focus on communications technology...

this month

- mainline st-5 RTTY demodulator 14
- vhf fm receiver 22
- rf impedance bridge 34
- electronic counter dials 44
- reactance nomograph 50

an INTEGRATED-CIRCUIT BALANCED MODULATOR
The SEVENTIES ARE HERE!

THIS IS THE ALPHA SEVENTY POWER AMPLIFIER
A NEW STANDARD OF COMPARISON

THIS COMPACT POWERHOUSE —

• LOAFS ALONG AT MAXIMUM LEGAL POWER in any mode . . .
  but it's smaller than some popular amateur receivers.

• OPERATES COMFORTABLY ALL DAY AT A FULL LOCKED-KEY D-C
  KILOWATT . . . yet it weighs less than many exciters.

• THUNDERS THROUGH THE PILE-UPS . . .
  while it leaves your shack soothingly quiet.

• PROVIDES INSTANTANEOUS VOX OR TRUE BREAK-IN without clutter . . .
  it's fully compatible with all modern exciters and transceivers.

The ALPHA SEVENTY is designed and rated for commercial service. It offers quality features not found in ordinary linear. Like the vacuum variable plate tuning capacitor . . . a
rugged vapor-cooled ceramic-metal triode . . . tape-wound Siletron® transformer . . . giant
oil-filled filter capacitor . . . and vacuum T/R changeover relays.

The innovator who introduced amateur radio to today's state-of-the-art is at it again. ETO's
ALPHA SEVENTY is available now for use by amateurs who demand the ultimate in
performance and quality.

Write for more details — or to order your ALPHA SEVENTY. ETO is represented in the
West by Amrad Supply, Inc., 1025 Harrison St., Oakland, Ca. 94607.

ETO
EHRHORN TECHNOLOGICAL OPERATIONS, INC.
BROOKSVILLE, FLORIDA 33512
If you've ever used a repeater,

If you haven't already received a copy of our NEW 1970 Catalog of Precision Quartz Crystals & Electronics for the Communications Industry.

SEND FOR YOUR COPY TODAY!

Somewhere along the line, in virtually every ham repeater in the world, you'll find a couple of Sentry crystals.

Repeater owners and FM "old-timers" don't take chances with frequency—they can't afford to. A lot of repeater users depend on a receiver to be on frequency, rock stable...in the dead of winter or the middle of July. The repeater crowd took a tip from the commercial "pros" a long time ago—and went the Sentry Route.

That's one of the reasons you can depend on your local repeater to be there (precisely there) when you're ready to use it. FM'ers use the repeater output as a frequency standard. And for accuracy, crystals by Sentry are THE standard.

IF YOU WANT THE BEST, SPECIFY Sentry CRYSTALS.

You've used a Sentry Crystal

Send for your copy today!
R. L. Drake quality-built R-4B Receiver is versatile, accurate, dependable, as is the Drake TdXB Transmitter. They stand on their own merits used independently, but...

**TOGETHER they're incomparable!**

Ideal for transceiving, 160 and MARS

---

**R-4B RECEIVER**

- Linear permeability tuned VFO with 1 kc dial divisions. VFO and crystal frequencies pre-mixed for all-band stability
- Covers ham bands 80, 40, 20, 15 meters completely and 28.5 to 29.0 Mc of 10 meters with crystals furnished
- Any ten 500 kc ranges between 1.5 and 30 Mc can be covered with accessory crystals for 160 meters, MARS, etc. (5.06.0 Mc not recommended)
- Four bandwidths of selectivity, 0.4 kc, 1.2 kc, 2.4 kc and 4.8 kc
- Passband tuning gives sideband selection, without retuning
- Noise blanker that works on CW, SSB, and AM is built-in
- Notch filter and 25 Kc crystal calibrator are built-in
- Product detector for SSB/CW, diode detector for AM
- Crystal Lattice Filter gives superior cross modulation and overload characteristics
- Solid State Permeability Tuned VFO gives superior cross modulation and overload characteristics
- Solid State Permeability Tuned VFO
- AVC for SSB or high-speed break-in CW
- Excellent Overload and Cross Modulation characteristics
- Dimensions: 5½"H, 10¾"W, 12¼"D.
- Wt.: 16 lbs. $475.00 Amateur Net.

---

**T-4XB TRANSMITTER**

- Covers ham bands 80, 40, 20, 15 meters completely and 28.5 to 29.0 Mc of 10 meters with crystals furnished; MARS and other frequencies with accessory crystals, except 2.3, 3, 5-6, 10.5-12 Mc.
- Upper and Lower Sideband on all frequencies
- Automatic Transmit Receive Switching on CW (semi break-in)
- Controlled Carrier Modulation for AM is completely compatible with SSB linear amplifiers
- VOX or PTT on SSB and AM built-in
- Adjustable Pi-Netwrok Output
- Two 8-pole Crystal-Lattice Filters for sideband selection, 2.4 kc bandwidth
- Transmitting AGC prevents flat topping
- Shaped Grid Block Keying with side tone output
- 200 Watts PEP Input on SSB—200 watts input CW
- Meter indicates plate current and relative output
- Compact size; rugged construction
- Solid State Permeability Tuned VFO with 1 kc divisions
- Solid State HF Crystal Oscillator
- 11 Tubes, 3 Transistors and 12 diodes
- Dimensions: 5½"H, 10¾"W, 12¼"D.
- Wt.: 14 lbs. $495.00 Amateur Net.

---

*Get together with your distributor, or write for free brochure...*

**R. L. DRAKE COMPANY** 540 Richard Street, Miamisburg, Ohio 45342

---

*Togetherness...it's wonderful!*
contents

6 integrated-circuit balanced modulator
Roy C. Hejhall, K7QWR

14 mainline ST-5 RTTY demodulator
Irvin M. Hoff, W6FFC

22 vhf FM receiver
Ronald M. Vaceluke, W9SEK
Joseph C. Price, WA9CGZ

28 multimode 6/2-meter transmitter
Donald W. Bramer, K2ISP

34 rf impedance bridge
Henry S. Keen, W2CTK

40 neutralizing small-signal amplifiers
Earnest A. Franke, WA4WDK

44 electronic counter dials
E. H. Conklin, K6KA

48 audio oscillator-monitor
N. J. Nicosia, WA1JSM

51 reactance nomograph
Alfred Wilson, W6NIF

54 parasitic oscillations in high-power transistor RF amplifiers
Robert C. Wilson, W0KGI

56 direct-conversion CW transceiver operation
Richard S. Taylor, W1DAX

60 troubleshooting RF and IF amplifiers
Larry Allen

4 a second look 70 new products
94 advertisers index 94 reader service
83 flea market 60 repair bench
66 ham notebook 76 short circuits
Microwave acoustics is a new technology that promises to revolutionize communications equipment design in the future. Recent laboratory experiments with microwave acoustics have resulted in amplifiers, oscillators, resonators, signal couplers and delay lines. Nor is this a scientific curiosity confined to the inner sanctum of the lab—Zenith is working on a 40-MHz acoustic-wave bandpass filter to replace the tuned circuits in color television sets.

The word "microwave" has traditionally been used to describe work in that part of the spectrum where wavelengths are defined in terms of centimeters. However, in "microwave acoustics" the term "micro" is associated with the micron wavelength of an acoustic wave on the surface of a crystal—at 30 MHz, for example, a 100-micron wavelength is possible because acoustic waves travel 100,000 times slower than electro-magnetic radiation.

At the heart of all acoustic-wave devices is the delay line shown below. It consists of a piezoelectric substrate, such as quartz, and input and output transducers. The input transducer is basically a transmitting antenna that converts the incoming electrical signal into an acoustic wave on the surface of the substrate. When the acoustic wave reaches the opposite end of the substrate it is converted back into an electrical signal by the output transducer. The wave propagates rather slowly across the surface of the substrate, and by changing the spacing between transducers signal delay can be controlled.

Transducer design is extremely important because mass and shape affect efficiency, and size affects bandwidth. The interdigital structure shown in the drawing consists of two separate arrays of metal electrodes which resemble interlaced fingers. By changing the number of fingers the bandwidth can be tailored to circuit requirements. Thus, the basic acoustic-wave delay line becomes a resonator that may be used in place of tuned LC circuits.

Engineers have recently come up with an acoustic-wave amplifier that uses a semiconductor structure spaced a short distance away from the substrate. Since the electric field associated with the propagation of the surface wave extends out of the surface of the substrate it interacts with the electrons in the semiconductor. If the dc supply voltage is low, the surface wave is attenuated because energy flows from it to the slower moving electrons in the semiconductor. However, as the supply voltage is increased, the electrons speed up, and when their speed exceeds that of the surface wave, gain results. Laboratory-built amplifiers using this system have netted gains on the order of 30 dB.

Although it will be some time before these new devices will be available for amateur use, they lend themselves to batch processing. And batch-processed components mean big savings after the design becomes standard—look at the proliferation of low-cost batch-processed ICs currently on the market.

Jim Fisk, W1DTY
editor
WCCO
Radio and Television CBS Basic Affiliate

February 7, 1969

Mr. Irving Steinberg, Sales Mgr.
Hammarlund Mfg. Co.
20 Bridge Ave.
Red Bank, New Jersey 07701

Dear Sir:

I am enclosing a couple of glossy prints, showing our frequency measuring setup, to witch the Hammarlund MG-656/13 receiver is a key instrument.

We use it to receive AMV on 2.5, 5-10 and 15 MHz against whose signal we beat the output of our CR Calibrator for a zero beat. Signals to be measured are then received on the receiver, and in turn beat against the CR Calibrator output.

We measure the frequencies of two other television stations as well as those of some of the local broadcast stations. This includes the color burst frequency, the 4.5 MHz difference beat between visual and audio carriers and by use of Russell functions we check the calibration of the audio modulation monitor.

I have drawn a chart of the locations of the various instruments in the shack and am also enclosing it.

The man in one of the pictures is Stan Allston of our transmitter staff.

I forgot to mention that we also can check our tuning of the transmitter multiplier stages, receiver time checks from AMV, and use the receiver as a standby in case of failure of our ESQ receiver.

Sincerely yours,

Gerald King Allston
Transmitter Supervisor

---

Hammarlund Manufacturing Company Incorporated
A Subsidiary of Electronic Assistance Corporation
20 Bridge Avenue, Red Bank, New Jersey 07701
an integrated-circuit

balanced modulator

Integrated circuits are being designed that can perform more and more of the circuit functions in amateur communications equipment. This article describes one of these new circuits, the Motorola MC1596G balanced modulator. Included are circuits showing the MC1596G as a balanced modulator and several other applications including an a-m modulator, a-m detector, a product detector, a mixer, and a frequency doubler.

The Motorola MC1596 integrated-circuit balanced modulator contains 8 transistors, 3 resistors and 1 diode.

Although designed for balanced-modulator service, the Motorola MC1596G is readily adaptable to many other circuits for amateur use.

Roy Hejhal, K7QWR, P. O. Box 3265, Scottsdale, Arizona 85257
The MC1596G is available now. However, a less-expensive version of the device with a slightly lower carrier-suppression specification and a limited operating-temperature range will be available soon under the type number MC1496G. The MC1496G will still provide very adequate performance for many amateur applications, and the circuits and information in this article apply to the MC1496G as well.

MC1596 performs this multiplication is beyond the scope of this article, and interested readers are referred to the references. However, to put the MC1596G to work it's helpful to have a basic knowledge of the output signal characteristics. Therefore, a brief discussion of the multiplication process with two ac signals follows.

Let's assume we have two sine-wave input signals called A and B at frequencies $f_A$ and $f_B$ respectively. And suppose we have a device that multiplies signal A times signal B and produces a third signal, C, which is the product of A and B. A device that performs this task is the MC1596G, and signal C will then have the following characteristics:

1. The amplitude of signal C will be the product of the amplitudes of signals A and B.
2. Signal C will contain two (and only two) frequency components, $(f_A + f_B)$ and $(f_A - f_B)$.

Note there is no output at either of the input signal frequencies, $f_A$ and $f_B$.

**Fig. 1. Internal circuit arrangement of the Motorola MC1596G IC.**

**Description of the MC1596G**

**Fig. 1** is a schematic of the MC1596G. It consists of a dual differential amplifier driven by a standard differential amplifier. Transistors Q1 through Q4 make up the dual (upper) differential amplifier, while transistors Q5 and Q6 form the standard (lower) differential amplifier. Transistors Q7 and Q8 are constant-current sources for the lower differential amplifier.

The MC1596G has terminals for two input signals and one output signal. In operation, the circuit produces an output signal that is the product of the two input signals. A detailed discussion of how the circuits $f_A$ and $f_B$.
An example may be helpful at this point. Suppose we apply two input signals, one at a frequency of 1 MHz and the second at 4 MHz. The output signal will then contain frequency components at 3 and 5 MHz. In other words the output will be two separate, single-frequency sine-wave signals, one at 3 and one at 5 MHz. There will be no output at 1 and 4 MHz.

The signal amplitudes need a little further clarification at this point. The MC1596G has no built-in output load resistors; they must be added externally to develop an output-signal voltage from the output current. The magnitude of this output-voltage depends on the value of these outboard load resistors. Therefore, varying the load resistors will change the gain of the MC1596G. This means that the output signal will be the product of the input signal amplitudes times some constant, which is a function of the external load resistors and other circuit adjustments that affect gain. These gain-related items are described next.

**Gain Considerations**

In addition to the load resistors, two other parameters that affect gain, or amplification, from the modulating-signal input to output are the magnitude of the resistance between pins 2 and 3 and the dc-bias currents. For all applications shown here, a bias current of 1 mA in each transistor of the lower differential amplifier, Q5 and Q6, has been used. This is generally recommended for most applications.

The resistance between pins 2 and 3 can be readily tailored to the needs of a particular circuit. Increasing this resistance decreases gain but increases the signal-handling capability of the IC. This means that output-signal amplitude will be decreased, but a higher-amplitude input signal can be handled without distortion. Decreasing this resistance has the opposite effect. The resistance between pins 2 and 3 can be anything between zero and several thousand ohms, depending on the optimum desired combination of gain and signal-handling capability.

Now let's see how the MC1596G can be put to work.

**Balanced Modulator**

Fig. 2 shows the MC1596G as a balanced modulator. This circuit has the following advantages over a conventional diode ring balanced modulator often found in amateur equipment:

---

**fig. 2. Balanced modulator circuit. For use as an a-m modulator, merely change the two 10k resistors to 750 ohms. The pot can be adjusted for carrier null (ssb) or carrier insertion (a-m).**
1. Circuit simplicity. No transformers are required; only resistors and capacitors. Only a single carrier-null adjustment is used, while diode ring modulators often have two null adjustments. Further, the MC1596G carrier-null adjustment is in the dc portion of the circuit. This means the carrier-null potentiometer need not be located physically near the remainder of the balanced-modulator circuit—it could be located on the rear panel of the equipment or at any remote location.

2. Greater carrier suppression. This balanced modulator will provide typically 65 dB and 50 dB carrier suppression at 500 kHz and 9 MHz respectively.

3. Broadband operation. The basic circuit requires no modifications for carrier frequencies from audio to 100 MHz.

The balanced modulator shown in fig. 2 also has an extremely clean double-sideband output signal and a low-carrier-oscillator power requirement. Spurious sidebands are down 55 dB or more, and the carrier oscillator must deliver only 0.072 milliwatt to the modulator.

Construction and operation are simple. Reasonable care is needed to isolate output and carrier input. The modulator has such excellent carrier suppression that if care is not paid to circuit input-output isolation, there may be more carrier output signal passed through circuit stray capacitance than through the IC itself.

To place the modulator in operation, apply dc power and carrier signal. The recommended carrier input level is 60 mV (0.06 V) rms, but this isn’t critical and variations in this figure of as much as 50% won’t seriously degrade circuit performance. The carrier-null adjustment is set for minimum carrier output.

The audio modulating signal is then applied. This signal should have a value of 300 mV rms on peaks; but again, this level is not critical.

If you have no equipment available to adjust the carrier injection level to 60 mV, apply both carrier and a single audio-tone modulating signal and observe the double-sideband output level on a
voltmeter or scope. As the carrier injection is increased from a very low level (1–10 mV rms) the output will increase as carrier level is increased. Finally a point will be reached where further increase in carrier level causes no change in the output. The carrier level should be set at the point where the output signal just begins to level off.

If only a single 12-Vdc power supply is available, the circuit shown in fig. 3 may be used. Signal levels and operating instructions are the same as for the circuit in fig. 2.

amplitude modulator

The circuit shown in fig. 2 can be used for an a-m modulator if the 10k resistors are changed to 750 ohms. This modification gives the carrier-null adjustment the greater range necessary for carrier insertion.

could be used in an ssb/a-m transmitter or in an rf signal generator.

doubly balanced mixer

A doubly balanced mixer delivers only sum and difference frequency outputs and suppresses both the local oscillator and rf-input frequencies. The MC1596G may be used in this application also.

Fig. 4 shows a doubly balanced mixer with broadband inputs and a tuned output at 9 MHz. This means that the rf and local oscillator inputs may be any two frequencies with a sum or difference of 9 MHz. The circuit will operate with input frequencies from 160 meters up to 300 MHz. With a 10-meter input signal, the mixer has a conversion gain of 13 dB and a sensitivity of 7.5 μV for a 10-dB signal-plus-noise-to-noise ratio at the i-f output. At 220 MHz, it has 9-dB conversion gain and a 14-μV sensitivity.

The a-m modulator is operated with the same signal levels as the suppressed-carrier modulators described above. It can be used in a system where both suppressed carrier and a-m are required. Simply adjust the 50k pot for either a carrier null or carrier insertion, depending on which operating mode is desired. The modulator

Several variations of this mixer may be used. There are three signal ports, two inputs, and one output. These three ports may be used with any combination of either tuned tanks or broadband coupling circuits. Thus, with broadband circuits on all three ports, the mixer will deliver sum and difference frequency

fig. 4. Doubly balanced mixer with broadband input and tuned 9-MHz output. Circuit operates up to 300 MHz. L1 is 44 turns no. 28 enameled on a Micrometals 44-6 toroidal core.
outputs from audio through vhf. With tuned input and output circuits, much higher conversion gains of 20 to 30 dB may be achieved due to more efficient impedance matching.

The MC1596G, causes the product detector to have only the desired demodulated audio output.

Fig. 5 shows a product detector circuit. With a 9-MHz ssb i-f input, the

fig. 5. Product detector with 90-dB dynamic range. The high sensitivity of this circuit lends itself to direct conversion techniques.

**Product Detector**

An extremely sensitive product detector can be built with the MC1596G.

A product detector is really a mixer with its output in the audio frequency range. The ssb signal forms the rf input, detector has a sensitivity of 3 μV for 10-dB s + n/n at the audio output. For 20 dB s + n/n, the sensitivity is 9 μV. This means that for an ssb receiver with a 50-ohm antenna input impedance, a 0.5-μV rf input signal would require only 12 dB over all signal power gain from

and the carrier injection signal is the local-oscillator input. The audio output signal is at the difference (audio) frequency between the ssb and carrier frequencies. A low-pass filter that cuts off above 3 kHz is used at the output. This, together with the inherent suppression of both input-signal frequencies provided by antenna to detector input to produce a demodulated audio signal with 20-dB s + n/n at the detector output.

Of course there would be many other practical limitations on such a receiver such as agc range, audio-amplifier sensitivity, etc. But the point is that detector sensitivity would certainly not be a prob-
lem in any receiver employing the MC1596G as a product detector.

This high sensitivity product detector permits some interesting receiver techniques. For example, the circuit lends itself well to direct conversion. Furthermore, it's possible to build a sensitive superheterodyne receiver with no I-f gain. The latter principle has been realized in an hf ssb receiver (block diagram shown in fig. 6). The sensitivity of this receiver may also be increased at the cost of some decrease in detector sensitivity and gain by increasing the resistor between pins 2 and 3 to 500 or 1000 ohms.

**a-m detector**

The product detector shown in fig. 5 may be used as an a-m detector. Thus it can be used as the only detector in an a-m ssb cw receiver. For a-m operation, simply inject carrier and modulated signal inputs, as for

---

**fig. 7. Optimized a-m detector based on the circuit of fig. 5.**

**fig. 8. A low-frequency doubler. Circuit will deliver doubled output from input signals up to 1 MHz; all other frequencies are 30 dB or more below the desired output.**

---

on 15 meters is less than 0.1 μV for a 10-dB s + n/n ratio.

The product detector has a dynamic range of 90 dB. This means that it will...
ssb. The carrier injection is most conveniently obtained from the i-f signal, thus avoiding any drift problems that may be encountered if the carrier is generated locally, as for ssb reception.

Fig. 8 shows a low-frequency doubler. The two input terminals are simply coupled, and untuned RC coupling is used at input and output. At input frequencies up to 1 MHz, this circuit will deliver a clean doubled output with all other frequencies 30 dB or more below the desired output.

When modified with suitable coupling and bypass capacitors, the basic MC1596G doubler has been used at input frequencies as high as 200 MHz.

Suppression of input frequency and other spurious signals is not as good in the hf and vhf range. Therefore, it may be desirable to use a tank circuit at the output to obtain a cleaner output signal. Fig. 9 shows a vhf doubler with such a tank. This circuit doubles from 150 to 300 MHz, with all spurious outputs 20 dB or more below the desired output signal.

frequency doubler

Injection of the same signal frequency at both inputs produces an interesting result. The sum frequency output is twice the input frequency, and the difference frequency is zero. Therefore, the output consists of a single-frequency signal at double the input frequency, and we have a frequency doubler. The MC1596G operates as a frequency doubler without any tuned circuits from the audio frequency range through vhf.

Normally, a constant-amplitude local-oscillator (carrier) signal is injected at the local-oscillator input. To achieve this with a carrier signal obtained from the receiver i-f signal, a limiter would have to be used to remove the modulation. However, if a carrier injection level of 300 mV rms is used, the fully modulated signal may be injected directly.

While the product detector shown in fig. 5 may be used directly as an a-m detector by injecting a 300-mV signal into the carrier input and up to 30-mV signal into the signal input, a few modifications can be added to optimize the detector for a-m. The resulting circuit is shown in fig. 7.

references

Many newcomers to RTTY have complained that a current yet simple demodulator hasn’t been published for them to build. The W2PAT unit in the ARRL handbook is nearly 15 years old. In 1964 an attempt was made to replace the W2PAT design with a modestly priced updated unit, the TT/L. This design, together with the subsequent TT/L-2, is now the standard of the serious RTTY enthusiast. However, the original goal was missed by a country mile, since the TT/L-2 costs over $160 just for parts and has 14 tubes.

The ST-5 was a successful solid-state design that introduced integrated linear operational amplifiers to RTTY. It was still moderately complex, however, and fell short of the goal to supply the beginner with something that could be built in a few hours.

The ST-5 demodulator

While developing a unit based primarily on ICs to replace the TT/L-2, a very simple modulator with great potential was developed: the ST-5. As with any simple circuit, the cost of the power supply is out of proportion with the rest of the unit. At current prices, the ST-5...
costs only $14.50 less loop supply ($8) and a plus-minus 12-volt supply ($11).

The total cost of $33 is not overly impressive until you realize this unit can, if desired, be used as a building block for the more exotic ST-6, which will be published later in the year. Almost every component used here can be used in that unit. The ST-5 is a basis from which the beginner can expand—it's not just a collection of parts that will find no further use when he is ready to broaden his horizons to more sophisticated equipment.

features

The ST-5 uses two operational amplifiers (fig. 1). One is an audio limiter, and the other is a trigger stage to drive the keyer. It has a 175-volt loop supply of the same type used in the TT/L, which provides plus-minus voltages for keying a transmitter and also features narrow-shift cw identification. Finally, the ST-5 has a symmetrical plus-minus 12-volt power supply.

Rear panel of ST-5 shows jacks for audio, fsk and loop power. Enclosure is 6 x 8 x 3½ inches.

limiter

The 709C op amp has over 90-dB gain and is good to over 10 MHz. It makes an ideal limiter. The zener diodes on the input don't assist in the limiting; they merely protect the 709C against damage in the event of excessive audio input (hardly likely but worth the protection). The limiter puts out square waves and is so powerful it starts working on input signals as low as 200 µV. The 25k pot merely balances the small offset input voltage for maximum gain. This voltage varies slightly from one unit to another, so a control pot was added rather than a fixed resistor, which many units use.

discriminator/detector

It's difficult to use the same value inductor with different capacitors and expect to obtain two similar filters of equal characteristics. To get similar bandwidth, voltage output, noise response, etc., some loading is necessary. Most simple demodulators merely balance the voltage or ignore all the problems completely. Without belaboring the point, it's not a simple job to get all these factors to balance suitably; but it is possible, and the Mainline units all have filters that have been designed with care.

The ST-5 offers a choice of the 2125-2975 mark and space tones (considered standard), or the 1275-2125 low tones necessary in some modern receivers. (Actually nearly all these receivers respond beautifully to 2975 tones and higher, but a new bfo crystal is needed.) The best results come from the 2125-2975 tones, since the two frequencies are only about 28% apart while the 1275-2125 tones are 40% apart; thus it's a more difficult job to separate the harmonics and achieve proper filter design.

The detector features full-wave rectification for most efficient filtering of the dc ripple remaining after the audio has been rectified. A simple RC low-pass filter removes the remaining audio component.
slicer

The slicer takes the small voltages from the filters and changes them to roughly +10 volts for mark and -10 volts for space, regardless of the original amplitude. This in reality is a dc limiter, as a signal as small as a 100 μV or so will cause the unit to saturate completely, either plus or minus, depending upon the polarity of the applied signal voltage. The unit has so much gain that at the crossover point, a change at the audio input as small as one or two Hz will cause this trigger stage to flip from +10 to -10 volts. This is another way of saying shifts as low as 3–4 Hz could be copied on the ST-5 if tuned in properly.

keyer stage

A 300-volt Motorola 25W transistor selling for $1.06 is used. The normal loop-supply current for tty machines is 60 mA. This transistor has a large amplification factor and acts like an on-off switch. When on, the power consumed in the transistor is only 0.012 W; so in the ST-5 there's no way you could ever damage that transistor.

An RC network in the MJE-340 collector takes care of the back emf developed by the inductance of the selector magnets in the printer during the transition from space to mark. The transistor is biased off during space. A diode in the base circuit keeps this negative voltage below the
point at which the base-emitter junction would be reverse-biased.

**loop supply**

Here comes $8 of the $33 total right now. This unit uses the well-known "floating loop" I developed for the TT/L. As you go from mark to space, the voltage at the fsk output switches from negative to positive. This offers excellent keying characteristics for the transmitter, and provides a simple method of keying ssb transmitters needing conduct on mark instead of conduct on space, such as the Collins S-line. The Hallicrafters (and others using a 9-MHz heterodyne scheme with a vfo running from 5.0 to 5.5 MHz) needs both systems. If you are "upside down," merely reverse the diode in the fsk system. Few (if any) other systems offer this potential. The narrow-shift cw identification system can be set appropriately with the 500-ohm pot. If you are using a transmitter that conducts on mark and can't get suitable cw shift, try putting the connection to the 500-ohm pot on the other end of the 8.2 kilohm resistor. One of these two places has always been.

Printed-circuit boards hold all the components except the two transformers and the control switches.

The 2500-ohm resistor sets the loop current, which is in no way critical. Unless more than 10 mA in error from 60 mA (you may have used a different transformer and need a different resistor), don't bother changing anything.

**loop transformer**

The Stancor PA-8421 is far from cheap. However, I've never found a more suitable transformer at any lower price. Don't be alarmed at the 50-mA rating, which requires some explanation. The primary is capable of handling about 20 VA in the secondary. Since there's also a 6.3-volt winding rated at 2 A, this is almost 13 of that 20 VA. That only leaves about 7 VA for the high-voltage winding, or roughly 50 mA. However, if the filament winding is not used (and I don't use it), then the entire 20 VA is available to the high-voltage winding. This represents around 160 mA. So don't be alarmed at the 50-mA rating. You could pull twice that in this circuit and it wouldn't tax the transformer. Don't worry if the transformer gets warm; all transformers get warm. It's when you burn your hand on them that you have to watch out. I've had a loop supply similar to this running in the TT/L twenty-four hours a day for six years, and others throughout the country are doing the same.

**power supply**

The 709C op amps will take up to ±18 volts. If you wind up with more than the indicated ±12 volts, but less than ±18 volts, think nothing about it. You can lower the voltage by increasing the value of the resistors if desired. The plus voltage goes up or down at the same rate as the minus voltage, since both voltages are supplied by the same transformer. The op amps use symmetrical voltages. The 4000-µF capacitors are Sprague type 39D at $2.43 each. Other large-value brands may be used, and I suggest you use at least 3,000 µF for this purpose if substituting.
standby switch

When S1 is closed, the unit is placed in mark. When S1 is opened, the printer can follow whatever is fed into the limiter from the receiver.

As explained previously, the unit has so much gain that a signal as small as 3–4 Hz can be copied if tuned correctly; this is called straddle tuning. However, for 170-Hz shift you may wish to add a switch that changes the space filter to the new frequency. Fig. 2 shows the way this would be accomplished if using the normal 2125-2975 tones, and fig. 3 shows the circuit for the low tones of 1275-2125. This is merely an expedient and doesn’t result in proper filter balance, but it provides good 170-shift reception with the switch closed, or normal 850-shift reception with it open.

**tuning indicator**

Provisions are provided for connections to the vertical and horizontal amplifiers of a scope (fig. 1). It is customary to connect the mark signal to the horizontal amplifier and space signal to the vertical amplifier, although many reverse this method.

Most people prefer a scope indication, but an excellent tuning indicator is provided at point A (fig. 1). A voltmeter connected to this point will give equal voltage indication for mark or space. With rttty signals the meter should stand still. If it doesn’t, retune the receiver until it does. If straddle tuning a signal, the meter may read less than normal, although it won’t move. This is normal and merely indicates the shift being copied is not the correct shift for the filters you’re using.

Fig. 4 also shows how a 0–1 mA meter may be added. An inexpensive npn transistor is used, such as the MPS-3394, although any npn transistor would be satisfactory here. The capacitor merely dampens the meter so it doesn’t flip around too violently. If your meter is too damped, remove the capacitor or try a smaller value. This was suitable for the inexpensive imported meter used in my unit.

**the transmitter keyer**

Fig. 5 shows a typical FSK keyer for installation in the transmitter. The components can be mounted on a small terminal strip and placed near the vfo tube under a convenient mounting screw which also serves as a ground return. The trimmer is connected to the cathode of the vfo tube and the tube replaced in its socket; thus, no changes of any type are made to the transmitter and its resale value is not affected. There should be room for several keyers if you wish to have the convenience of both 170 and 850 shift.

Although a 3-12 pF trimmer is shown in fig. 5, some transmitters only require a 1.5-7 pF trimmer. It is suggested that you do not substitute for the IN270 diode as it is superior to most other types in this application.

If your signal is reported as “upside down,” reverse the IN270 diode. If you do not obtain sufficient cw shift with this connection (conduct on mark), the
500-ohm cw-shift pot should be connected to the opposite side of the 8.2k resistor at the junction of the two 15k resistors (fig. 1).

components

The 709C op amps are supplied by various manufacturers including Signetics, Fairchild, and Motorola. The prices in the order named are $2.62, $2.65 and $2.80 as of this writing. Prices are constantly being reduced as devices become available from more companies. When I first started working on a super deluxe demodulator in the fall of 1967, I paid over $10 each. Now they’re too cheap not to use.

VFO

fig. 5. To add fsk to literally any transmitter, connect a 3-12 pF trimmer to the cathode pin of the vfo tube.

The Motorola unit can be purchased through most distributors, including Allied and Newark. The Fairchild unit can be mailordered from the firms below.* Include about $1 extra for handling and postage; the surplus will be refunded. Specify the TO-5 can, as this is easier to work with than the dual in-line 14-pin type (same cost).

The diodes marked G in fig. 1 are 1N270 germanium at 32¢ each. Those marked SIL are most any silicon type, such as the 1N2069. The one in the loop supply should, however, be a minimum of 400 volts PIV. Fifty-volt PIV is suitable everywhere else.

*Hamilton Electro Sales, 340 East Middlefield Road, Mountain View, Calif. 94040 and G. S. Marshall Co., 732 North Pastoria Avenue, Sunnyvale, Calif. 94086 (also carries Signetics). If buying Motorola version, ask for the MC-1709CG. Texas Instruments 709 op amps are $1.50 each (or 7 for $10) from HAL Devices, Box 365H, Urbana, Illinois 61801; ask for SN72709L.

If you don’t wish to spend the money for the zeners on the limiter input, you can substitute regular silicon types as shown in fig. 6. These start clipping at 0.6 volt, however, and offer an inferior form of limiting, although they more than adequately protect the input to the limiter from excess voltage. The zeners are a much better choice.

The 88-mH toroids are available from various sources for about 40¢ each.† They’re wired in series for 88 mH, and the junction of the two windings is grounded.

If you have an accurate means of determining the frequency, you can tune the filters by removing turns of wire from each of the two sections concurrently to keep the turns ratio in the two windings the same. One turn from each of the two windings will increase the frequency about 6 Hz at the 2125 frequency, for example.

Use Mylar capacitors, such as the Sprague Orange Drop. Twenty-five-volt capacitors are adequate, but you’ll probably wind up getting 200V types. They are only 15–21¢ each.

The pots can be the inexpensive 39¢ Mallory PC board MTC types. Other power transformers may be used, but the Triad F-40X is an excellent buy.

printed-circuit board

The printed-circuit boards shown in the ST-5 in the photographs hold all of the components except the two transformers and the control switches. This greatly enhances construction, and at the same time makes it possible for nearly anybody

* An excellent source for 88-mH toroids is M. Weinschenk, Post Office Box 353, Irwin, Pennsylvania 15642. He will send you five 88-mH toroids for $1.50, postage paid.

† An excellent source for 88-mH toroids is M. Weinschenker, Post Office Box 353, Irwin, Pennsylvania 15642. He will send you five 88-mH toroids for $1.50, postage paid.
to build an extremely nice-looking unit. The printed-circuit board includes one section for the power supply and another for everything else. The board may be split down the middle and the two sections mounted back-to-back as I did in my unit, or the board may be left intact and used with a more shallow chassis.

adjustment
With no input signal, or with the input grounded, adjust the pot on the limiter for zero volts dc at pin 6. If this isn’t possible, you’d better write me and explain thoroughly, as you probably ruined the op amp somehow. By the way, unless you get too much voltage on pins 2 or 3, like the full power-supply voltage, or get the plus-minus hooked up backwards, it’s very difficult to ruin these things. By following even the most elementary construction practices, you’ll have no problems with the 709C.

After balancing the limiter for zero volts output, connect the receiver and tune to maximum mark and note the indication on your tuning indicator (fig. 4) or on a voltmeter connected to point A. Tune to space on the receiver and again note the reading. If the indications are not the same, adjust the 5k pot on the limiter output until they are. You have now finished all the adjustments and they should require no further attention at any time unless you switch to 170 shift, for instance. In this event you may or may not want to reset the filter balance pot. I suggest you leave it for the 850 setting and take what you get on the 170-switch position, as this is a somewhat artificial method of getting good 170-shift reception.

When transmitting be certain to first close the standby switch or you can get feedback, which will produce errors similar to those you would get when using a microphone if you didn’t turn off the speaker.

other op amps
The 709C is to other op amps what the Ford V-8 was to other automobiles. It not only led the way; it’s still in use. The 709C was (and is) one of the cheapest ICs of its type available. One would gain very little and stand to lose a lot by trying to substitute other units. The 741

*A printed-circuit board for the ST-5 RTTY terminal unit is available from Stafford Electronics, Inc., 427 South Benbow Road, Greensboro, North Carolina 27401. The undrilled board is $3.00; with critical holes drilled, $3.75; complete, ready to mount components, $6.50. A complete kit of components (less circuit board), including ICs, transistors, diodes, resistors, capacitors and toroids is available for $37.50 from HAL Devices, Box 365H, Urbana, Illinois 61801.
and 748, for example, have a bit more gain, higher input voltages, and require no frequency compensation. They cost $4.85 each, but their biggest disadvantage are an antispace circuit, an active 3-pole Butterworth low-pass filter, autostart with delayed motor control, and optional features such as bandpass input filters for

Fig. 7. Although this unregulated power supply may be used with the ST-5 RTTY demodulator, the circuit shown in fig. 1 is recommended.

here is that they’re not at all suited as audio amplifiers. At 2 kHz they have only 30-40 dB gain and make a poor audio limiter compared with the 709C. So unless you know what you’re doing, stick to the 709C.

the Mainline ST-6

This demod will be published as soon as possible. The ST-6 uses the same limiter and slicer as the ST-5 and the same keyer and loop supply. It uses the same power supply to which has been added some regulation. It has a total of 7 op amps and 9 transistors. Also featured are laid motor control, and optional features such as bandpass input filters for either 170 or 850 shift, fast-slow autostart, etc. This is only mentioned at this time to illustrate that if one builds the ST-5, the same parts may be used later for the more exotic ST-6 if you wish to expand your station.

Conclusion

The ST-5 was designed as a simple but highly effective RTTY demodulator using the best of currently available concepts. It should be a very popular unit for some years to come, as it’s impossible to imagine at this time how any additional performance could be made available—it’s already ridiculous to talk in terms of 90+ dB amplification. Only a completely different concept of RTTY processing could outdate the ST-5, and that seems quite unlikely to occur until we all get computer terminals in the shack.

References

1. RTTY, November, 1964; also QST, August, 1965.
2. RTTY Journal, September, 1967; also QST, May, June, 1969.
3. RTTY Journal, September, 1968; also QST, April, 1970.
An FM Receiver for Two Meters

Conservative design, solid-state construction, readily available parts—all add up to a really solid vhf fm receiver.

Within the last several years, hams have been giving increased attention to vhf fm operation. Although this mode has been used by hams for over 15 years, it is just beginning to be widely accepted. One of the reasons is because of the release from commercial service of the older, wide-deviation, tube-type gear. Commercial users had to go to a narrower deviation to open up more frequencies. One of the authors was on wideband fm 16 years ago using what was at that time fairly current equipment. After all these years, the same type of gear is still widely used. With today’s techniques and technology, much of the older tube-type equipment is obsolete. The tragic part is that since the demand for vhf fm equipment has increased, the law of supply and demand has raised the prices of these antiques out of proportion to their usefulness.

Lately several distributors have been selling imported fm gear designed for ham use. Although we haven’t tried this equipment, it probably works quite well. However, we felt that it should not be necessary to get a second mortgage on our homes to be able to purchase hobby equipment. A problem that can exist with imported electronic gear is the availability of adequate repair parts when needed. With all of these objectionable possibilities in mind, it was felt that the best approach to vhf fm operation was of the do-it-yourself type. The solid-state, conversion receiver described here is the result.

In establishing our design criteria we felt that it would be wise to spend a few extra dollars, build more than just a basic receiver, and do the job right the first time to obtain good rather than mediocre operation. In looking over readily available semiconductors, best use was made of both discrete and integrated devices.

The first version of the receiver was built on punched board, using eyelets at every point of component entry. Although this technique is adequate for initial design, it leaves something to be desired as far as a finished product is concerned. The second version was made using printed circuits.* All parts are readily available and standard. The i-f transformers are imported, but are a standard type used in portable radios. These are also available from J. W. Miller. Don’t overlook those defunct transistor radios at hamfests, etc., as a source of transformers. The coil forms in the rest of the circuit are made by Cambion (avail-

* A set of G-10 epoxy PC boards, tinned, drilled, and with swaged terminals is available for $9.50 P.P. A PC board for the power supply, G-10 epoxy, drilled and tinned is available for $2.50 additional. Order from RMV Electronics, P. O. Box 283, Wood Dale, Illinois 60191.
able at Newark Electronics, etc.) and can be shielded by the same size coil shields used on the i-f transformers.

**the front end**

For good cross-modulation and over-load characteristics, fet transistors are used in the front end (fig. 1). The first rf amplifier, Q201, is a conventional, grounded-source, neutralized MPF-102. Other types may be somewhat better; the MPF-105 or MPF-107, for example.

For good cross-modulation and over-load characteristics, fet transistors are used in the front end (fig. 1). The first rf amplifier, Q201, is a conventional, grounded-source, neutralized MPF-102. Other types may be somewhat better; the MPF-105 or MPF-107, for example.

The first mixer is a MPF-102 fet. The signal and local oscillator frequencies are fed to the gate. The source resistor was chosen empirically for the proper amount of local-oscillator injection. The mixer output is 10.7 MHz and is taken off by a link on T201.

View of the PC front end. At the left is the rf input and Q201, followed by Q202. At right center is Q203 mixer, and at the right end of board is the oscillator. The board will hold up to three crystals although only one is shown here.

A grounded gate stage, Q202, is used as the second rf amplifier to simplify construction and for ease of adjustment (no neutralization).

The first local oscillator consists of a crystal oscillator, Q204, operating at 45+ MHz, which is tripled to approximately 135 MHz by a 1N914 diode. The crystal frequency can be determined as follows:

\[
\text{xtal freq} = \frac{\text{operating freq} - 10.7 \text{ MHz}}{3}
\]

A trimmer capacitor in series with the crystal allows frequency zero adjustment. Be sure to use short leads from the base of Q204 to the crystal, or it won't oscillate. If a switch is used, the miniature variety is recommended since the larger ones have too much inductance. In the printed circuit version we used an ALCO MRA-3-3S switch. The pins went right through the board and to the foil.

The first mixer is a MPF-102 fet. The signal and local oscillator frequencies are fed to the gate. The source resistor was chosen empirically for the proper amount of local-oscillator injection. The mixer output is 10.7 MHz and is taken off by a link on T201.

**main i-f board**

The output of the first mixer is fed to the gate of Q101, the first i-f amplifier (fig. 2). Link coupling from the first mixer provides an impedance mismatch, which prevents Q101 from oscillating without neutralization.

Due to the low Q of the transformers in the mixer and first i-f amplifier outputs, there may be a problem with an image 910 kHz from the desired signal. If you're in an area with lots of activity, or discover later that this problem exists, an external filter can be added between the converter and first i-f.

The output of Q101 is transformer-
coupled to the base of the second mixer, Q102, where it is mixed with 10.245 MHz from the second local oscillator, Q103. The difference frequency, 455 kHz, is fed to a three-stage filter consisting of T102, T103 and T104. The selectivity depends on the coupling capacitors and also the tuning of the transformers.

Other types of filters are available that have better bandpass characteristics, but their cost and limited availability prohibit their use. By using i-f transformers as a filter, they can be adjusted for either wide- or narrow-band use. The i-f transformers are the type used in transistor radios.

The second i-f amplifier, U101, is an RCA CA3012 integrated circuit, which is low priced and has approximately 65 dB gain with good limiting characteristics. Because of the very high gain, the lead dress is important, and the bypass capaci-
tors should have short leads to prevent self-oscillation. A problem developed on the original printed circuit layout with this stage due to ground loops, which caused U101 to oscillate.

Transformer T105 couples the i-f amplifier output to the fm detector U102, which is a Sprague ULN 2111A. This integrated circuit contains an i-f amplifier, limiter, fm detector, and an audio stage. Other IC fm detectors are on the market, but this unit doesn’t require an expensive transformer and provides excellent a-m rejection.

The audio output of the fm detector feeds the audio gain and squelch pots. Transistor Q105, a noise amplifier, drives Q106, the noise detector. Transistor Q107 is a dc amplifier, which is driven by the noise detector and is used to turn the audio squelch gate Q104 on and off by biasing the emitter-to-base junction on and off.

Audio from the squelch gate drives the audio output stage, which is a relatively new integrated circuit from Motorola. The MFC4000 is inexpensive, small, and provides 250 mW output. While this is not quite enough for mobile use, it provides more audio than you can stand with a 4- or 5-inch speaker in normal room conditions.

**power supply**

The entire receiver operates from a 12-volt source. Audio output stage U103 requires 9 volts, which is obtained from a zener. This method was used rather than a dropping resistor, because the current to U103 varies widely and so would the voltage drop. If the receiver is used for mobile work, some additional filtering of the battery supply may be desirable. The amount can vary from car to car. To use the receiver in the home, a small ac power supply can be made. One of the authors has poor line regulation, so an electronically regulated supply using a Motorola MC1460R integrated-circuit regulator was built to power the receiver. The receiver draws approximately 60 mA when squelched (no audio) to around 150 mA on speech peaks with the audio gain wide open. As far as mobile is concerned, since the power requirements are so low, many hours of listening can be had without straining the car battery.

**alignment**

Although an expensive fm signal generator of the type used for commercial radio work would be nice, it’s not at all necessary. The i-f board can be initially tuned using any 10.7-MHz signal generator with a-m modulation. Some may question this; however, if the generator output is kept low as well as the percentage of modulation, the receiver will respond if the level is low enough to prevent limiting.
To start, inject 10.7-MHz to the gate input of transistor Q101. Since we need a dc return, (normally provided by the link on T201) a 2.5-mH rfc should also be connected from the input to ground. The generator coupling should be through a capacitor of approximately 100 pF. Peak all transformers for maximum audio output, but be sure to keep the generator output low to prevent limiting. Next, connect the front end to the i-f board. (Be sure to remove the rfc.) Place an rf probe connected to a vtvm at the diode (D201) cathode, and tune T202 for maximum reading. Next, couple a gdo or wavemeter to L206 and tune C218 for maximum. Then couple a signal at the operating frequency to the input of the front end. Peak L201, L203, L204 and L205 for maximum audio output. If Q201 oscillates, adjust neutralization coil L202. Turns may have to be removed or added, depending on the individual characteristics of Q201 and because of the limited tuning range of the coil.

The above has been a preliminary adjustment. A cooperating station on frequency can be used for final on-the-nose alignment. If an fm generator and sweep generator are available, by all
<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D101</td>
<td>3.9 volt zener diode, 1 watt (IN4730)</td>
</tr>
<tr>
<td>L101, L102</td>
<td>5.6 mH (Nytronics SWD-5.6 or equivalent)</td>
</tr>
<tr>
<td>L103</td>
<td>82 mH (Nytronics SWD 82000 or equivalent)</td>
</tr>
<tr>
<td>T101</td>
<td>CTC 3624-2 coil form wound full with no. 32, 3-turn link, shielded (winding area of CTC 3624 is 0.183&quot; long, 0.210&quot; winding diameter)</td>
</tr>
<tr>
<td>T102, T103</td>
<td>Miniature 445-kHz i-f transformer, 25k–600 ohms (J. W. Miller 9-C1 or equivalent)</td>
</tr>
<tr>
<td>T104, T105</td>
<td>CTC 3624-2 coil form wound full with no. 32, 8-turn link (see coil form info under T101)</td>
</tr>
</tbody>
</table>

fig. 2. i-f strip, discriminator, and af circuits. Bandpass filter following mixer consists of ordinary i-f transformers, allowing adjustable selectivity.

Means use them; however, an on-the-air signal is adequate. Peak all coils in the converter as well as in the selectivity strip (if used) and transformer T201 in the i-f strip for maximum audio output. If an on-the-air signal is used, attenuation may be necessary at the antenna input to keep the receiver from limiting. A weak signal is best. Transformers T102, 103, and 104 are stagger-tuned for desired bandwidth. Using a properly modulated on-the-air signal, tune these transformers for minimum distortion and clipping. T105 is adjusted for maximum audio output. T106 quadrature coil is adjusted for best audio quality. If a scope is connected to the audio output of U102, T106 should be adjusted for a symmetrical waveform. If more than one frequency is used, tune the rf coils for approximately the center frequency spread. All that’s necessary now is to adjust the volume and squelch controls for desired levels.

One of the authors has been using this receiver for mobile operation daily for several months and has found that it performs quite well. The mobile transmitter is a hybrid affair, but work is under way on a 100-percent solid-state transmitter. We will present this to ham radio readers at a later date if sufficient interest is shown. There is no reason why anyone who wants to get on vhf fm today can’t build a receiver such as we have presented and produce a unit that will perform to expectations at reasonable cost.
A previous article in *Ham Radio* featured transmitting mixers for the two- and six-meter bands. Regular low-frequency equipment provided excitation for the six-meter unit, while a 50-MHz source provided drive for the two-meter mixer.

Although these converters produce low output power, they are sufficiently complete to form basic subassemblies for a medium-power dual-band VHF transmitter. This article shows how to combine these printed circuit assemblies with a bias supply, control circuit, and linear amplifiers. Construction techniques will depend on individual requirements, so I've only highlighted physical details; these are shown in the photos and sketches. Circuit details are shown in the schematic (fig. 1).

Operating modes can be selected with a single control:

1. 6-meter a-m, using a low-power 50-MHz exciter such as the Heath "Sixer."
2. 2-meter a-m, using the same exciter as above.
3. 6-meter ssb, using a regular low-frequency ssb transmitter or transceiver.

4. 2-meter ssb, using the same low-frequency ssb source as above.

Carrier insertion allows cw operation in both mode switch positions. Break-in cw and vox are included to enhance enjoyment.

The Amperex 5894, which is interchangeable with the 829B, may be more efficient, particularly on two meters. However, if the 5894 is used some reduction will be required in neutralizing capacitance. Also, the grid-circuit inductance will have to be increased.

metering system
With the selector switch in the center position, grid current of either amplifier can be monitored. In the counter clockwise position, 2-meter output power will be indicated; 6-meter output is indicated when the switch is in the clockwise position. No grid current should flow in Class AB1. However, an indicator is required to show when grid current begins to flow to obtain maximum output with minimum distortion.

power supplies
Regulated +210 volts are required for the 6U8 oscillator-buffer, 5763 screens, and 12AT7 plates. Regulated Screen voltage for the 829B's is also required. Two independent series strings of OB2 regulators are used. This provides isolation between the oscillator and 829B screen-current fluctuations. A simple bias supply is used. A small 6.3-volt transformer is connected backward in the filament line. Its unloaded output (-145 volts) is applied through two resistors to 18- and 22-volt zeners. When the control relay is unenergized, both diode supplies float, allowing the bias lines to assume full muting potential of -145 volts. In the energized position, the zener circuit is grounded, providing -18 and -22 volts bias for the mixers and 829B grids respectively.

Supply voltages are brought in via a 12-prong male Cinch-Jones plug mounted on the chassis rear apron. Supply requirements include +800 Vdc, 150 mA; +300 Vdc; +275 mA; and 6.3 Vac, 6.5 A.

construction notes
My construction techniques are apparent in the photos. Three major structures...
are used; an L-shaped main chassis plate, a U-shaped rf shield for the final amplifier compartment, and a 1/8-inch-thick front panel. Rough dimensions are shown in fig. 2. Angular side supports can be added, as shown, to strengthen the assembly. Except for the front panel, all pieces are made from 0.05-inch-thick 5052-H34.

C1, C4  30-pF trimmer (Arco 461)
C2  25-pF butterfly variable (E. F. Johnson 167-22)
C3  140-pF air variable (Hammerlund HF-140)
C5  10-pF butterfly variable (E. F. Johnson 167-21)
C6  100-pF air variable (Hammerlund HF-100)
L1  5 turns no. 16, 7/16" diameter
L2  6 turns no. 16 each side of center, 5/8" diameter
L3  3 turns no. 10 each side of center, 15/16" diameter
L4  4 turns no. 14, 7/8" diameter
L5  2 turns no. 16, 1/2" diameter
L6  3 turns no. 12, 5/8" diameter, 11/2" long, center tapped
L7  2 turns 3/16" silver-plated tubing, 11/4" diameter, 1-1/8" long, center tapped
L8  1 turn loop around center of L7. Refer to photo for approximate size and position.

fig. 1. Schematic diagram of the 6- and 2-meter multimode transmitter.

aluminum. An aluminum angle, ½ x ½ inch, was drilled and tapped to form the fourth top surface edge of the rf shield compartment. I tailored the front panel to accommodate the assembly in a Heath "Seneca" cabinet, which I obtained from a surplus outlet. The knobs are from Heath.

Final amplifier components, panel meter, meter switch, and the bias supply transformer are mounted above deck inside the shield compartment. The control relay and voltage regulator tube sockets are mounted near the chassis rear center, outside the shield compartment.

The 829B sockets are E. F. Johnson type 122-105-100. The circular portions extend well below the chassis. Grid coils are suspended from the socket terminals with number 14 insulated solid wire leads. These are criss-crossed and extend up through ceramic wafer holes to form
neutralizing capacitors. The leads should run about one-half inch above the chassis surface. Capacitance is adjusted by bending the leads.

Link input coils, 1.5 kilohm grid resistors, and the bypass capacitors are suspended from a small terminal strip soldered directly to the base of each socket between pins 1 and 7. High voltage for the 829B tank is brought above deck with RG-58/U coaxial cable. Fahenstock spring clips, soldered directly to butterfly variable capacitors, provide 829B plate pin connection.

adjustment and operation

Reference 1 should be reviewed before attempting to set up this more complex system. If the printed-circuit subassemblies have been preadjusted, the remaining task is to stabilize the 829B stages and optimize their input coupling. Reference
fig. 2. Mechanical construction details of the 6- and 2-meter transmitter chassis.

to the ARRL Handbook will be helpful in obtaining correct adjustment.

First, apply heater power only. The appropriate heaters should light with the mode switch in each position. Next, check for -145 volts on the 829B grid and mixer-board lines. With the relay armature depressed, -22 and -18 volts respectively should appear on 829B grid and mixer lines.

**two-meter a-m adjustment**

Connect a 50-ohm dummy load to the 50-MHz output jack. Position the mode switch to "6 AM." With heater power and drive applied, the 829B stage can now be
neutralized. (A standard procedure is given in the ARRL Handbook.)

Apply 300- and 800-volt dc power. (It might be helpful to reduce the 800-volt power to 500 volts for this initial adjustment.) Adjust the controls for maximum power into the dummy load. This can be observed on the panel meter with the meter switch in the “6M OUTPUT” position. Peak trimmer capacitor C1 for maximum output indication on the meter.

two-meter a-m adjustment
Connect the 50-ohm dummy load to the 144-MHz output jack. Leave the 50-MHz exciter connected. Rotate the mode selector switch to the “2 AM” position and the meter switch to “2M OUTPUT.” Neutralize the 829B stage. Apply dc power and tune for maximum rf power into the dummy load. Alternately adjust capacitor C4 and the two-meter mixer board output capacitor (butterfly variable) for maximum 144-MHz output.

six- and two-meter adjustment
Connect suitable excitation to the low-frequency input jack. Rotate the mode switch to the “6 SSB” position. With the meter switched to read “6M OUTPUT,” gradually increase drive for 50-MHz output indication. Peak the 6-meter mixer-board output tank butterfly variable capacitor for maximum indication. Position the meter switch to read grid current, and increase drive until an indication of grid current is just apparent. This represents the maximum drive level at which maximum output will occur consistent with minimum distortion.

The unit is now adjusted for the “2M SSB” operating mode. Now rotate the mode switch to the extreme clockwise position, and adjust the controls for maximum output while observing the drive level.

final notes
It may be necessary to alter the value of the resistors in the output sampling circuit. Try different values near 27 kilohms until a good meter deflection is obtained at maximum output.

For a-m operation, tune for maximum output in the ssb mode first, then switch to the a-m mode position. The 50-MHz a-m input source must be attenuated to produce about one-half the ssb-mode output as indicated on the meter. Modulation up to 100 percent will then be amplified linearly. Peak envelope ssb output is about 50 watts, while output on a-m is about 12 watts on either band. Third-order distortion products on 144 MHz measure about 30 dB down.

reference
This instrument allows measurement of both resistive and reactive components of your antenna with the aid of the Smith chart.
placing a parallel-resonant tuned circuit across the load, as shown in fig. 2. By detuning this circuit from resonance, it's possible to introduce a controlled opposite reactance across the load and adjust the bridge to a perfect null. The reactive component of the load is measured by the direction and degree of this detuning. The equivalent circuit of the antenna therefore is represented by a resistance shunted by a reactance. Because these elements are in parallel, it's probably more accurate to regard this bridge as an admittance rather than an impedance bridge, and to perform any computations on that basis.

Two arms of the bridge are made up by the 100-ohm linear potentiometer. A third arm is a 51-ohm, half-watt carbon resistor, while the fourth arm is the load, shunted by the parallel-tuned circuit.

The variable capacitor should be at least 250 pF for most applications, while the switched coil sections (see photo) are merely sufficient in number that resonance on each band can be obtained on at least two settings of the selector switch. This provides for adjustment in either direction from resonance when a complex load is present.

A germanium rather than a silicon diode was selected because of its lower barrier potential. Although a 100-μA meter was used, its choice was dictated more by small size than current rating. For greater sensitivity, the 1.5k isolating resistor can be replaced by an rf choke.

calibration

No measuring device is better than its calibration. Many hams may feel they have too little precision equipment with which to calibrate a device of this type. However, a nice thing about this bridge is that the resistive and reactive controls can be calibrated separately. Before wiring the bridge, the resistive control can be calibrated against a purely resistive load. The resistive calibration can even be made with a couple of flashlight cells using the circuit of fig. 3. A handful of 100-ohm, half-watt resistors used in various combinations should provide sufficient useful calibration points. If you use as many resistors as possible (within reason of course) in these combinations, individual differences will tend to cancel.

Calibration of the capacitor is greatly simplified if you have access to a Q meter. Circuit capacitance, and the minimum capacitance of the variable capacitor itself can be ignored, as we are interested only in the incremental accuracy; i.e., the difference in capacitance between any two settings of the dial. A handful of silver-mica capacitors of known value can be used with a grid dipper for the calibration, ignoring any points that don’t lie on a smooth curve. A preliminary calibration by this substitution method was later repeated, using a precision decade-resistor box and a Q.
meter. The difference between the before-and-after measurements were well within 10%, which is a good working value around a ham station.

**measurement procedure**

A necessary device for this application is a reasonably well-matched 50-ohm load. A half-watt, 51-ohm resistor, mounted in a BNC connector performed quite well.

At a given frequency, the rf input to the bridge is first adjusted to produce full-scale deflection of the meter with the controls set at either extreme. The bridge is then balanced at this power level against the reference load, and the capacitor reading is recorded. The antenna is then substituted for the reference load, and the bridge is rebalanced. These resistive and capacitive readings are recorded, and the process repeated on other frequencies of interest.

To compute the equivalent antenna impedance, (or admittance) a table is set up as in table 1. For each frequency the setting of the capacitor that was obtained with the reference load in place is listed, then the resistive and capacitive readings with the antenna in the circuit. The two capacitive readings for each frequency are compared and their differences listed. The reactance, which must be computed for each frequency (represented by this differential capacitance) is then listed in the next column.

Normalized conductance and susceptance are next computed for a 50-ohm reference level by dividing 50 by the measured resistance and the computed reactance of the capacitive differential. If you’re using 70-ohm line, you should substitute 70 for 50; otherwise all procedures are the same. If the setting of the capacitor was reduced by substitution of the antenna for the reference load, the susceptance is positive (capacitive). If it was increased, the susceptance is negative (inductive).

These normalized admittances can now be plotted on a Smith chart, as in fig. 4, and successive frequency points connected by a smooth curve. This curve showed my quad to be resonant at about 21.15 MHz. As I normally operate ssb at about 21.35 MHz, the resonant point represented about 4 or 5 inches of wire in the length of the driven element.

To convert your admittance measurements to more familiar impedance values, all that’s necessary is to replot each point on the Smith chart at the same distance from the center of the chart, but located diametrically opposite the admittance.
points. When making this transformation, bear in mind that when we deal in admittances the equivalent circuit is a resistive and reactive element in parallel; while the equivalent circuit for impedance is a resistive and reactive element in series. To return to absolute values from the normalized quantities on the Smith chart, merely multiply the impedance components by 50 or 70, as the case may be.

fig. 4. Admittance plot of 21-MHz quad as measured through the 50-ohm coaxial line.

The distance of the plotted point from the center of the chart (fig. 4) indicated that the vswr at resonance, (the points closest to the center, in this case) is about 1.5.* Although this is a reasonable figure, the match can be improved in several ways. First, and most practical, is to replace the 50-ohm cable with 70-ohm cable. Second, the spacing between antenna reflector and driven element can be reduced until the antenna input impedance more closely approximates 50 ohms; and third, a matching network of some kind can be installed at the antenna end of the coaxial line.

Occasionally one hears of someone who trimmed the length of his coaxial line "to make it load." What probably happened was that the antenna was so badly mismatched that, coupled with an odd length of coaxial line, a shunt reactance appeared across the output network that was so large the network just couldn't compensate for it. Trimming the coaxial line didn't reduce the vswr, but it did reduce the reactive component to where the overworked matching network was finally able to handle the situation. If you're forced to this quick and dirty solution, at least the Smith chart will tell you exactly how much transmission line to remove. In fig. 4 it can be seen that moving the impedance plot about .092 wavelength nearer the load should remove most of the reactive component.

transmission-line length

A fair representation of what the antenna looks like to the feed line may be obtained by transferring each admittance (or impedance) point toward the load (counter clockwise) a distance equal to the electrical length of the feed line in wavelengths at each frequency. Each half-wavelength represents a complete revolution around the center of the Smith chart. This operation assumes the line to be lossless, frequently an optimistic assumption!

However for this move, the exact electrical length of the transmission line in wavelengths must be known. One method is to disconnect the center con-

*Because the circle through the resonant point intersects the R/Z₀ axis on the right-hand side of the chart at R/Z₀ = 1.5. Editor.
ductor at the antenna and grid-dip the line from the bottom end, coupling to a small one-turn coil. Above all don't trust the frequency calibration of the grid dipper, but check with a good wave-meter or calibrated receiver. If the transferred measurement points don't center on the scaled diameter of the Smith chart, your electrical length was inaccurate. Grid dip-sure the antenna looked like 100 ohms, for it could as well appear as 25 ohms to the 50-ohm cable. You'll therefore be able to tell in which direction the loading adjustment should be made.

Although this type of antenna measurement may seem to involve considerable pencil pushing, it results in much better than a ball-park estimate. Those

**ping to the odd harmonic nearest the operating frequency is probably best, but be sure you know which harmonic it is. The electrical length of the feed line is proportional to the frequency.**

**Conclusion**

Transferring the admittance or impedance data up to the business end of the feedline in this way will give you a piece of information otherwise hard to come by. Suppose, for example, an antenna shows a vswr of 2:1. You can't always be microvolts you're able to put into the other follow's receiver are expensive and hard to come by. It's nice to feel that you're getting everything possible from your installation because you did the job thoroughly, rather than settle for the too-frequent lick and a promise of which so many are often guilty.

**Reference**

HENRY RADIO PRESENTS THE BEST ANTENNA PACKAGES YET!

For three years Henry Radio has been providing a beam antenna-tower program for amateurs who wanted an efficient, but economical package. A package pre-engineered, pre-matched and pre-packaged to his requirements and pocketbook. Thousands have benefited from this offer in the past. And now Henry Radio has researched the field and updated the program... including the unique new tubular design Mini Mast for less expensive installations and the great new Magna Mast for the more deluxe installations. Now you can get the latest components at the same great savings.

HR—"Mini" Antenna Package
Tristao MM-35 "Mini-Mast" tubular tower — crank-up
CDR AR-22R Rotator
100 ft. RG-58A/U Coax
100 ft. 4 Cond. rotor cable
Complete with one of the following antennas:
Hy-Gain TH2MK3 ........ $240.00
Hy-Gain TH3JR ........ $240.00
Hy-Gain Hy-Quad ........ $255.00
Hy-Gain 203BA ........ $270.00
Hy-Gain TH3MK3 ........ $280.00
*MB-10 Free standing base, add $36.95
**TR-44 Rotator and cable, add $35.00

HR—"Standard" Antenna Package
Tristao CZ-454 crank-up tower w/mast
CDR TR-44 rotator
100 ft. RG-58A/U Coax
100 ft. Control cable
Complete with one of the following antennas:
Hy-Gain DB10-15A ........ $555.00
Hy-Gain Hy-Quad ........ $565.00
Hy-Gain 204BA ........ $590.00
Hy-Gain TH3MK3 ........ $590.00
Hy-Gain TH6DXX ........ $615.00
*Free-standing base, add $10.00
**Ham-M rotator, RG-8/U Coax, add $50.00

HR—"Magna" Antenna Package
MA-490 "Magna-Mast"
MAR-40 Rotor base
CDR Ham-M Rotator
100 ft. RG-8/U Coax
100 ft. Control cable
Complete with one of the following antennas:
Hy-Gain TH3MK3 ........ $735.00
Hy-Gain 204A ........ $735.00
Hy-Gain TH6DXX ........ $760.00
The Magna Mast is ideal for stacked arrays. Write for a quotation on the antenna of your choice.

Freight prepaid to your door in the Continental U.S.A. west of the Rockies. For shipment east of the Rockies add $10.00. Substitutions may be made... write for prices.

EASY FINANCING • 10% DOWN OR TRADE-IN DOWN • NO FINANCE CHARGE IF PAID IN 90 DAYS • GOOD RECONDITIONED EQUIPMENT • Nearly all makes and models. Our reconditioned equipment carries a 15 day trial, 90 day warranty and may be traded back within 90 days for full credit toward the purchase of NEW equipment. Write for bulletin. Export inquiries invited.

TED HENRY (W6UOU) BOB HENRY (WOARA) WALT HENRY (W6ZN)

Henry Radio
11240 W. Olympic Blvd., Los Angeles, Calif. 90064 213/477-6701
931 N. Euclid, Anaheim, Calif. 92801 714/772-9200
Butler, Missouri 64730 816/679-3127

"World's Largest Distributor of Amateur Radio Equipment"
neutralizing small-signal amplifiers

How to obtain maximum performance from preamps and converters

In most of the converters and preamplifiers built today the tubes or transistors are operated in the grounded-cathode or grounded-source configuration. Neutralization of the amplifier is necessary to compensate for the interelectrode capacitance in the tube or transistor. If not neutralized, this capacitance allows energy developed in the output circuit to be fed back to the input. The amplifier then acts as a tptg oscillator.

Amateurs unfamiliar with the theory of this phenomenon frequently encounter instability problems and find amplifiers hard to neutralize. This article provides basic data on neutralization and gives some hints on how to solve this problem. A properly neutralized amplifier will reward you with maximum gain and stability consistent with minimum noise figure, which is especially important at the higher frequencies.

gain measurement

Amplifier gain can be measured in the usual manner, from input to output. Gain in the reverse direction can be measured also, and should be zero or nearly so. Fig. 1 illustrates this concept.

The interelectrode capacitance in the amplifier allows a signal to be fed back from output to input. As the feedback capacitance is increased, the reverse gain also increases. Thus it is more important to neutralize amplifiers at the higher frequencies because of the decreasing capacitive reactance.

neutralizing methods

When neutralization is required over a small bandwidth (as in an i-f amplifier), a resonant system can be used. An inductor, L_n, is made to resonate with the interelectrode capacitance and any shunt capacitance existing in the circuit (fig. 2). The inductance value can be approximated by

$$L = \frac{1}{4\pi^2 f^2 C}$$

where f is the mid operating frequency, and C is the grid-plate or gate-drain capacitance of the tube or transistor. A large blocking capacitor, C, is inserted in series with the inductor to prevent shorting the supply voltage to ground through the input circuit. This blocking capacitance must be large enough to offer a negligible reactance at the operating frequency. Button capacitors are excellent because of their short lead length. Airwound inductors are preferred for the neutralization coil, because they have less stray capacitance than the slug-tuned type. The neutralization point may be found by using a tuning wand with a brass or iron slug at each end. Proximity of the iron slug increases the neutralizing coil inductance, requiring the coil
to be squeezed. Brass decreases the inductance, requiring the coil to be expanded to reach resonance.

At resonance the impedance of a parallel circuit is a resistance that is Q times the reactance of either the inductance or capacitance. Very high impedances can be developed by parallel resonance. Therefore, a higher-Q neutralization circuit will result in a larger isolation, as seen in fig. 3. As gain or bandwidth increases, the Q or impedance of the inductance must be improved to isolate the input and output circuits. Shunt capacity to ground must be avoided, which reduces the gain-bandwidth product.

Neutralization is necessary to reduce tuning interaction between input and output. Many amateurs simply tune the neutralization coil in the amplifier until the output circuit doesn’t affect the input. When the “blurps and squeals” disappear, neutralization is considered to be complete.

tube neutralization

When tubes are used, neutralization is simplified because the plate voltage is removed. The neutralizing coil is adjusted for a strong signal applied to the input. At the minimum output point, the coil resonates with the grid-plate capacitance, and circuit impedance is maximum. A simple neutralization procedure can be used, requiring a strong local signal to be fed to the input and a detector coupled to the output.

fet neutralization

Field effect transistors are being used more today because of their low noise figure, ability to accept large signals with small cross modulation, and low cost. Inside the fet is a capacitance, \( C_{RSS} \): the common-source, short-circuited, reverse-transfer capacitance. This capacitance between the gate and drain is a parallel combination of a voltage-sensitive depletion capacitance and lead capacitance. The behavior of the depletion capacitance is similar to the variable-capacitance effect obtained by reverse biasing semi-

fig. 1. Amplifier gain can be measured in forward or reverse direction. In the equation for power gain, \( R \) is the tuned-circuit impedance.

fig. 2. Neutralization scheme for an amplifier operating over a very narrow bandwidth or at a fixed frequency. This is known as the coil neutralizing method.

fig. 3. Impedance as a function of frequency with circuit Q as a parameter (parallel-resonant).
conductors.

Differing from the tube method, attempts to neutralize the fet by minimizing a signal applied to the input without the drain supply voltage applied will not work. The junction capacitance changes significantly when the supply voltage is applied.

Neutralizing with applied voltage

The following method can be used to neutralize a tube or fet amplifier with the supply voltage applied. An rf signal generator or sweep oscillator is coupled to the output circuit, as shown in Fig. 4. Generator level is increased until an output is noted by a sensitive detector or receiver connected to the input circuit. The neutralizing coil, L_n, is tuned for a minimum indication at the detector. The amplifier is "analyzed backwards" in this method, and reverse gain is measured. If a sweep generator is used, the oscilloscope presentation would resemble Fig. 5. A "suck out" will occur at the neutralized frequency, caused by the isolating high-impedance resonant circuit. The bandwidth of the "suck out" will be determined by the Q of the resonant neutralizing circuit and must be wide enough to cover the amplifying bandwidth of the amplifier in the forward direction.

Complete neutralization may still not be achieved if stray inductive or capacitive coupling exists within the amplifier components or extends to another stage. The answer to this problem is shielding or rearrangement of components. Proper bypassing, with short lead lengths, must be maintained to avoid oscillation.

With the mosfet semiconductor, any necessary neutralization is largely due to socket-lead capacitance. The feedback in the common-source configuration is less than that in a vacuum tube in the grounded-grid mode. You might get by without neutralization and still have a stable amplifier, but the noise figure and gain will be improved with it. Once tried, it is a simple procedure.

References

2. Ibid., p. 415.
MXX-1 Transistor
RF Mixer $3.50
A single tuned circuit intended for signal conversion in the 3 to 170 MHz range. Harmonics of the OX oscillator are used for injection in the 60 to 170 MHz range.
Lo Kit 3 to 20 MHz
Hi Kit 20 to 170 MHz
(Specify when ordering)

SAX-1 Transistor
RF Amplifier $3.50
A small signal amplifier to drive MXX-1 mixer. Single tuned input and link output.
Lo Kit 3 to 20 MHz
Hi Kit 20 to 170 MHz
(Specify when ordering)

PAX-1 Transistor RF Power Amplifier $3.75
A single tuned output amplifier designed to follow the OX oscillator. Outputs up to 200 mw, depending on the frequency and voltage. Amplifier can be amplitude modulated. Frequency 3,000 to 30,000 KHz.

BAX-1 Broadband Amplifier $3.75
General purpose unit which may be used as a tuned or untuned amplifier in RF and audio applications 20 Hz to 150 MHz. Provides 6 to 30 db gain. Ideal for SWL, Experimenter or Amateur.

For The Experimenter!
International EX Crystal & EX Kits
OSCILLATOR / RF MIXER / RF AMPLIFIER / POWER AMPLIFIER

Type EX Crystal
Available from 3,000 to 60,000 KHz. Supplied only in HC 6/U holder. Calibration is ±.02% when operated in International OX circuit or its equivalent. (Specify frequency)
$3.95

OX Oscillator
Crystal controlled transistor type. Lo Kit 3,000 to 19,999 KHz
Hi Kit 20,000 to 60,000 KHz
(Specify when ordering)
$2.95

Write for complete catalog.

INTERNATIONAL CRYSTAL MFG. CO., INC.
10 NO LEE • OKLA. CITY, OKLA. 73102

september 1970
One evening at the home of Stan Dixon, VK3TE, several of the VK3 gang were chatting about things of general interest when Harold Hepburn, VK3AFQ, mentioned that dials for accurate frequency indication were difficult to obtain in Australia. He was building a two-meter receiver using a 10–10.5-MHz vfo and wanted something reasonably accurate for frequency readout. He asked about the possibility of using a built-in electronic counter for the vfo that would indicate frequency directly.

This set me thinking about the problem. After considering the many angles, I concluded that this would be a feasible project, using inexpensive digital ICs. This was before any details of the signal/one receiver were available, which uses a digital dial readout that gives calibration accuracy of 100 Hz on each band.

conversion-frequency correction

All equipment won’t necessarily have the convenient vfo range that VK3AFQ had in mind, but may begin at some odd frequency. Furthermore, heterodyne conversion oscillators will have some error (unless they’re adjusted to exact frequency), which will be part of the readout.
This error may be different for different bands. Computer techniques could be used to remember the error and add or subtract the correction for the conversion frequency for each band, but a much simpler method is at hand.

If the bandswitch is provided with suitable contacts, the flip-flops in the frequency counter can be preset so that the counter will show the correct happening at the right time.

Some vfo's may tune up on some bands and down on others. This sounds like the last word in complexity for an electronic counter dial, but it's not impossible. By using gates that switch the circuit to count up or down, a single external contact can make the counter go either way. Several such circuits appear in references 2 and 3.

**fig. 1. A decade divider that counts down instead of up. Gating is such that, on leaving zero state, the circuit returns to the 9 state directly by inhibiting the B flip-flops and causing the D flip-flop to toggle during this condition only.**

frequency at the end of the dial. It would be necessary only to note the readout at the end of the tuning range, then wire the preset terminals of the counter ICs so that the additional count at the end-of-band vfo frequency would set the indicator to zero (000.0 kHz).

**backward vfo's**

Many vfo's tune backward: the highest vfo frequency is the lowest receiver frequency. Most counters count up, not down. It would be useful to avoid a computer subtraction process. Motorola's Application Note AN-251 states, "... a ripple counter will count down when the complemented output from one stage drives the clock input of the following stage..." Motorola's circuit showing how this is done is reproduced in fig. 1. Four NOR gates are added to keep events

**time-base generator**

A time-base generator will be required, as in other counters. If you would like to have an accurate frequency standard it would be worthwhile to combine functions and use this accurate base for the electronic counter dial as well. However, if you wish to settle for a dial that displays only four digits (three for integral kHz and one for tenths of a kHz), some inaccuracy can be accepted. Two decades of the counter won't have any readout. You could use the 60-Hz power-line frequency to generate the time base. The time-base generator may require only four dual JK flip-flops for a one-second count. Hewlett-Packard, in the instruction book for their little four-digit counter, states that an accuracy of 0.02 percent or better is expected from the use of the power frequency for
gating.

I have completed experimental work using the power-line frequency for gating. A report on this will be in a forthcoming article. It confirms that the inaccuracies, which are within 0.02 percent, will not affect a counter dial with two digits not displayed. It appears that you may expect an error of one or two counts (tenths of a kHz) occasionally in a four-digit dial indicator readout that displays kHz and tenths of a kHz in four digits. This should be good enough for tuning indicators.

display methods

It's possible to count vfo frequency, store the count, and display only the last completed count until it must be changed. (See the data on the Fairchild CL 9959 buffer-storage element and the CL 9960 decimal-decoder driver.) The count can remain unchanged until some later count requires the readout indicator to change to a new frequency. However, although storage, decoding, and lamp-driver ICs are available, we can get along with something even simpler.

Let's say we can use some of the available percent error to reduce the count period to 0.1 second rather than the more common 1-second interval. Without storing, or blanking the indicator during the count, we would then have 0.1 second during which the indicator runs through a count and gives no clear indication of frequency. This can be followed by nearly 0.9 second during which an unchanged frequency is displayed, even when the dial is being turned.

This action can be accomplished by using some of the ICs to produce a 0.1-second gating input, the total 1-second display period, and a preset signal before the start of the next count. As indicated earlier, this can preset the combined heterodyning frequencies for one end of the tuning dial, so that when the vfo frequency is counted at this point, the indicator will show 000.0 kHz.

The indicator can be any of the several types of digital displays. The less-expensive displays, such as the gas-filled National Electronics NL-950 shown in the Newark and Allied catalogs, cost about $6.25 per digit, or $25.00 for the entire four-digit display. For those who are satisfied with the binary-digital combination and are willing to read each digit in an 8-4-2-1 combination using four lamps, a somewhat lower cost is possible.

conclusion

Now let's see what we have. Inside our set will be a PC board about 4 by 6 inches, plus some space for the decoding gates or lamp-driver transistors. The vfo bandswitch will have contacts that preset the counter ICs to the correct frequency for the end of the vfo tuning range.

Outside, the unit will have a suitable knob with a convenient tuning ratio, but no associated indicator. Above it will be either four indicating gas-filled tubes or four rows of four lamps each for binary readout.

When the unit is turned on, the error or drift in the crystal-controlled heterodyne conversion oscillator won't be corrected in the tuning readout, but vfo error will be. If the knob is turned rapidly, the indicator will show an approximate frequency at 1-second intervals, thus lagging a bit behind a rapidly turned knob. When the knob rests for about a second, however, the readout will show the frequency to an accuracy close to 0.1 kHz.

references
NRCI’s NCX-1000
the Transceiver of the 70’s

1 KW Solid-State Transceiver

AGAIN — AND AGAIN — AND AGAIN

WRITE FOR COMPLETE DETAILS

NATIONAL RADIO COMPANY, INC.
111 Washington Street, Melrose, Mass. 02176
617-662-7700

september 1970
solid-state
audio
oscillator-monitor

Prompted by a recent article in *ham radio*, I fulfilled a long-time desire to design an audio oscillator that works with digital integrated circuit supply voltages, produces a clean sine wave at 1 kHz, drives a speaker, and is inexpensive and easy to build. The result is described in the following paragraphs.

circuit description

A minimum number of components is used in an efficient sine-wave oscillator circuit (fig. 2). Transistors Q1 and Q2 form a high input and low output impedance amplifier, a feature of operational amplifiers. A "basic isolated integrator network" is inserted between input and output. The circuit can be made to

fig. 1. Optional circuit for volume control.

N. J. Nicosia, WA1JSM, 85 North Street, North Reading, Massachusetts 01864

48 september 1970
oscillate at the frequency determined by the network constants by omitting a resistor between the base of Q1 and ground. Slight adjustment in frequency can be prevented from heating up by adding more resistance in series with the speaker. I don’t use a volume control, since the level of my unit is perfect for my needs.

fig. 2. Schematic of the 1-kHz audio oscillator. Output frequency is determined by integrator circuit between Q1 and Q2.

requirements. However, if one is desired, see fig. 1.

**power supply**

With a 4-volt supply and key down, the total power drain is 35 mA. For a power supply you can use three D cells in series or obtain 3.6 to 5 volts from your electronic keyer. A simple power supply is shown in fig. 3.

Logic levels of 4 to 0.6 volts are commonly encountered with keyers. I would be interested in hearing how the circuit can be tied into the many keyers described in the amateur literature.

**references**

GOOD NEWS FOR CANADIAN AND LATIN AMERICAN HAMS...

Now you can enjoy the fabulous Varitronics line of amateur VHF FM equipment too!

Like the IC-2F . . .

completely solid state,
2 meter FM transceiver,
20 watts, 6 channels
with a super hot receiver

And other transceivers and accessories, too.

Get full particulars on the equipment that has swept the U.S. For your nearest distributor write . . .

CANADA
Marathon Agencies, Inc.
4105 11th Street S.E.
Calgary 24, Alberta

LATIN AMERICA
Carvill International Corp.
P.O. Box 4039
Foster City, California 94404

UNITED STATES
See your local distributor
or

VARITRONICS INCORPORATED
2321 E. University Drive
P.O. Box 20665
Phoenix, Arizona 85036
nomograph for reactance problems

An easy-to-use computational tool that lets you solve complex inductive and capacitive reactance problems without mathematics

Nomographs are aids for quickly solving many electronic circuit problems. A straight-edge placed across appropriate scales allows you to solve equations without using a slide rule or pencil and paper.

The nomograph in fig. 1 can be used to solve reactance problems when one quantity is unknown and two are known. Chart A is used to determine magnitude and decimal-point location. The significant figures are determined from chart B.

practical example

Suppose you’re interested in a circuit such as that shown in fig. 2. It’s a Q-multiplier that can be added to your strip for increased selectivity. Let’s say you have an inductance of fairly high Q whose value is 5 mH. You’d like the circuit to resonate at 1 kHz; what value capacitor should you use in the op amp feedback circuit?

You could determine the capacitor’s value by well-known mathematical formulas, but the nomograph of fig. 1 will provide the answer much quicker. Here’s how it’s done.

In fig. 1A, a line is drawn between the two known values: 5 mH and 1 kHz. This is labeled 1 in fig. 1A. The intercept of line 1 on the $X_L$ scale of fig. 1A shows the inductive reactance of this combination to be somewhere between 10 and 100 ohms.

Moving to fig. 1B, a line is drawn between 5 on the L scale and 1 at the top of the F scale. This location of line 2 was

*Used by permission of C.M. Marcott, editor, Electronic Products Magazine, United Technical Publications, New York.

Alf Wilson, W6NIF, 3928 Alameda Drive, San Diego, California 92103

September 1970 51
purely arbitrary; the line, in this case, could just as easily have been drawn between 5 on the L scale and the bottom of 1 on the F scale.

The intercept of line 2 on the $X_L$ scale of fig. 1B is what's important. It intercepts the $X_L$ scale at approximately 3.2. This is the significant figure, or decimal multiplier, for the value determined from fig. 1A. The inductive reactance is therefore 10 (from fig. 1A) multiplied by 3.2, or 32 ohms.

determining capacitance

Returning to fig. 1A, a line is shown between 1 kHz on the F scale and 32 ohms on the $X_C$ scale. This is labeled 3 in fig. 1A. Line 3 intercepts the C scale at 5 $\mu$F, which is the desired capacitance for C1 of fig. 2.

An inductive reactance of 32 ohms is used to find C1's capacitance, because basic theory says that resonance in a tuned circuit requires that $X_C$ equal $X_L$. This is the principle behind the calculations shown here. The nomograph can be used to solve other reactance problems as well.

useful hints

When working with nomographs, the accuracy of the final result will depend
fig. 1B. Reactance nomograph. This chart is used to find significant figures after magnitude and decimal location have been determined from fig. 1A.

fig. 2. Basic Q-multiplier circuit using an operational amplifier. Desired resonant frequency is 1 kHz. With $L = 5 \text{ mH}$, value of $C_1$ is easily determined from nomograph in fig. 1.

on how accurately you draw the connecting lines between the unknowns. Many nomographs give you a "ballpark" answer. If you wish to refine the result, you'll have to use mathematics. If used with care, a nomograph is a great time saver and can provide answers with accuracy sufficient for most practical problems.

A sharp pencil or draftsman's dividers should be used to locate the end points of the two unknown variables. Lay a straight edge against one leg of the dividers and rotate the straight edge until you pick up the other point. Read the value at the intercept and mark it down on a piece of scratch paper. This will avoid cluttering the nomograph, which can then be used indefinitely as a computational tool.

Ham Radio
Parasitic oscillations in high-power transistor rf amplifiers

More than one design engineer has gained a few grey hairs trying to clean up the output of his 50- or 100-watt transistor transmitter. The reason is parasitic output frequencies, which were not mentioned by the textbooks and which may have been included in the output-power rating by the transistor manufacturer.

The subject of parasitic output has been avoided whenever possible by device salesmen, but in reality it's the one big reason why transistor transmitters aren't found in great profusion. Transistor parasitics are unlike tube oscillations, and the best solution to the problem is still to be found.

Transistor parasitic oscillations

There are three types of transistor parasitics. The first is the free-running type. This may be due to tuned or semituned circuits that self-oscillate at frequencies unrelated to the amplifier driving frequencies. The solution is the same as in tube design; that is, the problem circuit is reduced in Q or detuned. The second and third types of parasitics are much more insidious and difficult to eliminate.

The second type is due to the parametrically pumped characteristics of the transistor and is produced as submultiple frequencies of the amplifier driving frequency. These are very difficult to detect, as they are exactly locked to the drive frequency and are normally outside the range usually checked for spurious response.

The third type is low-frequency noise amplification, due again to parametric pumping. The low-frequency noise is not harmonically related to the amplifier drive frequency, but may be of either the so-called 1/f origin or from any low-frequency circuit that can be pumped into oscillation. This type of parasitic may be noticed as a rough-sounding spurious signal in the vicinity of the desired signal, or as white noise centered symmetrically around the desired frequency. If type 3 occurs it is low in frequency, but it will modulate the desired signal in the same way as any modulator, except with highly undesirable results.

The last two types may be detected indirectly by sudden increases in power output, or as changes in collector current while tuning. Because most people tune for maximum output as indicated by a power meter, most likely these spurious frequencies will be maximized.

Stabilization methods

Despite the fact that it has often been advocated, detuning the amplifier is no
solution to the problem. The real solution is to prevent the occurrence of the parasitic under any condition. To date this has not been possible, but several techniques will make rf amplifiers reason-
ably stable. One method, recommended widely, is to prevent low-frequency response in the amplifier by using very small values of inductance in the base return and collector dc feed. Fig. 1 is an example. A problem occurs when the frequency is reduced in that the chokes must be larger, and often the expected result happens; that is, parasitics.
Tube-type neutralization networks are generally ineffective. The reason is that the transistor capacitance vary at an rf rate, while the neutralization components are constant. A method I've found useful is to suppress low-frequency gain by resistive feedback (fig. 2). The cost is a small amount of lost rf gain (perhaps 1 dB) and a somewhat increased dc-circuit current. The thing to remember is not to bias the transistor full-on in the quest for feedback. The result in a noncurrent-limited circuit is the immediate burnout of the transistor—a very costly fuse!
Summarizing, at least three types of rf transistor parasitics occur. These often go unnoticed, because they're not at expected frequencies and are sometimes produced in ways foreign to tube engineers. So far, techniques for parasitic reduction leave much to be desired as they are brute-force methods rather than elegant solutions to the problem. Clean, high-power rf amplifiers are a possible but ticklish proposition and await some yet undiscovered technique to produce optimum results.

**fig. 1.** This is the brute-force method of stabilization, where pumped frequencies are swamped by shorting out low-frequency power. Values shown are for 150 MHz. Components marked with an asterisk are used to stabilize the amplifier.

**fig. 2.** A 160-meter stabilized amplifier using various methods of reducing types 2 and 3 pumped parasitics. Components marked with an asterisk are used to stabilize the amplifier.

---

**bibliography**

cw transceiver operation with transmit-receive offset

It's easier to operate cw with a slight frequency offset between direct-conversion transceivers—here's why

Recently while playing with a design for a direct-conversion cw transceiver, I had some thoughts about the significance of transmitting and receiving on slightly different frequencies, as this design requires. No one seems to have given this idea much thought, although many apparently operate this way all the time. My first reaction was that there might be some situations in which the offset would cause real problems—for example, two identical transceivers trying to talk and getting nowhere because one of them was tuned to the wrong side of zero beat.

My conclusion is just the opposite. The offset adds no new problems to the operation of the transceiver. In fact, if the transceivers are identical (and the offsets the same) it’s easier to operate with the offset than without it.

First, the frequency offset occurs in a direct-conversion transceiver (fig. 1) because the vfo must be offset from the received signal frequency to produce an audio beat note. Since the transmitted signal is just the vfo output amplified, the transmit and receive signals are different by the frequency of the beat note. Fig. 2 shows a response curve of a cw direct conversion transceiver (dct) and how two other dcts might communicate with it.

In fig. 2, the rf response curve has the form of the audio filter plus its mirror image. The mirror image occurs because signals are audible on either side of zero beat. Stations anywhere under the curve can be heard. In looking for a contact transceiver one, say, tunes for a signal above zero beat and responds. The home rig will hear him at f<sub>2</sub>. Transceiver two tunes for a signal below zero beat, home hears him at f<sub>3</sub>. Communication is possible in either case. Note that the beat frequency, although different in the two cases, is the same between pairs of stations. When home and station one talk, they both will have a beat frequency of f<sub>b1</sub>; when home and two talk, it will be f<sub>b2</sub>. This requirement for a common beat frequency may be disconcerting to operators whose ears peak at different frequencies, but it doesn’t prevent contact from being made.

Operating with another station that’s not a transceiver is just as simple and proceeds as above, except that now each station can choose a favorite beat note because of the bfo control at the non-transceiver station.

calling CQ

In answering a CQ with a transceiver the home station does not zero beat, because he can’t hear the calling station.

The home station must tune the calling station to one side or the other of
zero beat. The choice will probably be made on the basis of least interference. If the other station is also a transceiver, communication will automatically be established. If the other station is not a transceiver, the offset probably won’t be noticed as he tunes for replies.

In calling CQ with a transceiver, however, the replying station, if not a transceiver, will probably zero beat the transceiver carrier. The transceiver would then have to be retuned to hear the reply. On the second go-round the replying station might think the transceiver has drifted (it has, of course), but as long as the replying operator retunes only his receiver and leaves his vfo alone, communication will be established on the second try, and no further retuning would be necessary.

If the transceiver were retuned to reply to a crystal-controlled station, no contact would be made. This is, of course, the same thing that would happen with an ssb transceiver. The solution is to listen around your own frequency and wait for people to come to you, as is done on ssb.

So the offset need not be a problem. At least it should be no more of a problem than the inability to listen on any frequency but one’s own, which is the characteristic of any transceiver.

What about audio selectivity?

Surely, the wide-open bandpass shown in fig. 2 is unsuitable in today’s conditions. Audio peaking can improve receive selectivity, but this introduces a problem (fig. 3). Here, both the home station and station one have added audio selectivity, but at different frequencies. The home station is peaked at $f_{b2}$; station one is peaked at $f_{b1}$. Let’s say station one is calling CQ and the home station hears him, tunes him to his audio peak, and replies. But home station’s transmitting frequency is outside station one’s audio peak and, therefore, may not be heard. Avoiding this situation requires either opening the bandwidth of both transceivers, or standardizing the offset between them.

I recommend offset standardization by means of identical peaked audio filters at
the two transceivers. Not only is improved selectivity achieved, but a system advantage is gained as well. Tuning is simpler. Once home tunes the incoming signal to his audio peak, communication is optimized, because the signal transmitted from the home station will be at the audio peak of the other transceiver. One envisions highly selective transceivers with but one frequency control, which is attractive.

**bandwidth considerations**

The best shape for the peaked bandpass requires careful consideration. A sharp peak is desirable from the standpoint of both offset standardization and selectivity. It would be undesirable to have too accented a peak, however, as it would be hard to hear stations with offsets different from your own. Possibly 6–8 dB would be a good number for the peak above the low-frequency response level (fig. 4). An optimum width might be a few-hundred Hz at the 6-dB points. An ability to hear stations below the peak (nearer zero beat) is desirable, so that stations which tried to zero beat your carrier would be audible. This would make the direct-conversion transceiver a good performer when working all kinds of rigs—not just when working other transceivers.

It's entirely possible to build a direct-conversion transceiver using phasing techniques that would provide true single-signal reception with a response on only one side of zero beat. It would look much like the direct-conversion ssb receiver I described in reference 1. I don't believe there is any advantage to doing this, however, because the sideband that the single-signal receiver ignores may well be the one on which the responding station replies. If such transceivers became common, it would be necessary to designate which sideband was to be used on each cw band to ensure that the transceivers would communicate. The dsb version; i.e., with response on both sides of zero beat, seems the best choice, at least at present.

**conclusions**

1. Transmit-receive frequency offset is not a hindrance to cw communication, whether between two transceivers or a transceiver and regular stations.

2. Frequency offset standardization is required if good cw selectivity is to be obtained.

3. This standardization is best achieved by means of a standard peaked filter response to be used in all cw transceivers.

Maybe the cw dct would be the thing to get a lot of us back on the cw bands. Certainly the simplicity is attractive.

**reference**

AMATEUR RADIO TECHNIQUES
J. Pat Hawker, G3VA

Do you have the time to review all the dozens of amateur and commercial magazines which are brought out each month to collect the best of their many good new ideas. Here it has already been done for you in this very complete collection of material taken from a number of periodicals. It is presented in a most useful and well organized manner.

Chapter headings include Semi-conductors, Receivers, Transmitters, Oscillators, Antennas, Power Supplies and Test Equipment.

Many added pages and a new improved binding make this a most appealing book.
finding faults in rf and i-f amplifiers

What do you do if you can only pick up nearby or strong stations? What if they come in weak and perhaps noisy? First thing you should do is suspect the rf amplifiers in your receiver.

This isn't unusual, particularly with transistor front ends. If the manufacturer (or you, if the receiver is homebrew) designed the rf amp to use the sensitive but delicate field-effect transistor, a gate punctured by static surge isn't at all uncommon.

The problem lies in recognizing a bad front end. If the mixer and i-f stages are naturally quiet, and transistor stages often are, you may not know an i-f failure from an rf one. Or the fault may be in the automatic gain control (agc) system. Only careful testing will tell you for sure.

amplification vs noise

Familiarity with your receiver is the best assurance of knowing when there really is trouble. You should get to know how much natural receiver noise to expect when there's no station.

Then, when suddenly you can't pick up stations you know should be there, make a listening test. Tune the receiver dial to an empty spot. Turn rf and af gain up.

Is receiver noise (the background thermal hiss) up to snuff? If so, the i-f stage must be amplifying. Also, the mixer stage is probably okay; much front-end thermal noise normally originates there.

Yet, some of today's field-effect transistor (fet) front ends are too quiet for this kind of analysis. It's normal to hear almost no receiver hiss. You have no choice then but to rely on other testing methods. You try to determine rf-stage sensitivity. Or, you can just test the stage by regular dc-measurement methods.

what's in a rf stage

Most of what I say about troubleshooting rf stages can be applied to i-f stages, too. There's little difference.

In most a-m receivers, rf stages tune over several different bands. The i-f stages are fixed-tuned. But it's common to tune ssb receivers nowadays by synthesis—the same as the transmitter. In that case, the receiver rf stages are fixed-tuned. You troubleshoot them the same as i-f stages.

A typical old-fashioned tube-type rf stage is drawn in fig. 1. Only one deck of the bandswitch is shown; the input band coils are omitted for simplicity.

Most hams can figure out a way to track down trouble if they are sure what a stage is supposed to do. I don't mean in just a general way, but specifically—each part of the stage. Take the stage in fig. 1 for an example.

First and foremost are the input and output circuits. T1 and C2 are the input
coupling components. R1 is the input load, decoupled by C3. Ordinary signal tracing or injection is the way to make sure these components work.

The output circuit is T2, decoupled by C7. Those decoupling components are an important part of the input and output circuits, so don’t forget them when you analyze stage operation.

There are also tuned circuits to contend with, although part of them are not shown in Fig. 1. T1 and C1 make a tuned circuit. But they are in parallel with band coils you can’t see. The band coils, with the inductance of T1, set the band the stage is to tune across and C1 tunes the specific frequency. If there’s a fault in one of these coils, that band won’t tune properly. If the fault is in T1 or C1, none of the bands tune as they should.

Next, consider the supply circuits. They carry dc voltage to the tube elements.

The plate supply is through R6 and the primary of T2. Capacitor C7 is important in the plate dc supply circuit only because of the possibility it might short. You therefore must consider it part of the plate supply circuit when you’re diagnosing.

Resistors R4 and R5 are the chief components of the screen supply circuit. C6 is a potential part of it—if the capacitor happens to become leaky or shorted. Leakage in C6 would put voltage intended for the screen onto the cathode. Consider that possibility when you analyze the screen or cathode dc circuit.

The cathode dc circuit, which can be considered dc supply even though it’s just a ground return, is through R2 and R3. C4 or C5 can become part of this circuit if either happens to short. Otherwise, they don’t affect cathode dc voltage.

Notice that R3 is variable. It’s the rf gain control for the receiver. (In the receiver from which this example is taken, R3 also is part of the i-f stages.

That connection is omitted here for simplicity.) Changing the value of R3 between R2 and ground varies cathode bias on the tube. The pentode is a sharp-cutoff type; its gain depends sharply on its bias. Thus, by changing bias, R3 controls rf amplification.

Voltage at the grid is controlled from the agc stage. The agc control voltage is fed through R1. Decoupling capacitor C3 is part of the grid-supply circuit only if it shorts or gets leaky. C2 and C3 might become part of that circuit if either went bad.

There’s another resonant circuit. It isn’t tunable. It may also be called a trap circuit, because that’s what it’s there for. L1 and C3 form it, and it’s resonant to 9 MHz, the i-f of this receiver. It traps out any stray 9-MHz signals, preventing them from being amplified and running through the mixer to upset the i-f stages.

That about sums up the circuits in this rf stage. Input, output, tuning, bypass or decoupling, and trap: those are the signal-carrying circuits. Plate supply, screen
supply, cathode return, and grid bias: those are the dc-carrying circuits. You have to consider each when you set about troubleshooting an rf stage like this one.

**transistor rf stages**

The transistor input stage from one receiver is drawn in fig. 2. You can probably identify the circuits. They may look a bit different from those in fig. 1 because they’re in a transistor stage.

The input circuit comprises L1, C1, C2, and both R1 and R2 as load resistors. Decoupling for the two resistors isn’t in the diagram, but it’s understood. The agc line has a bypass capacitor not shown; so

does the 12-volt supply.

L1 and C1 are fixed-tuned, although adjustable with a tuning tool. They form a broadband tuned circuit. (This particular rf stage is part of a one-band transceiver.) The taps on L1 are for impedance matching.

The output circuit comprises L2, C4, R5, and C5. L2-C4 are a tuned tank, with R5 as a band-broadening load across it. L2 is adjustable for band-peaking. C5 couples amplified rf energy to the mixer stage (through another tuned circuit, omitted for simplicity).

The only other signal circuit is emitter bypass capacitor C3. If it opens, substantial degeneration can occur, but it only makes the stage weak—it doesn’t make it dead.

There are only three dc supply circuits. That’s because a transistor has only three elements to receive voltage.

The transistor is pnp. Therefore, normal forward-bias operation puts the emitter positive, the base less positive (same as more negative than emitter), and the collector far less positive (same as far negative from the emitter).

The emitter gets voltage directly from a positive 12-volt supply line through R4. C3 is the decoupling capacitor, and is a concern to the dc circuit only if it shorts or gets leaky.

Collector goes to ground through L2. The winding has no appreciable dc resistance, so for dc the collector is grounded. That puts it far negative with respect to emitter.

The base has the only complicated supply network. The main dc comes from the 12-volt line through R1. However, a connection through R2 lets the actual voltage—and therefore bias on the transistor—be varied by the agc line and by the setting of rf gain control R3. The transistor operating characteristic is such that bias controls amplification. Thus the rf gain control sets optimum gain of the stage, and agc varies it to accommodate signal strength.

Of course, C2 is part of the base dc circuit only if it comes defective. A faulty decoupling capacitor in the agc line could also affect base bias. You need remember these capacitors only if you’re troubleshooting and find the base voltage is wrong.

**external influences**

One other thing you can’t forget when...
you’re troubleshooting rf and i-f stages. A trouble in the stage may be caused somewhere else.

A blocked i-f or rf stage is common. Sometimes, that’s traced to an agc stage overdoing its bias thing. Or, the i-f or rf amp may block on strong signals—a sign of overload. That, too, may be traceable to a faulty agc stage—this time not doing enough.

The receiver block diagram is sometimes helpful in spotting stages that affect rf or i-f. Some don’t show that much detail and you have to rely on your ability to read the schematic. Fig. 3 is a partial block diagram of the set from working right is to measure its gain. In modern transistor receivers you can expect to find a voltage-gain factor of 20 or more. A tube stage usually gives even higher gain.

You can make this measurement fairly easily if the output of your rf generator is calibrated. First, clamp the agc line with whatever dc voltage produces normal idling (no-signal) bias on the rf or i-f-stage you’re testing. That bias is usually written on the schematic or on the voltage chart.

Clip your vtvm to the a-m detector output, or through an rf probe to the output of the last i-f amp. Feed the generator signal to the input of the rf or i-f stage being measured. Note the dc meter reading. Set the generator output level for some meter reading that’s easy to remember. Make a note of the rf output level of the generator.

Move the generator signal to the output of the stage being tested. Turn up the generator level until the meter reads the same as before. Divide the new generator output-level reading by the earlier one. The result is the voltage gain of the stage.

As an example, suppose 0.7 microvolt of signal drives the meter to 1 volt dc when the generator is connected to the stage input. When you connect the generator to the stage output, you have to turn the generator up to 14 microvolts to get the

fig. 3. Relationships between rf or i-f amplifiers and other stages are often shown by block diagram. If not detailed enough, look for connections on the schematic.
that 1-volt dc reading on the meter. Dividing 14 by 0.7 gives 20. That’s the voltage gain of the stage.

Unfortunately, only the more costly signal generators have calibrated output. You may have to use a less accurate way. It’s only relative, and your best bet for using it is to make measurements while your receiver is working normally and record them for reference.

You’ll need a doubler-type rf probe for your vtvm. A suitable circuit is sketched in fig. 4. It’s more sensitive than the ordinary single-diode probe. The vtvm should be a very sensitive one, with lowest full-scale reading 1.5 volts or less.

Again, clamp the agc. Turn the rf gain control wide open. Keep the generator tuning the coil wide open. Keep the generator output for some very small but definite voltage indication—say 0.01 volt. Don’t change the generator setting.

Move the vtvm probe to the base of the mixer. The reading should be much higher now—say nearly 0.2 volt dc. That represents a gain of about 20 if you’re using the doubler probe.

Obviously, these figures are approximate. Voltage gain for a tube is roughly the same. For tubes or transistors, however, the surest system is to make a record of normal amplification while your receiver is new. Then use the same measurement method when you test on the repair bench.

dc troubleshooting

You should already know the methods of tracking down the cause of incorrect dc voltages on an rf stage. You might want to make dc tests before you go to the trouble of putting the rf probe on your vtvm.

But usually you’ll find that kind of fault is obvious—as when the stage is completely dead. It’s for subtle weakness or abnormal overloading you need to clamp the agc and test stage gain. Then you can hunt down the small voltage problem—or bad transistor or tube—that’s causing the trouble.

checking the stage another way

You can also use a form of signal injection. Connect the vtvm, without a probe, to the a-m detector of the receiver. If it’s handier, keep the probe on the vtvm and connect it to the i-f input of the product detector (or at the output of the last i-f amp). Clamp the agc as before.

Connect the rf signal generator, tuned to the rf frequency as already described, to the input of the mixer stage. Turn up the generator output just enough to cause a reading on the meter. Make a note of the reading.

Move the generator back to the input of the rf stage. Note the increase in the reading. The dc-voltage increase should be about the same as the one already described. Without the doubler probe, a 10-times increase means about 20 gain in the rf stage. With a doubler probe instead of the set’s a-m detector, a 20-times increase means roughly 20 gain in the rf stage.

Now go a step further. Be sure you’ve got the generator frequency set precisely. Try tuning the coils in the tuned circuits. If the meter reading doesn’t vary, the coils may be at fault. Before you replace

---

fig. 4. Circuit for a voltage-doubling probe you can use with a vtvm to measure relative rf signal levels in rf and i-f stages. Entire probe should be shielded to prevent hand capacitance from upsetting the reading.
them, though, make sure the capacitor that decouples each coil is not open.

Finally, if tuning is erratic and you can't seem to make head nor tails of how the coils tune, check the bypass capacitors on the supply lines and on the agc line. One of them may be open.

looking to the future

Remember that the ways of checking rf stages outlined here can be used just as well with i-f stages.

There's still another way of troubleshooting rf and i-f stages: with sweep alignment. Unfortunately, no inexpensive sweep generator available today goes down far enough in frequency.

In a future column I'm going to show you how to make your regular sweep generator go down far enough to sweep 60-kHz, 455-kHz, and other i-f amps. You can do it without modifying the instrument you have.

First, though, there's a new troubleshooting system that has come to my attention. It's called 1-2-3-4 Servicing by its originator, Forest H. Belt. In the next issue of repair bench, I'll tell you what 1-2-3-4 Servicing is all about. That'll prepare you to understand what goes on when you use the sweep-alignment method of rf and i-f troubleshooting.

ham radio

"Don't ever let it slip to my wife that field day isn't the second and fourth Saturday of every month ..."
protection for solid-state power supplies

The current crop of Heathkit solid-state power supplies is great. I have three of them, which I use in ham work and in areas far removed from hamming. Some problems developed with these supplies, and the purpose of this note is to recommend a slight design change that you can make to protect your power supply. Even if your supply isn't a Heathkit—home brew, for example, but using similar circuits—you might consider this inexpensive way to add protection against external influences.

Many experimenters have surplus relays, especially the 28-volt type with coils that require about 200 mA for operation. It is convenient to test them with a solid-state power supply. The stored energy in the relay coil can develop quite a wallop when the circuit is opened to de-energize the coil. Standard practice is to connect a diode across the coil to suppress the stored voltage. However, when checking many assorted relays, the tendency is to go the easy way and take a chance that the switch gap, upon opening, will dissipate the stored energy. You might get away with this a few times, but not for long. Sooner or later a large negative voltage spike will back up into the power supply, and you've got problems.

The easiest way to protect the supply in this case is to add a diode across its output terminals. Solder the diode to the lugs on the back of the binding posts, cathode to positive; anode to negative. A 1N4003, 1N538, 1N645 or similar type will work. Any negative transients trying to sneak back into the supply will be shorted to ground at the terminals. So much for protection from one external influence.

Another external influence is a short circuit, often a dead short, across the supply. Heath has a dandy circuit that cuts off the current when a short circuit is sensed. Upon removal of the short, current is restored, and no harm is done. The Heath circuit contains two supplies, each mutually independent. One is the heavy-duty supply, which provides power to the load. The other is a zener-regulated, constant-voltage reference source. Across this source is a potentiometer that provides a variable voltage. The positive terminal of the reference source is tied to the positive terminal of the power supply. The pot output is applied to the base of an error detector/amplifier transistor. During normal operation, the unregulated supply will attempt to match the level of the reference-supply voltage. The error detector senses the difference between these voltages. The result is a slightly positive voltage at the error-detector transistor base. As the pot is varied, the output voltage will tend to follow the reference voltage.

Suppose a short circuit develops. The current-limiting circuit will reduce output current to near zero, reducing the output voltage to near zero. The voltage difference at the error-detector transistor base
will be some voltage between the output voltage (zero) and the reference voltage—anything up to 35 V, for example. Since the reference voltage is negative with respect to common, the full negative reference voltage will appear at the error-detector transistor base, instantly zapping the transistor.

To prevent this disaster, Heath uses a diode in series with the error-detector transistor base. The diode will pass current in the positive direction only. However, if regulation is lost (this happened to me), the output voltage will shoot up to the full unregulated amount, say 50 V. As before, the error detector will sense the difference between output and reference voltages; except this time about +15 V will appear at the error-detector transistor base. Here the diode offers no protection; its job is to protect the supply in the event of a short circuit. The relatively high positive voltage on the error-detector transistor base will pass a high current through the base-emitter junction, and ZAP!

The answer to protection during loss of regulation is extremely simple. A resistor is placed in series with the error-detector transistor base, as in fig. 1, to limit base current. The cost in performance will be a slowdown in supply response—about 15 ns.

reference


Frank Case, W3NK

independent keying of Heath HG-10B vfo

For owners of the Heathkit HG-10B vfo who might wish to make it independent of other equipment, the following idea will be helpful. My vfo is keyed with a Heathkit HD-10 keyer. The problem was how to use this model keyer with the vfo. The instruction manual for the keyer warns against using a voltage above −105 V.

The circuit of fig. 2 shows how I solved the problem. All components except the transformer and fuse holder were mounted on a small piece of Vector board. The existing 4-conductor cable was removed and replaced with a length of ac cable. The fuse holder was mounted between the key jack and ac cable. The transformer, an inexpensive Japanese unit, was mounted vertically on the underside of the chassis next to the mode-switch wafer. The Vector board will fit nicely between the transformer and the rear chassis wall next to the terminal strip holding the neon lamp.

The connection from the key jack was removed from the cathode circuit and connected as shown. No switch was used, as I intended to leave the vfo on constantly.

James H. Crouch, K4BRR
break-in control system

For really fast and effective cw break-in, many amateurs use separate transmitting and receiving antennas. With such an antenna system and fairly low power (under 100 watts output) the control circuit described here is all that’s required for full and complete break-in operation. It uses the old idea of inserting additional resistance in series with the receiver gain control when the key is down to automatically decrease receiver gain and prevent overload. This method also allows the transmitted signal to be monitored in the receiver.

Fig. 3 shows the circuit. When the key is up, U1A turns on, and the output at pin 7 goes low (0 volts). The output of U1B goes high because both its inputs are low. This turns Q1 off and Q2 on, so that the transmitter keyed circuit is open, and the auxiliary gain control is shorted to ground. The receiver now has full gain. Closing the key causes U1A to turn off, the output at pin 7 goes high, which forces the output at U1B pin 6 to a low state. As a result, the transmitter is keyed and the auxiliary gain control decreases receiver gain to its preset level.

Since I have two types of transmitters (cathode and block-grid keying), I added a negative source of voltage and Q3 to key the grid-blocked rig. With the key up, the positive voltage on U1B pin 6 overrides the negative supply at Q3’s base, holding it off until the key is closed.

This new system replaces a dpdt relay and its keying circuit. In addition it provides for independent cathode and grid-blocking keying of different transmitters. I’m breaking only about 20 Vdc with Q1 and Q2, so the devices shown work fine. The 2N398 would be required for most grid-blocked keying systems.

The whole thing could be powered from a few dry cells, but the surplus transformer was available to make the system operate on 117 Vac.

Cal Sondergoth, W9ZTK
ssb input source for vhf, uhf transverters

Many amateurs require a good vfo for use in the vhf/uhf bands. The 28-MHz output of an ssb transceiver or transmitter can be used as an input source for an up-converter to obtain the desired vhf/uhf frequency. It's highly desirable to maintain the original modulation system of the transceiver or transmitter.

For output on 144 MHz, one could use 166 + 28 MHz; for 432-MHz output, the conversion can be made by mixing 404 and 28 MHz. The best method to obtain output on 1296 is to use 28 + 518 MHz, then mix the 546-MHz resultant signal with 750 MHz. This method will avoid all frequency components except the desired one.

It's possible to obtain the 28-MHz source from the transmitter or transceiver by (a) running the output into a dummy load and feeding a certain amount of energy through a small capacitor to the transverter, or (b) feeding the output to the transverter through an attenuator. These methods are inefficient and wasteful of power. Therefore, I've taken a new approach to the problem.

I use a type 6HM5/6HA5 tube in a cathode follower (fig. 1). This tube is very small, like the 6AK5. The circuit is installed on a little subchassis, which fits nicely in the 6JB6 input compartment of my TR4. The output bnc connector is at the rear, close to the 6JB6 output compartment, and is mounted with the switch on a small panel. When the switch is on, the 6JB6's are disabled, and no power is wasted.

The output impedance is given by $Z_{\text{out}} = 1/S = 1/0.02 = 50$ ohms, where $S$ is the tube transconductance. With 135 V on the plate, this tube has a transconductance of 20k $\mu$hos. This results in a normalized value of 50 ohms output impedance.

Because the input impedance of a cathode follower is high, only a very small amount of capacitance is needed to feed the 28-MHz signal from the driver stage, and no misalignment will occur.

Using this method I can obtain 1–10 volts of cw or ssb signal; it also works well on a-m. The stability of the vfo is the same as in the HF bands. The overall stability is determined by the crystal oscillator. I've been using this addition to my TR4 for two years on 144 and 432 MHz with very good reports. The idea can be used in other ssb equipment with equal results.

Jacques Mainardi, F8MK

home-made heat sinks

Anyone who works with solid-state devices knows that when a large amount of power is applied to a transistor, a heat sink is required.

Many tv, fm, and other commercial broadcast stations use tubes such as the 4CX250 and similar types. In most cases these tubes aren’t worth rebuilding when they go bad and can be had for the asking.

I found that by cutting the top section from the tube, plus a small amount of filing (and in some cases a little ingenuity), an excellent heat sink can be made for many power transistors. The convenience of having the heat sink around the transistor, rather than spread out along the chassis, can be realized.

Greg Larsen, WA0WOZ
Allied Radio has introduced a new five band ssb/cw transceiver that covers the range from 3.5 to 29.7 MHz in seven bandswitched ranges. The new transceiver features a solid-state vfo circuit with a linear tuning system that permits accurate readings to 1 kHz on all bands. The transceiver has built-in sidetone, vox, ptt, fast or slow agc, 25-kHz crystal calibrator, receiver incremental tuning and sharp-cutoff crystal filters, including a 500-Hz filter for cw work.

Power input is 160 watts from 3.5 to 21 MHz, and 120 watts on ten meters. Carrier and sideband suppression are rated at -40 dB. Receiver sensitivity is 0.5 μV for 10-dB signal-to-noise ratio (3.5 to 21 MHz, 1.5 μV on 28 MHz). Selectivity on ssb is 2.4 kHz at -6 dB, 4.8 kHz at -60 dB. On cw the selectivity is 500 Hz at -6 dB and 1.5 kHz at -60 dB.

The Allied A-2517 transceiver is priced at $400. The A-2518 matching speaker/ac power supply is $99.95. A matching external solid-state vfo, the model A-2519, provides increased versatility by allowing transmit and receive operation on different frequencies; price is $89.95. Allied products are available exclusively through Allied Radio Shack stores, or by mail. For further information, write to Allied Radio Shack, 100 N. Western Avenue, Chicago, Illinois 60680.

transistor manual

The new edition of the RCA "Transistor, Thyristor and Diode Manual" includes the latest available information on basic technology, operating principles, characteristics and ratings, applications and test of RCA semiconductors. This new manual is 20 percent larger than its predecessor and continues as an authoritative reference on bipolar transistors. In addition, it provides information on mos field-effect transistors, thyristors (scrs, triacs and diacs), silicon rectifiers and other types of solid-state devices. Definitive data are given for more than 900 different semiconductor devices; comprehensive data and design curves for transistors and thyristors are provided. In addition, tabular data are given for silicon rectifiers, other semiconductor diodes and discontinued transistor types.

In the circuits section of this manual schematic diagrams, detailed parts lists and descriptive writeups are provided for 38 practical circuits. Most interesting to the amateur radio experimenter are a mosfet preamplifier for 6, 10 and 15 meters, a two-meter converter, a stable vfo (3.5–4.0, 5.0–5.5 or 8.0–9.0 MHz output), microphone preamplifier, 40-watt 50-MHz transmitter with load mismatch protection, transistor dip meter and an electronic keyer. Other applications include fm tuners, an fm stereo multiplex demodulator, hi-fi amplifiers, power supplies and voltage regulators, battery chargers, an electronic heat control unit, light flashers and dimmers, and several digital circuits. 656 pages. $2.50 from your local RCA distributor; ask for Technical Series SC-14.
A new solid-state uhf wave/dip meter and marker oscillator has been introduced by the Melsey Corporation. This new instrument provides continuous tuning from 400 to 1150 MHz. Frequency readout—by the use of a 30-inch steel tape—is better than 1%. Design features include a battery-operated transistor oscillator in a cavity configuration that is tuned by a precision glass-invar capacitor. The instrument has an outside coupling loop for general use, and a miniature coaxial receptacle for direct connection with 50-ohm coax cable. The connector assembly can be rotated to obtain variable attenuation (30dB minimum).

In addition, special applications are possible with modifications developed by the manufacturer. With a minor adjustment the output of the unit can be increased to function as a local oscillator for uhf mixers. It can also be tracked to an rf circuit, or used as an fm, a-m or pulse modulated signal generator or target transmitter. The SN-2 wave/dip meter is $185 from Melsey Corporation, 202 Carle Road, Carle Place, L. I. New York 11514.

Vector Electronic Company has announced a new breadboarding socket that is designed for 12-lead TO-5 integrated circuits. The device consists of an epoxy-glass wafer with a 12-pin socket, the tabs of which have been soldered to two adjacent rows of solderless Springclip terminals. The board is furnished with two pins on the bottom that may be press fitted into pre-punched terminal board with 3/32 inch holes such as AA-pattern Vectorboard.

This new breadboard socket simplified integrated-circuit experiments because as many as four solderless connections can be made quickly to any terminal pin, and the user may use as many ICs as he needs by simply using additional breadboard sockets. The price of the 570F IC socket is $3.95 and may be ordered from the manufacturer, Vector Electronic Company, Inc., 12460 Gladstone Avenue, Sylmar, California 91342.

If you’re looking for practical design data on field-effect transistors, this new expanded 2nd edition by Jerome Eimbinder, managing editor, EEE Magazine, contains nearly 25% more material than the previous volume. The in-depth information furnished by editor Eimbinder will be of immediate value to anyone looking for new ideas and unique fet circuit applications, including many basic fet circuit descriptions. Contents include introduction to the fet and basic fet characteristics, biasing fet stages, fets as oscillators, low-noise audio preamplifiers, source followers, phase splitters and switches. Also included are fet measurements, the photo fet, mosfet biasing techniques and fets as voltage-controlled resistors. The appendix includes often-needed data and charts arranged to serve as a convenient quick-reference source. 352 pages. $14.95 from Tab Books, Blue Ridge Summit, Pennsylvania 17214.

Vector Electronic Company has announced a new breadboarding socket that is designed for 12-lead TO-5 integrated circuits. The device consists of an epoxy-glass wafer with a 12-pin socket, the tabs of which have been soldered to two adjacent rows of solderless Springclip terminals. The board is furnished with two pins on the bottom that may be press fitted into pre-punched terminal board with 3/32 inch holes such as AA-pattern Vectorboard.

This new breadboard socket simplified integrated-circuit experiments because as many as four solderless connections can be made quickly to any terminal pin, and the user may use as many ICs as he needs by simply using additional breadboard sockets. The price of the 570F IC socket is $3.95 and may be ordered from the manufacturer, Vector Electronic Company, Inc., 12460 Gladstone Avenue, Sylmar, California 91342.
IT'S WHAT'S INSIDE THAT "COUNTS"

Accuracy and stability has been placed first in the design of the TBL-1 Marker. We feel a marker should be more accurate than the receiver it is going to calibrate — so no compromise has been made with quality.

Fairchild, Motorola, JFD, Jan, Mallory, IRC and Keystone components are used throughout. It costs more, but calibrate with the best. Hundreds have been sold to government, amateurs, SWL's, schools and laboratories around the world.

Try one today.

Frequency marker, less cabinet and switch
Specifications: Glass Epoxy Board, Adjustment to zero beat with WWV. Uses 100 KHz crystal (not supplied). 3 to 4 VDC. Compact — 1.75 x 3.75 inches. Install anywhere!
Complete easy-to-assemble kit $16.50 Wired and Tested $19.95
SWITCH $1.00 CRYSTAL ONLY $3.50 with purchase of any of above

SELF-CONTAINED UNIT

The TBL Marker is a complete unit including the circuit board shown at left and powered with 3 "C" type flashlight batteries. Merely connect to your receiver antenna — no internal wiring necessary. A front panel control allows zero beat with WWV.
Special introductory price $29.95
Less crystal and batteries POSTPAID U.S.A.
SOLD WITH MONEY BACK GUARANTEE
THE RADIO SHOP, LAB 1
48 ELM STREET, NEW CANAAN, CONN. 06840
Tel. 203-966-3553

ambient compensator

Isotemp Research, Inc. has recently announced an ambient temperature compensator for quartz crystals that uses a proportional solid-state control circuit to maintain crystal temperature within ±0.05°C at constant ambient temperature and constant voltage supply. The set temperature of the unit is 75 ±2.5°C. Warmup time is approximately 6 minutes from -30°C. Maximum power demand is 4 watts; approximately 1¾ watts are required to maintain crystal temperature at -30°C ambient. Required supply voltage is 12.0 Vdc (6 Vdc to 24 Vdc are standard, 28 Vdc to 48 Vdc are available).

The model 1CL6P-2 ambient compensator is designed for one HC-6/U crystal holder, the model 2CL6P-2 holds two HC-6/U crystals. Models are also available for HC-13/U holders. The small quantity price for the 1CL6P-2 ambient compensator is $10.00. Order from Isotemp Research, Inc., 1216 Harris Street, Charlottesville, Virginia 22901. Isotemp Research specializes in the design and manufacture of temperature-control sub-assemblies for electronic equipment and offers a variety of proportional-control crystal ovens in very small packages.

two-meter amplifier

The new solid-state two meter power amplifier from Dynamic Communications puts out 10 watts with a maximum of 20 mW drive. The 101-500 power amplifier operates with a 12-volt power supply and is an ideal booster for 2-meter fm walkietalkies or as a mobile final amplifier.
(With a 6-volt supply the amplifier puts out 4 to 5 watts.)

The DyComm power amplifier is completely broadbanded and will operate anywhere between 143 and 149 MHz with no re-tuning. The unit measures 2x2x6”, including the heat-sink enclosure. $59.95 from Dynamic Communications, Inc., 301 Broadway, Riviera Beach, Florida 33404.

**pulse-generator adapter**

The all-new pulse-generator adapter from Blulyne Electronics Corporation is the answer for the experimenter who has a sine/square-wave generator but needs a high-speed laboratory-quality pulse generator. The new pulse generator allows you to calibrate your scope at high frequencies (50 MHz rise time), to test check amplifiers for frequency response, to control chopper circuits, or to test any electronic circuits requiring fast rise times. The generator features variable pulse width from 100 nanoseconds to 500 milliseconds (50% duty cycle maximum); pulse amplitude is variable from 0.6 to 10.0 volts, and rise and fall times are each less than 20 nanoseconds.

The unit may be used with any sine- or square-wave generator with an input from 1 Hz to 10 MHz; input impedance is 5000 ohms. Two models are available: The APG-150 with 50 ohms output impedance, and the APG-100 with 100 ohms output impedance. Price of the APG-150 is $49.95; the APG-100 is $39.95. For more information write to, Blulyne Electronics Corporation, 3 Sand Springs Road, Williamstown, Massachusetts 02167.

---

**new 18th Edition of the famous E & E Radio Handbook**

by WILLIAM I. ORR, WSSAI

biggest selling book for the amateur

Completely revised and updated. This is the comprehensive manual which is the industry standard for radio amateurs, electronics engineers, and technicians. Explains in authoritative detail how to design, build, and operate all types of radiocommunications equipment.

**LATEST HOW-TO-BUILD DATA**

The new 18th Edition of the famous Editors & Engineers RADIO HANDBOOK presents complete design data on the latest transmitters, receivers, transceivers, amplifiers, and test equipment. Covers SSB design and equipment, RTTY circuits, and latest semiconductor circuits, as well as IC’s. Also includes coverage of r-f feedback amplifiers and special-purpose computer circuitry. All equipment described is of modern design, free of TVI problems.

**COMPLETELY UPDATED—INVALUABLE**

Provides a complete understanding of the theory and construction of all modern circuitry, semiconductors, antennas, power supplies; full data on workshop practice, test equipment, radio math, and calculations. Includes aspects of the industrial and military electronics fields of special interest to the engineer and advanced amateur. The 18th Edition of the RADIO HANDBOOK provides the broadest coverage in the field—complete information on building and operating a comprehensive variety of high-performance equipment. All data is clearly indexed. 896 pages; 6½ x 9½"; hardbound.

No. 24020, RADIO HANDBOOK, 18th Ed., only $13.50

Order from your electronics parts distributor or send coupon.

---

**EDITORS and ENGINEERS**

Howard W. Sams & Co., Inc., Dept. HR-090 4300 W. 62nd St., Indianapolis, Ind. 46268

Send me ________ copy (ies) of the new 18th Edition RADIO HANDBOOK.

$_________ enclosed. □ Check □ Money Order

Name   
Address 
City   State   Zip

---

september 1970
**CQ de W2KUWS**

WE NEED YOUR SURPLUS TUBES

1P21  3CX2500
2C39  3CX3000
2K25  3CX5000
2K48  3CX10,000
2K (any digits)  3E29
3-400  3K (any digits)
3-1000  4-65
3B24  4-125/4D21
3B28
4-250/5D22  4CX3000A/8169
4-400A/8438  4CX5000A/8170
4-1000A/8166  4CX5000R/8170W
4X150A  4CX10,000/8171
4CX250B  4X150G/8172
4CX250R/7580W  4PR60A or B
4CX300  4PR (any digits)
4CX350A/8321  5-125B/4E27A
4CX1000A/8168
5R4WGB  304TL
6BL6  VA (all types)
6BM6 or 6A  250TH
6L6  450TH
7D21  450TL
8D21  QK (all types)
9C21  715C
9C25  802
75TL
805  891R
807  TW (all types)
810  TWT (all types)
811A  NL (all types)
812A  4000 series
813  5000 series
832A  6000 series
833A  7000 series
891  8000 series

Please send us your surplus inventory lists. We want to buy other tubes and TX — RX — test equipment.

5% Bonus over Best Offer

The TED DAMES Co.

308 HICKORY ST., ARLINGTON, N. J. 07032

Phone: 201 998-4246

---

**Principles of Electronic Technology**

Most textbooks written for electronics fall into one of four categories: (1) Texts and manuals for engineers, usually pertaining to theory with a mathematical approach, generally at the upper college level. (2) Texts and laboratory manuals for training electronic technicians for maintenance of consumer or industrial devices. (3) Texts, handbooks and Q&A books for preparing the reader for an FCC exam, or to build and maintain amateur or commercial radio stations. (4) Hobby books presented for the casual hobbyist and basement experimenter.

These four classes of books sadly neglect a very important category: basic electronic theory, presented at a high school level of math but with attention to detail that would do honor to an engineering text. Carl B. Weick's new book, "Principles of Electronic Technology," fills the gap.

Weick has done an admirable job with his book. It goes into great depth and detail in explaining how and why the basic circuit elements (R, C and L) function. A similar treatment is given to the behavior of fundamental ac and dc circuits. Electronic devices and wiring diagrams are left to other texts. What's unique about "Principles of Electronic Technology" is the thoroughness with which it prepares the student for progression to other levels of electronic technology, whether it be maintenance, engineering, or being a true amateur of radio. It is best suited for study in conjunction with an organized class. Like many other books, though, a home reader with real determination can master the text quite well. This, as always, requires reading, rereading, and thinking about each element presented, working out every problem and using every review question.

Don't be too ready to look down on basic electronic theory. There are few, other than practicing engineers and instructors who deal with such topics as daily routines, who truly have a compre-
hensive understanding of the basic subject. Why? Because engineers touch lightly on basics only as a hasty stepping-stone to the higher and more complex subjects. Once learned, the basics are quickly pushed to the back of their minds, to be recalled, if at all, only with studied effort.

Radio amateurs often scan only the surface of the basics, grasping only those facets we believe will be of use in passing the various grades of licenses examinations. We dig a bit deeper when we plan a construction project but then only in a narrow, specialized field of our immediate interest. If you feel your mastery of electronic theory is not as complete as you’d like, “Principles of Electronic Technology” may be just what you’re looking for!

power circuits manual

The latest edition of RCA’s “Power Circuits Manual” has been updated and expanded to include the latest information on solid-state power devices. This new manual provides design information on a broad range of circuits that use power transistors, silicon rectifiers, and thyristors. In addition, it includes a brief introduction to semiconductor physics, as well as detailed descriptions of the construction, theory of operation, characteristics and circuit applications for each type of device.

The large comprehensive chapter on high-frequency rf power amplifiers covers the design of rf power amplifiers, matching networks, ssb transmitters, microwave amplifiers and oscillators, and frequency multipliers. Other chapters include rectifiers, power conversion, power regulation, thyristor ac-line voltage controls, and control and low-frequency power amplifiers. If you’re experimenting with power-type semiconductors, you need this book on your workbench. Each topic is covered with the usual thoroughness that one expects from RCA. 448 pages. $2.00 from your local RCA distributor, as for Technical Series SP-51.

HAL DEVICES

HAL 311BC ELECTRONIC KEYER

THE most versatile keyer now available.

Send for full details on the HAL 311 BC and the complete line of HAL electronic keyers. There is a model to fit your requirement and budget from $16.00 to $48.50. Now available in kit form for even greater value.

TOUCHCODER II KIT

Complete kit of parts, excluding keyboard, for the W4UX CW code typer. All circuitry, including PS and monitor on one G10 glass PC board. Transistor grid block and cathode keying. Only $45.00. Write for full details.

RYRYRYRYRYRYRYRYRYRYRYRYR

HAL RTTY/AFSK KIT

All RTTY and AFSK circuitry, including PS, on one 3x6” G10 glass PC board. 850, 170, and CW ID shifts. Zener protected transistor loop switch. High and low impedance audio output. $40.00 HAL TU/AFSK cabinet $6.50

RYRYRYRYRYRYRYRYRYRYRYRYR

HAL 25KHz MARKER GENERATOR

50 KHz or 25 KHz markers to 144 MHz. Small 1x2” G10 glass PC board. Requires 100 KHz signal and 3 vdc $4.75 wired, $3.25 kit. Postpaid.

DOUBLE BALANCED MODULATOR KIT

For the DBM in March 1970 Ham Radio 7x8x2” G10 glass PC board. 4 HP 2800 hot carrier diodes matched by HAL. 2 Indiana General CF102-Q1 toroids. Instructions included. $5.50 postpaid.

For complete catalog, remit with order; please add postage.

HAL DEVICES Box 365 H, Urbana, Ill 61801

september 1970
short circuits

**hcd noise blanker**

In the hot-carrier noise blanker circuit on page 17 of the October, 1969 issue of *ham radio* the 47k resistor connected to pin 4 of the second Nuvistor should be connected to pin 8. Pin 4 is connected directly to the .005 µF bypass capacitor.

digital clock

Several parts values were omitted from the schematic diagrams of the digital clock on page 51 of the April, 1970 issue. R1 through R10 should be 20k for 170 Vdc operation of the Nixie tubes; R11 and R12 are each 270 ohms; C3 in the power supply should be 2000 µF. All gates are Fairchild µL914 or equivalent, and all flip-flops are µL923s.

Stafford Electronics advises the following price changes (first price is complete kit, price in parenthesis is for etched circuit board only): 12- or 24-hour clock, $145 ($13.50); 12- or 24-hour clock less seconds, $125 ($13.50); power supply/clock generator, $35 ($3.00); alarm circuit, $35 ($3.00); walnut cabinet, $30.

**solid-state power supplies**

In fig. 21 of the "Survey of Solid-State Power Supplies" article, page 36, February, 1970, pin number 10 of the MC1460G voltage-regulator IC should be connected to the common bus.

32S1 modification

The wrong crystal was listed with the 32S1 modification that appeared in the *ham notebook* on page 82 of the December, 1969 issue. The correct Collins part number for the 457.550 kHz crystal is 290-8709-00. The parts department at Collins has been alerted to this error, so if you already ordered a crystal you should receive the correct frequency.

75A-4 modifications

There was an error in fig. 28 of the 75A-4 modification article that appeared in the April, 1970 issue of *ham radio*. The correct schematic is shown below.

![Schematic Diagram](image)

**tilt-over mast**

When calculating guy-wire tension (last item in fig. 7, page 48, February, 1970 *ham radio*) the wind loading at the top of the mast should be divided by the sin of angle B, not the tangent. The sine and tangent of 9.7° (example used in text) are numerically alike and no error of great magnitude exists, but for installations where angle B is much larger the error is large.

2-meter transmitting mixer

The E. F. Johnson Company has discontinued the type 189-253-5 PC butterfly capacitor specified for the 2-meter transmitting mixer featured in the April, 1969 issue of *ham radio* (fig. 5, page 13). For C1 and C2, 8.5 butterflies, use Johnson 160-208. At C3, 10 pF butterfly, use Johnson 160-211; C4, 10 pF, use Johnson 160-104; C5, 20 pF, use Johnson 160-110. Capacitors C1 and C2 may be soldered upside down to the foil side of the printed-circuit board to the appropriate connection points.
If You Have What It Takes to Qualify for Training in Electronics We'll Not Only Train You...
SAVE OVER 75%!
PULSE GENERATOR ADAPTER

Attach the output of your present square or sine wave generator to the input of a Blulyne Pulse Generator Adapter and you have a high-speed lab quality pulse generator featuring variable pulse width, variable pulse amplitude and variable frequency at less than 25% of the cost of a separate unit.

SPECIFICATIONS

Frequency response 1 Hz to 10 MHz
Rise time less than 20 nsec.
Fall time less than 20 nsec.
Input Impedence 5000 ohms
Output Impedence (APG-100) 100 ohms
(APG-150) 50 ohms
Connectors (APG-100) phono (APG-150) BNC
Pulse width (variable) 100 nsec. to 500 msec. (50% duty max.)
Pulse Amplitude (APG-100) 0.6 v - 6.0 v (unterminated)
(APG-150) 0.6 v - 10.0 v (unterminated)

Many valuable uses for the designer, experimenter, engineer and technician.

Model APG-100 $39.95  Model APG-150 $49.95

Write for illustrated brochure on this and other BLULYNE PRODUCTS

BLULYNE ELECTRONICS CORP.
3 SAND SPRINGS ROAD
WILLIAMSTOWN, MASS. 01267

COMDEL
Speech Processor

for optimum voice power & clarity
- 10 dB power gain
- instantaneous limiting
- no harmonic distortion
- all silicon solid state

$120 less batteries

COMDEL inc.
beverly airport
beverly, mass.
If you have any interest in the frequencies above 30 MHz then you need this book. It is probably the most comprehensive work of its kind ever produced, ranging from advanced material to simple circuits for the beginner to vhf. An attractive layout and clear style make the VHF/UHF Manual a most worthwhile addition to your library.

book division

comtec

Box 592 • Amherst, New Hampshire 03031

"WE ARE THE EXCLUSIVE NORTH AMERICAN DISTRIBUTOR FOR RSGB PUBLICATIONS — DEALER INQUIRIES INVITED"
SPACE AGE KEYER

Only $67.50

- Planar epitaxial integrated circuits for reliability. No tubes—No separate transistors.
- Precision feather-touch key built-in.
- Fully digital—Dot-dash ratio always perfect.
- No polarity problems—Floating contacts switch $300-V @ 100-ma.
- Rugged solid construction—will not walk.
- Send QSL or postcard for free brochure.

TEST EQUIPMENT SPECIALS!!

BALLENTINE Model 314 AC VTVM, 100UV to 1000V FS. These are less probe which consists of a 10 Meg. Res. in parallel with 0.6 pf. Add $7.50 and we will make probe. Condition very good & calibration checked. $50.

Beckman Model 5571/1 or 5572 Eput Counters. 1 MC $250. 110 MC $100. Sell separately or by the set & SAVE. As a PKG. $325.

Beckman Model 5580 Pwr Supply with 5581/4 Reference Generator. $150.

Hewlett Packard Model 460AR Wideband Amp. $100.

Spencer Kennedy Model 202D Chain Amp. $150.

General Radio Sweep Drive w. Gears Model 1750A $100.

Computer Measurements Corp Model 707B Freq. Per. Counter, 10 MC $350. Model 730C Pwr Supply & 731B Conv. for above 100 MC $100. Separately or by set & SAVE. As a PKG. $425.

R F TORIDS

PREWOUND RF & OSC SET FOR ARRL RCVR. The Pair $75. $3.00 PPD. Unwound Cores as above only. $5.00 ea PPD.

TOROID ASSORTMENT FOR THE SERIOUS BUILDER

20 CORES Only $3.50 PPD.

COLOR CODE
1-C Core 50KHz-5MHZ Blue
5-E Core 500KHz-30MHZ Red
1-TH Core 2MHZ-40MHZ White
2-QI Core 500KHz-30MHZ Red & Blue
1-02 Core 10MHZ-90MHZ Black
9-SF Core 10MHZ-90MHZ Yellow
1-Misc. Core

WE BOUGHT THOUSANDS TO BRING YOU THIS BUY!!!

CIRCUIT BOARD ASSEMBLY

Unusual Find!!! Digital Assembly. 3 Boards mounted on a frame with panel. Fixedหรือ board. Outside boards are hinged and swing out. Use frame for breadboard assemblies. Panel 2½ x 8½. Depth 15". All parts easy to remove. 700-1658, 77-114 Sw. Xistors, 2754 Zeners, Unjunctions, Tantalums, & much more.

Board #1 As above $4.00
Board #2 As above + 1 Clare Mercury wetted relay module, #HGS1001 $5.50
Board #3 As above + 3 Clare Mercury wetted relay modules, #HGS1001 $6.50

SHIPPING WEIGHT 5 LBS.

HAYDON TIMER MISTERS

1-RPH 115 VAC ¾" Shaft $0.75 PPD.

COBBER CLAD LAMINATES

<table>
<thead>
<tr>
<th>Width</th>
<th>£1.00</th>
<th>£5.00</th>
<th>£20.00</th>
<th>£50.00</th>
<th>£100.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/32&quot;</td>
<td>$1.50</td>
<td>$7.50</td>
<td>$40.00</td>
<td>$120.00</td>
<td>$250.00</td>
</tr>
<tr>
<td>3/32&quot;</td>
<td>$1.50</td>
<td>$7.50</td>
<td>$40.00</td>
<td>$120.00</td>
<td>$250.00</td>
</tr>
<tr>
<td>1/16&quot;</td>
<td>$1.50</td>
<td>$7.50</td>
<td>$40.00</td>
<td>$120.00</td>
<td>$250.00</td>
</tr>
<tr>
<td>3/32&quot;</td>
<td>$1.50</td>
<td>$7.50</td>
<td>$40.00</td>
<td>$120.00</td>
<td>$250.00</td>
</tr>
<tr>
<td>1/8&quot;</td>
<td>$1.50</td>
<td>$7.50</td>
<td>$40.00</td>
<td>$120.00</td>
<td>$250.00</td>
</tr>
<tr>
<td>3/16&quot;</td>
<td>$1.50</td>
<td>$7.50</td>
<td>$40.00</td>
<td>$120.00</td>
<td>$250.00</td>
</tr>
</tbody>
</table>

The above prices are for copper clad laminate only and do not include other materials such as foam or plastic. Every order unconditionally guaranteed.

TRI RIO Electronics

20 Burnett Avenue, Winnipeg 16, Manitoba, Canada

90 september 1970
NUVISTOR LOW NOISE PREAMPLIFIER

For 27 (CB), 28, 50, 144 or 220 MC. (Also available for 150-170 MCS)

Add this Ameco Nuvistor Preamplifier to your receiver (or converter) to improve the sensitivity and noise figure. Two tuned circuits also improve rejection of image and spurious frequencies. Compact, easily connected and low power requirements, wired and tested with tube.

Models PV 27, 28, 50, 144 & 220

Write for details on 150-170 mcs and others.

Ideal for improving performance of surplus FM Two-Way equipment for "NET" operation on the 2 and 6 meter bands.

MANUFACTURERS OF FM AND AM TWO-WAY RADIO, SSB AND ISB COMMUNICATIONS, CONTROLLER FUEL CONTROL AND DATA EQUIPMENT, AMECO\textsuperscript{\textregistered} HAM, CB AND SHORT WAVE LISTENING EQUIPMENT.

AMECO EQUIPMENT CORP.
A SUBSIDIARY OF AEROTRON, INC. • P. O. BOX 6527 • RALEIGH, N. C. 27608

What's Your Freq?

MONITOR YOUR

"ON-THE-AIR" SIGNALS —
CONTINUOUS!
AUTOMATIC!
ACCURATE!

- Large (\(\frac{1}{2}\) inch numbers), bright "NIXIE" display
- Measures Khz and Mhz
  Example: A transmitter on 7204 Khz would read \(7.2\) Mhz or \(04\) Khz
- Operates with any exciter — transceiver — transmitter
  (1 to 600 watts — 1 to 30 Mhz)
- 100 Khz crystal reference (adjustable to WWV)

fm-6 Freq Meter — Kit — $139.50
Assembled — $169.50

Micro-Z Co.
Box 2426 Rolling Hills, Calif 90274
CRYSTAL FILTERS
By KVG of WEST GERMANY

High performance 9 and 10.7 MHz crystal filters for SSB, FM, AM and CW application. Small size (1-27/64" x 1-3/64" x 3/4") perfectly suited for miniaturized solid-state equipment.

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>XF-9A</th>
<th>XF-9B</th>
<th>XF-9C</th>
<th>XF-9D</th>
<th>XF-9E</th>
<th>XF-9M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>SSB Trans.</td>
<td>SSB</td>
<td>AM</td>
<td>AM</td>
<td>FM</td>
<td>CW</td>
</tr>
<tr>
<td>Number of Filter Crystals</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Bandwidth (6dB down)</td>
<td>2.5 kHz</td>
<td>2.4 kHz</td>
<td>3.75 kHz</td>
<td>5.0 kHz</td>
<td>12.0 kHz</td>
<td>0.5 kHz</td>
</tr>
<tr>
<td>Insertion Loss</td>
<td>&lt; 3 dB</td>
<td>&lt; 3.5 dB</td>
<td>&lt; 3.5 dB</td>
<td>&lt; 3.5 dB</td>
<td>&lt; 3 dB</td>
<td>&lt; 5 dB</td>
</tr>
<tr>
<td>Input-Output</td>
<td>Z+ 500 Ω</td>
<td>500 Ω</td>
<td>500 Ω</td>
<td>500 Ω</td>
<td>500 Ω</td>
<td>500 Ω</td>
</tr>
<tr>
<td>Termination</td>
<td>C+ 30 pF</td>
<td>30 pF</td>
<td>30 pF</td>
<td>30 pF</td>
<td>30 pF</td>
<td>30 pF</td>
</tr>
<tr>
<td>Shape Factor</td>
<td>(6.50 dB) 1.7</td>
<td>(6.60 dB) 1.8</td>
<td>(6.60 dB) 1.8</td>
<td>(6.60 dB) 1.8</td>
<td>(6.60 dB) 1.8</td>
<td>(6.40 dB) 2.5</td>
</tr>
<tr>
<td>Stop Band Attenuation</td>
<td>&gt; 45 dB</td>
<td>&gt; 100 dB</td>
<td>&gt; 100 dB</td>
<td>&gt; 100 dB</td>
<td>&gt; 90 dB</td>
<td>&gt; 90 dB</td>
</tr>
<tr>
<td>Price</td>
<td>$21.95</td>
<td>$30.25</td>
<td>$32.45</td>
<td>$32.45</td>
<td>$32.45</td>
<td>$23.00</td>
</tr>
</tbody>
</table>

Matching HC-25/U crystals: 8998.5 (USB), 8999.0 (BFO), 9000.0 (carrier), 9001.5 (LSB). $2.75 each.

10.7 MHz filters for 20.25 and 50 kHz FM channel separation. 8 pole type. $30.25 each.

PARTS!
NEW – CLEAN MANY IN ORIGINAL CARTONS

<table>
<thead>
<tr>
<th>MRTL</th>
<th>MC 790 P</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.90 each</td>
<td>$18.00</td>
</tr>
<tr>
<td>10 for</td>
<td>.55 each</td>
</tr>
<tr>
<td>10 for</td>
<td>$5.00</td>
</tr>
<tr>
<td>100 KHz FREQ. STD. CRYSTAL HC 13/U</td>
<td>$4.00</td>
</tr>
<tr>
<td>PC SUBMINIATURE TRIM POTS made by CTS</td>
<td>$6/1.00</td>
</tr>
<tr>
<td>250 Ω, 1 K, 10 K, 25 K, 100 K</td>
<td></td>
</tr>
<tr>
<td>ERIE CERAMIC TRIMMER 3-12 pf, 5-25 pf</td>
<td>$5/1.00</td>
</tr>
<tr>
<td>PHENOLIC BASE</td>
<td></td>
</tr>
<tr>
<td>TRIPLETT H METER MODEL 227-T 0-25 ma DC</td>
<td>$8.00</td>
</tr>
<tr>
<td>NEW IN BOX</td>
<td></td>
</tr>
<tr>
<td>1500 25v ELECTROLYTIC 2½&quot; x 1&quot;</td>
<td>$.50</td>
</tr>
<tr>
<td>UTC TRANSFORMERS (BOXED)</td>
<td></td>
</tr>
<tr>
<td>CG 140</td>
<td>$4.75</td>
</tr>
<tr>
<td>H-72</td>
<td>$3.75</td>
</tr>
<tr>
<td>HA 106</td>
<td>$9.00</td>
</tr>
<tr>
<td>HA 137</td>
<td>$8.00</td>
</tr>
<tr>
<td>WW RESISTORS 5 w .2 ohm 3 Ω</td>
<td>6/$1.00</td>
</tr>
</tbody>
</table>

PLEASE ADD POSTAGE

LOGIC COMPONENTS
BOX 224
NEW CANAAN, CONN. 06840

82 september 1970
TELEGRAPH KEYS WANTED: Wire, wireless, Spark or CW. Related books, Ted Dames, W2KUW, 308 Hickory St., Arlington, N. J. 07032.

DELTA QSO PARTY — All amateurs are invited to participate in the first annual, WIXY QSO Party, 12 to 2000 GMT Sept 12 to 0200 Sept 14. No time or power restrictions. Amateurs outside the Delta Division will attempt to contact as many amateurs in Ark., Miss., Ill., Ill., and Miss. Delta Division amateurs will attempt to contact as many amateurs as possible both inside and outside the Delta Division. The exchange will consist of QSO Number, RST, and QTH (ARRL section for non-Delta Division, county and state for Delta Division). Logs must include date/time, station working, exchange, band, emission, and multiplier. Stations may be worked on each band/mode. Mobiles may be twokayed if the change counties. Scoring: Delta Division, QSO's times ARRL Sections. Outside Delta Division, QSO's with Delta Division stations times counties worked (max 316). DX stations must be worked, but do not count as multipliers. Any station disrupting a Delta Division traffic net will be disqualified. The general call will be "CQ Delta" on SSB, and "CQ Delta" on CW. Logs must be postmarked no later than Oct. 11, 1970 in order to be eligible for awards. Mobile and portable stations must file a log for each county from which they operate. Each log will be considered as a separate entry for award purposes. Send logs to: William P. K., WSRUB, 213 Moonmist, Vicksburg, Miss. 39180.

NEW, 3rd edition, Amateur Radio Techniques by J. Pat Hawker, G3VA. Latest edition of this popular book has 48 more pages and much valuable new material. Just out in hardcover at $15.95 or deluxe binding at $18.95. Available today from Comtec, Box 592, Amherst, N. H. 03031.

TORROIDS 44 and 88 mhy. Unpoled. 5 for $1.50 ppd. Weinschenker, Box 353, Irwin, Pa. 15642.

MAYFLOWER '70 CERTIFICATE ISSUED BY PLYMOUTH (England) RADIO CLUB — Will all radio societies please note a correction to the previous announcement. All log extracts should be sent to the Hon. Secretary, P. O. Box 9, R390A, Plymouth Road, Plymouth, PL2 2LL, Devon, England. Dates for qualification for this Certificate are from March 1970 to November 1971. Requirements are: one QSO with GBUSA or any three members of Plymouth Radio Club or any THREE Plymouth City stations. GBUSA, the Plymouth Mayflower station will be operational from 19th July to 15th August, 1970. On the H, bands on SSB. To obtain a certificate when qualified, send two sherlings sterling or two IRC's to the Hon. Secretary. The Exchange of address is the incentive.

WANTED: To buy or borrow for copy: Manuals and schematics re: Collins rec. in July, R390A. J. W. Logan, Hibbadee House #5, Poughkeepsie, NY 12603.

FOR SALE — HY GAIN TH4 $50.00. Henry Ingwerson, Topsfield, MA 01983.

GREENE DIPOLE CENTER INSULATOR . . . see ad page 93. May, 1970 Ham Radio.

QSLS, SECOND TO NONE. Same day service. Samples 25¢. Ray, K7HLR, Box 331, Clearfield, Utah 84015.


TELETYPE #28 LXRX4 receiver-transmitter "as is" $105.00. Sample questions: Price list $1 refundable. Edco Enterprises, P. O. Box 432, Sparks, Nevada 89431.

DON'T BUY QSL CARDS from anyone until you see my free samples. Fast service. Economical prices. Little Print Shop, Box 9848, Austin, Texas 78757.

TORROIDS: Lowest price anywhere. 40/$10.00 POSTPAID. Center tapped 88 or 44mhy. (5/$2.00). Lorenz 60 speed page printer, with built in reper and TD ($125. Teletype model 32KS8, reconditioned, perfect page printer (60 or 100 speed) $200. Reperatera tape 11/16" $10/case/40. Stamp for list. Van W2DLT, 302H Passaic Avenue, Stirling, N. J. 07980.

CINCY STAG HAMFEST: The 33rd Annual Stag Hamfest will be held Sept 6th and 7th 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. Identity Mr. Hamfest and grand prize. $5.00 cost covers everything. For further info, contact, John Bruning, WDBSR, 6307 Fairhust Avenue, Cincinnati, Ohio 45213.

WORLD QSL BUREAU — see ad page 89.

THE NEW ENGLAND DX ASSOCIATION (NEDXA) will hold its annual banquet, in conjunction with the ARRL National Convention, on Saturday, Sep- tember 26, 1970, at the Statler Hilton Hotel, Bos- ton, Mass. A luncheon will be served and the principle speaker will be Bob Denison, W0DX, and slides of the recent Malpeo Island DXpedition will be presented by him. On Sunday, September 27, 1970, in the ballroom West from 3 to 5 p.m., an open DX Forum will be held with Dale Strieri, W4DGQ presenting slides of the 1969 Navassa Island DXpedition and Ellen White, W1WYM, conducting a DX quiz. All DXers are welcome. Any information and tickets for the luncheon can be obtained from: Chuck Banta, KISHN, 90 Park Ave. East, Lowell, Mass. 01852.

COMMERCIAL LICENSE EXAMS: Second $18.00. First $24.00. Sample questions: Price list $1 refundable. Edco Enterprises, P. O. Box 432, Sparks, Nevada 89431.

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 every 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.

September 1970 83
An outstanding technical guide to all phases of amateur radio. In 832 pages 20 complete chapters are devoted to such subjects as single sideband, antennas, mobile equipment, RTTY and much, much more.

This excellent book has received wide acclaim on both sides of the Atlantic and belongs in your library...now. $11.95

OTHER POPULAR RSGB PUBLICATIONS
Radio Date Reference Book $2.50
VHF-UHF Manual 3.75
Amateur Radio Techniques 2.50
Amateur Radio Circuits Book 2.00
World at Their Fingertips 2.50
All prices postpaid in USA & Canada

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

This is the oldest and most widely read British amateur radio magazine. Published monthly it provides complete coverage including such popular features as: Technical Topics, a monthly survey of the latest ideas and circuits, Four Meters and Down, a rundown of the latest in VHF and UHF and much more.

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

Act Quickly! A price increase will be announced very soon. Send your subscription to us today while it is still only $6.00 per year.
WANTED: CUSTOMERS: No experience necessary: "HOSS TRADER ED MOORY" says he will not be undersold on Cash Deals! Shop around for best price and then call or write the "HOSS" before you buy! SEPTEMBER BARGAINS: Guaranteed: Swan 501C $449.00; Swan 274G $420.00; Drake T4-XB, $395.00; R4-B, $372.00; TR-4, $599.00; 2B, $199.95; TH-GXX, $139.95; Ham-M, $89.00; HT-37, $169.95; 75A-4, $209.00; SB-34, $245.00; NC-303, $169.00; GT-550, $415.00; 30L-1, $349.00; 75S-3, $389.00; Factory Reconditioned Drake TR-3, $389.00; CE 200V (as is), $299.00. CONTACT us for Special Deals on New Tower and Beam Packages. Moory Electronics Co., Box 506, Dewitt, Arkansas 72042. Phone (501) 946-2820.

SUMMER HOUSECLEANING! Making room for new gear. Many goodies must go at unbelievable bargain basement prices. Send $5.00 for detailed list. Special includes Comdel CSP-11 Speech Processor, $75. Amphenol FET voltmeter, $75. Pana model 219 IF filter, $10. 1000 MHz reflectometer, $150. UHF signal generator, LAE-2, 500 - 1300 MHz, $75. Heath AM-1 antennascope, $10. Eico 711, electronic keyer, $40. Waters coaxial switch, $5. 3-amp Variac, $8. 5-amp Variac, $12. Antenna noise bridge, $20. Dow-key coaxial relay, $10. Transco T-type coax relay, N-connectors, provided, $10. 5000 MHz, $20. 1500 Vdc electrolytics, $2.00 each. 500 µf, 310 Vdc computer electrolytics, $1.00 each. WIDTY, Box 25, Rindge, N. H. 03461. (603) 899-5483.

WORLD RADIO's used gear has trial-terms-guaranteed EVERY SATURDAY! KW2E - $699.00; Duoband XQ-1 - $1099.00; Galaxy 5 mk 2 - $259.95; 5 mk 3 - $279.95; GT550 - $379.95; 2NT - $119.95; Valiant - $129.95; SB2LA - $219.95; RF-2000 - $799.95; Live Coverage of SSTV and 3 fields. Interceptor 6/2 - $199.95; SS1 - $291.95; HQ1700C - $179.95; Drake 2A - $159.95; F455B60 filter - $19.95; GO1D4 - $199.95; Swan TV2(20M) - $199.95. Free "blue-book" list for more. $345 West Broadway, Council Bluffs, Iowa 51501.

THE SOCIETY OF WIRELESS PIONEERS on the West Coast meets every Thursday night at 8 p.m. PDST (7 p.m. PST) on 3555 KHz CW. After bulletin traffic from Los Angeles, San Francisco and Washington-Oregon, the NCS stays by for all on-the-air members. It is hoped that East Coast and Midwest SOWP amateurs will develop similar nets. 3555 KHz is also the general calling frequency for all members. For more information concerning the races, contact WA6NEL, 1911 Barnett Valley Road, Sebastopol, California 95472.


CRYSTALS AIRMAILED: Novice — all bands, frequencies; accurate — $1.00 per crystal. Crystal Select 6e. Free-amateur-experimental general frequency price-order bulletin. Your crystal shop since 1933. WOLPS. C-W Crystals, Box 22-B, Marshfield, Missouri 65706.
GET IN ON
THE ACTION

HAM RADIO continues to grow at a pace we find hard to believe ourselves. Last year we doubled in size. It looks like we will do it again in 1970.

Don't take the chance of missing a single issue of this exciting magazine. Remember a three year subscription costs less than 1/2 the newsstand price.

HAM RADIO MAGAZINE — Greenville, NH 03031

HELP ME SAVE MONEY

Enclosed is ☐ $12.00 for 3 years ☐ $6.00 for 1 year

Name ........................................................................................................................................

Address ......................................................................................................................................

City ............................................................ State .............................................................. Zip .................
DECIMAL INDICATOR TUBES similar "Nixie" B5750. Brand new, $3.50 p.d. SASE full information. WIDMU, Box 1, Corinth, Vermont 05039.

ORIGINAL EZ-IN DOUBLE HOLDERS display 20 cards in plastic, 3 for $1.00, 10 for $3.00 prepaid. Guaranteed. Patented. Free sample to dealers. Tepabco, John K4NMT, Box 198R, Gallatin, Tennessee 37066.


FOR SALE: HALLICRAFTER HT-37, good condition, $175.00. Hammarlund HQ-170, $300.00 or both for $450.00. W6EXW, Har Silverman, 15142 Ver-mont St., Westminster, Calif. 92683.


SAROC, JANUARY 7-10, 1971, Flamingo Hotel Convention Center, Las Vegas, Nevada. Sponsored by Southern Nevada ARC, Inc., Box 73, Boulder City, Nevada. Advance registration $14.50 per person accepted until January 4, regular registration at door, includes flamingo Hotel Late Shows and drinks, Sunday Breakfast, Cocktail Parties, technical seminars and meetings, ARRL, DX, FM, MARS, QCW, WCAR, 712, WPP, 392 and WSSBA. Ladies Program. Flamingo Hotel SAROC room rate $12.00 plus room tax, per night, single or double occupancy January 3 thru 12, 1971. Mail accommodations request to Flamingo Hotel. Mail advance registration to SAROC. W7PRM, Club President. W7PV, SAROC Convention Chairman.


THE WINDBLOWERS V.H.F. SOCIETY will sponsor the 16th annual Big Blow Contest on Saturday, September 26, 1970, from 13:00 to 20:00 E.D.S.T. There will be four stations on the 2-meter band. Certificates will be awarded to those contacting all four. Location and call letters will be as follows: W2ZDR/2 Washington Township, New Jersey; W2RRP/2 Sam's Point, N. Y.; W2ZZAU/1 Topstone, Conn., W2ERZ/3 High Knob, Pa.

READ RADIO COMMUNICATION. Britain's finest amateur magazine. 1 year subscription $6.00 from Comtec, Box 592, Amherst, N. H. 03031.


APR-14 RECEIVER WANTED. I am looking for a APR-14 surplus V.H.F. UHF receiver. Write or call Leroy Sparks, W6SYC, 924 W. McFadden Avenue, Santa Ana, Calif. 92707. Phone: (714) 557-8122.


SCOTT'S QSL SERVICE. Cards forwarded anywhere 3¢ except U.S. to U.S. Free information on manager services. WA5UHR, 1510 Lynnview, Houston, Texas 77055.

FORCED SALE: Collins 75S-3B receiver with 500 cycle filter $600.00; 325-3 transmitter with 516F-2 AC power supply $725.00; 30L-1 linear $400.00, Drake MN-2000 $100.00; Waters 334A $85.00. All equipment new March 1970. Write: Box D, Ham Radio, Greenville, NH 03048.

TELL YOUR FRIENDS about Ham Radio Magazine.
ARROW HAS MOVED
NEW ADDRESS
ARROW SALES-Chicago Inc.
7049 W. ARCHER AVE.
CHICAGO, ILL. 60638
PHONE: 586-7441
— Opening Special —
R19/ARC Receiver
118 to 148 MC
$19.95

BACK ISSUES
ALL AVAILABLE 68 & 69 BACK ISSUES
12 IN ALL
Only $4.00 postpaid

FORWARD ISSUES
1 YEAR SUBSCRIPTION
$6.00
3 YEARS SUBSCRIPTION
$12.00

ORDER TODAY FROM
HAM RADIO MAGAZINE
GREENVILLE, N. H. 03048

New!
MULTI-ANTENNA COUPLER
Eliminates Antenna Switching!
• Change bands without having to switch antennas!
• Combine your antennas into a multi-band antenna system while retaining optimum antenna performance on each band!
• Coupler feeds any combination of antennas from a single transmission line! Saves operating time! Saves coax and switches!
• Coupler isolates the line from all antennas but the one in use!
• Works with all types of antennas! Handles full legal power!
• Models available for any bands, 2 to 150 meters! Weatherproof!
Write for free information on a coupler for your antenna system, listing antennas and bands used. Non-amateur frequencies available. Indicate impedance and type of line used.

antennalabs
POST OFFICE BOX 456, OCEAN BLUFF, MASSACHUSETTS 02065

NEW ADDRESS
ARROW SALES-Chicago Inc.
7049 W. ARCHER AVE.
CHICAGO, ILL. 60638
PHONE: 586-7441
— Opening Special —
R19/ARC Receiver
118 to 148 MC
$19.95

10 AMP. FILAMENT CHOKE KIT
$2.00

COMPLETE INSTRUCTIONS FREE ILLUSTRATED FLYER

AMIDON
Ass'cates
12033 OTEGO STREET
NORTH HOLLYWOOD, CALIF. 91607

12X100 MM ROD
$1.25

ELECTRONIC FIST...THE PROFESSIONAL KEYER
Every feature you need for easy, accurate CW
- IAMBIC FOR SQUEEZE KEYS
- VARIABLE WEIGHTING FOR DX'ers
- DOT MEMORY FOR EVERYONE
- COLORS TO MATCH YOUR RIG
KIT OR WIRED. PRICES START AT $69.95
WRITE FOR SPECIFICATIONS
Box 4090, Mountain View, California - 94040

NEW! MULTlANTENNA COUPLER
Eliminates Antenna Switching!
• Change bands without having to switch antennas!
• Combine your antennas into a multi-band antenna system while retaining optimum antenna performance on each band!
• Coupler feeds any combination of antennas from a single transmission line!
• Coupler isolates the line from all antennas but the one in use!
• Works with all types of antennas! Handles full legal power!
• Models available for any bands, 2 to 150 meters! Weatherproof!
Write for free information on a coupler for your antenna system, listing antennas and bands used. Non-amateur frequencies available. Indicate impedance and type of line used.

antennalabs
POST OFFICE BOX 456, OCEAN BLUFF, MASSACHUSETTS 02065

BACK ISSUES
ALL AVAILABLE 68 & 69 BACK ISSUES
12 IN ALL
Only $4.00 postpaid

FORWARD ISSUES
1 YEAR SUBSCRIPTION
$6.00
3 YEARS SUBSCRIPTION
$12.00

ORDER TODAY FROM
HAM RADIO MAGAZINE
GREENVILLE, N. H. 03048

New!
MULTI-ANTENNA COUPLER
Eliminates Antenna Switching!
• Change bands without having to switch antennas!
• Combine your antennas into a multi-band antenna system while retaining optimum antenna performance on each band!
• Coupler feeds any combination of antennas from a single transmission line!
• Coupler isolates the line from all antennas but the one in use!
• Works with all types of antennas! Handles full legal power!
• Models available for any bands, 2 to 150 meters! Weatherproof!
Write for free information on a coupler for your antenna system, listing antennas and bands used. Non-amateur frequencies available. Indicate impedance and type of line used.

New!
MULTI-ANTENNA COUPLER
Eliminates Antenna Switching!
• Change bands without having to switch antennas!
• Combine your antennas into a multi-band antenna system while retaining optimum antenna performance on each band!
• Coupler feeds any combination of antennas from a single transmission line!
• Coupler isolates the line from all antennas but the one in use!
• Works with all types of antennas! Handles full legal power!
• Models available for any bands, 2 to 150 meters! Weatherproof!
Write for free information on a coupler for your antenna system, listing antennas and bands used. Non-amateur frequencies available. Indicate impedance and type of line used.
THE TAWAS HAM-FEST featuring a gigantic "Swap and Shop" Equipment displays, Banquet, Ham-of-the-Year Award and Auction will be presented by the Iosco Amateur Radio Club on September 26, 27, 28 at Tawas Golf Club on US 23, 60 miles North of Bay City. Plenty of activities for the ladies such as: Boat trips, Air Base Tour, Ladies' Luncheons. Bring the family for a weekend of fun. Additional information write: HAM-FEST, P. O. Box 3321, Jeff, Sta., Detroit, Mi. 48214.

FOR SALE: Motorola FMTRU40V 12 volt transceiver, $60.00. FMTRUS05B transmitter with IDC, $35.00. RCA CMV-10 trans/power supply, receiver with crystals for 146.88, 146.94, manual, $30.00. CV-2 receiver, rack mounted, 110 vac power supply, on board. $35.00. A. C. McIntosh, Jr., P. O. Box 572, Mundelein, Ill. 60060.

CIRCUITS for 32 electronic projects, R.F., audio and gadgetry, complete plans for standing ads not changed each month. Commercial advertisers write for special discounts.


SAVE. On all makes of new and used equipment. Write or call Bob Grimes, 89 Aspen Road, Swamp, Montana, 617-598-2530 for the gear you want at the prices you want to pay.

F.M. SOLID STATE ICE TRANSCIEVER on 146.34, 146.76, 146.94 mc for new $150. PMR-8 receiver $135. $38 Receiver $25. W. Davis, 4434 Josie Ave., Lakewood, Calif. 90713.


NORTHERN CALIFORNIA Hams: Best deals — new and reconditioned equipment. Write or stop for free estimate. The Wireless Shop, 1305 Tennessee St., Sacramento, Calif. 95814.

BUY, TRADE, SELL. Used amateur receivers. Steven Kullmer, Evergreen Hatchery, Dysart, Iowa 52224.


WANTED: Conn., Selmer or Buffet B-flat Tenor Saxophones. Will trade DX 40 and 80-10 VFO or purchase outright. Herman Salisbury, K2RUB, 12 Green St., Greene, New York 13778.

PC BOARD. 3/32 inch. 2 oz. Copper one side, paper base. Specify size desired. 1.5e per square inch plus postage. HAL Devices, Box 365H, Urbana, Illinois 61801.

THE SOUTH JERSEY RADIO ASSOCIATION will hold its 22nd Annual Hamfest on Sunday, September 13 at Molla Farms, off Route 47 at Malaga Lake, Malaga, N. J. 1000-1700 Hours. E.D.S.T. Talk-In and Hidden Station Hunt on 2, 6 and 10 Meters. Registration is free but modest fee for prize-draw tickets. Send check or money order to Charles Sellwood, W2RHQ, 902 1st North Street, Syracuse, New York 13208.

THE ANNUAL SYRACUSE VHF ROUNDPUP will be held at the Onondaga Rivers Inn, Route 5, 10 miles north of Syracuse, N. Y., Saturday, October 10, 1970. Reservations and information from Charles Sellwood, W2RHQ, 902 1st North Street, Syracuse, New York 13208.

YOUR AD belongs here too. Commercial ads 25e per word. Non-commercial ads 10e per word. Commercial advertisers write for special discounts for standing ads not changed each month.

THE ANNUAL SYRACUSE VHF ROUNDPUP will be held at the Onondaga Rivers Inn, Route 5, 10 miles north of Syracuse, N. Y., Saturday, October 10, 1970. Reservations and information from Charles Sellwood, W2RHQ, 902 1st North Street, Syracuse, New York 13208.

YOUR AD belongs here too. Commercial ads 25e per word. Non-commercial ads 10e per word. Commercial advertisers write for special discounts for standing ads not changed each month.

THE ANNUAL SYRACUSE VHF ROUNDPUP will be held at the Onondaga Rivers Inn, Route 5, 10 miles north of Syracuse, N. Y., Saturday, October 10, 1970. Reservations and information from Charles Sellwood, W2RHQ, 902 1st North Street, Syracuse, New York 13208.

YOUR AD belongs here too. Commercial ads 25e per word. Non-commercial ads 10e per word. Commercial advertisers write for special discounts for standing ads not changed each month.

THE ANNUAL SYRACUSE VHF ROUNDPUP will be held at the Onondaga Rivers Inn, Route 5, 10 miles north of Syracuse, N. Y., Saturday, October 10, 1970. Reservations and information from Charles Sellwood, W2RHQ, 902 1st North Street, Syracuse, New York 13208.

YOUR AD belongs here too. Commercial ads 25e per word. Non-commercial ads 10e per word. Commercial advertisers write for special discounts for standing ads not changed each month.

THE TAWAS HAM-FEST featuring a gigantic "Swap and Shop" Equipment displays, Banquet, Ham-of-the-Year Award and Auction will be presented by the Iosco Amateur Radio Club on September 26, 27, 28 at Tawas Golf Club on US 23, 60 miles North of Bay City. Plenty of activities for the ladies such as: Boat trips, Air Base Tour, Ladies' Luncheons. Bring the family for a weekend of fun. Additional information write: HAM-FEST, P. O. Box 3321, Jeff, Sta., Detroit, Mi. 48214.

FOR SALE: Motorola FMTRU40V 12 volt transceiver, $60.00. FMTRUS05B transmitter with IDC, $35.00. RCA CMV-10 trans/power supply, receiver with crystals for 146.88, 146.94, manual, $30.00. CV-2 receiver, rack mounted, 110 vac power supply, on board. $35.00. A. C. McIntosh, Jr., P. O. Box 572, Mundelein, Ill. 60060.

CIRCUITS for 32 electronic projects, R.F., audio and gadgetry, complete plans for standing ads not changed each month. Commercial advertisers write for special discounts.


SAVE. On all makes of new and used equipment. Write or call Bob Grimes, 89 Aspen Road, Swamp, Montana, 617-598-2530 for the gear you want at the prices you want to pay.

F.M. SOLID STATE ICE TRANSCIEVER on 146.34, 146.76, 146.94 mc for new $150. PMR-8 receiver $135. $38 Receiver $25. W. Davis, 4434 Josie Ave., Lakewood, Calif. 90713.


NORTHERN CALIFORNIA Hams: Best deals — new and reconditioned equipment. Write or stop for free estimate. The Wireless Shop, 1305 Tennessee St., Sacramento, Calif. 95814.

BUY, TRADE, SELL. Used amateur receivers. Steven Kullmer, Evergreen Hatchery, Dysart, Iowa 52224.


WANTED: Conn., Selmer or Buffet B-flat Tenor Saxophones. Will trade DX 40 and 80-10 VFO or purchase outright. Herman Salisbury, K2RUB, 12 Green St., Greene, New York 13778.

PC BOARD. 3/32 inch. 2 oz. Copper one side, paper base. Specify size desired. 1.5e per square inch plus postage. HAL Devices, Box 365H, Urbana, Illinois 61801.

THE SOUTH JERSEY RADIO ASSOCIATION will hold its 22nd Annual Hamfest on Sunday, September 13 at Molla Farms, off Route 47 at Malaga Lake, Malaga, N. J. 1000-1700 Hours. E.D.S.T. Talk-In and Hidden Station Hunt on 2, 6 and 10 Meters. Registration is free but modest fee for prize-draw tickets. Send check or money order to Charles Sellwood, W2RHQ, 902 1st North Street, Syracuse, New York 13208.

THE ANNUAL SYRACUSE VHF ROUNDPUP will be held at the Onondaga Rivers Inn, Route 5, 10 miles north of Syracuse, N. Y., Saturday, October 10, 1970. Reservations and information from Charles Sellwood, W2RHQ, 902 1st North Street, Syracuse, New York 13208.

YOUR AD belongs here too. Commercial ads 25e per word. Non-commercial ads 10e per word. Commercial advertisers write for special discounts for standing ads not changed each month.
GET YOUR NEW ISSUES NOW!

Over 290,000 QTHs in the U.S. edition $7.95
Over 140,000 QTHs in the DX edition $5.95

NEW EDITION EVERY: MARCH 1 - SEPT. 1
JUNE 1 - DEC. 1

These valuable EXTRA features included in both editions:

- QSL Managers Around the World!
- Census of Radio Amateurs throughout the world!
- Radio Amateurs' License Class!
- World Prefix Maps!
- International Radio Amateur Prefixes

See your favorite dealer or order direct (add 25c for mailing in U.S., Possessions & Canada. Elsewhere add 50c).

WRITE FOR FREE BROCHURE!

RADIO AMATEUR CALLBOOK INC.
Dept. E. 925 Sherwood Drive
Lake Bluff, Ill. 60044

SURPLUS CRYSTAL FILTERS
6 XTAL - MOD MEL-3 - 115 MHz = $1.14
6 DB BW 36 KHZ - 60 DB BW 100 KHZ
INPUT & OUTPUT TERM, 50 OHMS.
INS. / LOSS 3 DB MAX - ULT 75 DB MIN.
1/2-3/4 SQ X 1/3 HIGH.
MATCHING 115 MHz XTAL DISCRIMINATOR
DOE SHEET INC. MOD MAL-1 $10.00

WE HAVE SURPLUS XTAL FILTERS WITH BANDWIDTHS FROM
400 Hz TO 2500 KHZ.
CENTER FREQ, 50 KHZ TO 36 MHZ.
SEND DIME FOR LIST OF OVER 50 TYPES.

TOROID CORES POPULAR T-200-2
2" DIA. CARBONYL E. CORE. MAKE A KW ANT.
BALUN, H.D. FIL. CHOKER, OR A TAPPED TANK COIL. FOR YOUR LINEAR.
T-200-2 EACH $2.25 OR 3 FOR $7.00

J. T. MCCULLOUGH, W6BHG - TEL. 816-781-5666

E.S. Electronic Labs
301 AUGUSTUS EXCELSIOR SPRINGS, MO. 65042

PERSONALIZED CUP AND STEIN, GOLD LEAF HANDLE AND PERMANENT BLACK LETTERS MACHINE WASHABLE, ATTRACTIVE AND USEFUL. GIFT FOR ANY HAM. SPECIFY RIGHT OR LEFT HANDED. CALL AND NAME. CUP $2.50. STEIN $4.75. PP. U.S. AND POSSESSIONS ONLY. CHECK OR M.O. CALIF. ADD 5% SALES TAX. SPECIAL CLUB OR COMMERCIAL INQUIRIES SOLICITED.

DE PIAZZA ENTERPRISES
P. O. Box 1127
Costa Mesa, CA 92626

WE PAY HIGHEST PRICES FOR ELECTRON TUBES AND SEMICONDUCTORS

H & L ASSOCIATES
ELIZABETHPORT INDUSTRIAL PARK
ELIZABETH, NEW JERSEY 07206
(201) 351-4200

GREENE Center of
Dipole Insulator
FLIER FREE
"B" $12.00 PP
Without Balun $9.00 PP
O. WATSON GREENE
Wakefield, R. I.

ALL BAND TRAP ANTENNA

ALL STAINLESS STEEL HARDWARE
RUN FULL LEGAL POWER
INSTRUCTIONS SUPPLIED
104 FT. LONG

IDEAL NOVICE ANTENNA
LIGHT WEIGHT
ONLY 4.5 PER TRAP

MAY BE USED WITHOUT BALUN BUT 1:1 BALUN IS RECOMMENDED FOR BEST PERFORMANCE

THE NEW "BOOMERANG II" 80-40 METER TRAP ANTENNA

DEALER INQUIRIES INVITED

LITERATURE ON REQUEST

PRICE:
AB-1 1:1 BALUN $10.95 PPD
ATH TRAPS PAIR $12.95 PPD
ATH TRAPS AND AB-1 BALUN $22.95 PPD

ORDER FROM:
M. WEINSCHENKER K3DPJ
BOX 353
IRWIN, PA. 15642
SAROC, Flamingo Hotel Room rate $12.00 plus tax, single or double occupancy. Mail to Flamingo Hotel, Las Vegas.

SAROC, advance registration $14.50 per person, regular registration at the door, Flamingo Hotel Late Show, Sunday Breakfast, Cocktail Parties, Seminars and Meetings. Mail to SAROC.

SAROC, sponsored by Southern Nevada ARC, Inc., Box 73, Boulder City, Nevada 89005.

Contact SAROC for
Charter Flights from Chicago and New York

THE FABULOUS Flamingo HOTEL
Special-Purpose Receivers, Panadapter
RAK-7 complete, w/dwg, 15-6000 kHz TRF
$125.00
RFL (Noise Field Strength Meters) are basically radio
rcvs. TS-587/UP (no ant. accessories) somewhat modified as
an RFL Meter, OK as rcrv, 15-4000 mhz, $195. FERRIS
#32a, .15-20 mhz, complete, OHC, w/charts & book, $175.
#32b is later model, $275. Navy OBL, 15-175 mhz, OHC,
with book, $25. MORE PROFESSIONAL setups, to $4000.00.
STODDARD and EMPIRE DEVICES: ASK! Also ask about
SPECTRUM ANALYZERS, if interested.
455 kHz Panadapter, various models, all 100% OK, all
with instruction books $357.50
WWW COMPARATOR RCRV has meter to zero-beat your
signal with WWW switched tuning at 21/2/21/5/11/15/20/25
mhz. BECKMAN #905R sold for $650. From us, OHC
and with book $175.00

Hi-Sensitivity Wide-Band AM/FM RCRV
38-1000 MHz: AN/ALR-5 consists of brand-new Tuner/
Converter CV-253/ALR in original factory pack and an
exc., used, checked OK & grrd. main rcrv R-444 modified
for 120 v, 50/60 hz. Packed with each tuner is the factory
checkout sheet. The one we opened showed
SENSITIVITY: 1.1 V at 38 mhz, 0.9 at 133 mhz, 5 at
358 mhz, 41/2 at 778 mhz, 7 at 1 ghz.
$275.00
With book & pre-input plug, all for
R-390/URR Rcrvs: Collins xtl-zero-beating,
$795.00
driftless receiver grrd 100% perfect.
R-390A/URR has mech. filters, grrd perfect.
$995.00

PP-106/U: Metered. Knob-adjustible 20-970 up to 80
ma @ 15 v. Also select an AG of 6.3 v 50 ma or 12.6 v 21/2 A
or 28 v 21/2 A. With mating output plug &
technical data. Shpg. wt. 50 lbs.
$19.50

BARGAINS WHICH THE ABOVE WILL POWER:
LM-350 Freq. Meter: .125-20 MHz, .01 MHz, CW or AM,
with serial-matched calib. book, tech. data, mating plug.
Shipping wt. 16 lbs.
$57.50
Same, less calib. book
$27.50
A.R.C. R11: Modern Q-5'er rcrv 190-550 kHz
$12.95
A.R.C. R22: 540-1600 kHz rcrv with tuning graph
$17.95
A.R.C. R32: 100-132 kHz rcrv
$32.50

If you don't see it here, ask for it!
But don't ask for a general catalog . . . we believe that
is nonsense - surplus - we get new things in almost
every day! WE ALSO BUY! So tell us what you have,
condition, and your asking price!

R. E. GOODHEART CO. INC.
Box 1220-HR, Beverly Hills, Calif. 90213
Phone: Area Code 213, Office 272-5707

THE AMATEUR RADIO
QSO WITH
WHCU
IN ITHACA, NEW YORK
EVERY SATURDAY

92 september 1970
Just About EVERYONE WILL BE THERE!

* 1970 Hudson Division Convention

October 17-18

The Hudson Amateur Radio Council cordially invites you to enjoy two full days of exciting events that feature virtually every interest and specialty in amateur radio. Special program for YLs and XYLs, too.

- Exhibits, lectures, demonstrations, contests, prizes, banquet, New York sightseeing, fun. All at the Hilton Motor Inn, Tarrytown, N. Y., located on the scenic and historic Hudson River.
- ARRL Hq. Speakers
- MARS – DX – VHF Sessions
- Wound Hong – SWOOP – Initiations
- Spectacular Banquet
- Contests and Prize Drawings
- And Many Other Special Events

Advance registration: Checks or money orders to: Larry Strasser, K2UMM, 3591 Bainbridge Ave., Bronx, N. Y. 10467. Registration $3.00; - Banquet, Advance, $10.00; $12.00 at the door.

Make room reservations direct to the Hilton Inn, 455 South Broadway, Tarrytown, N. Y. 10591.

NEW TRANSISTOR TESTER from BARRINGTON INSTRUMENTS

LATE VERSATILE DESIGN. MEASURES DC BETA
10 TO 10000 UP TO 2% OR BETTER ACCURACY.
TESTS TRIACS, SCRS, UNIJUNCTIONS AND DIODES. READ hFE (DC BETA) DIRECTLY ON YOUR VOM (current ranges required).

Do you build or design transistor circuits? Measure hFE at any IC range 0.1mA to 1A. Match transistors in pairs. If you use surplus transistors, this tester is a must. Check them instantly without readjustment each time when testing the same type at a speed of perhaps 50 a minute. Test hipower TO-36 or tiny TO-92.

If you build servo or regulated supply, check DC BETA. It will make the job so much easier.

Test Triacs and SCRs and other variety of devices. 12 connecting jacks for current and voltage measurements, inserting load resistors and meters. Battery voltage can be adjusted for precise results. Comes with detailed manual.

Model IM-73 Specifications:
- Size: 7¾ x 6½ x 3½
- Four "D" cells, not included. 9 fixed and 1 variable ranges. Measurements-hFE, hfe (in-direct), VBE, VCE (sat), IGT, VGT, IH, N, many others by connection.
- Complete Kit IM-73 — $19.88
- Plus $1.00 shipping USA
- Calif. res. add 5½% sales tax.
- Technical manual only $2.50 ppd.

ACTIV ENGINEERING
7726 BURNET AVE., VAN NUYS, CALIF. 91405
check-off

... for literature, in a hurry —
we'll rush your name to the companies
whose names you "check-off"

INDEX

- Activ
- Aerotron
- Amidon
- Antenna Labs
- Arrow
- Baker & Winnay
- Barry
- Blulyne
- Comdel
- Comtec
- Curtis
- Dames
- Denver
- DePiazza
- Drake
- ES Labs
- E-Z Way
- Erhorn
- Flamingo
- Flinn
- Goodheart
- Gordon
- Greene
- H & L
- HAL
- Ham Radio
- Hammarlund
- Henry
- Hudson
- International Xtal
- Jan Crystals
- Logic Components
- Madison
- Meshna
- Micro-Z
- National
- Palomar
- Pennwood
- R & R
- Callbook
- Radio Shop
- SAROC
- Sams
- Sentry
- Signal/One
- Spectronics
- Spectrum
- Structural Glass
- Swan
- Tri-Ex Tower
- Tri-Rio
- United Technical
- Vanguard
- Weinschenker
- Western
- World QSL

September 1970

Please use before November 30, 1970

Tear off and mail to

HAM RADIO MAGAZINE — "check-off"
Greenville, N. H. 03048

NAME..................................................
CALL...............................................
STREET........................................ ....
CITY............................................... 
STATE.............................................. ZIP  

September 1970
NEW
TRI-EX'S
MW SERIES

Pound for pound the strongest self-supporting steel towers available.

The new economy MW Series towers are designed to support up to 9½ sq. ft. of antenna area. Featuring Tri-Ex's extra strong torsional twist resistant "W" bracing, the all steel MW crank-up towers come in three sizes, each fully galvanized for carefree maintenance. Models available, by height, are: MW-35', MW-50', and MW-65'. Nested height is between 21' and 22'. Hinged base and wall bracket included with MW tower order! See your local dealer or write for free catalog today. Prices start as low as:

$157.35

Feature This

Signal/One's

CX7 gives you

More performance than any transmitter/receiver combination
More convenience than any transceiver
More versatility

Compare the CX7 with any receiver for sensitivity, selectivity options, dynamic range, AGC merit, VFO smoothness, interference rejection.

Compare the CX7 with any transmitter for continuous power output in all modes, P.A. ruggedness, crisp audio punch, low distortion, instant CW break-in and spotting, quick band-change.

Compare the CX7 with any transceiver for total size and weight.

Consider the best at an amateur retail price of $2195.

Write for all the details of the magnificent CX7 from Signal/One.

"It Speaks for Itself"

Signal/One

A Division of ECI (An NCR Subsidiary)
2200 Anvil Street No.
St. Petersburg, Fla. 33710

september 1970
Measuring only $7\frac{1}{2}'' \times 3\frac{3}{4}'' \times 3\frac{3}{4}''$, and weighing slightly under 2 pounds, the Sansei 6803 Mini-Generator is a completely solid-state sine and squarewave instrument of unusually high quality. Especially suitable for field engineers, broadcast stations, and government agencies, this little beauty is winning favor among our ham fraternity as well.

Of Wein bridge design, using an FET oscillator with both a thermistor and copious amounts of inverse feedback, the output is maintained at minimum distortion and constant level (less than 0.3% for the range 200 Hz–100 kHz with less than 0.8% between 10 and 200 Hz). A stabilized power supply (100–120 VAC 50/60 Hz input) is held to 0.1% against incoming fluctuations.

Squarewave risetime is only 0.2 $\mu$s – the output impedance is $600\Omega \pm 100\Omega$ unbalanced. This beautifully built miniature instrument can be of incalculable value to audio buffs, technicians, and even those of us on sideband who want proper measurements. Shipped postpaid in U.S. and Canada: only $75.00.
The Yaesu FTdx 560 is a great rig, but it's no bargain.

At $450, it's a steal.

Considering all the FTdx 560 offers, you might think its $450 price tag was for a kit. But it isn't.

You get a powerful, air-ready station. A handsome, completely hand-crafted transceiver that's fully guaranteed for one year.

You'll have maximum input of 560 watts PEP in the SSB mode or 500 watts CW. And except for speaker, mike and antenna, you'll have nothing else to buy. Power supply, WWV, calibrators, VOX, warranty and all the other items you usually have to pay extra for are included.

One more point: About 90% of the amateur stations in the Orient are Yaesu; in Europe, it runs about 80%. They're good. It is quite likely Yaesu is the best transceiver made anywhere in the world.

Send for our free information packet that tells the Yaesu story and gives you facts, specifications and schematics for the FTdx 560. The radio you can steal.

Please send me your free Yaesu FTdx 560 information packet:

Name______________________________
Street____________________________
City______________________________
State_________ Zip Code____________
Call______________________________

SPECTRONICS WEST
Box 338, Lakewood, Calif. 90714 / Telephone: (213) 421-6167

SPECTRONICS EAST
Box 1457, Stow, Ohio 44224 / Telephone: (216) 923-4567
The new SWAN 270B transceiver has the same...

- UNEXCELLED PERFORMANCE
- RUGGED RELIABILITY
- PORTABILITY
- 260 WATT P.E.P. RATING
- 5 BAND COVERAGE
- FINEST CRYSTAL FILTER
- CRYSTAL CALIBRATOR
- BUILT-IN SPEAKER
- AND AC POWER SUPPLY

...as the Swan 270

BUT IT'S NEW LOW PRICE IS ONLY $499

This price reduction has been achieved by making 12 volt DC operation an optional plug-in accessory. The DC components are now contained in a 1½ x 3 x 4 inch box which plugs in back of the 270 B, in place of the AC connector. Servicing and maintenance are made easier, and we are able to pass the savings in cost on to those of you who do not require 12 volt operation. The DC converter, model 14A, may be purchased at any time. Except for this difference, the 270 B is identical to the 270. It is truly a top notch performer and an even better value. See the new 270 B at your SWAN dealer today.

Model 270 B ........................................ $499
Model 14A, 12 volt DC converter ............... $39.50

SWAN ELECTRONICS
305 Airport Road
Oceanside, California 92054
A Subsidiary of Cubic Corporation