is via UPS when possible, and via insured parcel post otherwise. Please give a street address. Catalog of all items 24¢ postage.

HAL DEVICES, Box 365H Urbana, IL 61801

# flea market



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

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

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

**CINCY STAG HAMFEST:** The 34th Annual STAG Hamfest will be held on September 26, 1971 at Stricker's Grove, Compton Road, Mt. Healthy, Cincinnati, Ohio. Door prizes each hour, raffle, lots of food, flea market, model aircraft flying, and contests. Identify Mr. Hamfest and win prize. \$5.00 cost covers everything. For further details, contact, John Bruning, WBDSR, 6307 Fairhurst Avenue, Cincinnati, Ohio 45213.

**WANTED — OLD BOOK,** "The Ocean Wireless Boys on the Ajax". Ted Woolner, WA1ABP, 30 Cedar Road, Shrewsbury, Mass. 01545.

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

**TELETYPE #28 LRXB4** reperforator-transmitter "as is" \$100; checked out \$175. Includes two 3-speed gearshifts. Alltronics-Howard Co., Box 19, Boston, Mass. 02101. 617-742-0048.

**ACTION TRADER:** The Action Trader can sell your Ham, CB, Hi-Fi & Misc. Electronic gear without emptying your wallet. Write for free issue or send \$2.00 for Eight issues. Action Trader, P. O. Box 27315, Columbus, Ohio 43227.

**JAMAICA (6Y5)** Reciprocal licensing authorizations are now available to W/K amateurs. Write Ham Radio Magazine for application.

**TRI-STATE PICNIC,** Pulaski Park, West Gloucester, RI (off Rt. 44), 9:30 a.m. to sunset, September 19. Trunk sales. Bring your own picnic. Talk in K1ZKR on 50.36. RI Swamp Yankee Amateur Radio Club & Eastern Conn. Amateur Radio Club.

**AUDIO FILTERS:** Knock down that background noise. KOJO SSB, AM, and CW filters do the job. Write for free brochure and see how serious DX boys hear them. KOJO, Box 7774, 741 E. Highland Ave., Phoenix, Arizona 85011.

**WORLD QSL BUREAU** — see ad page 91.

**THE ANNUAL IOWA 75** meter phone net picnic will be held on Sunday, August 15, 1971 at River-view Park in Marshalltown, Iowa. All amateurs, of course, are cordially invited. There will be a swap table and nice prizes to be given away. The festivities will start with a pot luck dinner at 12 noon with the remainder of the festivities occurring Sunday afternoon.

**FOR SALE:** Marker Luxury 2-meter FM transceiver \$100 under Drake price. Accessories. Crystals for 34/94. Will ship express or bus COD. \$230. No trades. D. B. Olson, Box 86, Van Ormy, Texas 78073.

**12th NEW JERSEY QSO PARTY.** The Englewood Amateur Radio Association, Inc., invites all amateurs to take part. From 1900 GMT Saturday, August 21 to 0600 GMT Sunday, August 22 and from 1200 GMT to 2300 GMT on Sunday, August 22. Phone and CW are same contest. A station may be contacted once on each band — phone and CW are considered separate bands. New Jersey stations may work other New Jersey stations. Suggested frequencies: 1810, 3555, 3740, 3930, 7060, 7275, 14075, 14280, 21100, 21375, 28800 kHz, 50-50.5, 144-146 MHz. Suggest phone activity on the EVEN HOURS. Exchanges consist of QSO number, RST, and QTH (ARRL Section or country). N.J. Stations will send county for their QTH. Certificates will be awarded to the first place station in each N.J. county, ARRL section, and country. In addition, a second place certificate will be awarded when four or more logs are received. Novice and technician certificates will also be awarded. Logs and comments should be sent to Englewood Amateur Radio Association, Inc., 303 Tenafly Road, Englewood, New Jersey 07631. A size #10 SASE should be included for results.

**TRADE:** GT550 with AC supply, vox, and calibrator all in perfect condition. Interested in T4XB or SB220 or best cash offer. Jim Fleming, 7528 Brynmawr, Chicago 60631. 775-8179.

**FOR SALE: HOMEBREW** 50w. CW XMTR 80-10 mtrs w/Heath VFO, RC bridge and lots of good junk. \$100. F. Redburn, 505 Kenniston Dr., #101, Austin, Texas 78752.

**THE NORTH TEXAS REPEATER ASSOCIATION** is hosting the summer meeting of the Texas VHF-FM Society on Saturday and Sunday, 14 and 15 August, 1971. The meeting will be held at the Cibola Inn, US Highway 80, Arlington, Texas 76010. Prizes, Displays, Technical Sessions, XYL program. No registration fee. Just pay your own lodging, meals and entertainment.

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

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

**THE ANNUAL SIERRA HAMFEST** will be held on August 14, 1971 at the California Building in Idlewild Park, Reno, Nevada. For information contact George Lyle, K7ZAU, 1047 Mark Way, Carson City, Nevada 89701.

**MOTOROLA 80D** — 12v, crystallized up and operating 146.94-146.94. 2-freq. xmit, accessories. George Evans, K2SLI, 17 George, Freehold, NJ. 201-431-0649

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**THE LINCOLN, NEBRASKA** Amateur Radio Club will operate a special prefix amateur radio station using the call KQ0NEB. Operations will commence at 2100 GMT September 1, 1971 and will be continuous 24 hours a day through 0500 GMT September 9, 1971. Transmitters will be on 10, 15, 20, 40 and 80 meters, both CW and SSB. DX contacts will be QSLed via Bureaus. Stateside contacts must send cards with SASE to W0YOY, Box 5006, Lincoln, Nebraska 68505. As with past operations of the Club, a special QSL card will be used.

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**THE NORTH ALABAMA HAMFEST** will be held on 15 August in the cafeteria of John C. Calhoun Technical and Junior College located north of Decatur, Alabama on U.S. Highway 31.

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**THE PUGET SOUND COUNCIL** of Amateur Radio Clubs will issue an operating achievement award signed by Governor Daniel J. Evans, for contacts made during Washington State Amateur Radio Week, September 4th to 12th, 1971. Out-of-state amateurs must work ten Washington stations, and in-state amateurs must work twenty other Washington stations during this week. Send list of stations worked, their locations, dates of contacts, and your name, call, and address to: The Puget Sound Council of Amateur Radio Clubs, 12306 80th Avenue East, Puyallup, Washington 98371. An SASE would be appreciated.

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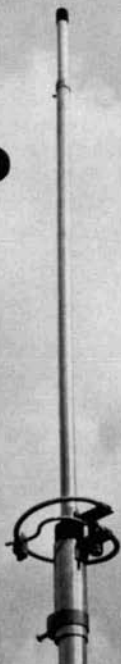
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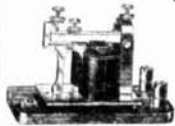
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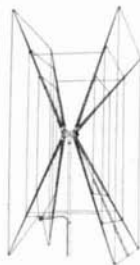
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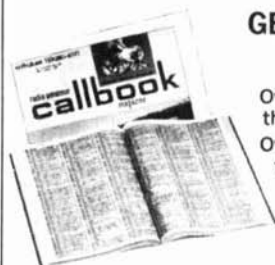
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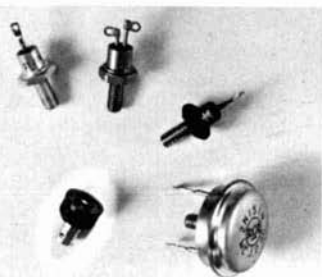
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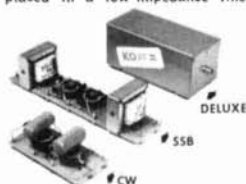
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# Now you don't have to pay twice the price to get twice the rig.



Picture this pair in your shack. The Yaesu FLdx 400 transmitter and the FRdx 400 receiver. Loaded with power. Loaded with sensitivity. Loaded with features. Loaded with value. Read on, and discover how you can have the most up-to-date receiver-transmitter rig in the world... and at an unbelievably low price.

## The FRdx 400 Receiver

Get a big ear on the world with complete amateur band coverage from 160 meters through 2 meters, including WWV and CB reception. Four mechanical filters do it—they provide CW, SSB, AM and FM selectivity. Separate AM-SSB-FM detectors are included, along with squelch and transmit monitor controls. Plus a noise limiter and a variable delay AGC. And a built-in notch filter with front panel adjust for notch depth.

The FRdx includes calibration markers at 100 KHz and 25 KHz, with accurate calibrator checks verified by WWV. A solid-state FET VFO for unshakable stability. And a direct-reading 1 KHz dial affords frequency read-out to less than 200 Hertz.

The FRdx 400 sells for \$359.95.

## The FLdx 400 Transmitter

Here's how to set yourself up with dual receive, transceive or split VFO operation. The FLdx 400 with its companion receiver brings you the ultimate in operational flexibility. Flexibility like frequency spotting, VOX, break-in CW, SSB, AM and even an optional FSK circuit.

The completely self-contained FLdx 400 features a built-in power supply, fully adjustable VOX, a mechanical SSB filter, metered ALC, IC and PO. A completely solid-state FET VFO provides rock-solid frequency stability.

We rate the FLdx 400 very conservatively. That rating guarantees you 240 W PEP input SSB, 120 W CW and 75 W AM. The FSK option will go all day at a continuous 75 W. And you get full frequency coverage on all amateur bands—80 meters through 10

meters—with an optional provision for certain other bands that you can personally specify. For all that, you pay just \$299.95.



## FL2000 B Linear Amplifier.

Ideal companion to the Series 400, this hand-crafted linear is another example of Yaesu's unbeatable combination of high quality and low cost. Designed to operate at 1500 watts PEP SSB and 1000 watts CW, this unit provides superb regulation—achieved by a filter system with 28 UF effective capacity.

Other features include dual cooling fans (one for each tube), individual tuned input coils on each band for maximum efficiency and low distortion, and a final amplifier of the grounded grid type using two rugged carbon-plate 572 B tubes. Ready to operate at only \$299.95.

## SPECTRONICS WEST

Dept. H, 1491 E. 28th, Signal Hill, Ca. 90806 / (213) 426-2593

## SPECTRONICS EAST

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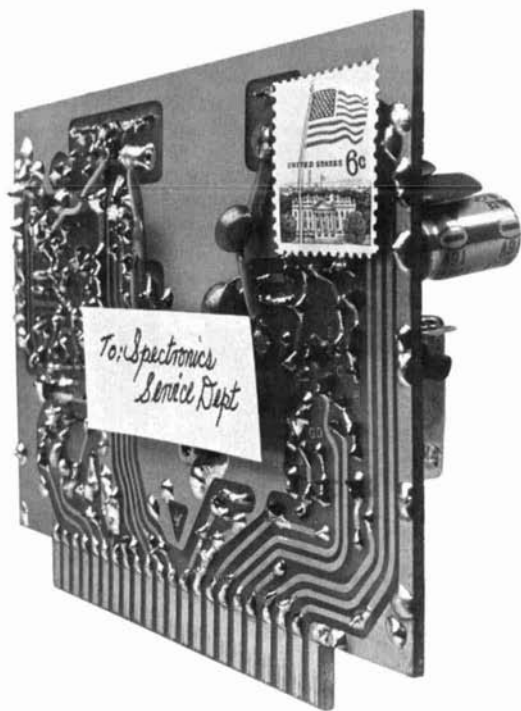
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# Repair by mail.



Except for driver and finals, the Yaesu FT-101 is all solid state. Ten FET's, 3 IC's, 31 silicon transistors and 38 silicon diodes do the job—solidly. Most of these components are found on computer-type plug-in modules. Should one of them ever give you trouble, just send us the module. We'll send you a factory-new replacement by return mail.

But with the FT-101, you can expect everything but trouble. Like a built-in VOX, 25 KHz and 100 KHz calibrators, the WWV 10 MHz band,

built-in power supplies right in the package. You supply the 12 or 117 volts plus an antenna and you're air-ready.

For in-motion operation, a noise blanker is essential. We didn't forget to include it in the FT-101. It picks out noise spikes and leaves you with nothing but clean, crisp signal copy.

Though plug-in modules mean quick, convenient repair, we don't really expect to hear from FT-101 owners. Unless it's on the air. Maybe that's why we unconditionally guarantee it for a year. The FT-101 — only \$499.95.



a high Q permeability tuned RF stage and a 5 KHz clarifier. All of that in a portable rig that sounds like it was home base.

The FT-101 is thirty pounds of power. You can work the world on 260 W PEP, 180 W CW or 80 W AM maximum input power. The world between 80 meters and 10 meters. And you'll hear it back with 0.3 microvolts sensitivity—and a 10 db signal-to-noise ratio.

This rig even includes 12 VDC and 117 VAC

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# For \$450, you just can't beat the Yaesu FTdx 560.

## You can't even beat it for \$800.

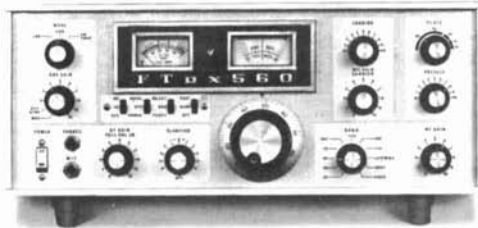
How come the Yaesu is such a good deal?

First of all, it's made in Japan, where people do painstaking electronic assembly work for a lot less money than they do in the U.S. Secondly, it's probably the highest quality transceiver made anywhere in the world, regardless of cost.

Also we import the Yaesu and sell it direct to you, eliminating the usual dealer profit.

The Yaesu FTdx 560 is a fully assembled, fully guaranteed transceiver with 560 watts PEP of SSB power, 500 CW. Included in the selling price are many of the things you usually have to pay extra for. Like power supply, WWV, calibrators, VOX and the one-year warranty. And a lot more.

To see how much more you get with Yaesu, send for our new information packet. It includes things like a chart and photos that compare Yaesu and Yaesu workmanship with other transceivers, plus a complete schematic. Study this packet and you'll see right away how much more value there is in a Yaesu.



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# NEW! Improved rugged 8122W's, 8121W's, 8072W's, and 8828W's, from EIMAC

EIMAC's new 8122W family of premium, second generation tubes are directly interchangeable with earlier equivalents in most FM, linear or modulated equipments.

These rugged, long life power tetrodes combine high screen dissipation and excellent thermal stability in a heavy duty structure which gives you improved performance in demanding communication circuits.

EIMAC's new design features rigid precision-wound gold plated molybdenum wire grids. The result is a direct-replacement tube with higher screen overload capability and greater resistance to shock and vibration. The EIMAC 8122W family is ideal for applications where you

have experienced problems under environmental or electrical stress.

EIMAC's unique 8122W electron-gun structure is available in four anode configurations: Axial air flow cooling (8122W), Transverse air flow cooling (8121W), coolerless (8072W) and conduction cooled (8828W). Special heat sink coolers are also available upon request.

EIMAC's Application Engineering Section stands ready to assist you in designing these exceptional tubes in new equipments. Contact EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070, or your nearest Varian/EIMAC Electron Tube and Device Group Sales Office.



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