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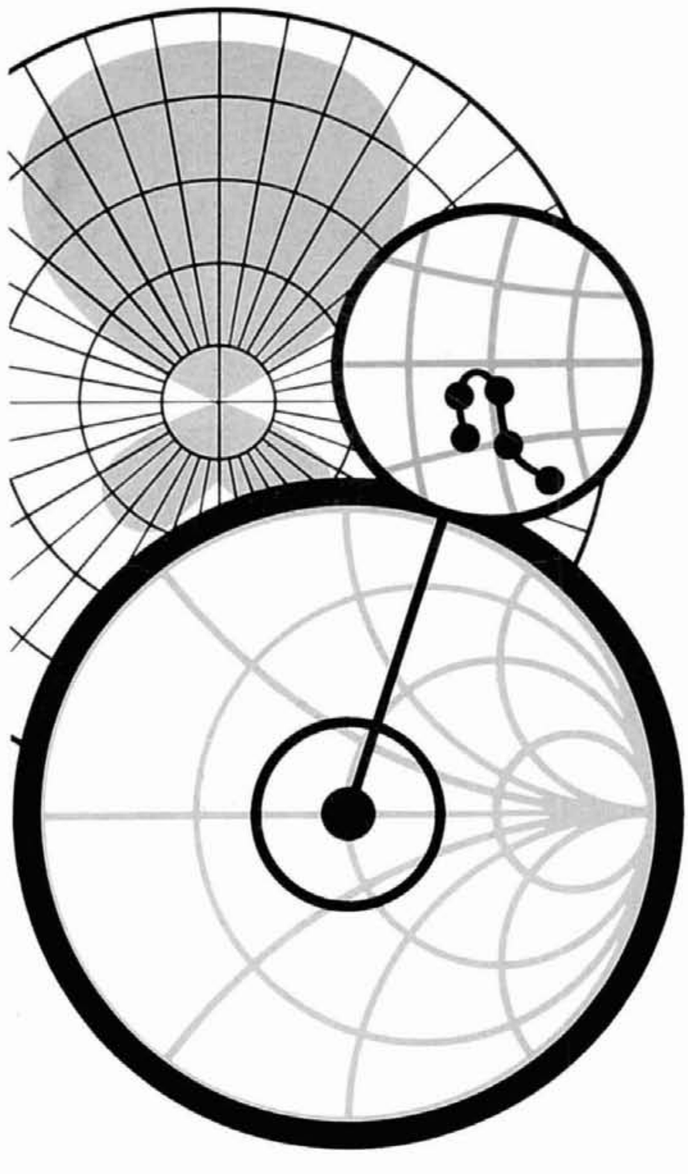
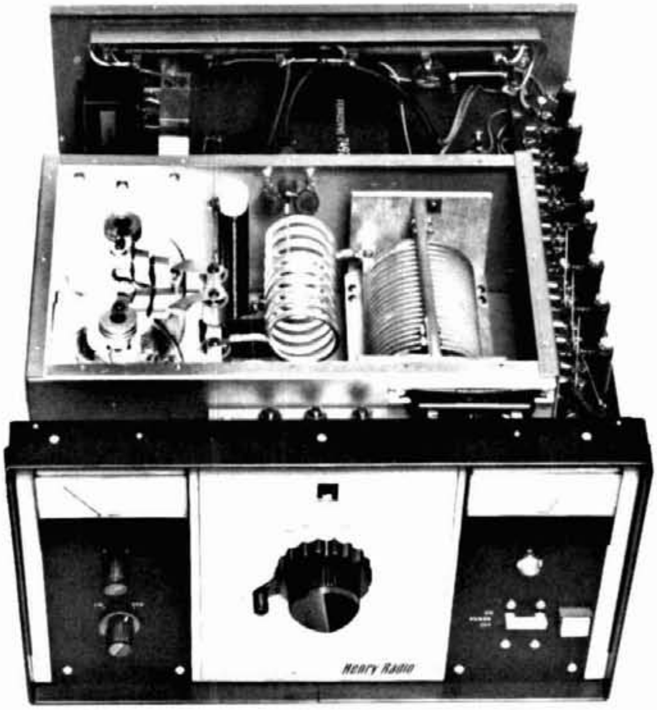
ham radio magazine

SEPTEMBER 1978



Antenna Matching Systems

Before you buy an amplifier



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Tempo 80A10	10W	80W	$149.00
Tempo 80A02	2W	80W	$169.00
Tempo 50A10	10W	50W	$ 99.00
Tempo 50A02	2W	50W	$129.00
Tempo 30A10	10W	30W	$ 69.00
Tempo 30A02	2W	30W	$ 89.00
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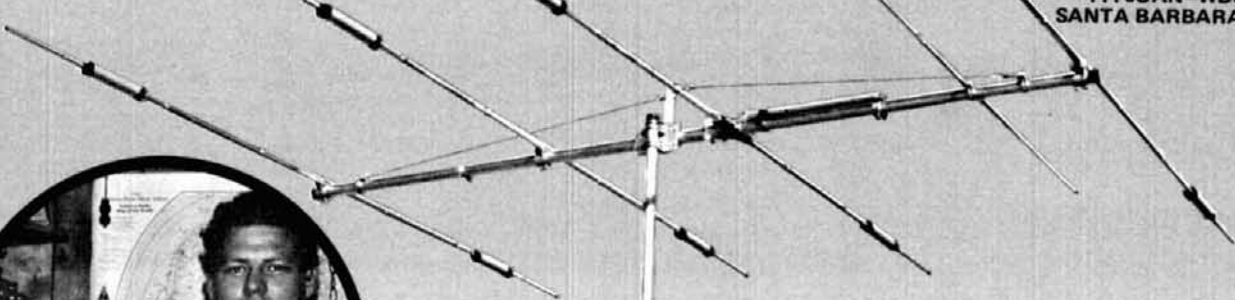

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MESSAGE BUTTONS SELECT DESIRED 25 CHARACTER MESSAGES.

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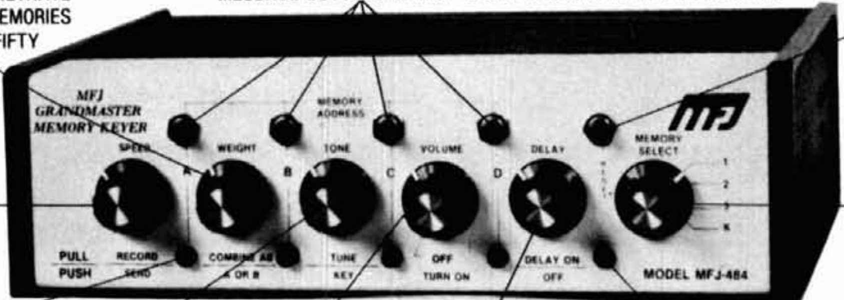

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LED INDICATES DELAY REPEAT MODE.

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A switch combines 25 character messages for up to three 50 character messages.

To record, pull out the speed control, touch a message button and send. **To playback,** push in the speed control, select your message and touch the button. That's all there is to it!

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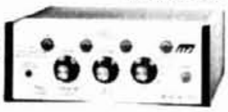

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More Details? CHECK—OFF Page 142

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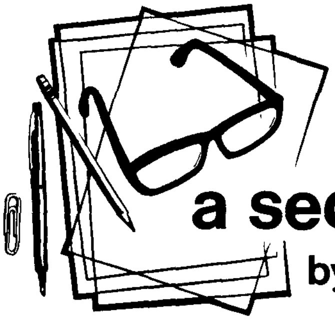

a second look

by Jim Fisk

The editor of an amateur radio magazine must wear several different and diverse hats. In fact, I could use up several pages describing all the details that need attention to keep the magazine running smoothly. However, I'd like to talk for a moment about one very important task that sets the tone of the magazine: selection of articles.

Most of the articles published in *ham radio* are contributed by readers who want to share an idea or the details of a particularly successful project. Authors range from enthusiastic hams who have never written anything more than a short story for their English professor to fellows with engineering backgrounds who make their livings in front of a typewriter; all want to share an idea. I welcome the output of anyone who is interested in contributing something that will benefit all amateurs.

Prospective authors often ask, "What kind of articles are you looking for?" That's difficult to answer because new manuscripts arrive in the mail every day, so our needs are continually changing. However, I'm always on the lookout for simple construction projects that can be put together in one or two weekends. Larger projects are also welcome, but most of our readers must divide their leisure time between amateur radio and other interests, so they don't have time to build a Chinese copy of a complex piece of equipment. I'm also interested in good technical articles that cover any facet of radio communications.

Although I can accept only technical or construction articles for *ham radio*, articles for our sister publication, *Ham Radio Horizons*, can focus in on any aspect of amateur radio. In addition to simple construction projects for the beginner, I'm looking for DXpedition travelogues, adventure tales, articles on getting started in ham radio, and human interest stories with an amateur radio theme. If you have something you think would be of interest to our *Horizons* readers, I would like to have the opportunity to consider it for publication.

Once a month we set aside one or two days to go over all the manuscripts that have come in during the previous month. Since I seldom use more than a dozen articles in any issue, I don't accept more than that during any one-month period. This is sometimes a nearly hopeless task because there may be three-dozen or more to be considered. The first things I look for are originality and interest value. If the contribution passes this test, the next thing I look for is technical accuracy and attention to detail.

The contributed article doesn't have to be a literary masterpiece to be accepted. If you have a good idea and it's well documented, if the illustrations and technical discussion are clear and accurate — you may have a winner! On the other hand, if the article rambles from one topic to another, or presents inaccurate or misleading information, you will receive a rejection slip.

If your article has been accepted for publication, don't expect to see it published in the very next issue. The production times for a monthly magazine are probably much longer than you ever imagined. The articles for this issue, for example, were being prepared for publication during the month of May. As you are reading this we are putting together material for the December issue of *ham radio*.

In addition to writers, I am always on the lookout for new and unusual ways of *looking* at amateur radio, especially for *Ham Radio Horizons*. If you are an illustrator, painter, photographer, or sculptor, I would like to have an opportunity to review drawings, slides, or pictures of artwork for possible future consideration. Media can include airbrush, pen and ink, wash, watercolor, oils, collage, paper sculpture, *ad infinitum*; subject matter includes full-color covers and lead artwork for articles covering every aspect of amateur radio: antennas, hamshacks, satellites, vhf fm, DXing, field days, etc. Obviously, all artwork which is submitted for publication must be of professional caliber. Artwork done on consignment involves preliminary layouts or sketches, and must follow a regimented deadline schedule. If the prospect interests you or any part-time Rembrandts you know who enjoy amateur communications, write directly to our art editor, Jim Wales, for more information.

Jim Fisk, W1HR
editor-in-chief

The ICOM LSI System

COMPATABILITY IS THE KEY TO SUCCESS

Owning an ICOM LSI radio is a true pleasure for anyone in Ham Radio. Putting two of them side by side in a matching station certainly more than doubles the pleasure and performance. The compatable styling of the **IC-211** and **IC-701** provides an operating station which is a beauty to look at as well as a joy to operate. The compactness of the units and the similarity of controls and switch layout help to take the confusion out of knowing which knob to turn. Microphones and other accessories are also compatable with both radios, such as the **RM-2** remote microprocessor frequency controller, shown above.

When used with the **IC-211** or **IC-701** (or **IC-245,** for that matter), the **RM-2** provides memory and frequency control, including automatic band change and memories for four different frequencies, plus auto-increment or single step tuning in 100 Hz, 1 KHz or 15 KHz steps. The **RM-2** also provides automatic offset for repeater operation when used with the **IC-211** or **IC-245.** The tone generator accomodates operation of telephone type devices or a two-tone signal for an external amp that needs to be tuned. (Naturally there is no tuning needed on an **IC-211** or **IC-701.**)

No one could ask for a better Oscar station than the **IC-211** and **IC-701** together for "mode A": and adding a transverter to the **IC-701** mode B or mode J opens newer, better satellite horizons. Within the ICOM LSI based radios there is the capacity for the technically minded Amateur to tune one radio of the pair with the VFO knob of the other. (Oscar transceive, anyone?) In addition, the LSI lends itself to being controlled by a parallel port on one of the increasing number of microprocessors now available for Amateur use.

The complexity of features built into these ICOM LSI twins will be used for a long time into the future. The possibilities are so numerous that even we have not thought of all of them yet.

All ICOM radios significantly exceed FCC specifications limiting spurious emissions.

Shown left to right: IC-211, multi-mode 4MHz trxvr; **RM-2,** remote microprocessor; **IC-701,** multi-mode HF trxvr; **IC-701PS,** power supply / speaker.

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presstop

EXPANSION OF U.S. AMATEUR PHONE bands, proposed in four Petitions for Rule Making (RMs 2150, 2828, 2870, and 2999), has been rejected by the FCC. The Petitions were dismissed on the grounds that the subject had already been covered in Docket 19162 and that the subject had already been covered in Docket 19162 and that strong opposition from overseas Amateurs made any U.S. subband expansion unwise at this time, just before the 1979 World Administrative Radio Conference, where the bands are likely to be shaken up anyway.

RESPONSE TO THE EIGHTH NOTICE of Inquiry on WARC 79 was by far the heaviest yet, with almost all of the increase apparently from Amateur Radio ranks. In a quick review of the 400 or so Amateur submissions, the majority — perhaps 95% — were concerned principally with potential Amateur losses at 160 and 80 meters and changing 40 to exclusively Amateur use. Most said a few words endorsing a new band at 160-190 kHz. The proposed new 10, 18, and 24 MHz Amateur bands got surprisingly little comment — though one Amateur actually opposed them as being ripoffs by Amateur equipment manufacturers so they can sell new gear!

Still Another Notice of Inquiry appears likely, with the end of September the target date to permit replies to be in and analyzed before the year's end. This NOI, if it does come out at all, would be of limited scope, probably touching only those areas in which severe conflicts still remain.

A COMBINED AMATEUR MEDIA and WARC Advisory Committee for Amateur Radio meeting is being considered for sometime in October, following release of the anticipated additional WARC Notice of Inquiry. Tentative plans are to have the two-day session in Gettysburg, where excellent meeting facilities are available and those attending would have a chance to see the Commission's licensing facility in operation.

Suggestions As To Topics for the media meeting, timing and location should go to John Johnston at the FCC.

CB RULES VIOLATORS and "HF" outlaws are losing not only their CB licenses but their right to upgrade (legitimately) to an Amateur license. FCC releases have detailed a number of such cases in which an otherwise qualified applicant for an Amateur license was rejected because of a past history of FCC rules violations, plus several cases in which the licenses of Amateurs were revoked for operating on the "HF" frequencies just below 28 MHz.

Instructors Of Amateur Radio training courses would do well to warn their students of the risks that illegal operating poses to their future Amateur licenses.

FIELD DAY NETTED AN AIRCRAFT CONTACT for W8TN that won't be included in his Field Day score but did generate some nice publicity for Amateur Radio in area papers. He and WD8CPN had set up at the Jackson County (West Virginia) airport and were still going strong at 4 AM when they heard an airplane circling the darkened field. After attracting the pilot's attention with a flashlight, Clark was able to contact him by using the radio in a parked aircraft and learned he'd been trying unsuccessfully to activate the field's radio-controlled runway lights (they were down due to construction damage a week earlier). The two Amateurs then positioned cars at opposite ends of the runway with their headlights on, and, after making an exploratory pass, the pilot landed safely.

OSCAR 8'S ORBITAL DATA is off 0.00205 minutes per orbit, an error of two minutes, 55 seconds for orbit 1427, for example, and three minutes and 35 seconds for orbit 1748.

OSCAR 8's Delta Launch Vehicle's first stage was mistaken for OSCAR 8 by the tracking radar, leaving OSCAR 8 unnoticed above and behind the rest of the launch payload and accounting for the error in its orbital data. At present OSCAR 8 is about 1700 km behind its "imposter." Updated correction data for the OSCAR 8 orbital predictions will be provided periodically, rather than by attempting to prepare a predictions booklet this year.

AT THE JULY BOARD meeting, the Directors approved the CAC's recommendation that the 1979 ARRL DX Contest be cut back to one weekend per mode, with the specific weekends still to be decided. In addition, any submitted log with 2% unpurged duplicate contacts will result in automatic disqualification. Also, more than 2% "rubber-clocking" — the practice of running over the permitted amount of operating time, will similarily result in automatic disqualification.

ANOTHER SUPER POWER RADAR is reported to be about ready for test in or near unspecified Amateur VHF/UHF bands. Any reports of reception of pulse-type signals in the Amateur bands should be reported to ARRL and ham radio. The system in question is supposed to be a 10-15 megawatt over-the-horizon radar.

HAWAIIAN USE OF 1800-1810 kHz has been extended indefinitely by IRAC following a one-year trial period during which no interference to Pacific area navigational signals was noted.

calculator design

Dear HR:

I just have to tell you how much I've enjoyed and appreciated your articles in the last six months or so on various kinds of design approaches suitable for use with pocket calculators.

The Whyman pi network article in the September, 1977 issue; the Anderson circuit analysis article in the October issue; and the Ball satellite tracking article in the February issue were very good indeed; and you really hit the jackpot with the Anderson, Hoff, McNally-Keen, Fisk, and MacCluer articles, in March, 1978 *ham radio*. While I'm still digesting this last batch, you come along with several more juicy items in April and May; so unless you slacken up a bit, I may never catch up.

I acquired a TI-59 calculator just about the time this string started and have really enjoyed the task of digging into all the design methods and programming them for my TI machine. Having to "translate" the HP-25 program listings into the corresponding algorithms only added to the spice. And, with the 480-step/60-memory capacity of the TI-59, there was plenty of room to expand and improve the programs. I recall that one of the articles mentioned that the calculations were awkward to handle on non-RPN calculators, but I found them to be very straightforward and easy on the TI–59.

It is a bit ironic that I no longer have any real need for any of this. I retired from my engineering career about three and a half years ago at age 67, so have no use for it professionally. I got back on the ham bands at about the same time (after being off some forty-four years), but am not particularly interested in doing my own building or design work. There is just a very high degree of simple intellectual pleasure in finding out what really goes on in networks, transmission lines, and the like.

The orders of magnitude improvement in the speed and accuracy with which one can do complicated calculations can really make all those equations in our musty old engineering textbooks come alive in a way they could never do when one had to struggle with manual calculations, slide rules, and log tables. What an incalculable boon the calculators must be to young engineers just starting out and facing the awesome potential range of engineering knowledge and techniques.

These marvelous little calculators can also be used in ways which were never contemplated by their designers. I've come up with one such use for my TI–59, a fairly simple little program that will convert the TI-59 into an ID timer to let me know when it is time to send my call sign during a QSO.

Robert F. White, W6PY
Palo Alto, California

noise bridge construction

Dear HR:

I have just finished constructing and compensating the noise bridge described in the February, 1977, issue of *ham radio*. I had not expected that a major source of trouble would be the 180 pF capacitor. First, I used a ceramic capacitor, since I assumed it would be the least inductive. But, after a long and often disappointing search for the source of the erroneous behavior of my bridge, I found that this capacitor had 1 or 2 ohms of effective series resistance. Since the equivalent parallel resistance at 28 MHz, was only 500 ohms, the R_p reading was too low at the higher frequencies. Several different types of capacitor were tried, but most of them gave the same poor results. The only good results were obtained with a Philips 82 pF ceramic capacitor, and later with a 180-pF "micropoco" capacitor of the same brand. The latter type is a miniature, tubular-molded film capacitor with a polystyrene dielectric.

With this capacitor, the compensation of the bridge was completed as described. It certainly pays to give some attention to this detail beforehand, as it took me quite a long time to find out what was wrong with my bridge.

I built the series range expander in a UG-260/U and a UG-1094/U screwed together. The dielectric and the center conductor of the UG–1094/U have to be shortened, and a little hole is drilled into the remaining part of the center conductor. The two are locked with the large nut from the UG-1094/U.

Arjen Raateland, OH2ZAZ
Helsinki, Finland

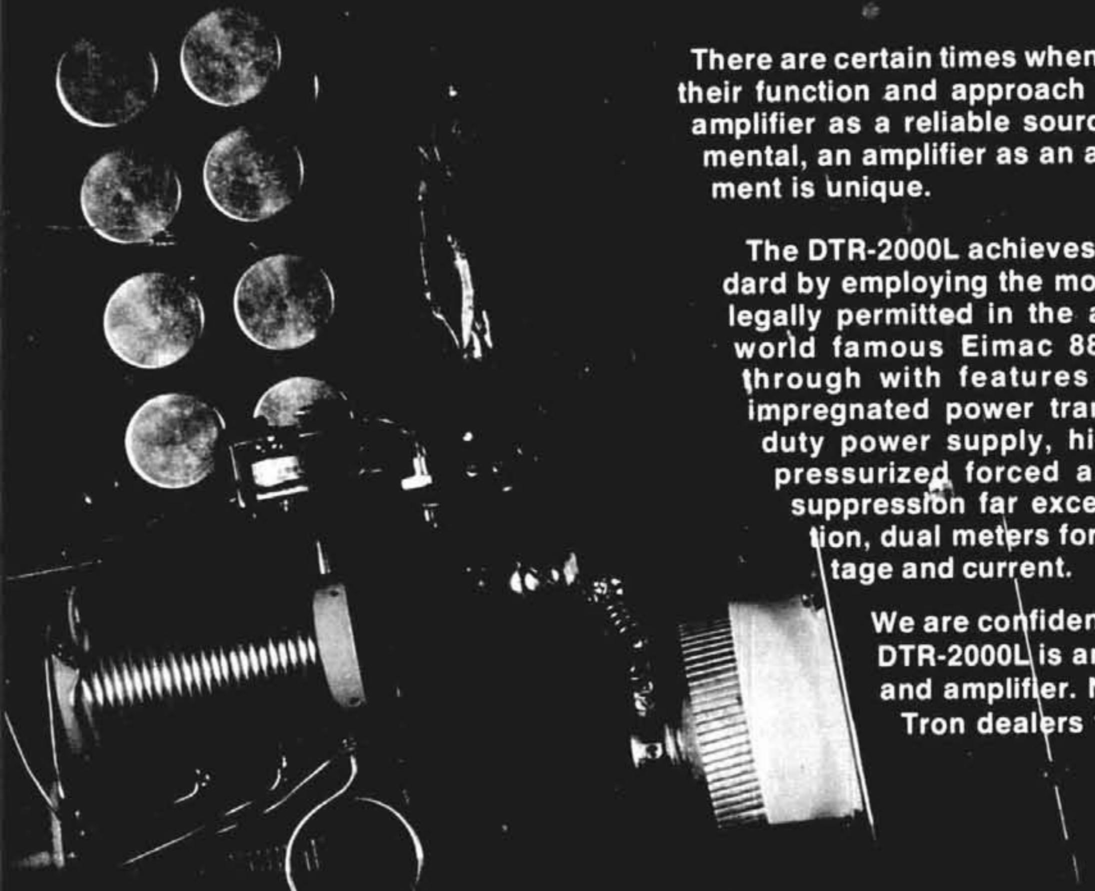
micoder matching

Dear HR:

In your May, 1978, issue of *ham radio*, Wesley Johnson presented a circuit in the *ham notebook* for impedance matching of a Heath HD-1982 micoder. It works beautifully. However, he specifies miniature Calectro coupling capacitors. Like many hams, I just couldn't find these parts anywhere. I eventually substituted 0.47 μF and 4.7 μF Radio Shack tantalum caps; they are small enough and can easily be purchased. I made a 2.5 × 2.5 cm (1 × 1 inch) printed circuit board and as he described, it fits perfectly between the top mounting posts and the case. Using the micoder with a Yaesu FT227R yields very good audio reports.

R. A. Stellarini, WB8VUN
Canton, Ohio

A Blend of Art and Amplifier



There are certain times when amplifiers transcend their function and approach the status of art. An amplifier as a reliable source of power is fundamental, an amplifier as an artful precision instrument is unique.

The DTR-2000L achieves this uncommon standard by employing the most powerful final tube legally permitted in the amateur service. The world famous Eimac 8877. Then, following through with features such as a vacuum impregnated power transformer, continuous duty power supply, hi-lo power switching, pressurized forced air cooling, harmonic suppression far exceeding FCC specification, dual meters for monitoring plate voltage and current.

We are confident you'll agree that the DTR-2000L is an exciting blend of art and amplifier. Now available at DenTron dealers throughout the world.

- Covers 160-15 meters & most MARS freqs.
- Continuous 1KW input CW, SSTV, RTTY, 2KW PEP SSB
- Built-in adjustable ALC
- Easily changed 117V or 234V AC, 50-60 Hz
- FCC TYPE ACCEPTED
- DTR-2000L suggested price $1099.50

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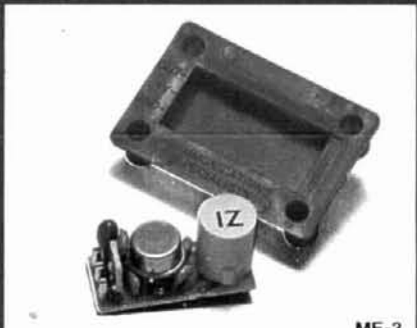
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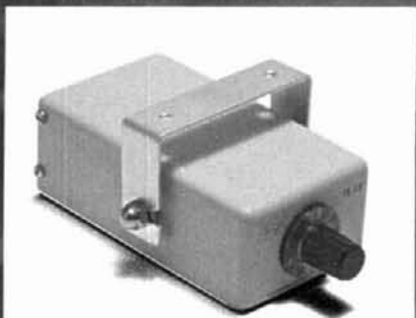
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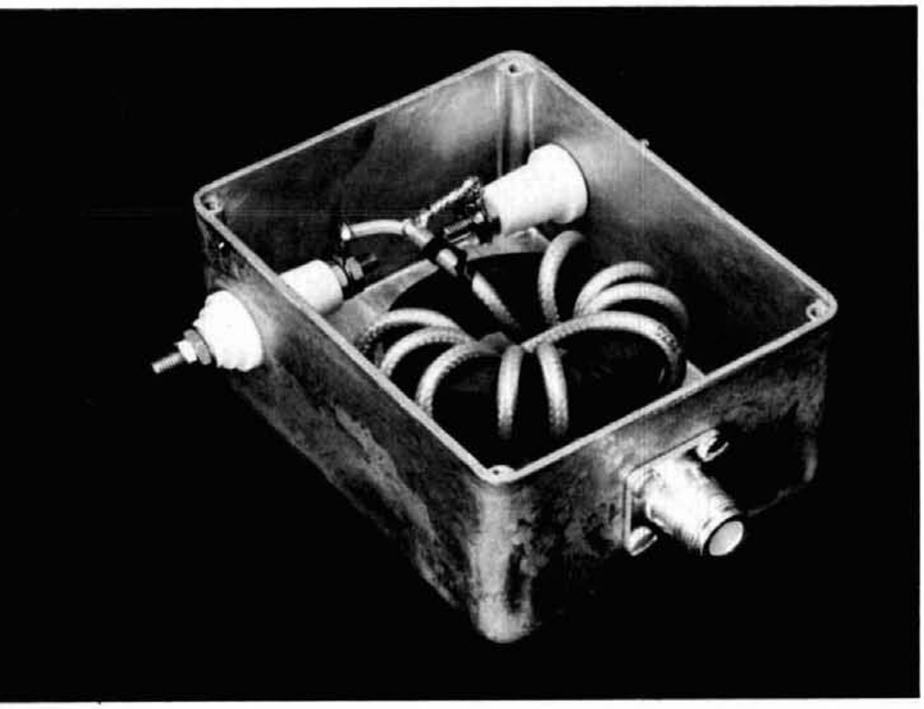


simple and efficient broadband balun

Construction of a new, improved balun which introduces no reactive components to the antenna feed system

Balanced versus unbalanced, balun or no balun — how many times have you heard long, philosophical discussions on this subject? I must admit I have had many sessions on the subject myself. Some of the pros and cons on baluns will be discussed in this article; then a new and improved broadband balun design will be described.

Balun vs no balun

It seems obvious that a ground-plane antenna is an example of an unbalanced antenna and therefore can be fed directly with an unbalanced feedline such as coaxial cable. It also seems obvious that a center-fed dipole is a balanced antenna and therefore requires a balanced feed system. This could be twin lead, open-wire line, or a balun fed with coax cable.

Judging from discussions heard on the air, it isn't obvious why a balanced feed system is required or what it "buys" the user. Reading the advertisements of some manufacturers could lead you to believe that a balun is required to prevent TVI or to lower your vswr. This is nonsense, as you will see later.

By Joe Reisert, W1JR, 17 Mansfield Drive, Chelmsford, Massachusetts 01824

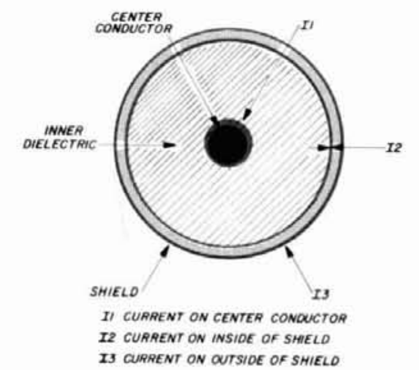


fig. 1. Three-wire representation of a coaxial feedline.

Over the years, coaxial feedline has become very popular while open-wire lines have practically vanished. One erroneous and often-heard story is that open-wire lines radiate, while coax does not; this is not true. The main reasons coax cables are popular are that they do not require special mounting techniques and they are easily monitored for both power and vswr. This has often led to the use of coax cables to directly feed a balanced antenna, especially on the amateur bands below 14 MHz.

There is a simple way to look at this situation;[1,2] a coaxial cable can be viewed as a three-wire feed system since the skin effect will allow one current to flow on the inside of the shield and another, a different current, on the outside (see **fig. 1**). The current on the inside of the shield is equal and opposite to the current flowing on the center conductor. The current on the outside of the shield, however, is a function of the currents induced by the field of the antenna (see **fig. 2**). This current is affected primarily by the geometry; the least current on the outside of the coax occurs when the feedline is at a right angle to the antenna, a rather unlikely situation.

How does feeding a balanced antenna directly with a coaxial cable affect the antenna's performance? The most obvious point is that when a horizontal antenna is used, the feedline re-radiation, if present, will most likely be in the vertical plane. Hence, some of the transmitted signal will also be radiated vertically. Below 14 MHz this probably won't degrade performance because the antenna pattern is probably already distorted — a little vertical radiation may fill in some nulls as well as radiate some power at lower angles. Another effect will be to cause rf feedback or a "hot" rig.

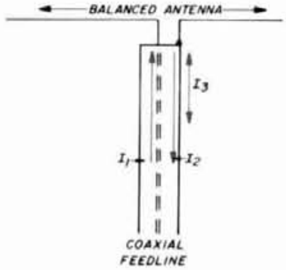


fig. 2. Current on the outside of the coaxial shield, I_3, is affected by relationship of the feedline to the antenna. I_3 is minimum when the feedline is located at right angles to the antenna.

When balanced, directional antennas are fed with coax, however, especially on 14 MHz and above, the feedline re-radiation as described above can be devastating, since it may cause undesirable high-angle signal off the back of the antenna or strong, local, vertically polarized signals which interfere with weak DX signals. Therefore, if coax cable is to be used to feed a balanced antenna, always use a balun.

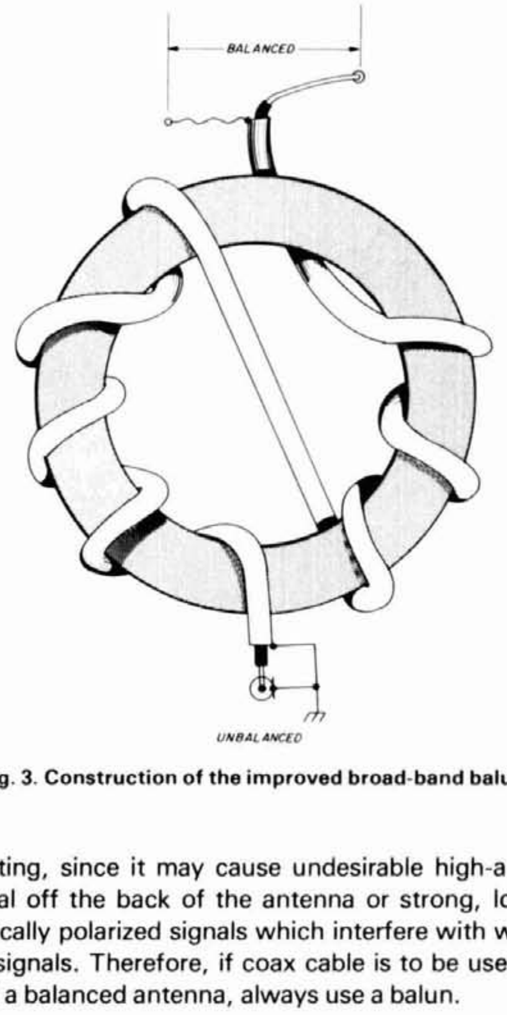


fig. 3. Construction of the improved broad-band balun.

balun types

The most common baluns are the toroid and ferrite-rod types.[1,3] The biggest problem with all these baluns is that they are all frequency sensitive to one degree or another, especially if a wide frequency range (3 to 30 MHz) is desired. Personally, I have had the best luck with the ferrite-rod type.

There are several other problems with toroid and ferrite-rod baluns: they all have some loss and, if not perfectly constructed, can introduce a mismatch; a

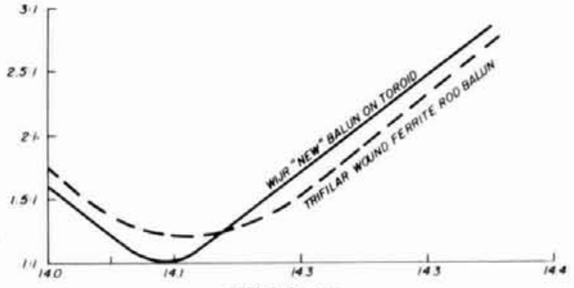


fig. 4. Measured vswr of a TH6DXX antenna on 20 meters with a ferrite-rod balun compared to vswr with the improved coaxial balun. The ferrite-rod balun contributes reactive components to the feed system, as discussed in the text.

less understood problem is the effect of using a toroid or ferrite-rod balun with a mismatched antenna, a common situation since a 1:1 vswr is only present at one discrete frequency on any band. This led me to search for a new type balun which did not suffer from these problems.

new type of balun

In the search for a better balun, I studied the coil of coax approach which is recommended by several antenna manufacturers. This type of balun solves some of the difficulties with mismatch loss, since the impedance is constant, but the thought of using 6-10 meters (20-30 feet) of coax with its loss was not too appealing.

Looking at **fig. 2**, it seems that all we have to do is prevent rf current from flowing on the outside of the coax. In other words, we must devise an rf choke on the outside of the coax shield. This can best be accomplished by wrapping the feedline on a ferrite rod or a toroid core, but some external field will still be present.

Then I saw an article on a super toroid, one that had almost no external field. *Voila*, an answer to my prayer! I quickly wound some RG-58/U coax on a Micrometals T-200-2 toroid, but results were disappointing. I reckoned that an inductive reactance of 500 ohms on the outside shield should be a minimum requirement. But the permeability of this powdered-iron toroid is so low that 14 turns were required on 10 meters — the toroid was barely large enough for that many turns, and 40 turns were required on 3.5 MHz! Hence, a search was conducted for a better core.

Then I looked at Indiana General's *Ferramic* cores and noted that the permeability of their Q1 material was 125 and suitable for operation from 3.5-30 MHz. The F568-1 core* also has a larger inside diameter — 35.5 cm (1.4 inch) versus 28.5 cm (1.25 inch) for the T-200 toroid. With the higher permeability, a suitable balun could be built at 3.5 MHz with only 12 turns of coaxial cable. Also the strays are lower, since the balun is based on coax which has the same impedance as the antenna.

*Indiana General toroids and coaxial cable are available from G. R. Whitehouse, 10 Newbury Drive, Amherst, New Hampshire 03031.

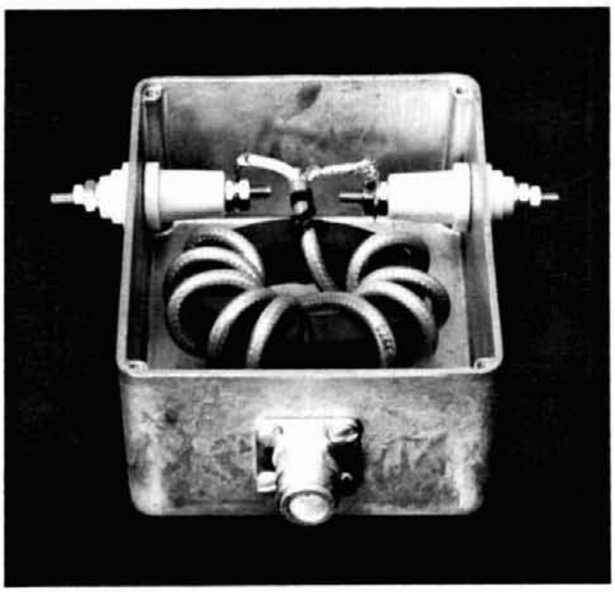
construction

The new toroid balun construction is shown on **fig. 3**. Note that an even number of turns is preferred, with half the turns going on one side and the other half in opposition. Note also that the ends of the coax are on opposite sides of the toroid, which is very desirable mechanically.

For a kilowatt balun for 3.5 to 30 MHz, the Indiana General F568-1 type core is preferred. RG-8/U coax is too large and RG-58/U is undesirable except for levels below 200 watts. A check of available coax cables narrowed the choice to RG-141/U, which is approximately 6.35 cm (0.25 inch) OD with a Teflon dielectric and can easily handle 1000 watts. However, RG-142/U is also acceptable but is quite costly, since it uses a double silver-covered braid. W2DU has also suggested RG-303/U. A 12-turn balun requires approximately 90 to 100 cm (36-40 inches) of coaxial cable.

Table 1 shows the minimum required turns versus frequency. Hence, a 10-turn coil would suffice for 7-30 MHz, but 12 turns are desired for 3.5-30 MHz and should also work at 1.8 MHz with slightly poorer performance. For lower frequencies the type TC9 core material would be a better choice with an appropriate number of turns as discussed above.

Photograph of the improved broad-band balun. The cast aluminum box is a Bud CU234 or similar.



The finished toroid can be placed in an aluminum or plastic box. I mounted mine in a Budd-type CU234 cast-aluminum box with a connector at one end and two insulated, ceramic feedthroughs on the sides. The coax shield should be debraided at each end and then twisted for insertion in the connector and solder lugs as shown in the photograph.

performance

I reasoned that a simple lab test would be to terminate the balun in its characteristic impedance, measure the vswr, and then measure the vswr with a short from the center pin side of the load to ground. If the balun is truly balanced, the short circuit should not affect vswr to a large degree. Indeed, a 10-turn balun tested at 10 MHz showed only negligible change when either of the output leads was grounded. Similar results were noted at frequencies with proper turns. Loss was negligible.

table 1. Minimum number of turns *vs.* lowest frequency of operation for the improved broad-band balun (assumes 500 ohms reactance for 50-ohm system).

frequency	inductance	turns T-200-2	turns F568-1 Q1
3.5 MHz	22.74 H	40	12
7 MHz	11.37 H	28	10
14 MHz	5.69 H	20	6
21 MHz	3.79 H	16	4
28 MHz	2.84 H	14	4

The supreme test was to replace my ferrite-rod balun on a TH6DXX tribander to see if the vswr would change. You will note from **fig. 4** that the original balun had a higher vswr at resonance and a somewhat lower vswr at the high end of the band than the new improved balun. This confirms that the ferrite-rod balun introduces a mismatch at resonance. The lower vswr at the high end of the band is probably due to the increased loss of the ferrite-rod balun, which tends to make the vswr look lower than it really is. Additional baluns are also now in use on a 160-meter dipole and several G5RV slopers on 80 and 40 meters.

other variations

This balun is not restricted to 50 ohms; indeed, any impedance coax could be used if the turns are calculated to yield a reactance at least 10 times the impedance. Smaller or larger cores or coax can also be used if lower or higher power is required. In addition, this type of balun is not frequency-limited to the high frequencies; it also works well at vhf if attention is paid to layout and lead length. The beauty of this type of balun is that it does not introduce any additional reactive components to the feedline.

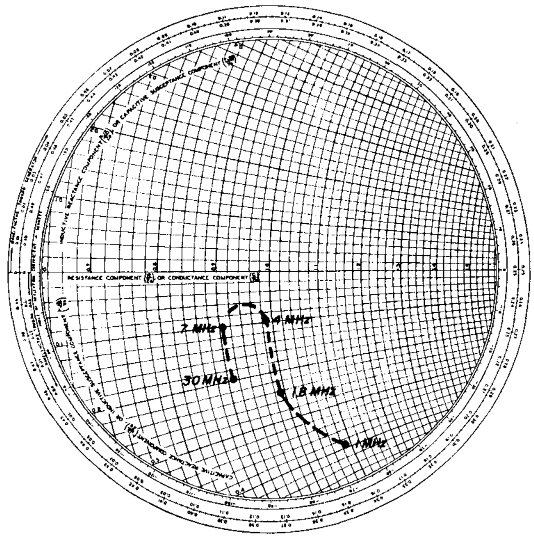


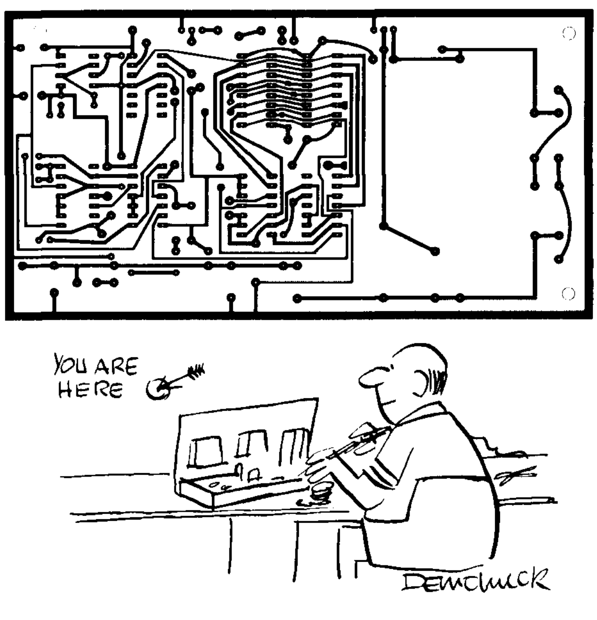
fig. 5. Smith chart plot of a 10-turn broad-band balun built by W1JR, as measured by DJ2LR over the frequency range from 1 to 30 MHz. Vswr is 1.3:1 or less on all high-frequency amateur bands.

I would like to express special thanks to Walt Maxwell, W2DU, and to Ulrich Rohde, DJ2LR, for their encouragement and assistance in preparing this material.

reference

1. Lew McCoy, W1ICP, "Is a Balun Required?" *QST*, January, 1968, page 28.
2. William Orr, W6SAI, "Broadband Antenna Baluns," *ham radio*, June, 1968, page 6.
3. T. A. O. Cross, "Super Toroids with Zero External Field made with Regressive Windings," *Electronic Design*, September 1, 1976.

ham radio



20 meter
delta-loop array

The use of a scale model and simple, but effective, construction techniques produces an effective delta-loop array

The cubical quad type of loop antenna has been a very popular and effective antenna for amateur use between 14 and 30 MHz. The Yagi antenna is probably the most popular of all amateur antennas, and both types have their avid defenders for the most "effective" antenna on a particular band. An excellent comparison of the two antennas is presented in an article by Lindsay, WØHTH.[1] There is another type of loop antenna, however, which is generally overlooked in amateur publications — the delta loop. The delta loop is simply another configuration of a full-wavelength loop antenna like a quad, but the delta loop offers certain advantages: plumber's delight type construction and extremely good vswr bandwidth.

There have been few articles written on either the design or the construction of the multi-element delta-loop antenna,[2,3] and none describe the antenna for use on 20 meters. After reviewing the available information, I concluded that the reasons for neglecting the delta loop on 20 meters were the physical size of the antenna and the resultant problems with successful construction. I hope that my results will bring to light a successful construction technique and a proof of performance that will encourage other amateurs to experiment with and use this antenna.

delta loop *vs* quad

Consider the current distribution of the familiar quad loop antenna shown in **fig. 1**. A current reversal occurs at the junction of each half wavelength section, so there is a current minimum in each vertical leg and a current maximum 180 degrees from the feedpoint. The electric field polarization of the quad loop is derived from the fact that the vertical components of the current elements produce radiated fields that tend to cancel each other, $y_1 + y_2 = y_3 + y_4 = 0$, and the horizontal components of the current elements produce radiated fields that are additive, $x_1 + x_2 + x_3 = x_0$, where x_0 is the effective field-producing current of the loop. The polarization of the electric field is a plane perpendicular to the plane of the loop. This same explanation of the properties of the full wavelength loop apply whether the loop is a square, a diamond, a circle, or a triangle.

For the case of the triangular or delta loop antenna, the current elements are shown in **fig. 2**. Again, the current reversal occurs at the junction of each half wavelength. Each current element can be broken into vertical and horizontal components. The vertical components of the current elements produce radiated fields that tend to cancel each other. Unlike the square loop, diamond, or circle, the delta loop produces a horizontal field component (proportional to $x_1 + x_4$) which is 180 degrees out of phase with x_0,

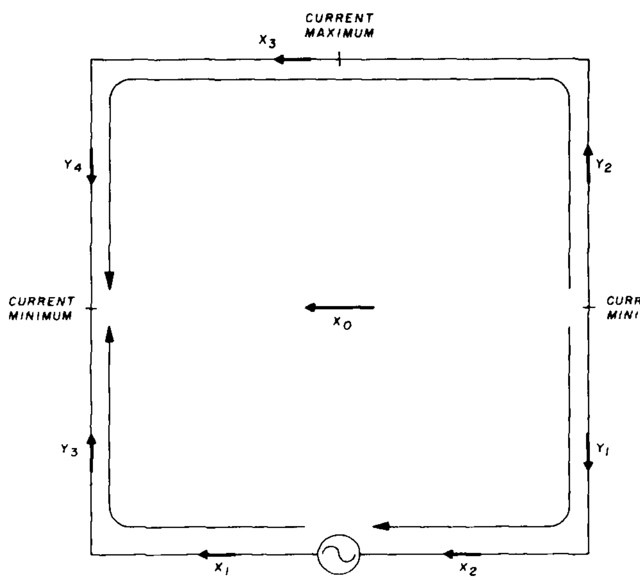


fig. 1. Current flow in a one-wavelength square loop produces two current nulls, one at the center of each vertical side. However, the horizontal current components do not cancel, producing horizontal polarization.

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the effective field current. Due to the geometry of the delta loop, however, the magnitude of this component, when compared with the magnitudes of all other horizontal components, yields the same overall effective field component as the other types of loops, x_0. Therefore, although the shapes of different full-wavelength loops vary, the effective field produced is of the same magnitude and of the same polarization when fed at corresponding locations. Admittedly, the preceding discussion is a simplistic view of electromagnetic field theory, but, without getting bogged down in the math involved, the concepts are adequate to subjectively describe the radiation of the loop antenna.

It is interesting to note that there is evidence that for a simple full-wavelength loop, the gain is approximately 4 dB above isotropic. In other words, assuming 2.15 dBi gain for a half-wave dipole, the full-wave loop shows a gain of 1.85 dBd (dB above half-wave dipole). This predicted gain differential has been experimentally supported by Lindsay's results.[1] The effect of this differential is to say that, for a given boom length, the loop parasitic array will exhibit a 1.85 dB gain above a Yagi array. Stating it another way, Lindsay's results show the array length of a Yagi must be about 1.8 times as long as the length of the loop parasitic array. This explains why an optimally spaced 2-element loop array is comparable in gain to an optimally spaced 3-element Yagi array.

antenna model

Since I was unfamiliar with the delta loop when I began this project, I decided the easiest way to experiment with a design for the antenna would be to build an operating scale model. A model design frequency of ten times the intended frequency reduced the dimensions by a factor of ten. I chose 147 MHz for the model because the dimensions were manageable and measurements could easily be made on 2 meters.

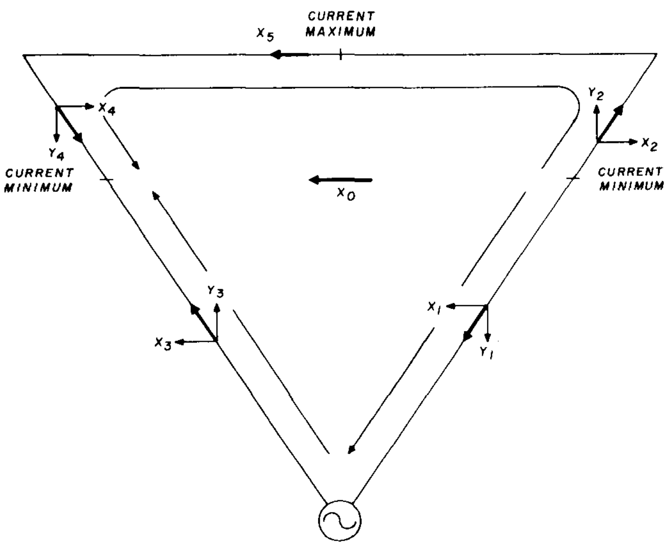


fig. 2. In a full-wavelength delta loop, the electric field is the same as that of the other configurations due to cancellation of the current components.

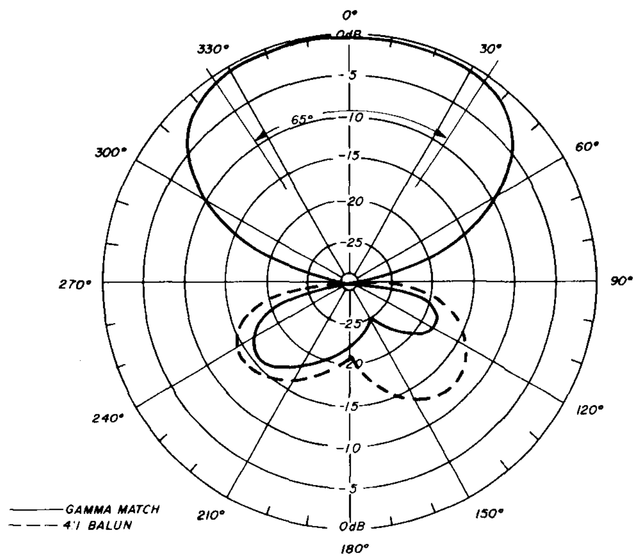


fig. 3. E-field patterns from the scale-model 2-element delta loop. This test was performed at 147 MHz and produced a front-to-back ratio of 22 dB and a front-to-side ratio in excess of 30 dB. The half-power beamwidth measured 65 degrees.

The generally accepted formulas for element length worked very well.

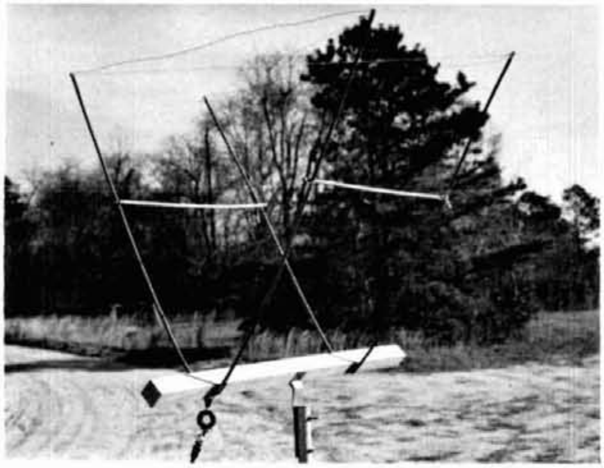
$$\text{driven element} = \frac{306.3}{f_{MHz}} \text{ meters}$$

$$= \frac{1005}{f_{MHz}} \text{ feet}$$

$$\text{reflector} = \frac{314}{f_{MHz}} \text{ meters}$$

$$= \frac{1030}{f_{MHz}} \text{ feet}$$

An element spacing of 0.17λ was chosen, as there was no noticeable difference between that and 0.2λ as seen using the model. Also, 0.17λ translated very closely to a 3.7 meter (12 foot) boom length on the full-size antenna. The model was constructed using 6.5 mm (1/4 inch) copper tubing for the sides of the loops and wire for the tops of the loops. The size of the copper tubing was a poor choice for the model because it presented an unrealistic element-diameter-to-wavelength ratio. But, as it turned out, the



Scale model of the 2-element delta loop. This model was used for measurements at 147 MHz.

performance of the model accurately predicted what I would eventually find with the 20-meter antenna.

Two methods of feeding the antenna were also tried. Measuring a single circular loop of wire showed the resistance to be between 140 and 150 ohms. With a 4:1 balun feeding the driven element, the vswr was about 1.4:1, as would be expected. A better match was obtained with a conventional gamma match, and a vswr of 1.1:1 was easily obtained. Both matching schemes provided an extremely wide vswr bandwidth. At the design frequency of 147 MHz, the vswr remained below 1.5:1 for 18.4 MHz (−9.4 MHz to +9.0 MHz), or a bandwidth of slightly greater than 12 per cent. E-field patterns were also measured with both versions of the scaled antennas, with the results shown in **fig. 7.** Using laboratory grade test equipment, the gain was measured on both versions and found to be 8 dBd at the design frequency. I was very encouraged with these results, and while I worked on the design of the full-size version, the model was used on 2 meters (vertical polarization is obtained by rotating the array 90 degrees — on its side).

construction

Each delta-loop element consists of two arms of aluminum tubing joined together at one end of the boom, with a third arm of wire completing the loop. As determined from an unsuccessful construction attempt, the critical part of the design is a reliable method of attaching the delta elements to the boom

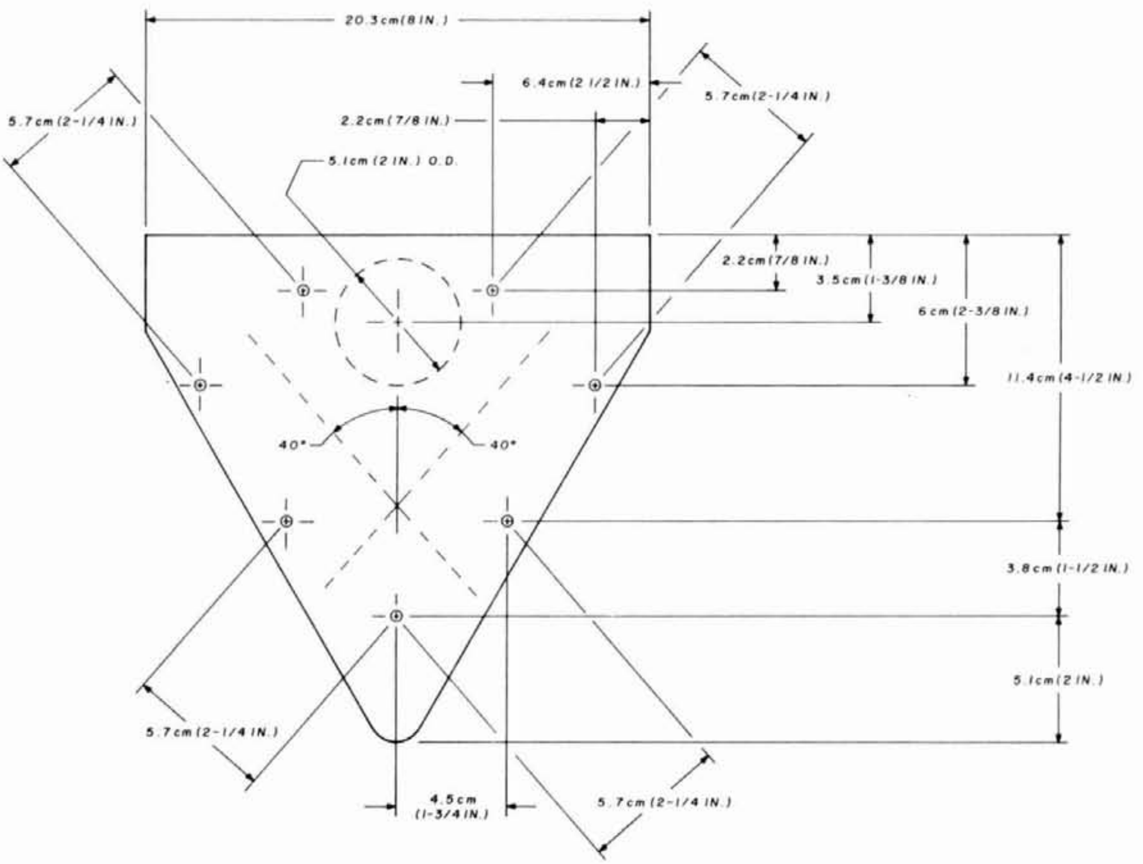


fig. 4. Drilling template for the element mounting plates.

— a method which will be stable in high winds and remain as light in weight as possible. I devised the following solution:

Two triangular aluminum plates are cut from 6.5-mm (1/4-inch) stock and shaped into the form shown in **fig. 4**. These plates are then welded onto the boom. (Any local welder with the ability to work with aluminum should be able to do the job inexpensively.) Care should be taken to ensure that both end plates are perfectly parallel and are not skewed around the boom. This would tend to make the assembled antenna unbalanced and will also degrade the front-to-back ratio.

Next, using **fig. 4** as a guide, holes for the galvanized pipe clamps are drilled in the end plates. The 19-mm (3/4-inch) pipe clamps work very nicely, and are a good deal less expensive than 25.5-mm (1-inch) U bolts. With respect to the end plate vertical centerline, each leg is angled 40 degrees, making a total angle of 80 degrees between the two legs. After both end plates are drilled and the pipe clamps are loosely mounted, one pair on each side of the plate, most of the work is done. All that remains is to make up the individual arms.

Each of the four arms is identical, consisting of a 2.7-meter (9-foot) section, a 2.4-meter (8-foot) section, and another 2.4-meter (8-foot) section, with respective diameters of 25.5 mm (1 inch), 22 mm (7/8 inch), and 19 mm (3/4 inch). Since this tubing is usually supplied in 3.7-meter (12-foot) lengths, the extra 1.2-meter (4-foot) section of 22-mm (7/8-inch) tubing is inserted into the bottom of the 25.5-mm (1-inch) tubing. One end of the 25.5-mm (1-inch) and 22-mm (7/8-inch) tubing is slotted, with hose clamps securing the three sections together. In addition, two sheet metal screws are used to secure the piece of 22-mm (7/8-inch) reinforcing tubing. All the aluminum should be type 6061-T6.

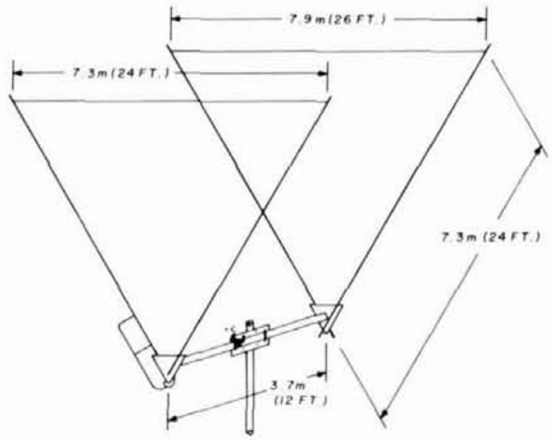
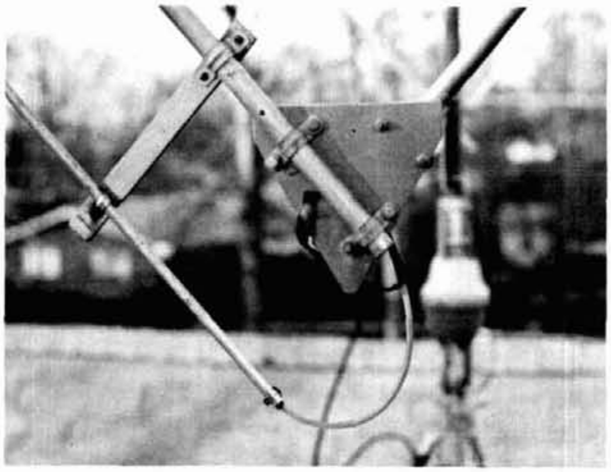


fig. 5. Final dimensions for the two-element delta-loop array.



Details of the gamma match system. Moving the tap point of the gamma arm and changing the amount of coax inserted in the gamma arm will allow you to adjust for minimum vswr.

After the four arms are completed, the top of each is drilled to accept a small eyebolt. The wire legs are then cut to the appropriate lengths and wrapped and soldered to the eyebolts. If the eyebolts are cleaned and well fluxed, a small blow torch will ensure a well-soldered joint.

The last item to be made is the plate that is used to attach the boom to the mast. This should be made of 6.5-mm (1/4-inch) aluminum or 3-mm (1/8-inch) steel. The boom is attached to the plate with 5.1-cm (2-inch) muffler clamps and the mast is attached using U bolts of the size required for the mast. The boom is a 3.7-meter (12-foot) length of 5.1-cm (2-inch) OD tubing with a 3-mm (1/8-inch) wall thickness, also of 6061-T6 material. **Fig. 5** shows the dimensions of the assembled antenna.

final assembly and testing

The antenna should be assembled either on the ground, using a ground-rigged mast, or in a position where it can easily be reached. I assembled mine on a 1-meter (3-foot) roof tower, but only after I had proven to myself that everything would fit.

Fix the boom to the mast and tighten all the clamps securely. Then, with someone to help support the boom, insert one leg at a time into the end plate and tighten the securing clamps. After both legs are in place, the completed element will be well-balanced and self-supporting. Finally, move the other end of the boom and complete assembly of the other element. The basic antenna is now complete, and all that remains is to add the gamma match assembly shown in **fig. 6**.

The gamma-match assembly is a length of 9.5-mm (3/8-inch) aluminum tubing, slotted at one end and bent at the other to the dimensions shown. The outer braid of the coax feedline is stripped away (about 1 meter [3 feet]) and the center conductor, with its insulation, is inserted into the gamma rod. The center conductor of the coax and tubing form the gamma capacitor, with the coax center-conductor insulation forming the capacitor dielectric. The length of coax inside the gamma rod is adjusted for minimum vswr and then secured by a small hose clamp at the bottom of the gamma rod. This is a trial-and-error procedure, and successive lengths of the center conductor can be cut off until the right amount of capacitance is obtained for resonance. Best results will be obtained if the vswr is measured right at the antenna while the adjustments are being made.

One obvious advantage of working with the scale model is the ease with which performance tests can be made. The measurements are more difficult to make with the full-size array, but the agreement in results obtained between the model and the full-size version was very good, and convinced me of the performance of the full-size version. **Fig. 7** shows the vswr and the front-to-back ratio measured at a distance of about 300λ. The reflector is easily tuned by loosening the pipe clamps and sliding the tubing down, thus shortening the overall circumference of the reflector loop. The initial dimensions for the re-

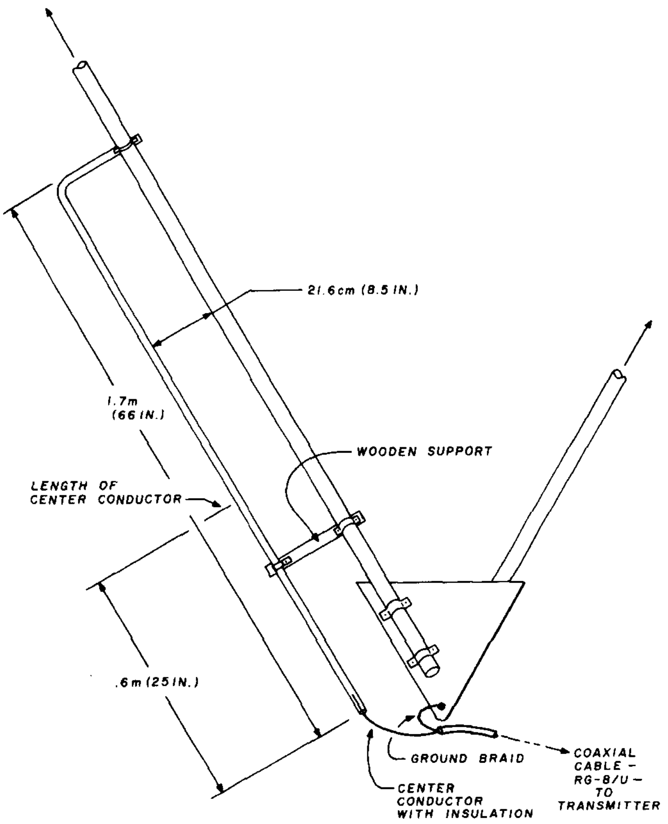
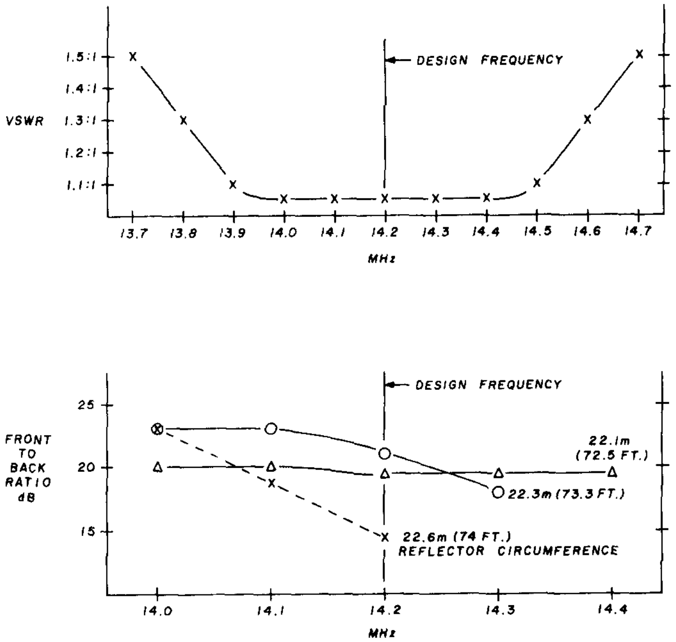


fig. 6. Details of the gamma match for feeding the delta loops.



Boom length	3.7 meters (12 feet)
Turning radius	4.3 meters (14 feet)
Weight	18.1 kg (40 pounds)
Wind load 97 km/h (60 mph)	36.3 kg (80 pounds)
Forward gain	8 dBd
Front-to-back ratio	>20 dB
1.5:1 vswr bandwidth	1 MHz
Impedance	52 ohms with gamma match
Half-power beamwidth	65 degrees horizontal
Cost	$100 price range

fig. 7. Front-to-back ratio and vswr curves for the full-size delta loops.

flector were purposely made long so that tuning could be accomplished.

conclusion

The 2-element delta loop has been a real performer for me. It's allowed me to compete in several DX pileups and compare favorably with others using full-size 3-element Yagis and 2-element quads. Even after my linear was recently sidelined, I was still able to work out very nicely just using my exciter. Also, the low vswr allowed me to bypass my antenna tuner and still enjoy a vswr of less than 1.5:1 across the entire band.

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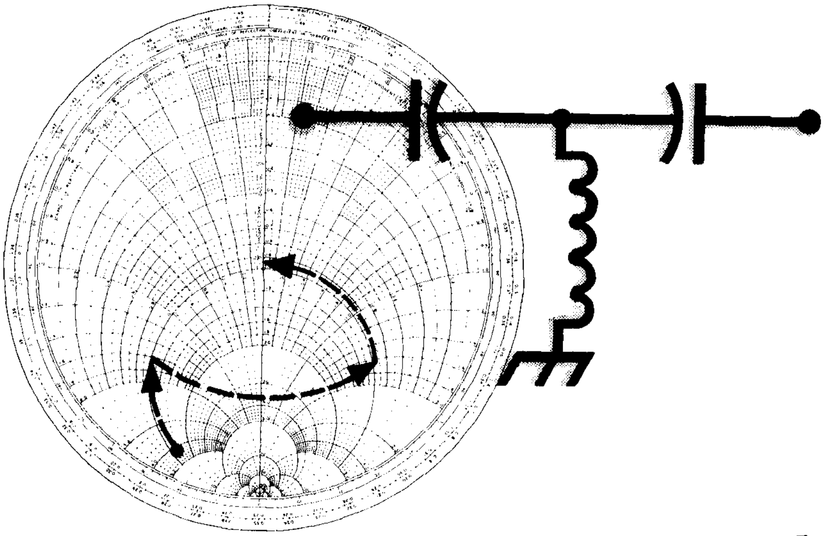

T-network

impedance matching to coaxial feedlines

Design of a five-band T-network for matching antennas to 50-ohm transmitters

The output circuits of almost all high-frequency transmitters, transceivers, and power amplifiers are designed for use with coaxial transmission lines. Most have a nominal impedance rating of 50 ohms; this means the equipment would like to see $50+j0$ ohms at the output terminals. The transmitter or amplifier is then matched to the antenna for any length of line; maximum power is transferred and loading is easy because the net effect is equivalent to connecting a 50-ohm non-inductive resistor across the output terminals. Reciprocally, this optimum condition also applies to receivers designed for 50 ohms input — maximum power transfer occurs from antenna to receiver.

It is not difficult to achieve the matched condition at a single frequency in a single high-frequency amateur band, but few amateurs limit their operation to a single frequency. Two simple antennas with low feedpoint impedance (when cut to resonance) that have an input resistance close enough to 50 ohms to make a reasonably good match with direct coaxial feed are shown in **fig. 1**. The quarter-wavelength vertical operated against a good ground has an input resistance near 35 ohms, and the half-wavelength center-fed dipole has an input resistance near 70 ohms. In both cases the standing wave ratio is less than 1.5:1 when 50-ohm coaxial cable is used and the tuning circuits in the transmitter can easily compensate for this small amount of mismatch.

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In practice there are two considerations which make the simple direct coaxial feed scheme of **fig. 1** unsatisfactory. First, many low feedpoint impedance antennas have an input resistance not equal to or even near 50 ohms. In **fig. 2A** for example, if input resistance R_a is 17 ohms, a 3:1 swr will exist at terminals **JK**. The impedance at the sending end of the line, terminals **AB**, will then be a function of line length,* and, depending on this length, may contain both resistance and reactance. **Fig. 3** shows impedances at all line lengths away from antennas which have an swr of 2, 3, and 4. These are determined from the constant swr circles which cross 2.0, 3.0, and 4.0 on the resistance axis of a Smith chart.[1]

The second consideration is that operation over an entire amateur band is usually desired, not just on one frequency. When an antenna with a low feed-

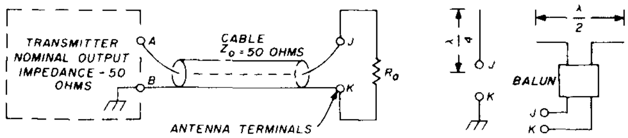


fig. 1. The quarter-wavelength vertical (above good ground) and half-wavelength horizontal dipole are two popular antennas which provide a suitable match to 50-ohm coaxial cable (R_a = *35 to 70 ohms*).

point impedance is operated away from its resonant frequency, resistance changes at a slow rate but reactance departs from zero at a rapid rate as shown in **fig. 4**. This is discussed in detail in reference 2. For any given antenna the actual value of R_a and antenna reactance X_a above and below resonance will depend on many variables: the conductor length-to-diameter ratio, antenna height above ground, orientation (horizontal or vertical), number and spacing of elements (if more than one), and proximity to conducting objects. **Figs. 2B** and **2C** show the equivalent circuits of an antenna when operated above and below resonance. A typical set of swr measurements taken at terminals **AB** is shown in **fig. 5**.

Whatever the exact values of R_a and X_a for any low feedpoint impedance antenna at any particular frequency in a band, the important point is they are *low* — probably less than 200 ohms in all cases over the frequency range of interest. It's the job of the matching network to make some low value of antenna impedance at terminals **JK** look like $50+j0$ ohms at terminals **AB**. The T network is ideally suited for doing just that. Moreover, the T network can be made extremely simple with only two active components, one coil and one variable capacitor. The operational fundamentals and design of such a network will be described in this article.

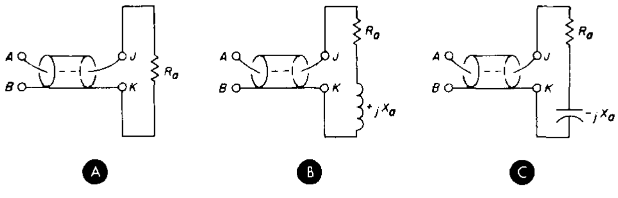


fig. 2. Equivalent circuit of an antenna at resonance (A), *above resonance* (B), *and below resonance* (C). With 50-ohm coaxial line, if the antenna resistance R_a is not near 50 ohms at resonance, the impedance at AB is a function of line length and the match may be unsatisfactory with direct coaxial feed.

impedance matching fundamentals

Assuming that the impedance at the point on the line near **AB** where the matching network will be inserted contains both resistance and reactance, the matching process consists of two steps:

1. Inserting opposite reactance at the output end of the network to result in a net reactance of zero

2. Transforming the remaining resistance value to 50 ohms

The reactance initially present, as represented by

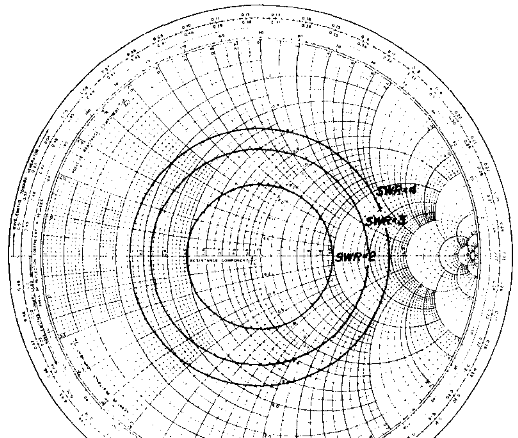


fig. 3. Effect of transmission line length on impedance for swr of 2:1, 3:1, and 4:1. Concentric circles are constant swr values of $R \pm jX$ along the transmission line.

*The impedance at the input of any transmission line is a function of the length of the line and the impedance at the load end. If the load resistance is purely resistive and equal to the characteristic impedance of the line, however, the impedance at the input end is equal to the load impedance, regardless of the length of the line.

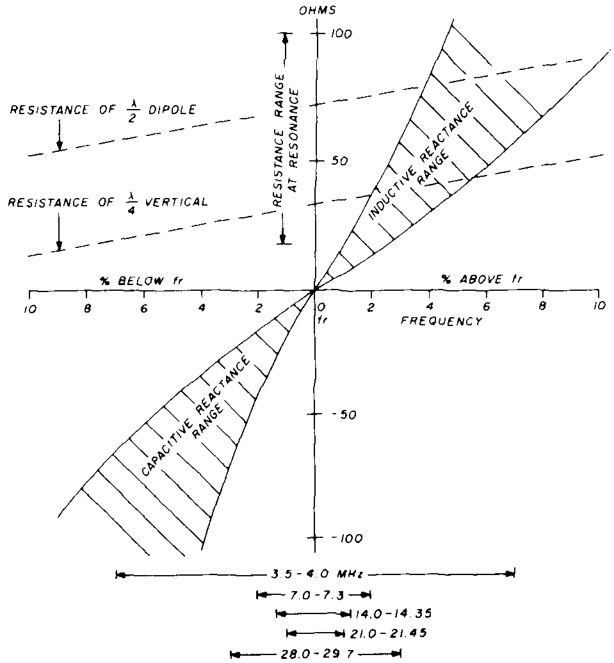


fig. 4. Typical change in resistance and reactance of an antenna as the operating frequency is moved away from resonance. The scales show the corresponding widths of each of the high-frequency amateur bands with resonance at the center of the band.

$+jX$ or $-jX$ in series with R at terminals **AB**, will be low as indicated by **fig. 3**. To compensate for this reactance a low equal value of capacitive or inductive reactance must be inserted either in series or in parallel. If inductive reactance is needed, it can easily be provided with a small coil. If a small amount of capacitive reactance is required, however, the size of the capacitor may be impractically large.

A simple way to take care of the reactance compensation for either case is to incorporate a series inductance leg at the output end of the matching network, and vary that inductance a small amount above and below the design value. This can be done by adjusting a tap on the output end. A T-network inherently provides this series inductance leg.

Having compensated for reactance at the output end of the network, the second step is to transform the remaining resistance to 50 ohms. A network containing inductance and capacitance is capable of doing this because for any series circuit containing R_s and X_s, **fig. 6**, there exists an equivalent parallel circuit containing R_p and X_p where in general R_p is different from R_s.

By definition, equivalence is the case where both series and parallel circuits exhibit the same magnitude and phase angle of impedance to an external circuit. To state this another way, both circuits must have the same external circuit Q where Q is defined as X_s/R_s for the series circuit, and R_p/X_p for the parallel circuit.

The equations relating R_p to R_s and X_p to X_s for any value of Q are as follows:

$$R_p = R_s\,(Q^2 + 1) \qquad (1)$$

$$X_p = X_s\left(\frac{Q^2+1}{Q^2}\right) \qquad (2)$$

If Q is 5 or more, **eqs. 1** and **2** can be simplified to the following with less than 4 per cent error.

$$R_p = Q^2 R_s \qquad (3)$$

$$X_p = X_s \qquad (4)$$

The L network in **fig. 7** is the basic matching network for transforming one resistance at terminals **AB** to another at **CD**. The pi network and T network in **fig. 8** can be thought of as two L networks connected in series. Because of the practical limitations on the size of capacitors for X_p, L networks are best suited for matching a low resistance to a high resistance or vice versa. The pi network is best suited for matching a high resistance to a high resistance, and the T network for matching a low resistance to a low resistance.

If a pi network is best suited for matching one high resistance to another high resistance, you might logically question why it is so universally used in the output stages of transmitters and amplifiers where the output resistance to be matched is 50 ohms. One of the reasons the pi network is popular is that, if a set

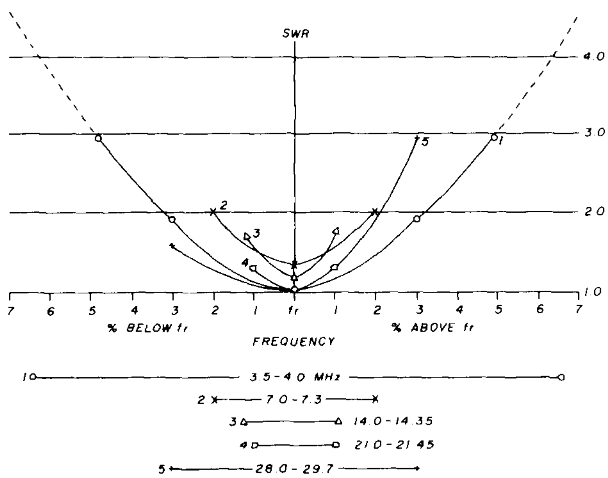


fig. 5. Plots of standing wave ratio as measured at the transmitter output terminals for an 80-meter inverted vee (1), 40-meter inverted vee (2), and three-band Yagi for 14 MHz (3), 21 MHz (4), and 28 MHz (5).

of fixed coil taps is used for all high-frequency bands and if the resistance on the input side is near 50 ohms and there is little or no reactance, adjustment of the capacitor on the output side is noncritical for proper loading.

If, however, the resistance is not near 50 ohms, or if considerable reactance exists on the output side (as occurs when changing frequency away from resonance), the pi network may not be able to provide satisfactory loading. Adding a series inductance leg on the output side to form a pi-L network is one way to take care of this problem.

T network external to transmitter

A T-network assembled as an individual unit can be inserted in a coaxial feedline at any convenient distance from the transmitter, as shown in **fig. 9**. Any reactance which exists initially at **AB** can be

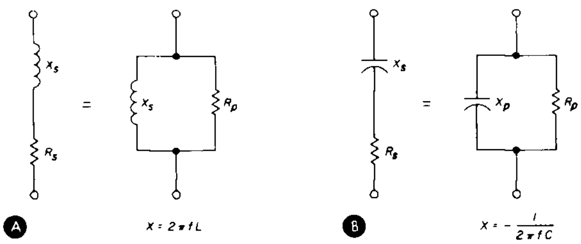


fig. 6. Equivalence of series and parallel circuits containing resistance and reactance. The equivalent element values may be determined from the relationship $X_s/R_s = R_p/X_p$.

tuned out by moving the coil tap on X_{s1}. Elements X_{p1} and X_{p2} of **fig. 7D** are combined into a single value of X_p equal to

$$X_p = \frac{X_{p1}\,X_{p2}}{X_{p1} + X_{p2}}$$

The right-hand side of the T network transforms the low resistance at **AB** to a high resistance at **CD**. The left-hand side then transforms the high resistance at **EF** to $50 + j0$ ohms. The high resistance at **CD** to **EF** is referred to as the *virtual* or "apparent" resistance, transformed from **AB** and **GH**, respectively. The resultant virtual resistance across X_p is

$$R_p = \frac{R_{p1}\,R_{p2}}{R_{p1} + R_{p2}}$$

If the resistance at **AB** in **fig. 9** is 50 ohms, and the effective resistance at **GH** is also 50 ohms, the T network becomes symmetrical; X_{s1} is equal to X_{s2}, and

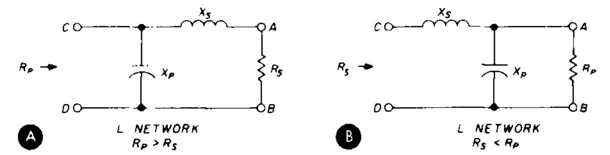


fig. 7. L networks are very useful for transforming one resistance value to another. Design formulas for L networks are found in reference 3.

X_p is one half of X_{s1}; R_{p1} is equal to R_{p2}, and their resultant, R_p, is one half of R_{p1}.

T network with single center-tapped coil

The two series inductance legs of the T network, X_{s1} and X_{s2} (**fig. 9**), don't have to be separate coils. Use of a single center-tapped coil not only simplifies construction but also increases the effectiveness of the network in its operation as a lowpass filter to attenuate harmonics. Each of the two series legs must have a larger inductance than two separate coils would have for a given value of Q, and the extra inductive reactance additionally impedes the flow of harmonic currents through the network.

Fig. 10A shows a center-tapped coil with connections **a** and **c** at its ends, and **b** at the center tap. The equivalent circuit is shown in **fig. 10B** and the coil assembled into a T network in **fig. 10C**. When connected as in **fig. 10C**, the coefficient of coupling k is negative and the effective inductance of each coil half is less than L.

Inductance of the coil alone, measured between **a** and **c**, is greater than twice the inductance between **a** and **b** or **b** and **c** by the factor $2Lk$, where k is defined as the ratio of mutual inductance M to L. To obtain a desired value of L for a T network, a relation between k and coil dimensions is needed. A curve of k vs the length-to-diameter ratio of a center-tapped coil is available,[1] but the same data can be obtained directly for any given set of coil parameters by using an ARRL L/C/F calculator Type A.*

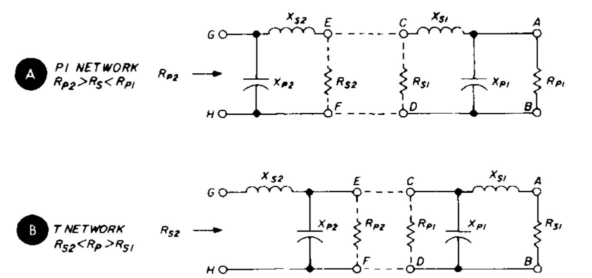


fig. 8. L networks may also be combined into a pi network (A) or a T network (B). The design of pi networks is discussed in references 4, 5, and 6.

*The ARRL L/C/F Calculator Type A is available for $3.00 from the American Radio Relay League, 225 Main Street, Newington, Connecticut 06111.

There are only two active components to be considered in designing a practical single-coil T network: the variable capacitor C1 and the full coil **ac** center-tapped at **b**. Determination of both depends on the lowest frequency at which the network is to be used,

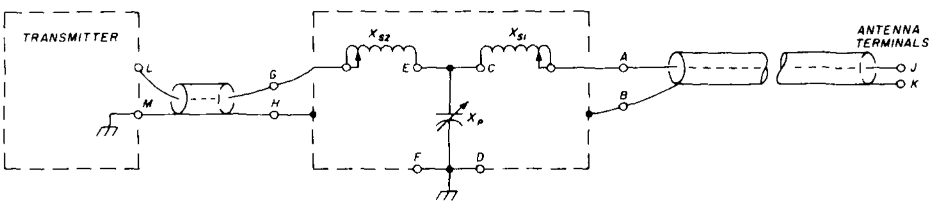


fig. 9. A T-matching network inserted in the line at or near the transmitter output terminals.

so you must decide whether this will be 3.5 or 7.0 MHz. If you choose 3.5 MHz, a second decision must be made as to whether a very large coil should be used to give a network Q of 8 to 10 at that frequency, or a more reasonable sized coil to give that Q at 7 MHz. In the latter case an additional fixed capacitor must be switched across C1 for operation on the 3.5-4.0 MHz band.

An air-wound coil 6.35 cm (2.5 inches) in diameter, 10.2 cm (4 inches) long, and 8 turns per inch (3 turns per cm) is readily available (B&W 3030). It is of reasonable size, and nearly optimum for 7 MHz, so it was chosen with the option of using additional capacitance at 3.5 MHz. A transmitting type variable capacitor should be used for C1 because the rf voltage across it will be Q times that at the input terminals **GH**. The capacitor should be calibrated so that values of X_c can be readily determined from the dial settings. A 30-220 pF transmitting unit was selected in my case.

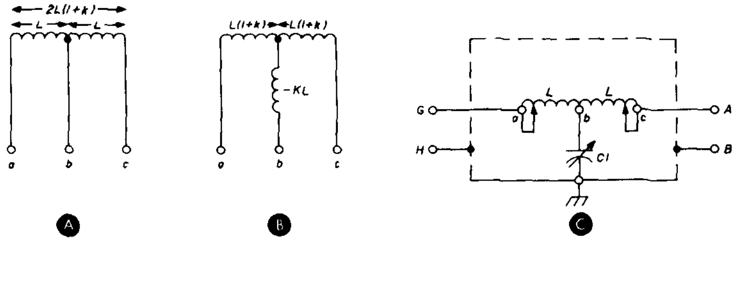


fig. 10. Inductance of a center-tapped coil is shown at (A) with its equivalent circuit at (B). A two-component T network with a center-tapped coil is shown at (C).

Using a Type A calculator the inductance of half coil L is determined as follows:

$$L_{ac} = 31\ \mu H$$

$$L_{ab} = L_{bc} = L = 12.8\ \mu H$$

$$L_{ac} = L_{ab} + L_{bc} - 2M = (2L - 2M)$$

$$M = -2.7$$

$$k = M/L = -0.21$$

The effective inductance of L, L_e, is $L(1+k)$.

$$L_e = 12.8\ (1 - 0.21) = 10.1\ \mu H$$

If the resistance at **GH** and **AB** is 50 ohms, and the full coil is in the circuit at 7.0 MHz, the network components, **fig. 7D**, are as follows:

$$X_{s1} = X_{s2} = 2\pi f L_e = 444\ ohms$$

$$Q = 444/50 = 8.88$$

$$X_{p1} = X_{p2} = 444\ ohms$$

$$(X_p = 222\ ohms\ (C1\ at\ 7\ MHz$$

$$= 1/2\pi f X_p = 102\ pF)$$

$$R_{p1} = R_{p2} = 78.85 \times 50 = 3942\ ohms$$

$$R_p = 1971\ ohms$$

At 3.5 MHz the network Q is 4.44 and X_p is 111 ohms, requiring a total capacitance at C1 of about 400 pF. A fixed transmitting capacitor of 0.0002 μF in parallel with the 220 pF variable may be used.

T network for five-band coverage

Fig. 11 shows the schematic of a tapped-coil network built from the above design data. Construction details are omitted because of the large number of possible options in components and additional convenience features such as tap switches. You may also want to add a coaxial switching scheme to bypass the network so that operation with a given antenna can be quickly compared with and without the matching network. The main construction criterion is to preserve electrical and mechanical symmetry between the input and output sides of the network.

A good method of determining coil tap locations is to connect a transmitter with a nominal 50-ohm output impedance at J1 and a 50-ohm dummy load at J2. An swr indicator should be inserted between the transmitter and J1. With a 50-ohm load the network will be symmetrical. For all bands higher than 7 MHz *where the full coil is used, a set of taps can be found* which give a 1:1 swr at any desired Q. The calculated values of X_p, X_s, and Q for the coil taps of **fig. 11** are listed in **table 1**.

With the antenna and coaxial feedline combinations which produce resistance at J2 anywhere between 25 and 100 ohms, the capacitor dial settings X_p will be close to the values in the table and the indicated swr will be at or very close to 1.0:1. At frequencies off resonance, where reactance appears at J2, the swr will still be close to 1:1 except at the edges of the widest amateur bands.

Maximum swr readings for antennas 2, 3, 4, and 5 *of* **fig. 5**, *without moving any of the coil taps, were* 1.2:1 on the 7 MHz antenna and 1.7:1 on the 28 MHz antenna. It is possible to get a 1.1 swr reading with any of these antennas on any frequency in the band by moving coil taps slightly, but this is not normally necessary.

With a 3.5-MHz antenna you should not attempt to use the antenna and network combination at frequencies where the swr is greater than 3:1 without the network. A broadband or two-frequency antenna should be used if full-band coverage is routinely required.

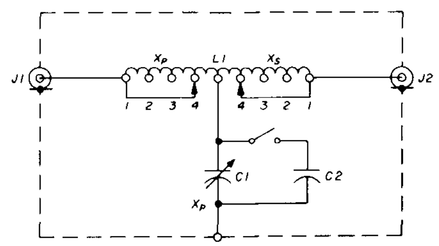
conclusions

Use of a T network in the manner described here is new only in the sense that its advantages have long been overlooked. I have been using a network similar to **fig. 11** at W6EBY for more than 15 years, and it has been used successfully on all frequencies in all five bands with a kilowatt amplifier. In fact, the acquisition of the amplifier and the distressing events which occurred when its load departed too much from 50 + j0 ohms were the motivations which originated the matching network in the first place.

The network can be just as useful, even essential in some cases, with lower power transmitters. Some of the new units with solid-state final stages are not tolerant of an swr greater than 3:1 and they are designed to shut themselves off when confronted with high swr. T networks, although they can't improve the performance of the antenna, will at least allow operation with the antenna as it is.

table 1. Calculated capacitance, inductance, and Q for the network of fig. 11, with 50 ohms at both input and output.

frequency (MHz)	C1, or (C1 + C2) (pF)	X_p (ohms)	X_s (ohms)	Q
3.50	394	115	230	4.60
3.75	342	124	248	4.96
4.00	302	132	264	5.28
7.00	102	222	444	8.88
7.15	98	227	454	9.06
7.30	94	232	464	9.26
14.00	41	277	554	11.08
14.175	40	281	562	11.22
14.35	39	284	568	11.38
21.00	49	155	310	6.18
21.225	48	156	312	6.24
21.45	47	158	316	6.32
28.00	45	126	252	5.06
28.85	43	128	256	5.14
29.70	40	134	268	5.36



C1	30-220 pF transmitting type variable capacitor
C2	200 pF, 5000 Vdc
J1, J2	SO-239 coaxial socket
L1	31 μH air-wound coil, 6.35 cm (2.5") diameter, 10.2 cm (4") long, 3.2 turns per cm (8 turns per inch), B&W 3030 or equivalent.

coil taps	1	2	3	4
Band, MHz	3.5, 7	14	21	28
Active turns	32	26	14	10
Turns each leg	16	13	7	5

fig. 11. Tapped-coil T matching network for the five high-frequency amateur bands, 3.5 through 29.7 MHz.

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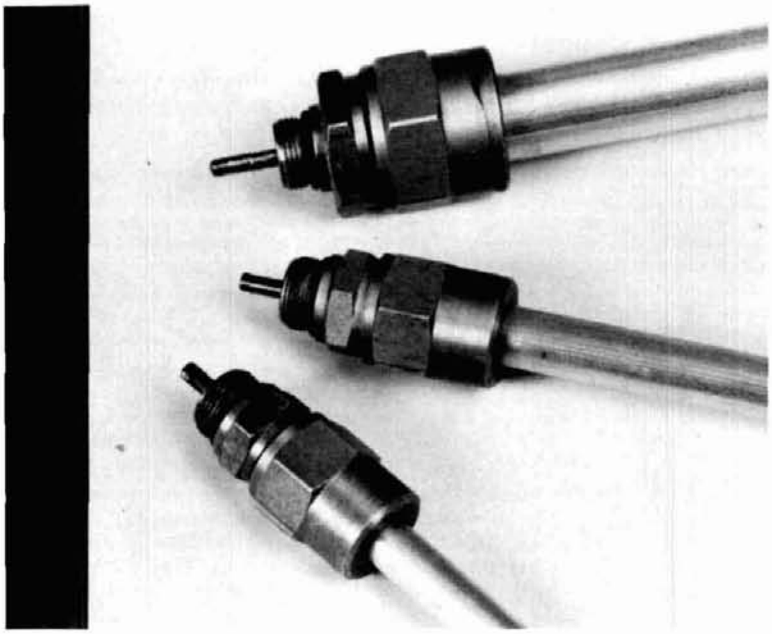

75-ohm cable
in amateur installations

Making use of 75-ohm CATV cable results in lower line loss, which means more power to the antenna

Many hams are not aware of one of the best coaxial cables available, the 75-ohm, solid-aluminum sheathed cable made specifically for cable television (CATV). The coax used in these systems is characterized by a minimum attenuation loss, minimum random-signal pickup, excellent weather resistance, and high structural return loss. All this not withstanding the fact that it can usually be obtained as scrap for next to nothing.

*The number assigned to each cable is actually the outside diameter of the aluminum sheath in inches. With cable of primarily U.S. manufacture, this number has become the generic name of the cable.

Leading the list of features is low attenuation loss. As a result, a 100-watt-output, 420-MHz transmitter, feeding power through 30.5 meters (100 feet) of 0.750* hardline, will deliver 75 watts to the antenna; this is quite an improvement over the 40 watts delivered by a comparable length of RG-8/U!

To further illustrate, **fig. 1** shows the loss exhibited by several different types of cable, starting with the relatively lossy RG-58 and ending with 0.750 cable. With CATV cable, even at the lower frequencies, impressive gains are available to people who use long cable runs.

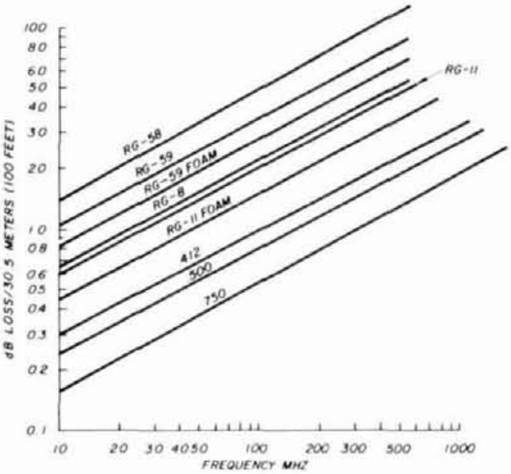

fig. 1. Loss *vs.* frequency for several types of cable. The CATV *cable examples refer to cable manufactured by Systems Wire and Cable, Inc., of Phoenix, Arizona. Cable from other manufacturers may have different attenuation values, but as a rule will be very close to these figures.*

In addition to its lower attenuation figures, solid aluminum sheath also reduces random-signal pickup and leakage. The best military braid specifications require only 96 per cent shielding, as compared to the 100 per cent provided by seamless CATV cable. And, as it turns out, most braided cable used by amateurs has a braid coverage in only the 75 to 90 per cent range, and sometimes as low as 60 per cent (see photograph)!

Weather resistance is also greatly improved by using cable with a seamless sheath. After a period of

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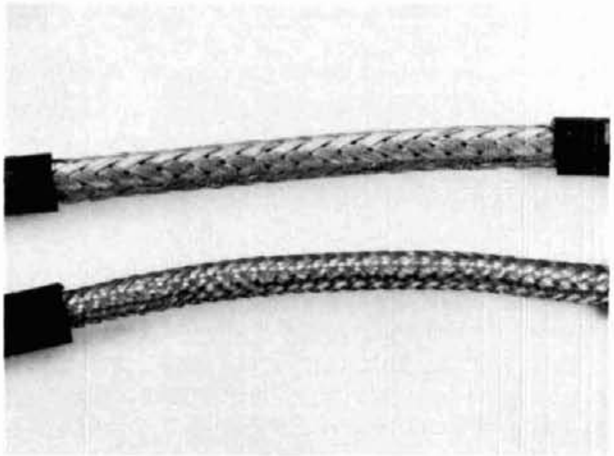


As seen in this photograph, braid coverage can vary radically. The two examples are both RG-59/U, except that the top cable is normally used in CATV installations. Use of the bottom cable may result in unwanted signal pickup and/or emission.

exposure to sunlight and air, the copper conductors in ordinary braid become corroded; they do not form an electrical bond to one another, but function more as insulated wires, increasing random-signal pickup and radiation losses. This can be easily checked by terminating a well weathered RG-8 line and noting the background noise level. Then, change to CATV cable, equally terminated, and your receiver will be dead.

CATV cable is normally bare, but it is also produced with a black polyethylene jacket if the cable is to be exposed to salt spray, fog, or industrial contaminants. It is also manufactured with a "flooded" polyethylene jacket for underground or underwater installation.

Different examples for using the adapters between 75-ohm CATV hardline and standard UHF connectors.

connectors

The major problem encountered by amateurs using 75-ohm CATV cable has been finding suitable connectors to use between the cable and ordinary UHF fittings. (Special cable connectors which mate with type N and F fittings are available, but they are difficult to locate and buy in small quantities.) There is a practical solution to this problem, however. This is the use of standard CATV "feedthrough" connectors, which, fortunately, end up with 6.5 mm (1/4 inch) of male 5/8 x 24 (M16-2) thread, the same thread as standard UHF connectors.

Making the adapter begins, as shown in **fig. 2**, with the installation of the appropriate feedthrough connector on the end of the cable. To mate with the UHF connectors, a PL258 female-to-female adapter is slipped over the end of the exposed center conductor. Joining the adapter and feedthrough connector is accomplished by using the threaded portion of the barrel from a PL259 connector.

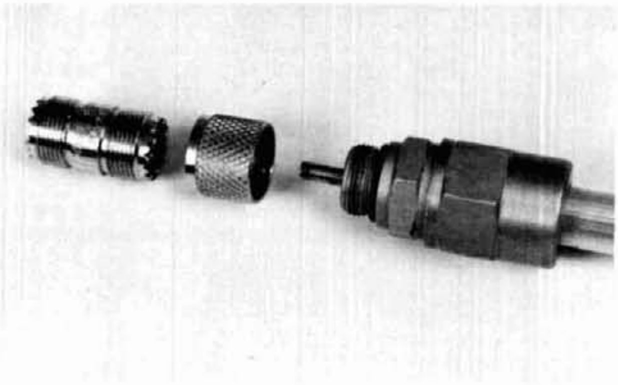


fig. 2. As shown in this photograph, adapting CATV cable to a normal UHF connector requires the use of a CATV feedthrough connector attached to the end of the cable. The 0.500 cable in this illustration has the brass tubing sweated over its center conductor. The threaded coupling cut from a PL259 connector attaches the PL258 adapter to the feedthrough connector.

On the 0.412 and 0.500 cable, you will have to sweat solder a piece of 4-mm (5/32-inch) OD brass tubing over the center conductor. (The brass tubing is available in short lengths from most hobby stores.) The center conductor of the 0.750 cable is heavily tinned to increase its diameter from 3.7 to 4 mm (0.146 to 0.156 inch).

If you want to directly hardwire the CATV cable to an SO-239 chassis connector, prepare the cable end as shown in **fig. 3**. Then, connect the SO-239 to the feedthrough connector, prior to inserting the cable. The final step consists of inserting the cable into the feedthrough connector, making sure that the center conductor mates with the SO-239, and tightening the cable ferrule. Generally, connectors are available from CATV equipment supply sources, although they are not enthusiastic about small-quantity orders. (Try these sources only if you can't con the local CATV system installer out of a few.)

installation

When installing solid-sheath aluminum cable, note that all bends should be made over a grooved form block. Also ensure that all bends are *never* made to a radius of less than ten times the cable diameter. Observing this precaution will prevent wrinkling the sheath, which can cause impedance bumps. Too tight a bend may also force the center conductor to one side, since the foamed dielectric is soft and subject to cold flow.

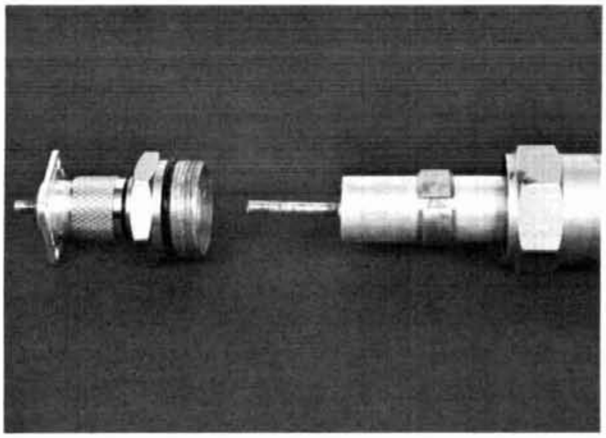


fig. 3. Attaching the hardline to a chassis-mounted SO-239 can be accomplished in the same manner. In this case though, the feedthrough connector and the SO-239 are mated before the cable is attached.

Another item available from equipment supply stores is special heat-shrink tubing that slides over the entire connector assembly. These tubes are usually about 23 cm (9 inches) long and have a special sealant inside that is effective against moisture.

summary

Before changing to 75-ohm transmission line, it is best to ensure that your transmitter and antennas will match the higher impedance. In general, most transmitters with a pi network will match the impedance presented when using 75-ohm cable. Even gamma matches on Yagi arrays can be readjusted to match the new cable. Unfortunately though, it can be an expensive proposition if you try to change your power meters to read correctly in a matched 75-ohm system.

Even with the small problems presented by connectors and, in some cases, matching, the use of 75-ohm CATV cable has one big advantage: more power at the antenna at a highly economical price.

ham radio

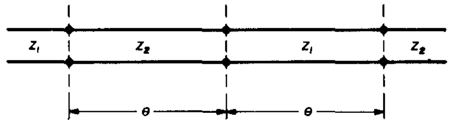
matching 75-ohm CATV hardline to 50-ohm systems

The previous article by W7VK pointed out the significant attenuation differences between the more commonly used RG-8 type coaxial cables and 75-ohm CATV type "hardline." In some amateur installations, changing to hardline could mean large increases in the power delivered to the antenna, especially where long cable runs are being used. As Woods pointed out, switching to this type of cable usually involves only antenna rematching and retuning the transmitter. Unfortunately, in some cases, rematching the antenna to 75 ohms is not possible, and the resultant swr may be intolerable; the ultimate isolation between sections of a repeater duplexer, for example, can be degraded by a high swr on the line. The matchable bandwidth of an antenna can also be reduced, since the output pi network was originally designed for 50-ohm loads. And finally, 75-ohm power meters are not commonly available.

matching

The standard quarter-wavelength transformer or *Q* section, one of the most popular forms of matching, is unfortunately not readily suited for this task. The impedance of the matching section has to be the geometric mean between the two impedances to be matched, or in this case $\sqrt{Z1 \cdot Z2} = 61.3$ *ohms*, not a common coax impedance value.

One little-known matching technique, the nonsynchronous impedance matching transformer, does offer a solution to the problem. W5TRS originally described this method in *ham radio*,[1] though only providing basic design information (see **fig. 1**). In a subsequent letter,[2] W3DVO briefly discussed the bandwidth in relation to a standard quarter-wavelength transformer. Until now, however, nothing has been published on the use of the nonsynchronous transformer. Since the required sections are the same impedance as those to be matched, this method would seem to be an easy solution to the 75-to-50 ohm matching problem, and warrants further examination.



$$\theta = \cot^{-1}\sqrt{\frac{Z_1}{Z_2} + 1 + \frac{Z_2}{Z_1}} \qquad \ell = \frac{\theta\lambda}{360}$$

fig. 1. Diagram of the basic nonsynchronous matching transformer as described by W5TRS. The lengths of the two matching sections will vary according to the impedance ratio.

To evaluate this method, I decided to compare the nonsynchronous transformer to another technique, stub matching. **Fig. 2** illustrates the situations that were considered. (If the load were replaced by an antenna, the system would not be too different from a typical antenna installation.) The main feedline was considered to have a 1 dB insertion loss and be 0.25 wavelength long at the center frequency. Since there will be a perfect match at only one frequency, having the feedline 0.25 wavelength long provided the maxi-

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table 1. Impedance values along the lines shown in fig. 1.

	nonsynchronous transformer			
frequency, MHz	point A	point B	point C	final swr
144	74.63+j0.63	75.34−j0.50	49.86−j0.44	1.0093
145	74.82+j0.31	75.15−j0.24	49.93−j0.21	1.0044
146	75.01−j0.02	74.99+j0.02	50.00−j0.01	1.0002
147	75.20−j0.36	74.85+j0.29	50.08+j0.22	1.0047
148	75.37−j0.70	74.72+j0.56	50.16+j0.41	1.0089
	stub matching			
frequency, MHz	point A	point B	point C	final swr
144	75.60−j0.12	75.75−j0.18	50.02+j0.86	1.0173
145	75.31−j0.06	75.39−j0.09	50.00+j0.42	1.0084
146	75.02−j0.00	75.03−j0.01	50.00−j0.02	1.0004
147	74.74+j0.05	74.67+j0.06	49.99−j0.01	1.0002
148	74.45+j0.12	74.30+j0.11	49.97+j0.04	1.0009

mum impedance change at other than the center frequency. This, along with the low insertion loss, will provide close to the worst-case swr. The matching sections were considered to be lossless lines.

test results

Table 1 shows the different impedance values as the 50-ohm load was rotated back toward the generator. In actuality, the values were determined with the aid of an HP-25 programmable calculator; the use of the Smith chart was precluded since the final differences were extremely small, and beyond the *accurate* resolution of even an expanded chart.

Because the initial results proved so favorable, another set of calculations were performed. This time, instead of the relatively narrow bandwidth afforded by the 2-meter frequencies (approximately 1.5 per cent), calculations were carried out for 80 through 10 meters, with the 80-meter extreme of 6 per cent bandwidth. **Table 2** shows the results for the nonsynchronous transformer when applied to **fig. 2A**.

As a final test, the line was terminated with eight different reactive loads, each selected to be on the 2:1 swr circle on a Smith chart (see **fig. 3**). The inner points represent the same impedances, but as seen at the generator (transmitter) end after the different rotations. **Table 3** lists the actual computed values.

summary

The nonsynchronous impedance matching transformer can be an extremely valuable tool. With a bandwidth basically comparable to either stub or

table 2. Swr values for the nonsynchronous transformer when used for 80 through 10 meters.

frequency, MHz	final swr	frequency, MHz	final swr
3.5	1.0571	14.3	1.0048
3.6	1.0322	14.4	1.0091
3.7	1.0091	21.0	1.0063
3.8	1.0086	21.1	1.0029
3.9	1.0224	21.2	1.0003
4.0	1.0319	21.3	1.0034
7.0	1.0150	21.4	1.0059
7.1	1.0045	28.0	1.0097
7.2	1.0038	28.2	1.0045
7.3	1.0188	28.4	1.0003
14.0	1.0097	28.6	1.0048
14.1	1.0045	28.8	1.0091
14.2	1.0003		

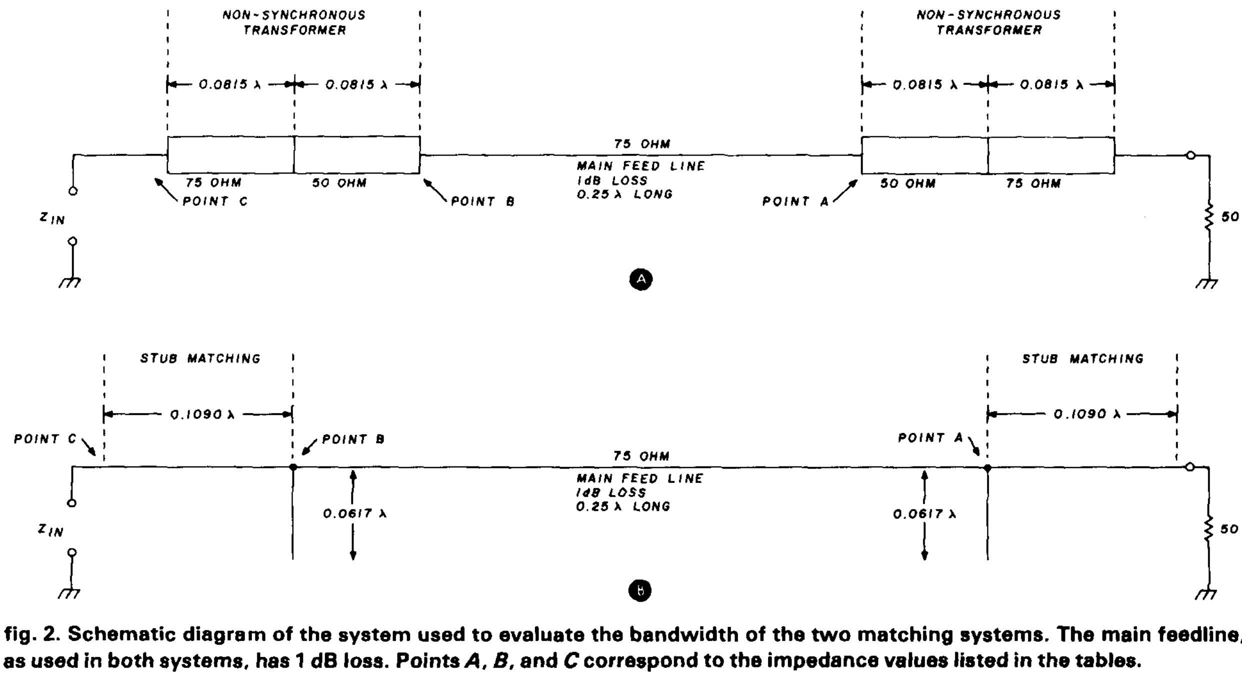


fig. 2. Schematic diagram of the system used to evaluate the bandwidth of the two matching systems. The main feedline, as used in both systems, has 1 dB loss. Points *A*, *B*, and *C* correspond to the impedance values listed in the tables.

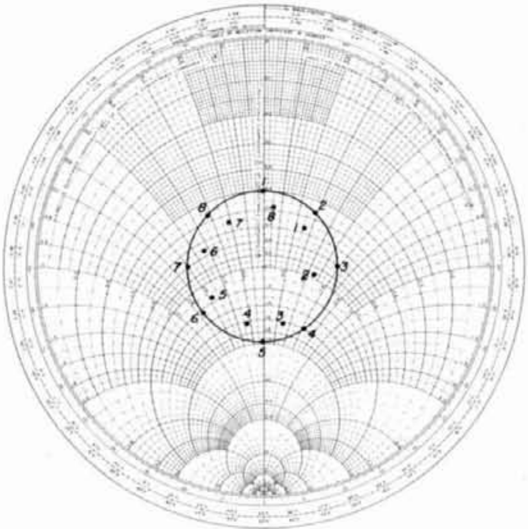


fig. 3. Smith chart presentation of the eight reactive loads used to terminate the line. The inner points represent the final impedances as seen at the transmitter end.

Q-section matching, it has the added advantage of requiring one-third less coax than the quarter-wavelength section and one-half less than a stubbed system. Though these differences may not be significant at vhf, they can save a considerable amount of cable on 80 through 10 meters. In addition, the construction of a nonsynchronous transformer appears to be inherently easier than that of a stub system because of the difficulty in correctly placing a T-type connector. Probably the two biggest disadvantages are that the feedlines have to be dedicated to a particular band (since each transformer length is frequency dependent), and the requirement that the coax be the same impedance as those to be matched. These factors certainly prevent its qualifying as an all-encompassing matching method, but it more than adequately will handle the problem of matching 75-ohm CATV hardline to a 50-ohm system.

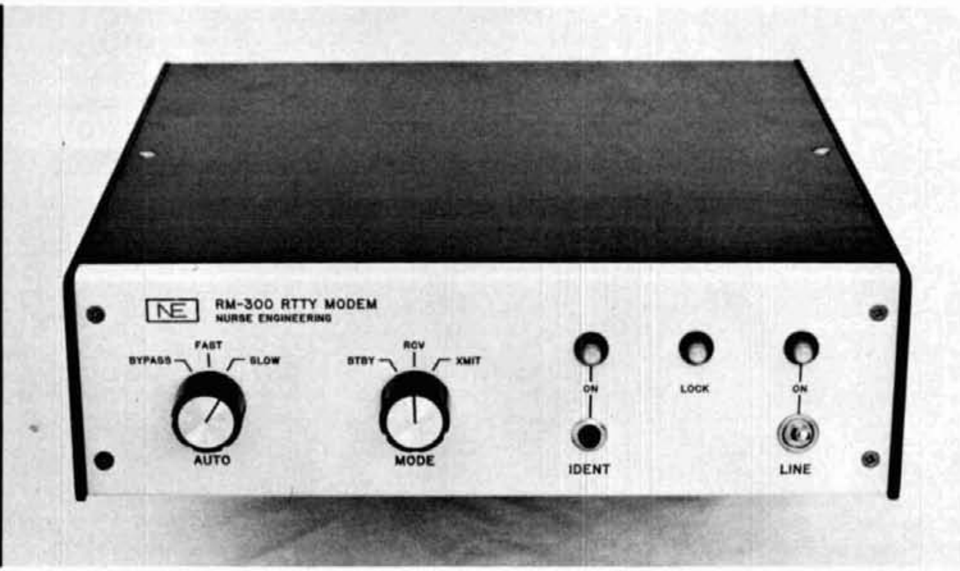
table 3. Computed swr values at 14 MHz with the line terminated in reactive loads.

termination	computed impedance values	final swr
25.00 ± j0	34.17 + j15.90	1.7097
28.09 + j14.90	48.40 + j26.48	1.7040
40.02 + j30.01	74.23 + j22.41	1.7080
69.53 + j36.84	83.89 − j10.66	1.7193
100.0 ± j0	59.09 − j28.80	1.7311
69.39 − j36.86	39.16 − j22.24	1.7367
39.95 − j29.96	30.58 − j9.84	1.7327
28.06 − j14.85	29.21 + j3.11	1.7215

references

1. Henry Keen, W5TRS, *ham notebook*, *ham radio*, September, 1975, page 66.
2. Raymond Aylor, W3VDO, *comments*, *ham radio*, May, 1976, page 63.

ham radio



RM-300 Modem

RTTY modulator-demodulator for vhf operation

Design and construction details for the hardware to get started in the RTTY mode on the vhf amateur bands

Operating RTTY on vhf fm is a joy. Bothersome fading, static crashes, interfering signals, and drifting VFOs don't stand between you and a QSO. Whether across town on simplex or across the state through a repeater, vhf RTTY is a reliable, trouble-free mode ideally suited for rag chewing or unattended operation.

The ingredients for a vhf RTTY station include a standard fm transceiver, a Teletype machine, a terminal unit (demodulator), an AFSK oscillator (modulator), and a means of sending your call in Morse code as required by the FCC.

The RM-300 Modem (*Mo*dulator-*Dem*odulator) was developed to provide a simple way for those interested in vhf RTTY to get on the air. The RM-300 contains a phase-locked loop (PLL) demodulator to convert the 2125/2295-Hz tones from your transceiver speaker terminals to Teletype keying pulses, a stable AFSK modulator to feed the microphone input of your transceiver, a read-only memory CW identifier, and auto-start logic — all on a single 114 x 152 mm (4.5 x 6 in.) circuit board. A second board, the RP-400, contains loop and low-voltage power supplies and loop keying circuits.

A schematic diagram for the RM-300 is given in **fig. 1**. The three major functions mounted on the cir-

*A complete kit of all parts is available from Eclipse Communications, 5 Westwood Drive, San Rafael, CA 94901. The RM-300 kit less PROM costs $71.25. A PROM programmed with one or two call signs (specify) costs $7. The cost of the RM-300 circuit board alone is $21.25. (The board is double-sided with plated-through holes and a solder mask on both sides. The component side is screened with part numbers and component values.) Add $1 for postage and handling with all orders. California residents add 6 per cent sales tax.

By **Howard L. Nurse, W6LLO**, 665 Maybell Avenue, Palo Alto, California 94306

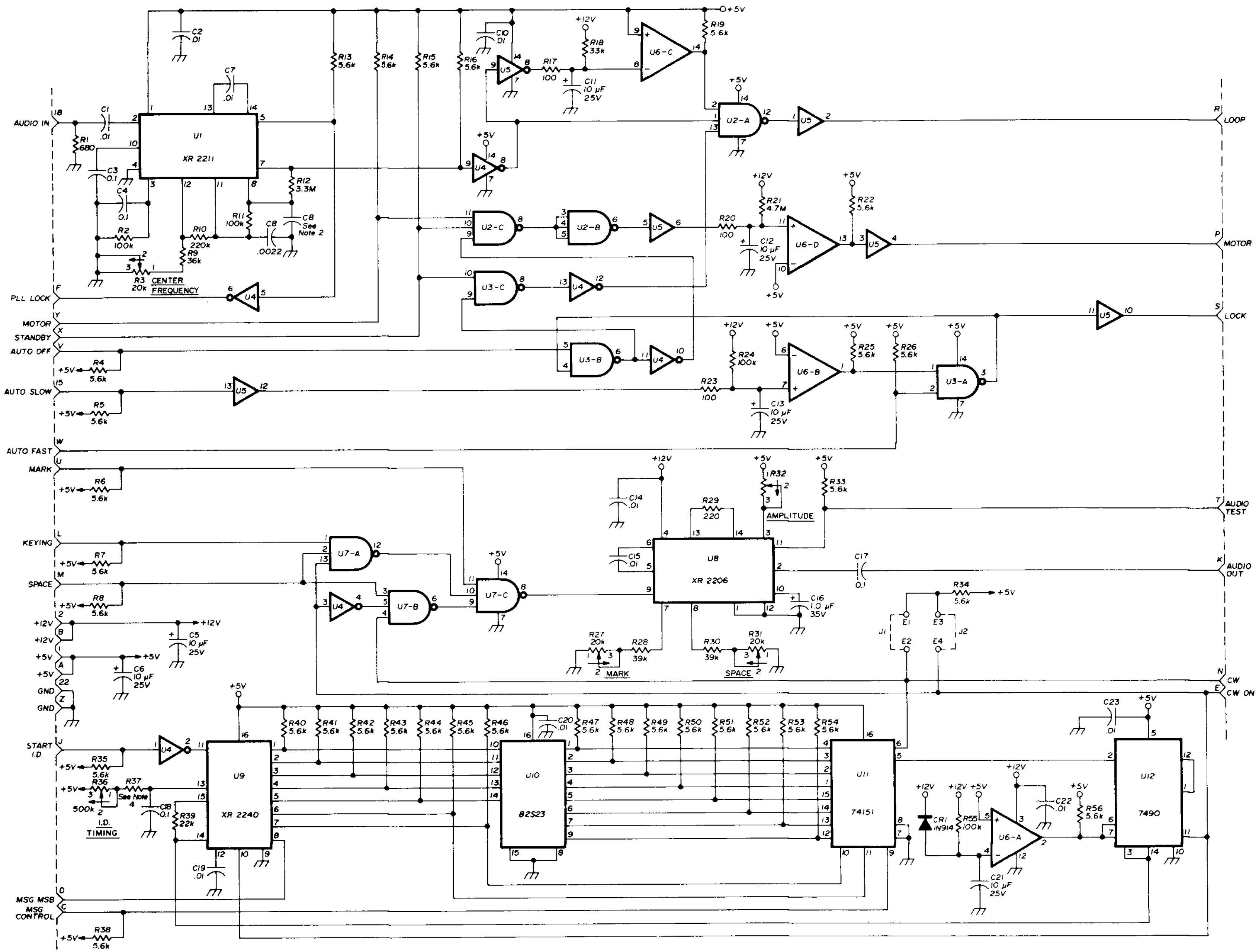


fig. 1. Schematic of the RM-300 Modem (modulator-demodulator) for those interested in vhf RTTY. A complete kit of all parts is available (see text).

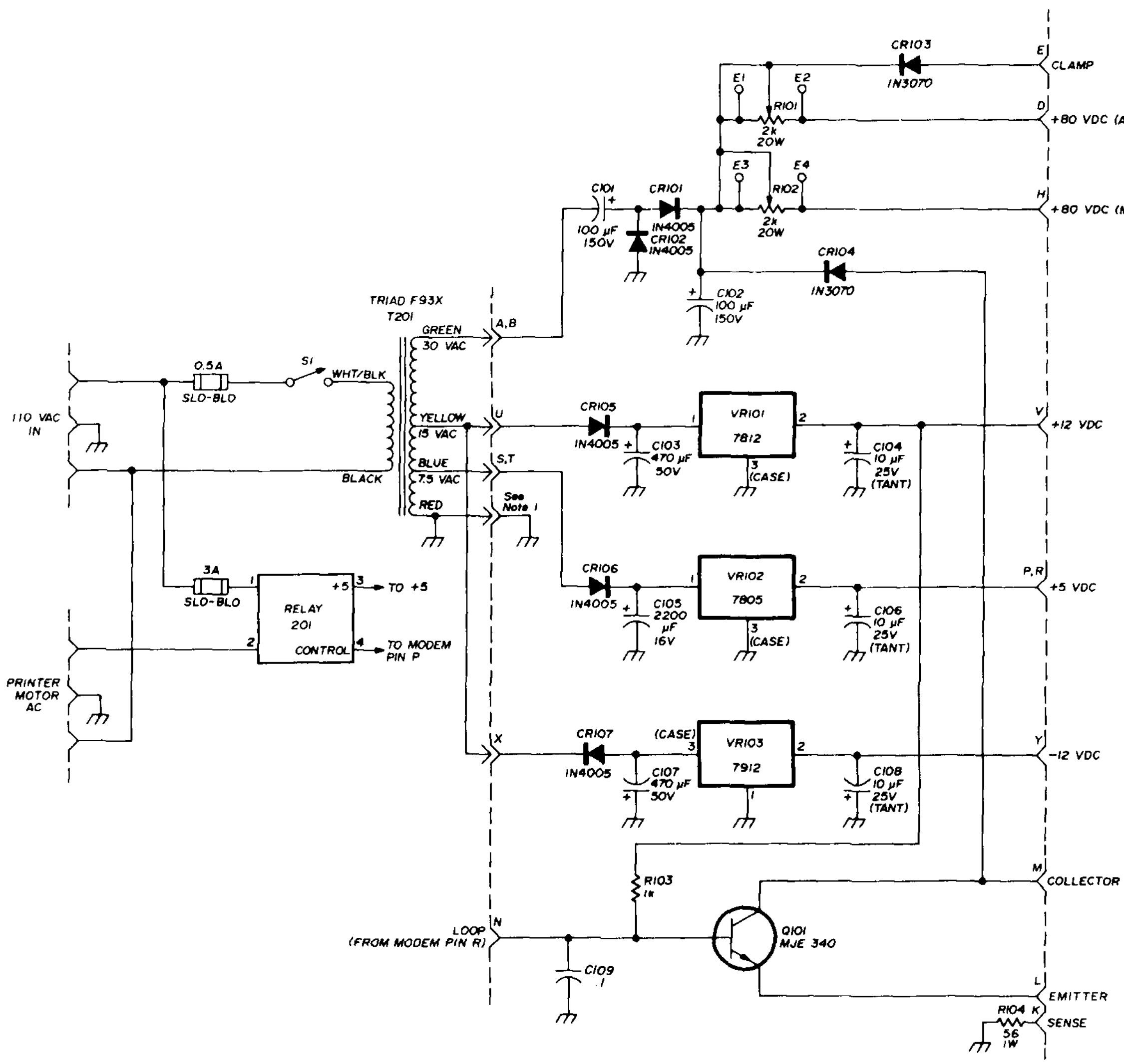


fig. 2. Schematic of the RP-400 power supply. The design features an auxiliary −12 V dc supply in addition to power required for the RM-300 Modem. Kits are available.

cuit board are grouped on the schematic. The demodulator portion is shown in the top third, the AFSK modulator in the middle third, and the CW identification circuitry in the bottom third of the schematic. Detailed descriptions of connections to and from the RM-300 circuit board are given in **table 1**.

demodulator and autostart

Audio from the transceiver is fed to the XR2211 PLL through pin 18 on the board edge connector. The PLL output on U1 pin 7 is at a TTL-compatible high level when the input tone is 2125 Hz (**MARK**) and low when the input tone is 2295 Hz (**SPACE**). The frequency at which the PLL switches from high to low is the PLL center frequency as determined by center-frequency potentiometer, R3.

The PLL output signal is inverted by U4 and applied to the antispace circuit (U5 and U6-C) and the keying inhibit gate, U2-A.

The antispace circuit prevents *space* tones longer than approximately 200 milliseconds from keying the loop. The output from U5 pin 8 clamps the voltage across C11 near ground as long as the PLL is detecting a *mark* tone. A *space* tone allows the voltage across C11 to rise at a rate determined by R18. If the voltage rises above 5 volts, the output of U6-C goes low, which forces the loop into *mark*-hold.

The autostart circuit and standby logic can also be used to force the loop into *mark*-hold. The PLL contains a carrier detector, which has a TTL-compatible output on pin 5 of U1. This output is low when a signal within the lock range of the PLL is detected. The carrier-detect output, after inversion by U4, can be used to control the *fast* or *slow* modes of the autostart. The *fast* mode allows the Modem to respond immediately to a detected signal, which is desirable when operating fast break-in. The *slow* mode yields a 0.5-second delay before the Modem responds, which gives sufficient noise immunity on vhf circuits. When a carrier is detected by the PLL, the *lock* output (edge connector pin S) goes low. This output can be used to control an LED on the Modem front panel.

If the *auto off* input (edge connector pin V) is grounded or a carrier has been detected, and the *standby* input (pin X) is high, the loop can be keyed by the PLL because pin 13 on U2-A will be high.

The open-collector loop output from U5 pin 2 is high for *mark* and low for *space*. It can be connected directly to a loop keying transistor or to the serial input of a UART.

The *motor* output (pin P) is low when a signal has been detected, the *standby* input is grounded, or the *motor* input (pin Y) is grounded. The *motor* output will remain low for approximately 25 seconds after a signal has dropped. This timing is determined by the RC time constant of R21 and C12.

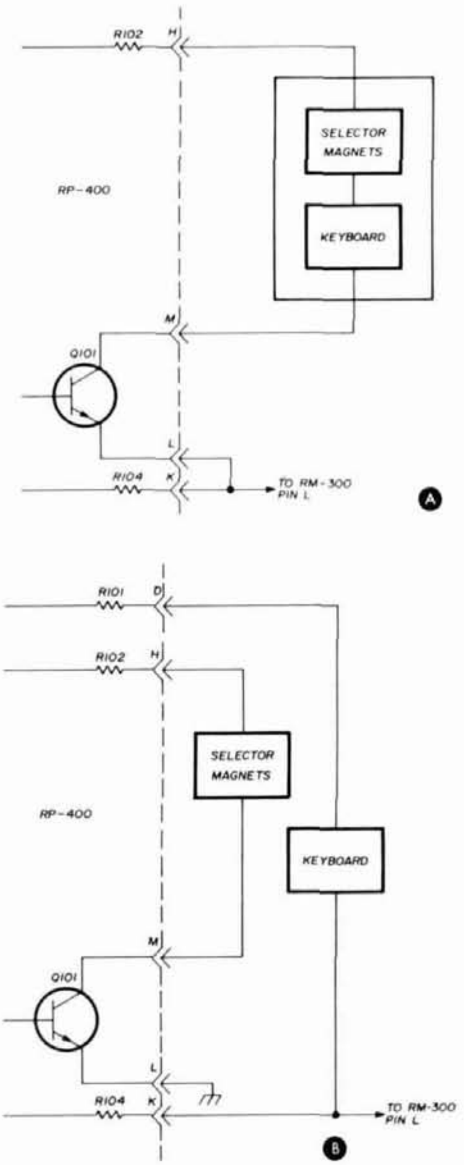
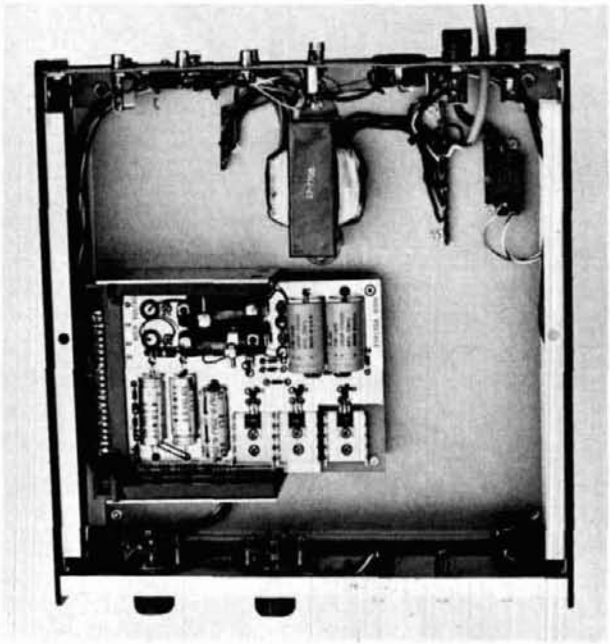


fig. 3. Two suggested ways of connecting your RTTY machine to the loop supplies and keying transistors. Sketch A shows the usual connection. Separate selector magnet and keyboard connections are shown in B.



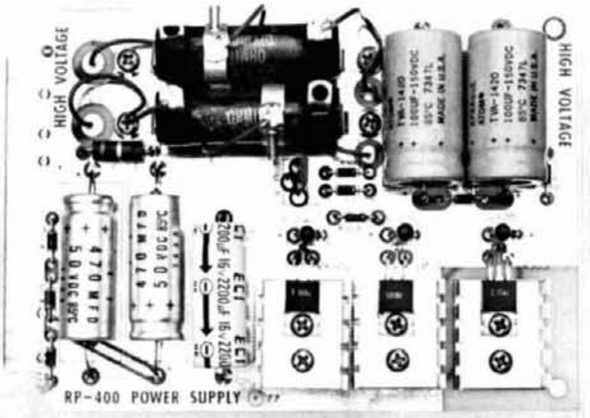
Interior of the RM-300 Modem. A solid-state motor-control relay is near the power cable at the rear of chassis. The RM-300 board is below the RP-400 power-supply board.

AFSK modulator

The heart of the AFSK modulator is an XR-2206 function generator integrated circuit. It produces low-distortion sine wave tones at a frequency determined by capacitor C15 and the resistance between pin 7 or 8 and ground, depending on the control input on pin 9. When pin 9 is high (*mark*), R27 sets the ouput frequency to 2125 Hz; and when pin 9 is low (*space*), R31 sets the output frequency to 2295 Hz. The output frequency can be monitored at the *audio test* output (pin T), which provides a TTL-compatible square-wave replica of the function generator output waveform.

The AFSK modulator output level should be adjusted to match the requirements of your transmitter's audio circuit using potentiometer R32. The output amplitude can be adjusted to a maximum level of approximately 5 volts peak-to-peak.

All control inputs to the AFSK modulator are TTL-compatible. The teleprinter keyboard signals are applied to the *keying* input (pin L). Consistent with the design convention used throughout the board, a high input yields a *mark* tone, while a low input yields a *space* tone. *Mark* and *space* override inputs are provided on pins U and M respectively. These inputs can be used to force the AFSK modulator to either state despite information present on the *keying* input. The remaining control input to the AFSK modulator is from the CW identifier.



The RP-400 power-supply board. The board is 114 × 152 mm (4.5 × 6 in.). See text for kit information.

table 1. RM-300 RTTY Modem input-output descriptions

name/pin number	description
AUDIO IN/18	Audio from receiver. 680-ohm impedance. Input level 10 mVrms to 3 Vrms.
PLL LOCK/F	TTL high when PLL locked to input signal.
MOTOR/Y	When grounded causes MOTOR/P to go low.
STANDBY/X	When grounded causes MOTOR/P to go low and LOOP/R to go high (MARK level).
AUTO OFF/V	When grounded forces Modem into receive mode without control by the PLL LOCK/F function.
AUTO SLOW/15	0.5-second Autostart control line.
AUTO FAST/W	Instantaneous Autostart control line.
MARK/U	When grounded forces AFSK modulator to MARK.
KEYING/L	Normal RTTY keying line. MARK (2125 Hz) is high and SPACE (2295 Hz) is low. This input is overridden by CW IDENT cycle.
SPACE/M	When grounded forces AFSK modulator to SPACE.
+12/2, B	+12 Vdc at 20 mA maximum.
+5/1, A	+5 Vdc at 200 mA or less.
START ID/J	Momentary ground starts CW IDENT cycle.
MSG MSB/D	Logic low for first 128 cycles of CW IDENT.
MSG CONTROL/C	When grounded enables first half of CW IDENT memory. When high, enables second half.
LOOP/R	Loop control output, high for MARK and low for SPACE. Can sink 40 mA at 15 volts.
MOTOR/P	Output goes low to turn on motor. Can sink 40 mA at 15 volts.
LOCK/S	Output goes low when PLL has locked.
AUDIO TEST/T	AFSK oscillator test output, 5 V p-p.
AUDIO OUT/K	AFSK modulator output, 600-Ohms, 6 V p-p maximum.
CW ON/E	Output goes low during CW IDENT.
CW/N	Output goes low during each IDENT key closure.

CW identifier

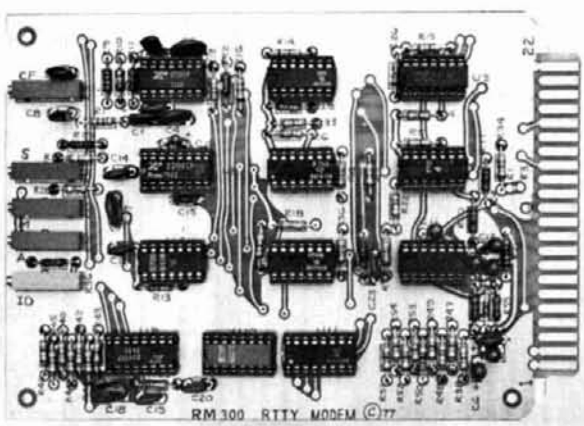
The CW identifier output signals include the CW keying line, which provides full-shift keying, and a *CW on* control line, which precludes all other keying when active. The CW identifier, started by momentarily grounding the *start ID* input (pin J), causes either **O** or **.** characters to be printed by the receiving station. The timing and memory programming required to accomplish this format were described in reference 1.

One new feature, available with the "0" option, is the ability to have two call signs in the read-only memory. One call sign is accessed by grounding the *message control*, pin C, while the other is obtained by leaving pin C open. If your call is too long to fit into half of the memory (128 bits), the whole memory can be used by connecting the *MSG MSB* output, pin D, to pin C on the edge connector.

On-off control of the CW identifier is accomplished with U9, an XR-2240, which contains an oscillator, an eight-stage divider, and a control flip-flop. The timing of the CW output is established by adjusting the *ID timing* potentiometer, R36. Five of the eight divider outputs from U9 address the 32 bytes of memory in U10, while the remaining three extract the CW characters from the selected bytes with multiplexer U11. Decade counter U12 monitors the CW output for consecutive "blanks;" after it detects eight, it turns off the control flip-flop in U9. Comparator U6-A and its associated circuit resets the decade counter so that the counter will start with the correct count when power is first applied.

adjustments

Proper adjustment of the Modem requires a frequency counter and a voltmeter or oscilloscope. The Modem can be adjusted with help from another sta-



The RM-300 Modem circuit board, which is the same size as the RP-400 power supply board. Kits are available (see text).

tion which has a counter or an AFSK oscillator/demodulator that has a known calibration.

AFSK generator. Connect a counter to *audio test,* pin T. Ground *mark,* pin U. Adjust R27 (**M**) to obtain a counter reading of 2125 Hz. Move the ground lead

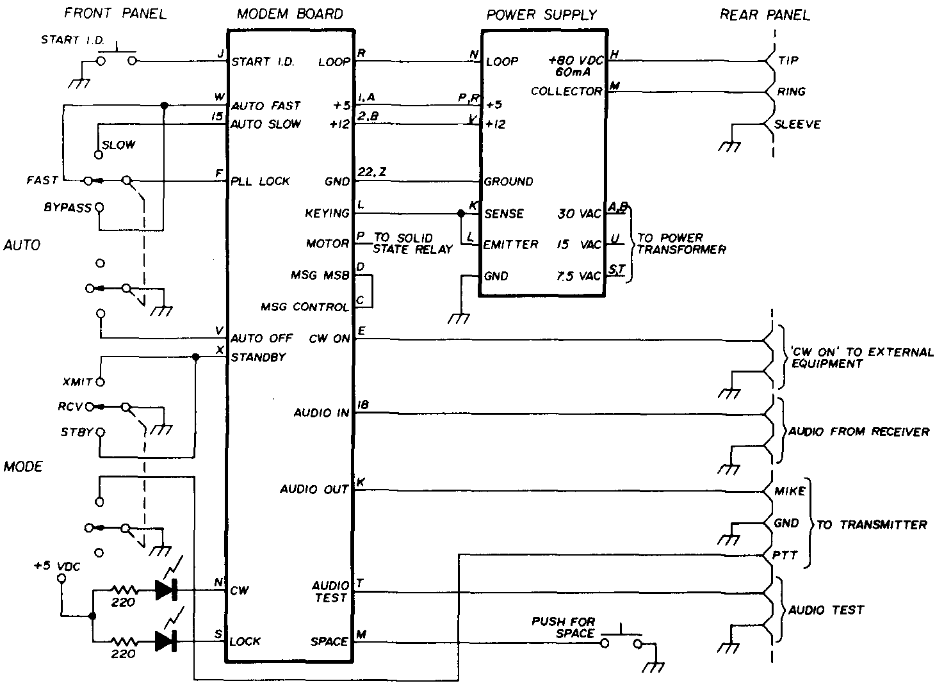


fig. 4. Interface wiring for the PC boards, front-panel controls, and rear-panel connectors.

from pin U to *space,* pin M. Adjust R31 (**S**) to obtain a counter reading of 2295 Hz. Use a voltmeter or oscilloscope connected to *audio out,* pin K, to adjust the output to a level compatible with your transmitter audio input using R32 (**A**). Remove the ground lead.

Phase-locked loop (U1). Use a jumper to connect *audio out,* pin K, to *audio in,* pin 18. Connect an oscilloscope or voltmeter to hex inverter U4-8. (This voltage will swing between ground and approximately 3 volts.) Ground *mark,* pin U, and adjust R3 (**CF**) until the hex inverter output goes high. Remove the ground from *mark,* pin U, and ground *space,* pin M. While counting turns, adjust R3 until U4-8 just goes low. (R3 should be adjusted in a ccw direction.) Divide the number of turns by two and adjust R3 in a cw direction by that number.

CW identifier timing. This adjustment is most easily made with the aid of another station. Initiate an ident while the other station monitors your signal with his printer. When the timing is adjusted correctly his printer should print 00000000. . . with the number of zeroes determined by your call sign. If you've selected the Baudot ident option, adjust the timing with R36 until the other machine prints the encoded message correctly.

power supply

The RP-400 power supply was designed to furnish the voltages required by the RM-300, in addition to an auxiliary −12 Vdc supply for other circuits you may wish to add, such as a UART. Included on the board are the following:

two 80 Vdc, 60-mA loop supplies
one +12 Vdc, 100-mA supply
one +5 Vdc, 300-mA logic supply
one −12 Vdc, 100-mA auxiliary supply

A high-voltage loop keying transistor is also located on the RP-400 power-supply board. A schematic for the board is given in **fig. 2.***

The loop supplies run from a voltage doubler consisting of C101, CR101, and CR102. The resulting dc is filtered by C102 before being sent to the adjustable wirewound resistors, R101 and R102.

Two suggested ways of connecting your Teletype machine to the loop supplies and keying transistor are shown in **fig. 3**. The usual connection, with the

*A complete kit of all the parts for the RP-400 power supply is available from Eclipse Communications, 5 Westwood Drive, San Rafael, CA 94901. The RP-400 kit costs $71.25. The cost of the RP-400 circuit board alone is $21.25. (The board is double-sided with plated-through holes and a solder mask on both sides. The component side of the board is screened with part numbers and component values.) Add $1 for postage and handling on all orders. California residents add 6 per cent sales tax.

selector magnets and keyboard contacts in series, is shown in **A** of the figure. Resistor R104 provides a TTL-compatible low level when the loop is open. If you desire separate selector magnet and keyboard connections, use the wiring diagram shown in **B** of **fig. 3**. Split wiring might be used when you wish to use the output of a repeater to provide local copy through a demodulator. By operating in this manner it's possible to tell instantly if you aren't making it through the repeater.

The low-voltage power supplies are similar in design. Each has a half-wave rectifier, filter capacitor, and three-terminal regulator.

construction

The RM-300 Modem board, the RP-400 power supply, the solid-state motor-control relay, and the power supply fit nicely inside a 30.5 x 30.5 x 8 cm (12 x 12 x 3 in.) Moduline enclosure.

Fig. 4 is a schematic showing one way to connect the boards, front panel controls, and rear panel connectors. Variations on this wiring will be determined by your requirements.

acknowledgments

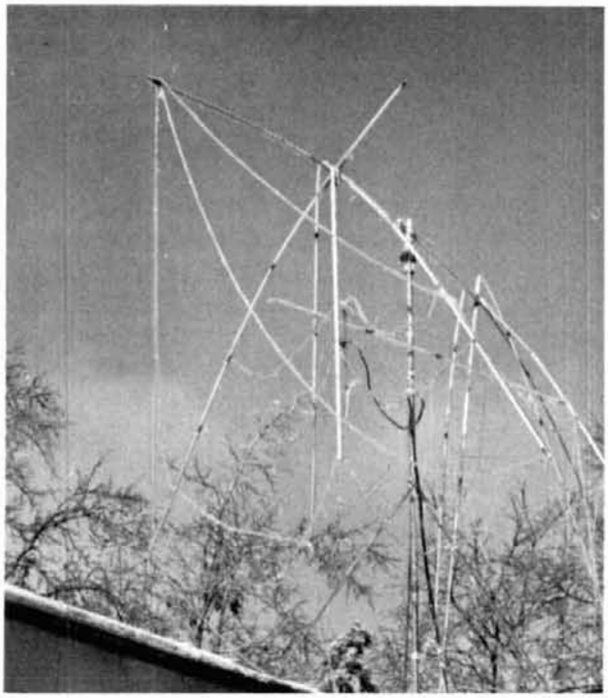
Special thanks are due Herbert Drake, Jr., WB6IMP, Rod Roderique, WAØQII, and Alan Bowker, WA6DNR, for their encouragement and suggestions during the development of the RM-300/RP-400 Modem and power supply.

reference

1. Howard L. Nurse, W6LLO, "CW Memory for RTTY Identification," *ham radio*, January, 1974, pages 6-12.

ham radio

stressed quad



As you can see by the photo, I have a problem. To eliminate this problem in the future, I have devised a means of stressing a quad (see **fig. 1**). As seen in **fig. 1**, the ends of the spreaders are connected together with 3 meter (10 foot) lengths of 45 kg (200 pound) test mono-filament fishing line. In addition, three 3 meter (10 foot) lengths of conduit are connected together with sleeve couplings and extended through the boom approximately 3 meters (10 feet) beyond the ends of the boom. Additional lengths of fishing line connect the ends of the spreaders to the extended ends of the conduit. With the lines tight, the quad now has the general appearance of a Zeppelin, but is stressed to withstand a large wind load. I also attempted this method with nylon cord, but it had too much stretch; the monofilament fishing line does not. Had I used fishing line first, I would not have this picture.

Ira Hargis, W5TIU

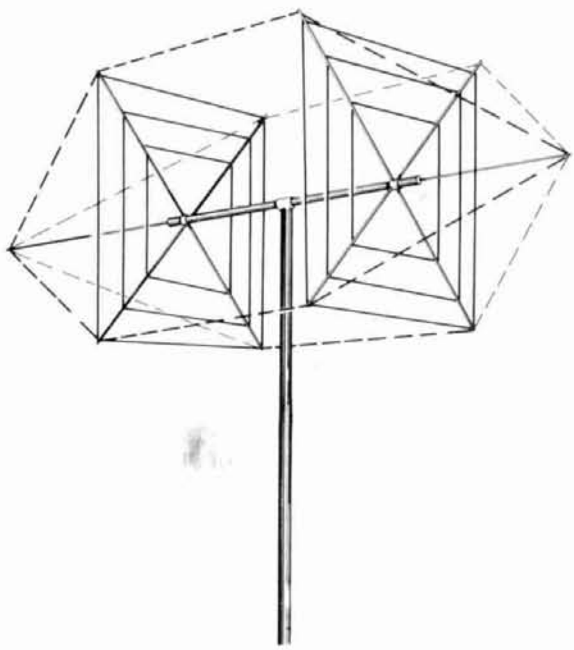


fig. 1. Diagram of the stressed quad as described by the author. The fishing line is almost invisible, yet keeps the spreaders under stress, increasing its survivability during high wind loads.

integrated circuit arrays

Using IC arrays permits the designer to reduce size and component count — without sacrificing performance

Integrated circuits have been around for a decade or so; starting off with just a few transistors on a single chip, inter-connected in amplifier arrangements, they have developed into complex circuits incorporating many transistors, diodes, Zeners, and other components in a single package, often requiring a minimum of external parts to perform the functions of any linear, digital, or logic application. Most hams are familiar with the smaller, linear ICs designed for specific applications. And generally, many would not bother to use discrete transistors for an i-f amplifier or audio power output stage when a single TO-5 can or 14-pin dual inline IC makes construction simpler and more reliable. The majority of ICs are "committed" devices, developed to perform a specific function. Their popularity in amateur construction projects has long been established from the proliferation of articles published on amplifiers, balanced modulators, and phase-lock-loops, in receivers, transmitters, and test equipment.

Much less apparent is the constructor's use of the "uncommitted" IC. These devices are independent diodes and transistors on a single chip, individually connected to the package pins. Known as IC arrays, they are widely used in commercial and industrial equipment for minimizing space and assembly effort. There are also "semi-committed" arrays, in which only two of the transistors have internal connections (such as a differential or darlington pair).

For building equipment, there are several reasons why using IC arrays, instead of discrete transistors or diodes, can be an advantage.

1. In many cases, the IC will cost about the same, or less, than the equivalent discrete components. Due to broad commercial use, many types are fairly inexpensive and easy to find — even at bargain prices from some surplus outlets.

2. The individual transistor and diode parameters are much more closely matched than discrete components of the same type, and also retain matching over wide temperature variations, due to the individual devices being etched on a common substrate. Some arrays have two specially matched transistors, ideal for balanced-circuit applications.

3. Printed circuit board layout may be simplified, using less space than with discrete devices.

4. By using low-profile IC sockets, troubleshooting and repair can be as simple as plugging in a new IC.

Most of the major solid-state device manufacturers

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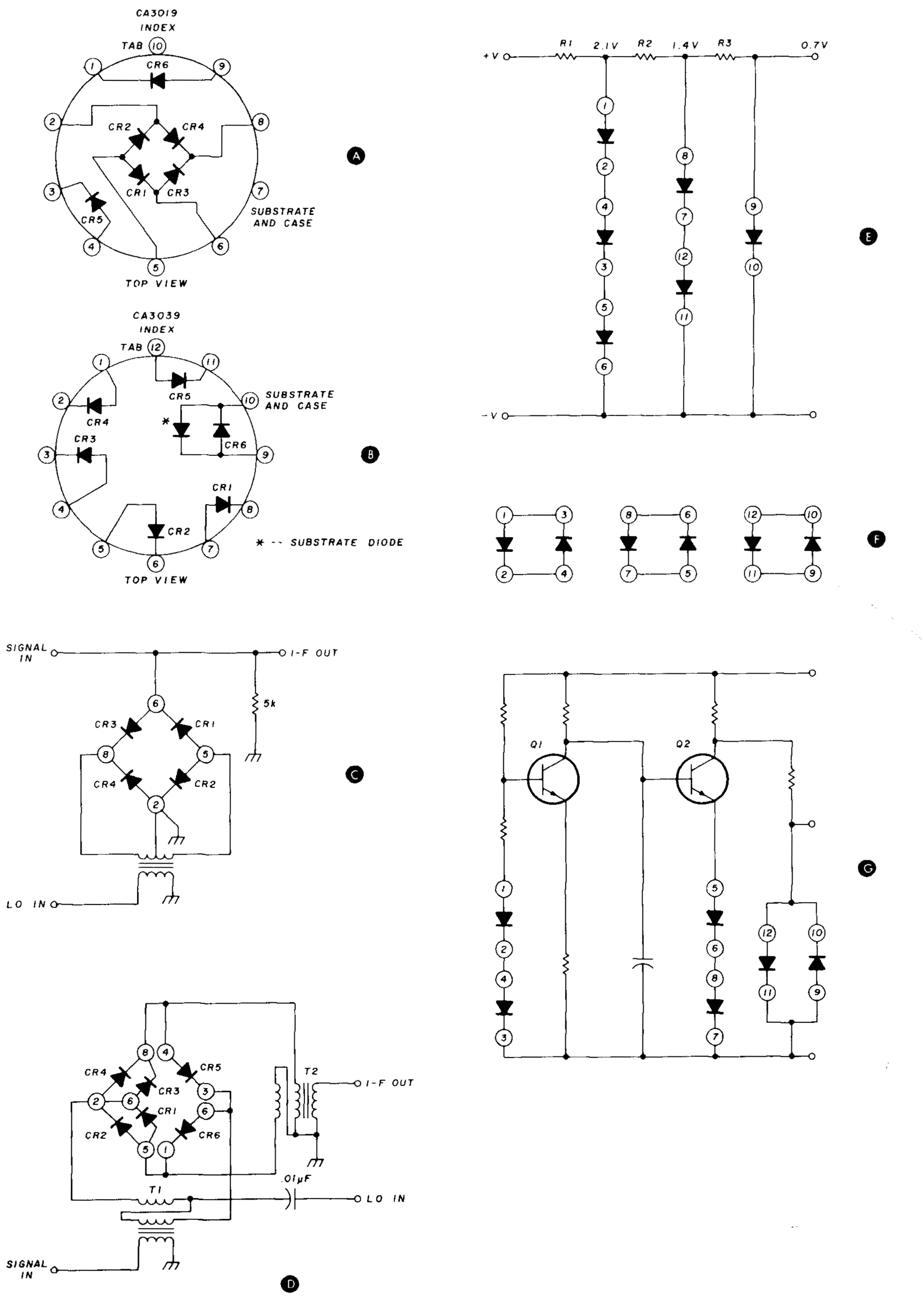

fig. 1. Pinout diagrams for the CA3019 and CA3039 are shown in A and B, respectively; C and D show two configurations for the CA3019, a balanced modulator and a double-balanced ring mixer. A 3-voltage regulator or reference, E, is obtained by using the forward-voltage drop across the diodes. By connecting the diodes back-to-back, they will also function as clippers (F). A typical application for almost the entire CA3039 package, including temperature compensation, emitter bias, and output limiting is shown at G.

produce transistor arrays. For the purpose of reviewing the more commonly available types, reference is made only to the RCA numbers. When a pin compatible equivalent is made by other manufacturers, the RCA number has an asterisk, and the equivalents will be found in **table 1**. Also, this review is divided into four logical categories, for easy future reference.

1. Diode arrays.
2. Uncommitted-transistor arrays.
3. Semi-committed transistor arrays.
4. Hybrid arrays (incorporating transistors and diodes, both uncommitted and semi-committed).

table 1. Pin compatible IC array equivalents

RCA	National	Fairchild
CA3019	LM3019	μA3019
CA3039	LM3039	μA3039
CA3018	LM3018	μA3018
CA3086	LM3086	μA3086

The review includes only essential information, and some basic applications circuits for each type, to assist device selection. The reader should refer to the manufacturers specification sheets, data manual, and application notes for complete information on any specific device. Some complete IC array circuits, both amateur and commercial, are included after the device review.

diode arrays

1. CA3019*

Configuration: Six silicon diodes, four internally connected as a quad, two independent.
Package: 10 pin, TO-5 (**fig. 1A**).
Applications: Modulators, mixers, analog switches (**figs. 1C** and **1D**).

2. CA3039*

Configuration: Six ultra fast, low capacitance silicon diodes, independently connected.
Package: 12 pin, TO-5 (**fig. 1B**).
Applications: Balanced modulators, demodulators, voltage reference and bias regulators, clipper limiters, (**fig. 1D**).

The inherent advantage of the diode arrays (**figs. 1A** and **1B**) is the close matching of the diodes when used as single or double-balanced mixers or product detectors. While the diodes in the CA3019 and CA3039 do not have identical characteristics, they are essentially interchangeable in many circuits. **Fig. 1C** shows the CA3019 quad as a balanced modulator. For this application, the diode "ring" is more commonly used. **Fig. 1D** shows how the CA3019 diodes can be connected as a "ring" in a double-balanced mixer. Since this involves paralleling the quad diodes, (CR1, CR2 and CR3, CR4) connecting pins 2 and 6, and using the independent diodes CR5 CR6 to complete the ring, balance will not be as perfect as with four individual diodes, though adequate for most purposes. If the circuit in **fig. 1D** is used as a product detector, it is recommended that the LO be fed into T2 and audio output be taken from the center of T1's secondary.

The CA3039's independent diodes lend themselves to any circuit requiring up to six fast silicon diodes. **Figs. 1E**, **1F**, and **1G** show these diodes used for low-voltage regulation, varistors, or transistor amplifier biasing with temperature compensation and output limiting (clipping). Note that the voltage regulator is for low current, limited to the maximum forward current of the diodes. It is best applied as a voltage reference, rather than high current applications in which reverse-polarity zener diodes are used. By using one to six diodes in series, low current, stable reference voltages of 0.7 V, 1.4 V, 2.1 V, 2.8 V, 3.5 V, and 4.2 V can be derived from one CA3039. As shown, regulated positive voltages are obtained, but by reversing the supply and diode polarity, negative voltages for fet or mosfet device biasing can be achieved.

uncommitted transistor arrays

1. CA3083/3183/3183A*

Specification: Five general-purpose silicon NPN transistors, independent substrate connection. Two transistors (Q1, Q2) matched. I_{cmax} 100 mA, h_{FE} 76 typical.
Package: 16 pin, plastic DIP (**fig. 2A**).
Applications: Signal processing/switching from dc to vhf, lamp and relay driver, differential amplifiers (**fig. 2E**).

2. CA3127

Specification: Five high-frequency general-purpose silicon, NPN transistors, with independent substrate connection. DC to 500 MHz. Low noise (3.5 dB at 100 MHz). High power gain (30 dB at 100 MHz).
Package: 16-pin plastic DIP (**fig. 2B**).
Applications: vhf amplifiers, mixers and oscillators. I-f amplifiers, synthesizers, synchronous detectors (**fig. 2F**).

3. CA3096A/3096AE

Specification: Three general-purpose high-voltage silicon NPN transistors, and two general-purpose, high-

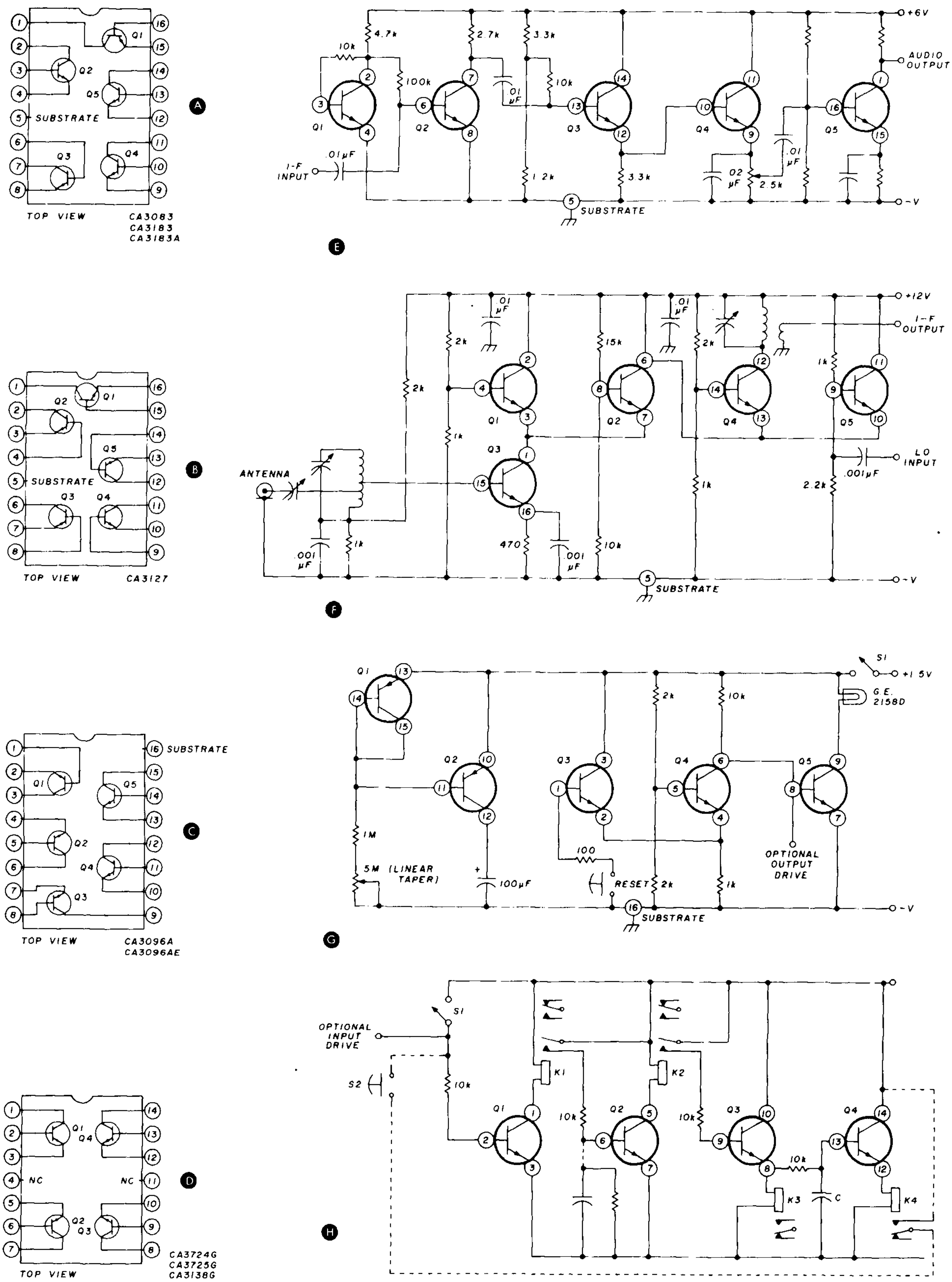

fig. 2. Pinout diagrams for different transistor arrays are shown in A through D; typical applications are shown in E through H. In H, the parallel time constant, from the base of Q2 to ground, causes K2 to open only after K1 has opened. This delay is adjustable according to the values used for the resistor and capacitor. By using S2 and the drive line from K4, the relays can be activated by S1 and de-energized by S2.

voltage silicon, PNP transistors, independent substrate connection.

Package: 16 pin, plastic DIP (**fig. 2C**).

Applications: Differential amplifiers, dc amplifiers, timers, lamp and relay drivers (**fig. 2G**).

4. CA3724G/3725G/3138G

Specification: Four high-current silicon NPN transistors. I_{cmax} 1 A fast switching (30 ns at 0.5 A).

Package: 14 pin, plastic DIP (**fig. 2D**).

Applications: High-speed switching, high-voltage switching, high-current LED, lamp and relay drivers (**fig. 2H**).

The first two devices in this group, the CA3083 and CA3127, have a lot in common, both having five independent NPN transistors which can be used in a very wide variety of circuits. However, the transistor characteristics in each type are quite different, even though there may be some circuits in which either could be made to work. The CA3083 has higher I_{cmax}, and is suited more for hf and audio circuits which require transistors with high-signal level parameters. **Fig. 2E** is a typical application for a final i-f amplifier (untuned), second detector, and first audio amplifier, using all five transistors in the CA3083. Q1 is used for bias stabilization of the first i-f amplifier. If Q2 was conventionally biased with two resistors, Q1 could be applied to some other function.

In contrast, the CA3127 incorporates transistors specifically designed for small signal, high power gain characteristics up to 500 MHz, making it ideal for receiver front-end use, including rf amplifier/mixer/oscillator combinations.[1] **Fig. 2F** is such an application, using all five transistors for the rf amplifier and mixer stages of a front-end suitable for vhf. Needless to say, with the high power gain of the individual transistors, considerable care should be exercised in the layout of such circuits to avoid building only oscillators.

The CA3096 is an interesting IC which contains a mixture of three NPN and two PNP transistors. The CA3096AE has more closely matched parameters between transistors, useful for complementary pair circuits.

Fig. 2G is the circuit of a ten-minute interval timer using all the transistors in the CA3096 — a handy device as an identification reminder for ragchewers. The time constants allow adjustment of the timer from 1.6 to 10 minutes by changing the 5-megohm potentiometer. The maximum time can be changed by increasing or decreasing the value of the 100 μF capacitor; minimum time is varied by changing the value of the 1-megohm fixed resistor in series with the pot. The lamp indicator may be replaced by a relay or audio reminder (such as NE555 oscillator), so long as Q5's collector current does not exceed 50 mA, or a load of less than 30 ohms at 1.5 volts.

Since the CA3724 was meant to be a high-current driver, an appropriate application is shown in **fig. 2H**. Many times it is necessary to close and release relays in proper sequence. Closing S1 turns on Q1, which closes K1, but two normally-open contacts on K1 are employed to put forward bias on Q2. Thus, K2 can close only after K1. Opening S1 will cause both relays to release at almost the same time.

If reverse sequencing is required, a parallel RC time constant, from Q2's base to ground, will cause K2 to open after K1. K3 and K4 are driven by the emitters of Q3 and Q4, with the voltage across the coil of K3 used to drive Q4. This technique eliminates the need for a pair of normally open relay contacts as in the Q1, Q2 arrangement. The single capacitor, from base to ground of Q4, provides for a time-delay release of K4; the time constant is dependent on the value of C, the 10-k ohm base resistor, and the resistance of K3's coil.

If a latching relay combination is desired, the normally open contacts of K4 can be used to connect drive through S2 (momentary pushbutton, normally on) to the base resistor of Q1. S1 should be changed to a momentary pushbutton, normally off. Push S1 to activate the relays and push S2 to release.

The circuits in **fig. 2G** and **2H** can be combined by connecting the optional drive output, from pin 8 of the CA3096, to the optional drive input of the CA3724. With this combination, the timer will activate the relay driver circuit after a preset time delay, initiated by the timer ON switch. This arrangement would be useful for a high-voltage time delay turn on in tube-type linears. S1 would, of course, be eliminated in this arrangement, but S2 may be left as an emergency OFF switch.

semi-committed transistor arrays

1. CA3018/3018A/3118/3118A*

Specification: Four general-purpose silicon NPN transistors, two independent; two internally connected as a Darlington pair. Independent substrate connection.

Package: 12 pin, TO-5 (**fig. 3A**).

Applications: General use in signal processing, dc through vhf range. Suitable for use in circuits similar to CA3083.

2. CA3086/3146/3146A/3045/3046*

Specification: Five general-purpose silicon NPN

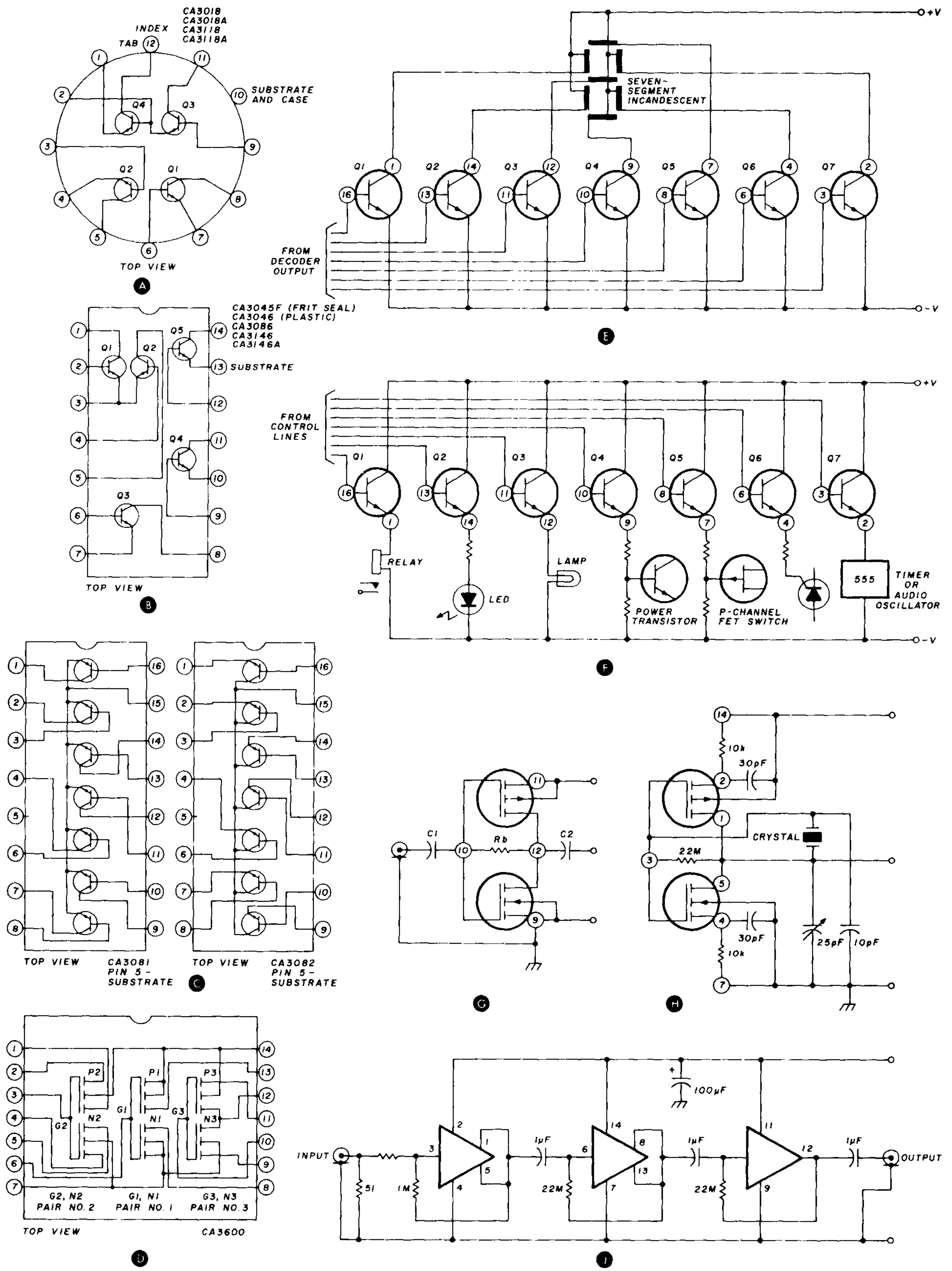

fig. 3. Pinout diagrams for transistor arrays which have internal connections between the transistors (semi-committed arrays). Various applications for the arrays are illustrated in E through I. Using the CA3600 mosfet array in I will limit the upper frequency to approximately 5 MHz. Even though the CA3600 has protected inputs, normal precautions should be exercised while working with the IC.

	transistors, three independent; two internally connected as a differential pair (common emitters).
Package:	14 pin, DIP package type varies with type number. CA3086/3146/3146A are plastic package (**fig. 3B**).
Applications:	General purpose use for signal processing in the dc to 120 MHz range.

3. CA3081 and CA3082

Specification:	Seven high-current silicon NPN transistors. (CA3081) All emitters internally connected in common. (CA3082) All collectors internally connected in common.
Package:	16 pin, plastic DIP (**fig. 3C**).
Applications:	Lamp, LED, and relay drivers.

4. CA3600

Specification:	Complementary mosfet array of 3 N-channel and 3 P-channel enhancement mode mosfets, gate protected.
Package:	14 pin, plastic DIP (**fig. 3D**).
Applications:	High input-impedance linear amplifiers, low-power oscillators.

As mentioned earlier, this group of arrays has two or more of the transistors internally connected in a partial circuit, but this does not eliminate their use as independent transistors, though there are more limitations than the undedicated group.

The characteristics of the individual transistors in the CA3018 and CA3086 families are sufficiently close to the CA3083 so that RCA specifies the same application note for all three. The CA3083 has an I_{cmax} of 100 mA, while the CA3018 and CA3086 have I_{cmax} of 50 mA. Otherwise, the parameters are close enough to make these three devices interchangeable in almost any circuit where the partially committed arrangement of the latter two permits. In both the CA3018 and CA3086, the four transistors may be used independently by allowing the pins of the fifth device to float unconnected. Or, in the CA3086, the pins of the differential pair may be jumpered (5-1 and 4-2) creating a single transistor with an I_{cmax} of 100 mA. Also, the darlington pair in the CA3018 may be used as a single, super-beta transistor by using pins 11 and 12 as the collector, 9 as the base, and 1 as the emitter. Since applications for the CA3018 and CA3086 are similar to the uncommitted CA3083, no basic circuits are shown for these types.

The CA3081 and CA3082 both incorporate seven NPN transistors having identical characteristics, the CA3081 having all collectors connected together, and the CA3082 with all emitters connected. These devices were designed to drive seven-segment displays as shown in **fig. 3E**. However, these devices can be used for low-current, remote driving of a variety of other components including relays, LEDs, incandescent lamps, power transistor switches, fet switches, SCRs, and complex devices such as an NE555 oscillator. The only constraint is that current supplied to the driven device does not exceed the I_{cmax} of 50 mA for each transistor. If a higher current rating is required, two or more of the transistors may be paralleled.

The CA3081 may also be used as seven independent amplifiers in circuits where grounded emitters are appropriate. Likewise, the CA3082 may be employed as seven emitter followers with independent inputs and outputs. Such circuits may be used as buffer mixers (separate inputs, common output) or distribution isolators (common input, separate outputs).

The CA3600 may be one of the less familiar ICs. This device has three pairs of complementary mosfet transistors, with the input gates of each pair connected. Each pair has one P-channel and one N-channel *enhancement*-mode mosfet. The N-channel, *depletion*-mode mosfet is familiar to most, appearing frequently in single- or double-gate versions for rf amplifiers and mixers. The depletion-mode devices have channels which are normally ON in the absence of gate bias. Enhancement mode mosfets have channels normally OFF until bias is applied to the gates, positive bias for P-channel and negative bias for N-channel. Using an ac input signal as bias, the linear amplifier shown in **fig. 3G** will have the P-channel transistor conducting on positive half cycles, and the N-channel device on negative half cycles. The output from C2 will be a complete, amplified replica of the ac input.

One nice thing about complementary amplifiers of this type is that they maintain a high-linearity output swing, over almost the entire limit of supply voltage. Therefore, you can obtain close to 10 V p-p output with a 10 Vdc supply. In addition, the input impedance is very high, with the circuits requiring a minimum of external components. **Fig. 3H** shows the basic amplifier expanded into a crystal oscillator, and **fig. 3I** illustrates the entire IC connected as a complete, cascaded 100 dB amplifier. The high input impedance and high off-resistance of the P and N channel enhancement-mode mosfets make them highly suited for switching circuits where the load current does not exceed 10 mA. For those who are hesitant to use CMOS devices, considering their sensitivity to static voltages, the CA3600 device has resistor/zener diode-protected gates to minimize the chance of static damage.

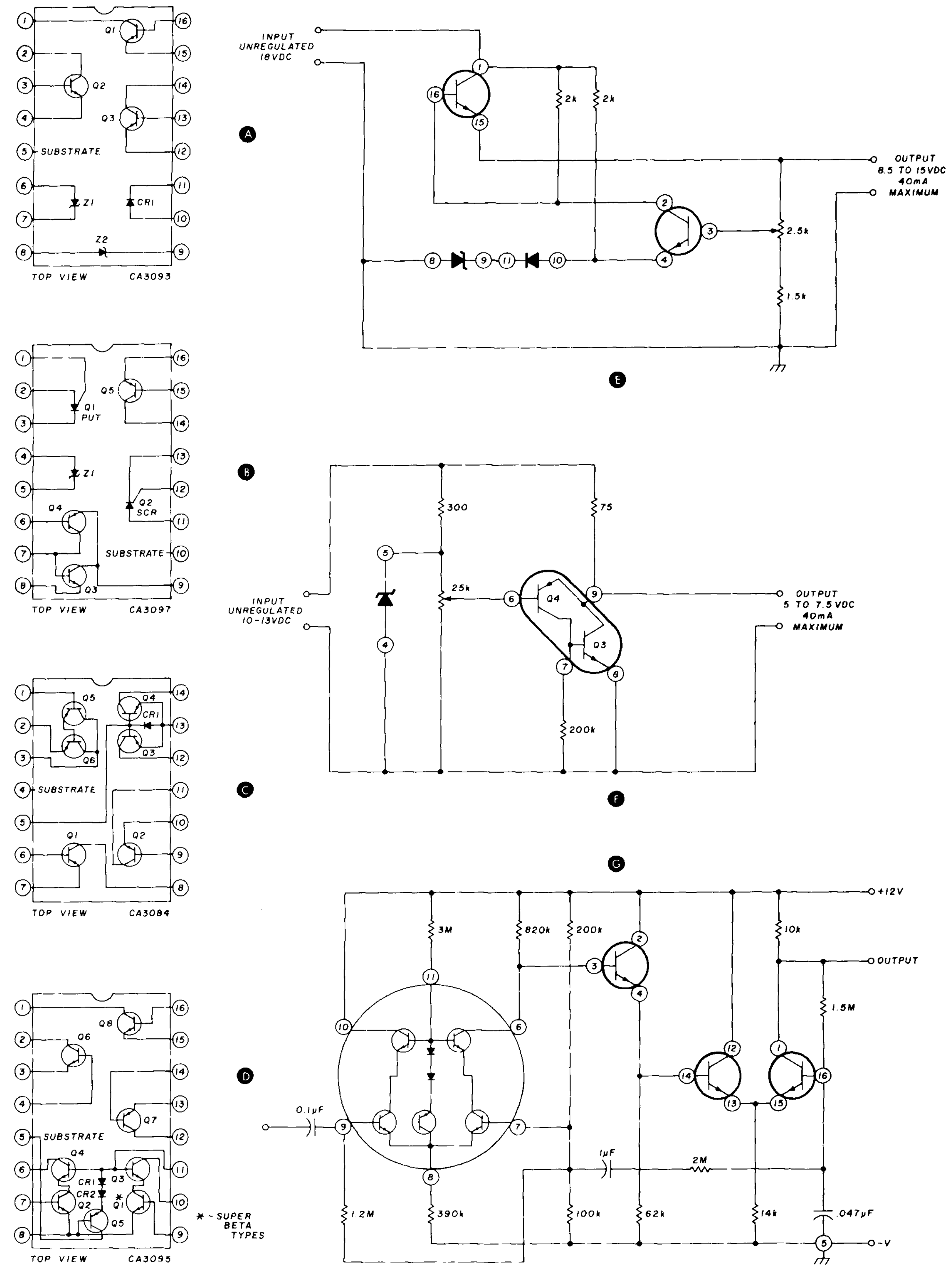

fig. 4. Pin diagrams for the hybrid integrated circuit arrays are shown in A through D. Applications for this group of arrays include voltage regulators and a low-noise preamplifier, as shown in E thorugh G. The amplifier in G has a voltage gain of 30 dB and a noise factor of 2 dB at 10 Hz, decreasing to 0.3 dB at 1 kHz.

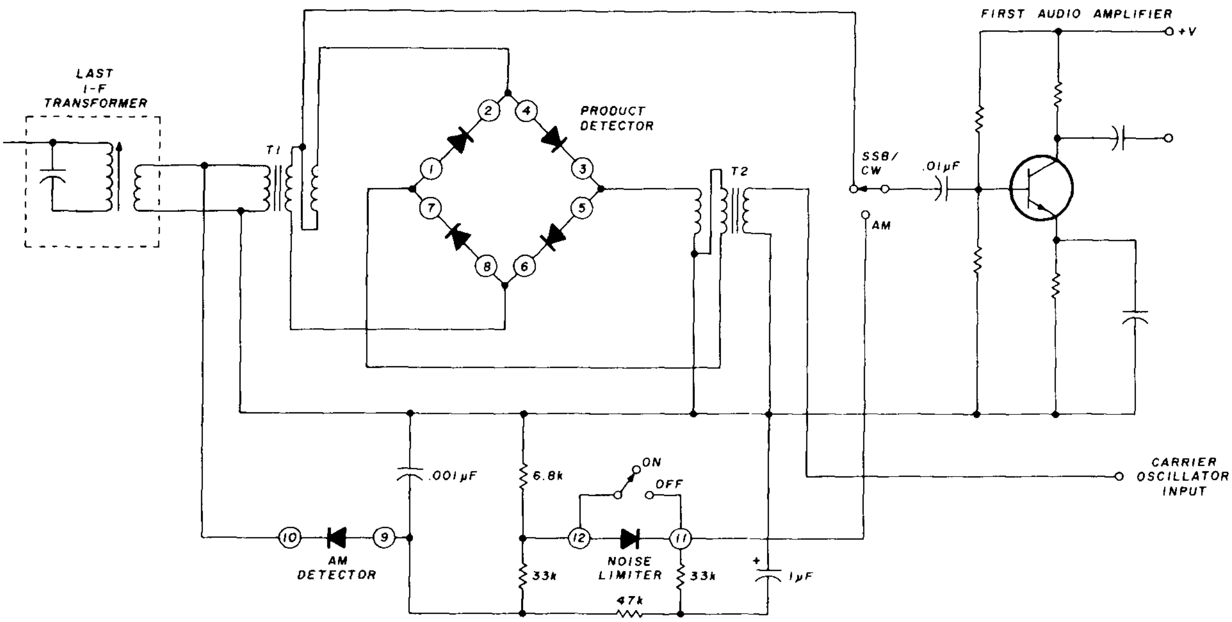

fig. 5. Schematic diagram of a product detector, a-m detector, and noise limiter using the CA3039. T1 and T2 are Q2 ferrite cores wound with 12 turns of no. 26 AWG (0.4 mm) enameled wire. The individual wires should be twisted approximately 1 turn per centimeter (3 turns/inch). The carrier oscillator signal (+7 dBm) must be off when the detector is used for a-m.

hybrid arrays

1. CA3093

Specification: Three independent general-purpose, high-current silicon NPN transistors — two independent 7-volt, 1/4-watt zener diodes; one general-purpose silicon diode. Two of the transistors, Q1 and Q2, are closely matched at 1 mA.

Package: 16 pin, plastic DIP (**fig. 4A**).

Applications: Signal processing/switching from dc to vhf. Temperature compensated voltage and current regulators.

2. CA3097

Specification: One independent silicon NPN transistor. An NPN and PNP transistor pair, one zener diode, one programmable unijunction transistor, and one silicon-controlled rectifier.

Package: 16 pin, plastic DIP (**fig. 4B**).

Applications: Voltage regulators, timers, constant current source, oscillators, multivibrators.

3. CA3084

Specification: Two independent general-purpose silicon PNP transistors, two PNP transistors connected as a Darlington pair, combination of two PNP transistors and one diode connected as a "current mirror."

Package: 14 pin, plastic DIP (**fig. 4C**).

Applications: General signal processing, low power, low frequency; double-balanced mixers/modulators, product detectors.

4. CA3095

Specification: Three independent high-voltage silicon NPN transistors, five NPN transistors, differential amplifier array, two of which (Q1 and Q2) are super-beta types.

Package: 16 pin, plastic DIP (**fig. 4D**).

Applications: Super-beta preamplifiers, high-impedance dc meter amplifier, low-noise video amplifier. The independent transistors are usable for signal processing from dc to vhf.

This group of arrays will test your imagination for using different solid-state devices. However, the manufacturers were not arbitrary in selecting the different devices.

Fig. 4E, one example of a use for the CA3093, is a temperature compensated, series voltage regulator, adjustable from 8.5 to 15 volts at a maximum of 100

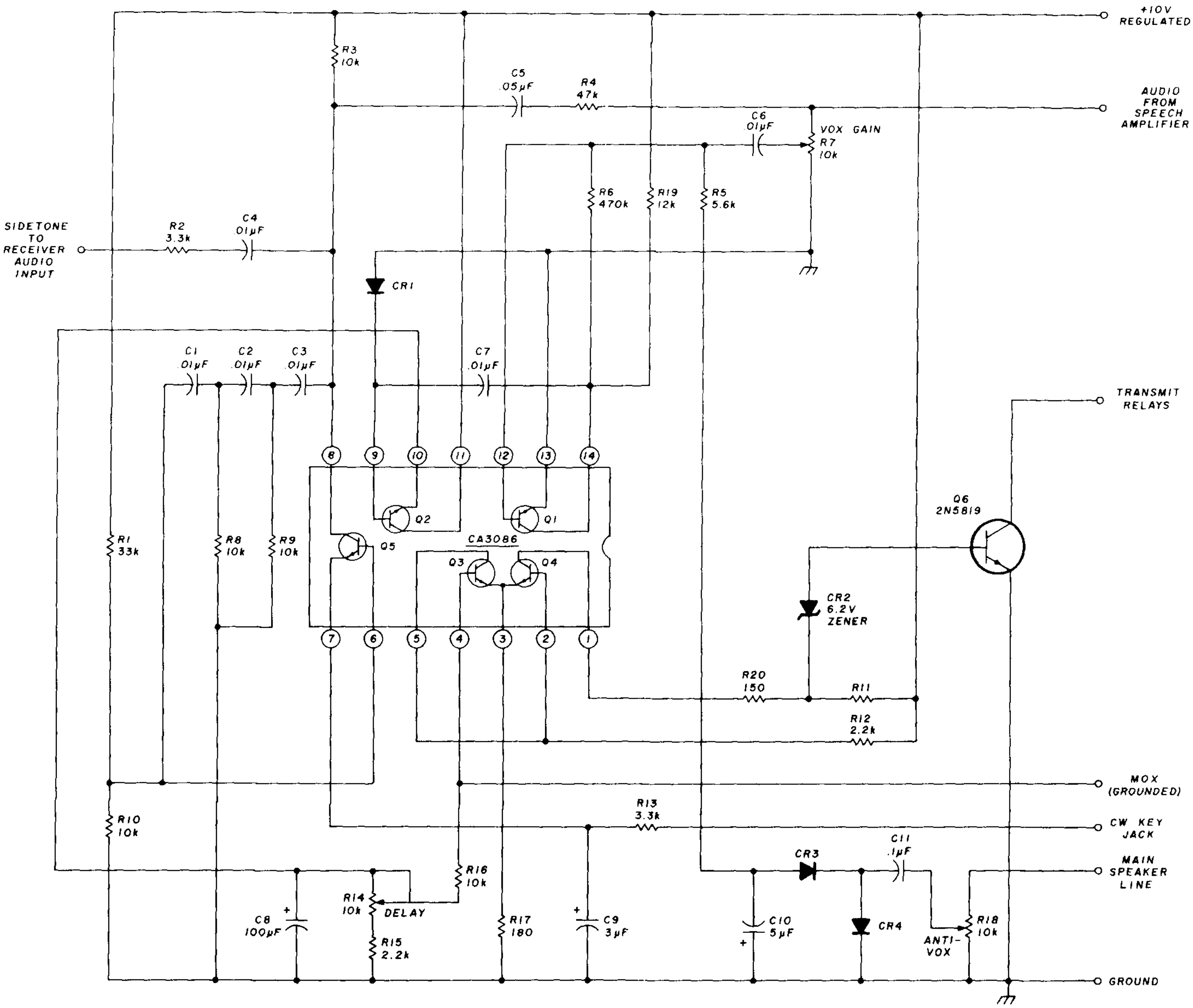

fig. 6. Schematic diagram for a vox/semi-break-in system using the CA3086. Q6 is an external transistor which must have a collector current rating sufficient to control the external relays. CR2 is a 6.2 volt, 1-watt Zener diode. CR3 and CR4 must be germanium diodes.

mA. **Fig. 4F** is a shunt voltage regulator using the CA3097, leaving one transistor, SCR, and a programmable UJT for other use.

The CA3084 includes four general-purpose PNP transistors, with Q3 and Q4 connected as a darlington pair. Also included is a "current mirror" arrangement of two PNP transistors and a diode. The two independent PNP transistors are closely matched, and can be employed in separate circuits, or as part of a balanced complimentary circuit with NPN transistors. The darlington pair, having three basic connections (base, collector, emitter), can be considered as a single super-beta transistor with an h_{FE} of 1250. The PNP current mirror is suited as an active load for differential amplifiers which use NPN transistors. In general, the CA3084 device is used to furnish circuit sections for other ICs or discrete devices, rather than providing a complete circuit function.

Three independent general-purpose NPN transistors are contained in the CA3095, in addition to a differential-amplifier array of five NPN transistors and two diodes. Two of the transistors (Q1 and Q2) are super-beta types with an h_{FE} of more than 1000. The differential amplifier and independent transistors may be used separately, or combined (**fig. 4G**) into a very high-input impedance, low-noise amplifier.

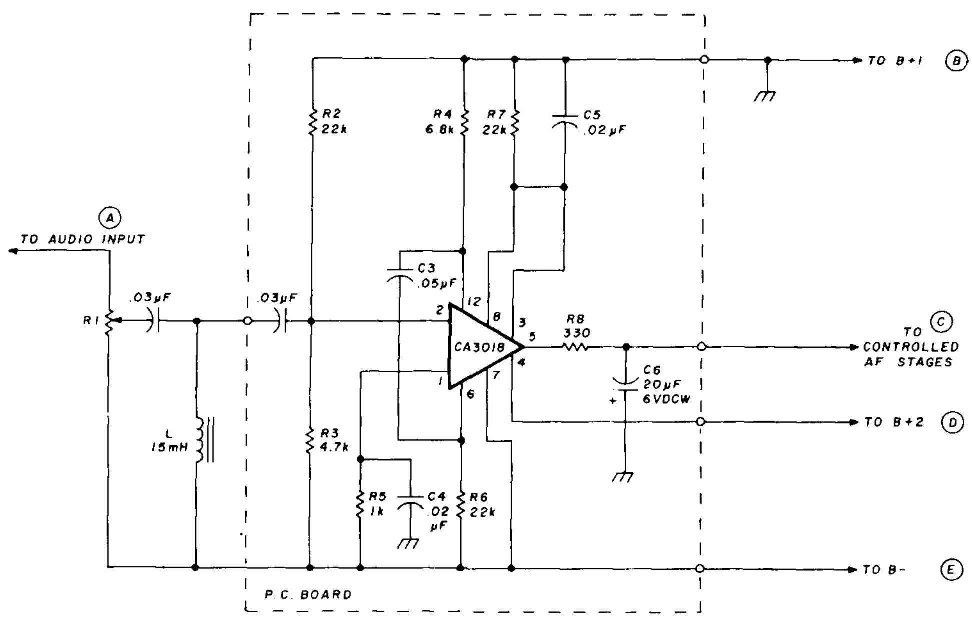

fig. 7. Schematic diagram of a squelch circuit using the CA3018.

getting the most from practical circuits

The basic circuits, illustrating the use of each type array, were intended as examples of the versatility of these devices. Many different uses will be found by the enterprising builder. Some of the array devices, such as the uncommitted transistor arrays, will find many more applications than the more specialized types.

Determining whether to build a project with an IC array or discrete components is a matter of planning and trade-offs. Once you have a circuit to construct, research the available devices to see if one of them incorporates all, or most, of the active components required. After all, it doesn't make sense to use a CA3093 to use only two transistors, leaving the third, plus two zeners and a diode as spares; though on occasions, one unused section can come in handy for later modifications. The real trick is working *all* of the active IC sections into a construction project, and

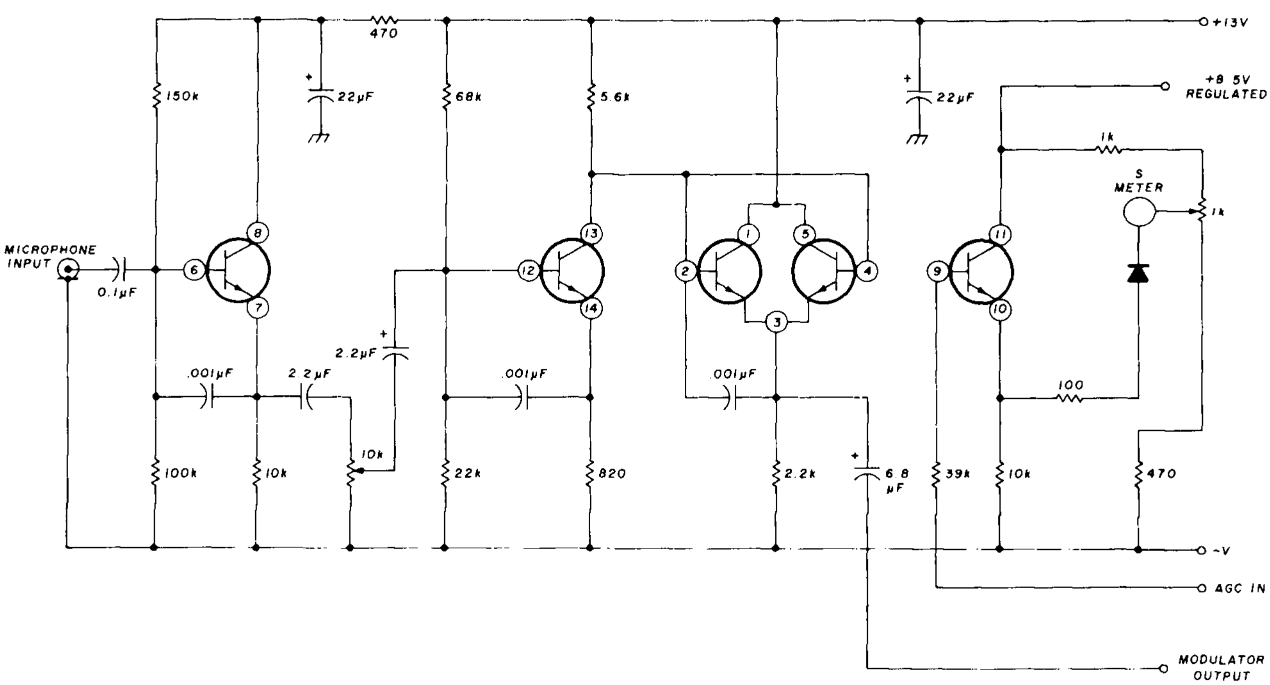

fig. 8. The CA3086 has been used to its fullest advantage in the Atlas series transceivers. This schematic shows the microphone/modulator amplifiers, and S-meter amplifier in the transceivers.

this article would not be complete without including some practical amateur and commercial circuits where this has been achieved to advantage.

Fig. 5 is a double-balanced, diode-ring product detector, a single-diode detector, and a series-gate noise limiter, using all the devices in a CA3039. The TO-5 package occupies less space than individual diodes flat on the board. In addition, the matched diodes give superior performance in the product detector. A module of this type, to replace the triode product detector in a tube receiver, has been built on a printed-circuit board measuring only 4 x 4 cm (1-1/2 x 1-1/2 inch).

Fig. 6A is the circuit of a complete vox and semi-break-in CW module, including sidetone using a single CA3086 IC. One external transistor, Q6, is used as a solid-state switch to energize the transmitter relays.

The output from Q1, the input audio amplifier, is rectified by CR1, applying bias to Q2. This emitter follower (Q2) with a variable RC time constant in the emitter lead, sets the vox delay. The differential pair Q3 and Q4, are connected as a Schmitt trigger, with Q4 normally conducting, its collector voltage is about +2 volt and the 6.2 volt zener (CR2) cannot conduct. When rectified audio causes the Schmitt trigger to switch, Q4 conducts and the resultant 10-volt collector voltage causes CR2 to conduct, turning on Q6. Q5 is an RC coupled, phase-shift audio oscillator, with an output from 700 to 800 Hz. When its emitter resistor is grounded through the key jack, the tone output is fed to the transceiver (or receiver) audio output stages, providing a sidetone in the CW mode. The oscillator's output is also fed to Q1, causing the vox circuit to function in the same manner as with a normal microphone input. A manually operated mode is provided by grounding the base of Q3. CR3 and CR4 rectify the speaker output, providing the anti-vox control.

Fig. 7 is the circuit of a squelch module, based on the CA3018,[2] for use with fm receivers. The entire circuit was built on a board measuring only 2 x 3.5 cm (0.8 x 1.4 inches).

The circuit for the microphone amplifier, balanced-modulator audio driver, and S-meter amplifier stages used in the popular Atlas Radio 210/215 series transceivers is shown in **fig. 8**. This is an excellent example of making full use of an IC array. Q1 is a high impedance emitter follower, Q2, a voltage amplifier, Q3 and Q4, a differential pair strapped to form a single low-impedance emitter follower.

references

1. *Bill Hoisington*, K1CCL, "Two High-Gain RF Stages in One IC for 2-Meter FM," *73*, May, 1974, page 47.
2. Peter Lovelock, K6JM, "The Postage Stamp Squelcher," *73*, May, 1975, page 103.

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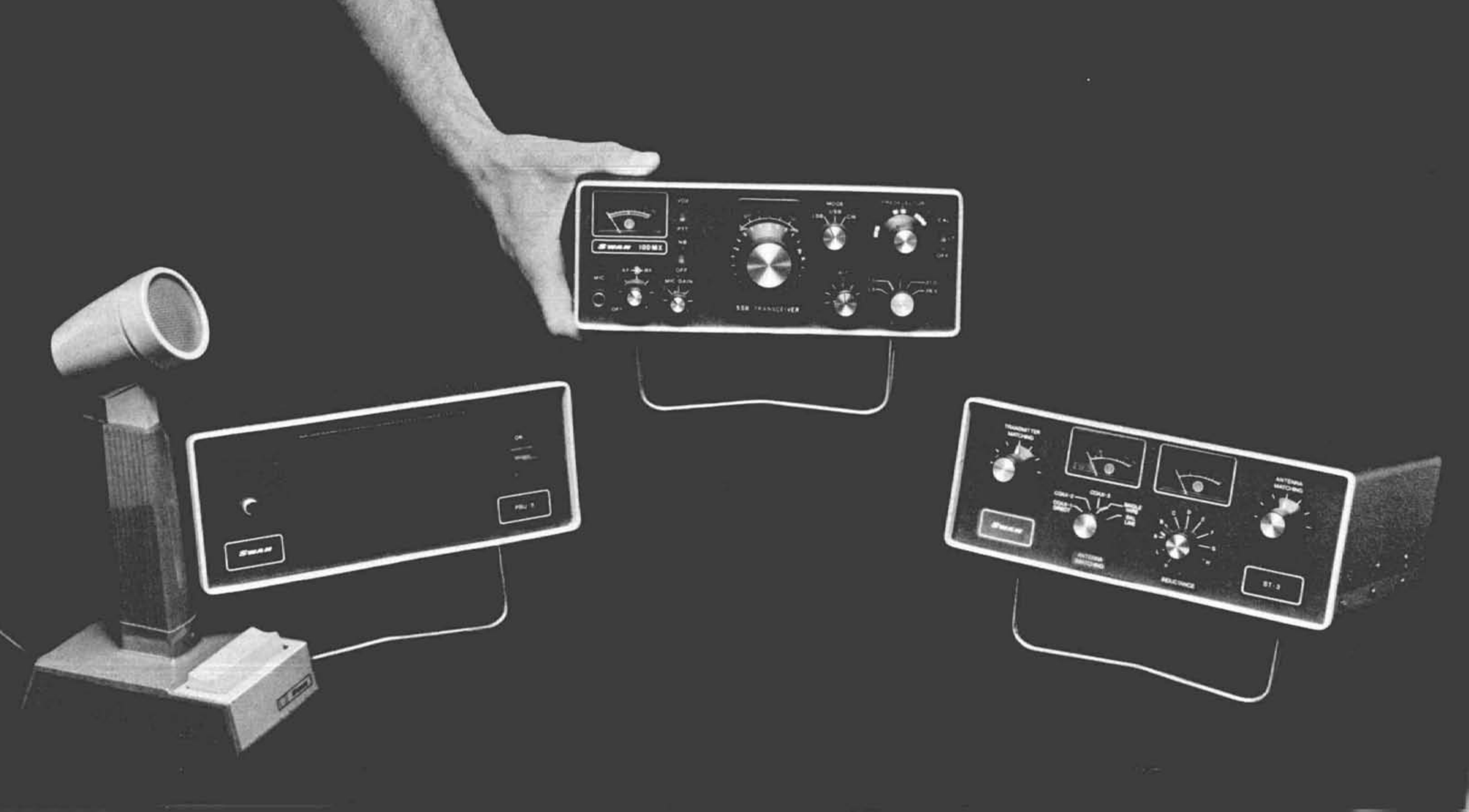

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tracking down repeater jammers

Malicious interference is increasing on the amateur bands, particularly on 2 meters — here are some ideas for concerned hams who want to do something about it

Repeaters seem to attract a variety of intentional jammers. Kerchunking is by far the most common offense, and nearly every 2-meter operator does it at one time or another to check that the rig is getting out. But there are others who do it regularly and repeatedly, even to the point of trying to play "Jingle Bells." They have been heard to say, "I guess I'll wear out another relay."

the problem

Almost every time a 2-meter rig is ripped off in the mistaken belief that it can be peddled as CB, there's an epidemic of jamming. It starts with kerchunking, progresses to attempts to raise another CBer, then often proceeds to false calls, obscenity, or the type of operation that's led to the term "Chicken Band."

Another source of repeater jamming is the malcontent who's unhappy because the repeater is operating on *his* frequency. Some of his tricks are blocking signal levels, noise modulation, endless kerchunking, and retransmission of signals from other channels or of other services. A really mean trick is to key the transmitter at a rate that may simulate "picket fencing," or may lead users to believe that a rig or repeater malfunction has occurred.

Amateur clubs (and stations) should have the ability to track down and identify these jamming sources.* For one thing, this can lead to the recovery of a stolen rig and to the word being passed to stay off ham equipment. Also, besides leading to a better repeater operation, the track and identification capability should be of major value in a manmade noise program. This can help all hams, not just repeater users.

Although the operations involved require individual effort, it's probably better to undertake such a program as a club effort. Some reasons for this are discussed at the end of the article.

interference plan

For an anti-jamming or interference program to work, a plan of action is needed. The basic elements are:

1. Detection
2. Alerting
3. Preliminary locating
4. Spotting
5. Identifying
6. Acting

Each involves some effort and some time. Several elements also involve some skill, but the effort per person can be kept low. These factors are among the reasons this anti-jamming effort makes a good club project.

detection

Detection can be left to chance, but it's a good idea to have at least some planned effort. In fact, jamming detection can also serve another purpose — intruder detection: the steps and procedures are the same.

One way to handle the detection problem is to

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*An example of what's being done to stem the vhf jammer problem appears in reference 1. **Editor.**

combine it with another one. At any time a club probably has one or more members who are shut in for some reason, usually illness. Many of these people are happy to have some light chore to help pass the time. Monitoring can help. The club can help by having a set of loan equipment available, or possibly two sets, one receive-only for nonlicensed members.

While any reasonable antenna and receiver combination is suitable for monitoring, a comprehensive plan should be based on the use of scanners. Very good commercial scanners covering up to ten channels or so are available at reasonable cost. Panoramic vhf receivers can sometimes be found in surplus sources, or a Panadaptor can be added to a vhf receiver. Incidentally, it doesn't make much difference whether an a-m or fm receiver is used. So older rigs can serve the monitoring function. A mechanical dial drive along the lines of the General Radio 1521 drive unit could be worked out for older, continuously tuned rigs.

Owners of synthesized rigs are in a good position to check all or at least a good number of the channels. However, doing this by throwing lever switches becomes very tedious. The procedure can be mechanized by the simple addition of a counter chain that feeds the rig's internal counters. The basic principles are shown in **fig. 1**. The OR gates can be mechanical switches, but a diode or IC OR gate is simpler. Some form of level changing will be needed to allow the squelch to stop scanning; it can be a relay. The same circuit can start a recorder.

A few simple logic circuits can be used to give a no-noise, unattended monitor system, which can also reduce time in checking for interference. The trick is to use two tape recorders. One would be set up to run when a signal is detected. Ideally it would be a two-track unit with time on the second track, say by digital clock readout or WWV/CHU recording. The other recorder would start when a signal is received and run for about thirty seconds. Then it would not restart until the signal had been off for, say, fifteen seconds. This avoids recording most legitimate contacts and long patches of interference. The compression allows fast review of a day's record. If suspicious signals are found, the full tape can be reviewed.

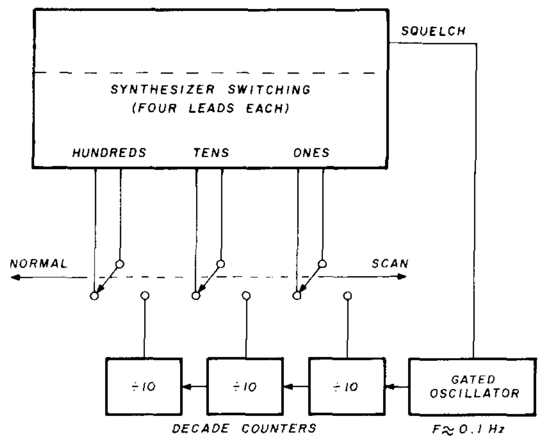

fig. 1. Adding scan-capability to a synthesized radio. Switching can be mechanical or by logic elements.

This type of system doesn't permit immediate action, but it is good for uncovering the operating habits of intruders, or of intentional jammers. It also gives a useful record for analysis and possible action.

alerting

The purpose of alerting is to bring the locating and identifying resources of the interference plan into play. For several reasons it's best to use a small number of alerters. This helps prevent false alerts and callup for marginally traceable interference. Also it helps prevent annoyance to a number of people — if a dedicated, intentional jammer is around it's virtually certain that he'll try to harass all concerned by trying to break up contacts by 3 AM phone calls or even dirtier tricks.

The alerters must be prepared to put up with such tricks and should be ready with appropriate counters — fast frequency change, power increase if necessary, and call monitoring by the phone company. In severe problems it may be necessary to go to a two-tier alerting plan — a fairly large number of people who will relay a detection notice to the actual alerter.

The alert should be in stages. The first step is to determine if further effort will be worthwhile. This can be done by one or two stations who can tell if the signals are strong enough to get a good DF bearing, if the interference source is fixed or moving, if it's distant or local, or if the problem warrants further action.

If further actions seems in order, enough direction-finding stations should be alerted to get a good fix.

Public awareness of personal two-way radio communication is keeping pace with the population — both are increasing. Adding fuel to the fire is the increasing availability of low-cost equipment, which means that almost anyone who wants to own a two-way radio can be in business with little effort and a modest outlay of cash, often without bothering to obtain a license. Along with this upsurge of personal radio activity is the inevitable: an increase in malicious interference by those of marginal mentality who seem to enjoy disrupting legitimate communications. The problem exists in the Citizen Band radio service as well as the Amateur service; the problem is particularly severe on 2 meters.

Radio amateurs are noted for policing their operating frequencies. In this article, author Haviland offers some ideas for those interested in ferreting out jammers on two meters. He presents an interference plan and suggestions for implementing it together with suggestions on avoiding legal pitfalls during final action. The theory behind the program is that, once the program is working and the pressure is on, jammers will give up and disappear. **Editor.**

One situation needing fast action is that of a ripped-off rig being tested. This is almost always a local fixed-station problem. Chronic and intentional interference may be local or distant, but doesn't require immediate action — it may be better to wait, perhaps

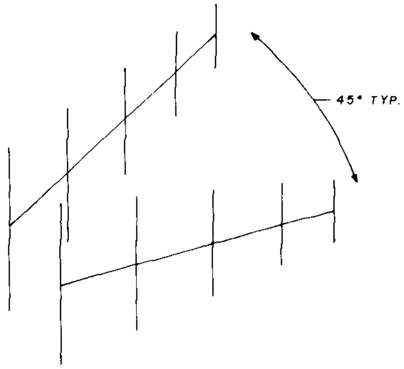

fig. 2. Skewed Yagis for direction finding. Feed may be switched between antennas or at the receiver.

until a key DF station is available or until signal levels increase so that a good DF bearing and good identification are possible.

Overall, the alerting must involve decisions on:

1. Preliminary evaluation
2. DFing
3. Mobile DFing
4. Identification
5. Urgency

Some of these decisions can be handled by landline but others require coordination and passing of data. A "jammer net" is good, with the alerting station acting as net control. Obviously, coordinating operations should not be on the channel subject to interference. Probably the operations should be simplex, although the net alert can be called by a repeater.

direction finding

The DF techniques will vary somewhat for fixed and mobile interference and for local and DX signals. The standard rules apply, of course: a minimum of two bearings are needed. A minimum signal-to-noise ratio is needed for good angle accuracy, and for good geometric resolution the bearings must cross at angles approaching 90°.

For preliminary evaluation, bearings can be obtained from any station with a rotary beam. Two such stations may give sufficient accuracy on local signals to justify dispatching one or more mobiles for pinpointing the source.

Better DF accuracy can be secured with a special DF antenna setup. One simple method, shown in **fig. 2**, is to mount two identical beams at an angle of 40° to 60° using two feed lines to a switch, which may be at the receiver. Rotating the array until the signals from the two beams are the same gives the signal bearing as the bisector of the angle between the arrays.

Somewhat better accuracy can be obtained with phased antennas. The Adcock array of **fig. 3** is very good. For this antenna the bearing is the angle giving a null signal and lies at right angles to the plane of the elements. Watch the 180° null.

For distant signals working at the null is not too accurate, and it may be necessary to use lobe-switched arrays as shown in **fig. 4**. As for the skewed array, (**fig. 2**), the bearing is that giving equal signals as the switch is operated.

Various refinements to these simple techniques can be made, such as fast switching, synchronized indicator switching for right-left indication, and visual presentation. See the various handbooks, such as Terman's *Radio Engineers Handbook* for ideas and data.

If the interference source is moving a special problem exists, which is related to the problem of relative motion for ships at sea. See Dutton's *Navigation* for solution to these problems by use of the maneuvering board.

pinpointing

Sometimes bearings from fixed stations will give sufficient accuracy to pinpoint a source, but it's often necessary to call on mobiles.

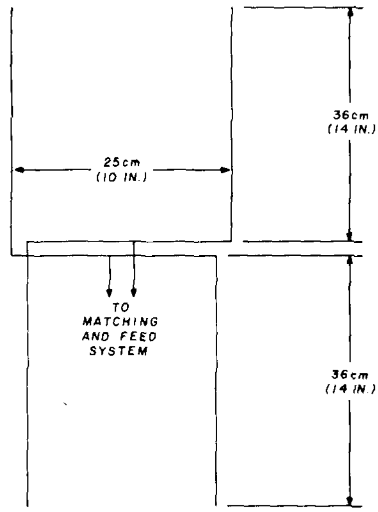

fig. 3. Simplified Adcock array. Matching may be omitted for receive only. The feed impedance is low. System can be made from simple materials.

Fair results can be obtained with mobiles having simple antennas if the receiver has an S-meter.[1] The procedure is to drive in directions that give signal-strength increases. Driving around a suspected area may confirm that the signal source is enclosed, and it may be possible to spot an antenna system. Mobiles doing this should remain on public access roads or areas and probably should not stop for any reason.

Better and faster results can be secured if the mobile has DF capability. Probably the simplest DF unit is made of two half-wavelengths of wire mounted on a wood pole, as shown in **fig. 3**. It's not too difficult to work out a window mount, which will allow DFing while in motion.

With this type of antenna, a very close fix is possible by using the process called "doubling the angle on the bow," a nautical technique. Drive in a straight line past the suspected location. When the angle to the signal is 45° to the line of motion, note the position along the route. Continue driving until the bearing is 90°. The signal is coming from a point at right angles to the route, and its distance from the route is equal to the distance from the first position, as shown in **fig. 5**. See navigation texts for variations in the technique.

This mobile pinpointing can be speeded up if the fixed-location DFing stations track the mobiles with respect to the interference. Angle differences can be measured more accurately.

identification

While locating and pinpointing are going on, steps that will permit identification of the signal can start. One element of this procedure is to show that harm to communications actually results from the interference. Another part is to show that the signal is coming from the pinpointed location. A final goal is to identify the transmitter causing the interference, or even the person responsible. This identification is not just for information — it may be crucial if action is to be taken, as discussed later.

The first element of identification is *complete* and *accurate* logging. This should show as a minimum

1. Date and time
2. Band and frequency
3. Station or communications being interfered with
4. Description of interference

In addition it's desirable to record any analysis of the interference, including bandwidth, center frequency, results of a-m and fm reception, and approximate or exact spectral distribution. Each log entry should be signed, and, if possible, witnessed.

The use of tape recordings for interference detection has been mentioned. These records are valuable in identification, especially if some simple precautions are taken. Each tape should start with an announcement of the fact that it is an interference

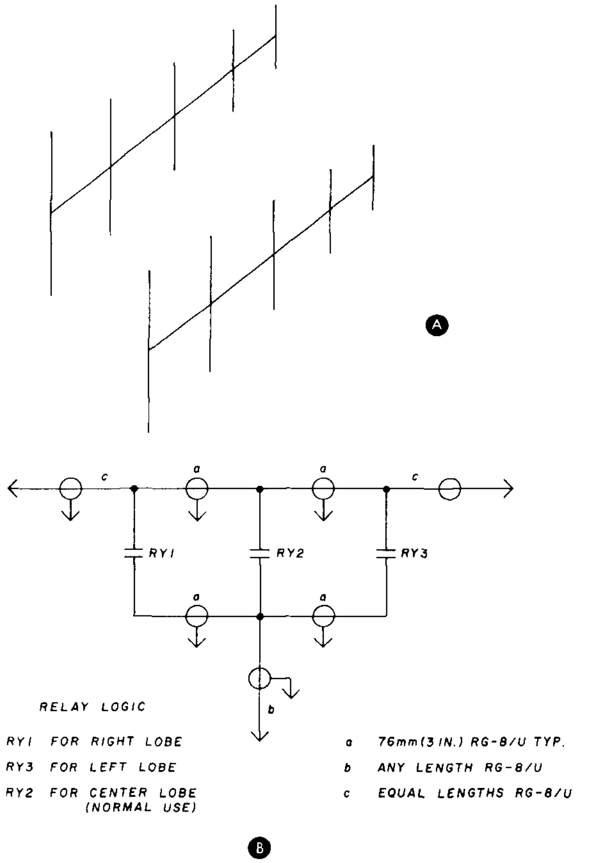

fig. 4. Lobe-switched system for DXing. Sketch A shows the antenna arrangement. Booms are parallel; spacing is typically one wavelength. The connection harness is shown in B.

record, and the date, time, operator, and place given. It is well to state the make and serial number of equipment used in reception and in recording. Before the recorder is shut off, the date and time should be repeated. Strip charts are also useful. These may give the pattern of interference, including times of occurrence and relative levels of wanted signal and interference.

Recordings should also be made by the mobiles used in pinpointing. Signal level at various locations is helpful in showing the extent of interference and the general location of the source. When the source location has been identified, simultaneous recordings at the locating mobile or mobiles and the tracking stations should be made. Each should be identified, of course.

In many interference cases pinpointing the location of a jammer, and showing by records that the interference *does* come from that location, is sufficient for action. However, cases may arise where further identification is needed.

Identification of a particular transmitter or person is not easy but possible. Two types of material are needed: the interference records and identified records of suspected sources. The identification rests on "signature" analysis and matching, that is,

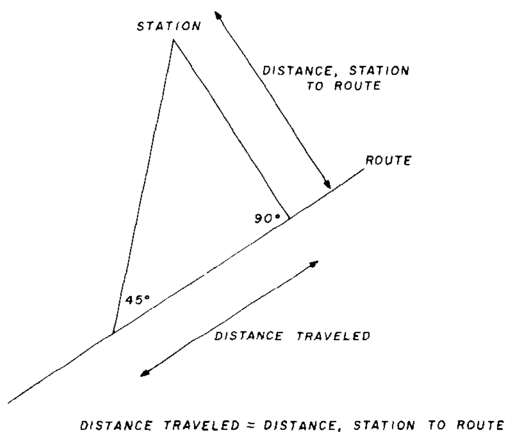

fig. 5. Method for pinpointing source location by using the navigational system of "doubling the angle on the bow."

an identifiable element of the signal that forms an identifiable characteristic. For example, the bias frequency in recorders varies. The frequency can be determined by comparing it to the 60-Hz hum frequency when present. Recorders, receivers, and transmitters may be identified by comparing the relative magnitude of hum components at 60 Hz, 120 Hz, etc. Sometimes special components are present, such as parasitics, peculiar background noise, or peculiarities of off-on characteristics.

Identification of individuals is also based on a form of signature analysis. For CW, this may be the ratio of dot to dash lengths, the way dash length changes from character-to-character, or individual tricks in spacing. For voice, the relative strength of components in the three major speech bands form identifier elements, as do word choice, syllable rates, and many other factors. It requires some detective work, but it can be done.

Signature analysis is certainly beyond the capability of most amateurs, and probably beyond the capability of most clubs. Those groups in areas with good laboratories can probably do the work or get it done: arrangements might be made to call on one of these groups if simpler steps are not sufficient. In any event, recordings should be made with the thought that analysis may be required as a part of the remedial action taken. Make at least *some* records with good-quality tape recorders; and, if there's reason to suspect an identified station or individual, make recordings of this station, giving identification.

action

In many cases interference of the type considered here disappears when the fact of an anti-jammer program becomes known. When this happens the plan should go into standby. It's a good idea to demonstrate that it works, say by a hidden transmitter hunt.

Unintentional interference will probably be corrected when the source is advised of its existence. If this type appears, a letter or telephone call discussing the problem appears to be in order.

Casual interference, say by kids, is usually not a great problem. If it persists, tracking down and notifying parents, the organization concerned, or even passing the information along the grapevine usually clears up the matter.

Interference caused by stolen rigs doesn't usually last long. If an attempt is to be made to recover the rig, however, fast action is needed. Several accounts of approaches to this problem have been published.

If interference continues and appears intentional or willful, there may be grounds for complaints to the FCC. Such factors as unidentified signals, or illegal forms of modulation, are direct grounds. However, interference *per se* is not necessarily adequate grounds. No amateur station has prior or exclusive rights to a frequency, and it's necessary to show that willful or malicious intent exists, which is difficult. In these continued interference problems, it's probably best to review the matter and the available records with the Commission field offices. But remember that these offices are understaffed and busy, so make sure you have a legitimate problem.

Some states have laws intended to apply to franchised communication services, which also apply to at least some amateur communications. Competent legal advice should be sought before any action is taken.

One thing should be watched. Individual action is not only unwise — it may even be dangerous. The news accounts of CBers' quarrels show this. Even group or club action should be carefully considered.

Fortunately, most interference problems can be handled without too much trouble. As noted, they tend to go away when there is a program to take care of them.

reference

1. Alf Wilson, W6NIF, "Happy Flyers — Helping People," *Ham Radio Horizons*, March, 1978, pages 12-22.

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More Details? CHECK—OFF Page 142

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high-performance rf-agc amplifier

Presenting a small step forward in front-end receiver design — an amplifier with high power gain and good agc characteristics

During construction of a 6-meter ssb transceiver, I needed an improved rf-agc amplifier. My requirements called for 15-dB minimum power gain, low noise figure, and good signal-handling capability that wouldn't deteriorate with the application of agc. Furthermore, a good input/output match to 50 ohms had to be maintained over the agc range. The well-known circuits I had used or seen in the past wouldn't meet *all* these *requirements simultaneously*. What follows is my approach to the problem of compatibility between a high-gain rf input amplifier and really good agc control. Also offered are some suggestions on further improving input/output linearity, and some equations for calculating power gain and impedance.

initial experiments

The dual-gate mosfet amplifier worked fine with constant bias, but signal-handling capability deteriorated with agc. Also, this circuit required a high-input impedance transformation for a match, a no-no in good front-end design. Next I considered the grounded-gate circuit, where an input match was easily obtained with a low-impedance transformation. Available power gain was disappointingly low, however, and input-impedance change with agc was totally unacceptable. From this initial investigation I reached two conclusions: A new amplifier configuration was necessary to meet gain, impedance match, and signal-handling requirements; and agc control

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must not involve changing amplifier bias level in any way.[1]

final circuit design

To make a long story short, the circuit evolved into that shown in **fig. 1**. The basic arrangement is a cascode jfet amplifier. However the input fet, Q1, receives drive at both gate and source terminals. This provides two advantages, the first being an input match with a transformation only slightly higher than that of a simple common-gate stage. Second, this type input permits a choice of gain in the range between common source and common gate arrangements.

turn on, shunting more and more signal current away from Q2, decreasing stage gain accordingly. Maximum gain cut is determined by the saturated ON resistance of Q3 in series with the coupling-capacitor impedance, together with the g_m (forward transconductance) of Q2. With a good high-current switch at Q3 (such as a 2N2222), a very respectable agc range of at least 35-40 dB can be achieved.

There are other, less obvious, advantages with this agc circuit. First, control takes place at the point of smallest signal voltage, or lowest impedance. Second, the control element operates with increasing forward bias as gain decreases (input signal increases). Both points are extremely desirable from

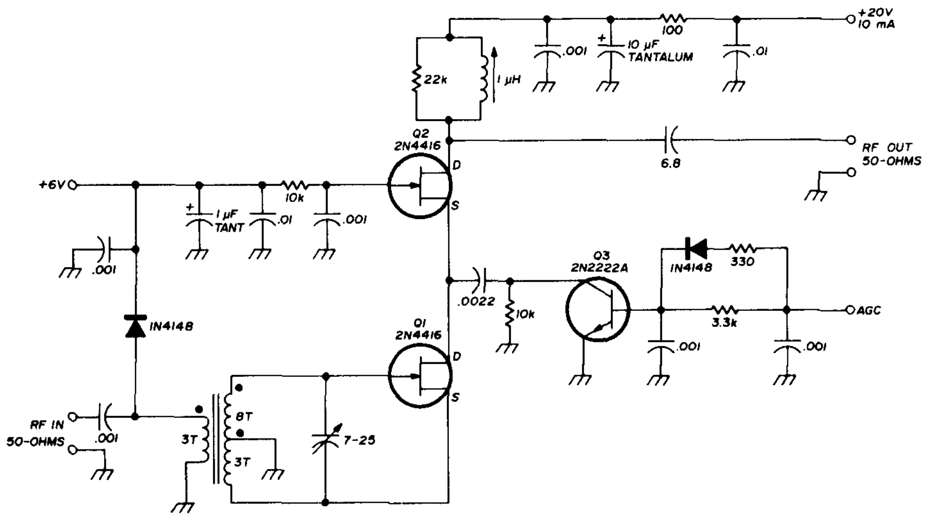

fig. 1. Schematic of the 50-54-MHz rf/agc amplifier. The input transformer is wound on a small toroid core; total secondary inductance is 0.5 µH. Coil data are sketchy because of the use of surplus cores and forms of unknown origin and characteristics.

In a related fashion, noise figure follows a similar relationship. The output fet, Q2, is conventional. Any reasonable output network may be used to meet gain and impedance requirements. The circuit isn't original with me, as a bipolar version is mentioned by Rheinfelder.[2] A similar arrangement has been described for use in vacuum-tube linear power amplifiers;[3] however, I've never seen its excellent capabilities put to use in modern ham equipment.

agc control

The method of agc control is unconventional (as far as I know) for an fet amplifier. It does bear some resemblance to a bipolar cascode circuit using a differential pair with current source, although operation does not involve changing amplifier bias level. In **fig. 1**, a transistor is ac-coupled to the interface between the fets. As long as this transistor remains biased off, it has little effect on the signal current passing from Q1 to Q2. With increasing agc voltage, Q3 begins to

a dynamic-range point of view. Finally, circuit complexity is only slightly greater than that of a standard cascode or mosfet stage.

circuit description

The circuit of **fig. 1** uses low-*Q* input and output networks to achieve an almost flat 16-dB power gain over the entire 6-meter band. A high-value shunt resistor across the output coil was sufficient to limit the gain to the desired value because of the low unloaded *Q* of the miniature coil I used. (A high-*Q* coil here would have resulted in a much lower shunt resistor to keep the gain down.) Input and output amplifier ports provide a very good match to 50 ohms, an important consideration for low-input vswr presented to the vhf antenna and cable and for the following multi-pole bandpass filter.

The agc transistor, a 2N2222A, receives its base drive through a nonlinear resistor-diode network. This arrangement linearizes the dB gain cut versus control voltage characteristic over the range I required. This or similar networks (using zeners, for example) can be used to tailor the agc levels and response curve to meet your specific requirements.

I found no need for parasitic suppression with this circuit; however, the layout is very compact with good bypassing and grounding, so other construction methods might require resistors or ferrite beads applied to Q2 gate and drain. A further point in this circuit is that Q2 was selected for a slightly higher I_{DSS} (zero-bias drain current) than Q1. This would not be necessary with sufficient source bias at Q1.

test results

Fig. 2 is a plot of the agc characteristics for the circuit. The linearity is acceptable but could be further improved by operating on the base drive to Q3. My test setup was limited to the 30-dB of gain cut shown, but at least 40 dB should be achievable.

Further tests of input-output linearity revealed a 1-dB gain compression level at +7 dBm output to 50 ohms, corresponding to a −9 dBm input level. Even at a gain cut of 30 dB, the input level for 1-dB compression didn't drop more than a couple of dB. Although this performance is good, further work is indicated, since this rf stage is still (on paper) the limiting strong-signal factor in my receiver.

Some possibilities for improvement: operate Q3 with some collector-to-emitter-current bias; use higher g_m fets; and maybe substitute PIN or rectifier diodes for Q3. Noise figure and IMD measurements are still awaiting completion of the receiver section, although I expect performance in this area to be good, at the very least.

calculating gain and impedance

When looking at published schematics, I've often wondered how other authors arrived at particular circuit values. So, at the risk of being blamed for too many technicalities, I'd like to present some equations and information for those wishing to experiment. For this, I'll use the simplified ac equivalent circuit of **fig. 3**:

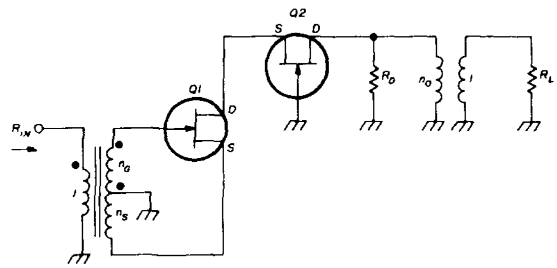

fig. 3. Simplified ac equivalent circuit for power gain and impedance calculations.

$$power\ gain = \frac{R_{in}R_L}{4}\ [g_m n_o (n_G n_s)]^2 \qquad \textbf{(1)}$$

where

n_o = output voltage step down ratio
n_G = gate winding step up ratio
n_s = source winding step up ratio
g_m = ac forward transconductance
R_D = combined resistive loading and coil losses
R_{in} = input impedance presented to input transformer primary
R_L = load resistance

Normally, $R_{in} \approx R_L = 50\ ohms$. In **eq. 1** it's assumed that sufficient resistive and coil loading exists so that $R_D = (n_o)^2 R_L$, which makes the circuit output resistance equal to that of the load. Once R_{in} is set, the following equation should be used to define the input turns ratios:

$$n_s(n_G + n_s) = \frac{1}{g_m R_{in}} \qquad \textbf{(2)}$$

A few iterations between these equations may be required to achieve reasonable proportions for the input and output turns ratios. But reasonable numbers usually result by choosing $n_s = 1$ so that $n_G = \frac{1}{g_m R_{in}} - 1$. Then all that's left is to solve **eq. 1** for the output turns ratio corresponding to the desired power gain.

It is my hope that the data presented here will help produce some small advance in communications-receiver performance. Obviously, this amplifier circuit isn't limited to the 6-meter band; in fact, I use similar versions for my receiver's 9-MHz i-f chain. I'd truly appreciate hearing from anyone who either uses or further evaluates this circuit.

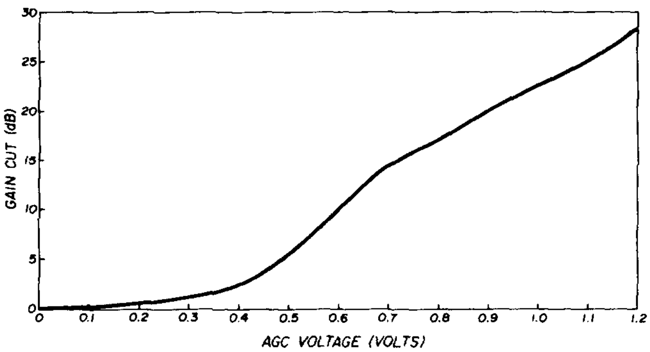

fig. 2. Agc characteristics for the circuit of fig. 1.

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3. Pappenfus, Bruene, and Schoenike, *Single Sideband Principles and Circuits*, McGraw-Hill Book Co., 1964, page 159.

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modified quad antenna

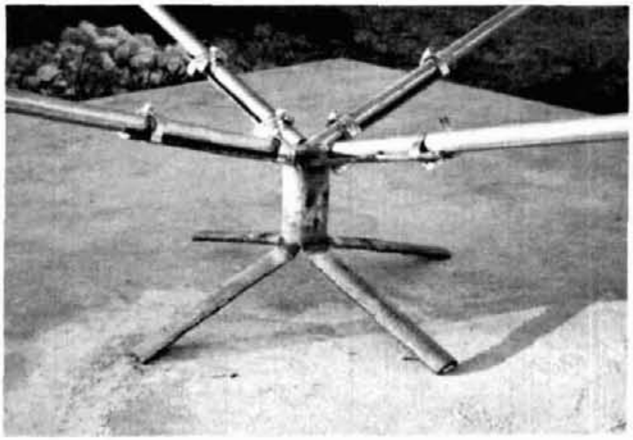
If you haunt the 20-meter band for DX you've no doubt heard ZF1MA — here's a description of the antenna that puts out his big signal

The quad has long been acclaimed a great DX antenna ever since Clarence C. Moore, W9LZX, made history with it in the mountains of Ecuador in 1939. Very few articles have appeared in the literature regarding its design changes. This article describes some novel changes to the quad, which makes it an efficient DX antenna.

construction

Fig. 1 illustrates the basic design of the quad. This antenna was made from locally available materials. Its design departs from conventional quads in several respects.

The spider. The first part to be constructed is the spider, which must be lightweight and strong. I made several spiders using different materials (aluminum and galvanized iron). These spider designs were abandoned as being either too heavy or too weak. Finally, a spider made from a 61-cm (24-inch) length of 51-mm (2-inch) diameter galvanized tubing had the necessary structural characteristics. This spider was cut as shown in **fig. 2**. The photo shows the spider in the half-finished stage.



Details of the spider used in the modified quad showing hose-clamp connections for the elements. All materials were obtained locally.

By **Joseph B. W. Jackman, ZF1MA,** P.O. Box 459, Grand Cayman Island, British West Indies

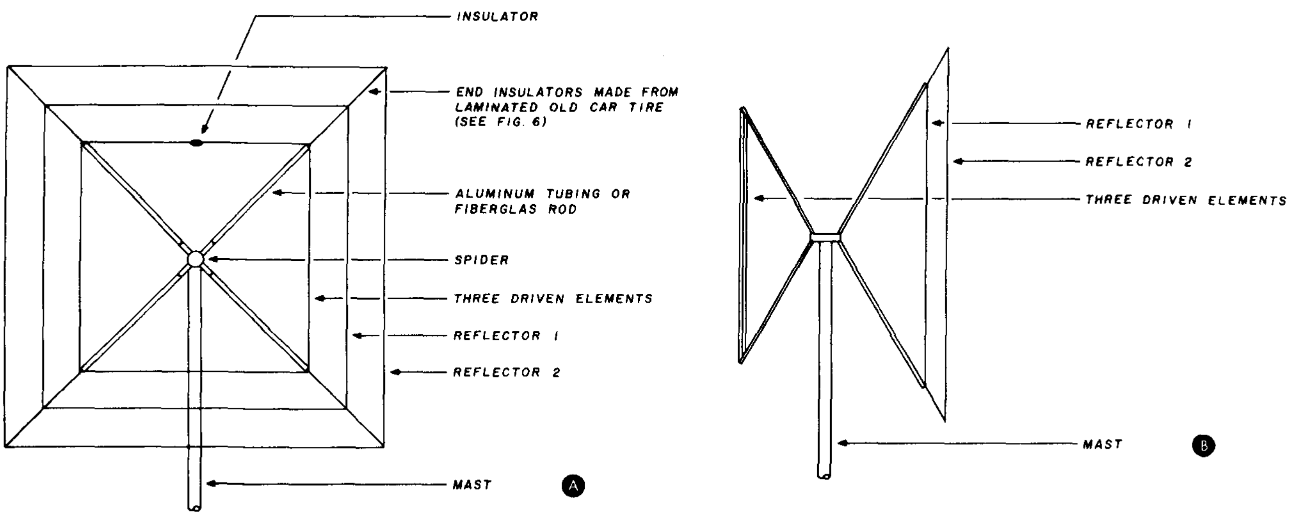


fig. 1. The modified quad antenna used at ZF1MA. Design uses three driven elements, which are fed with 450-ohm open-wire transmission line. Front view is shown in sketch A; side view in B.

Spider template. A template was used to bend the cut sections of tubing to the required angle consistent with the spacing used. The angle can be between 108 and 112 degrees. The template was made of stiff cardboard, which was cut as shown in **fig. 3**.

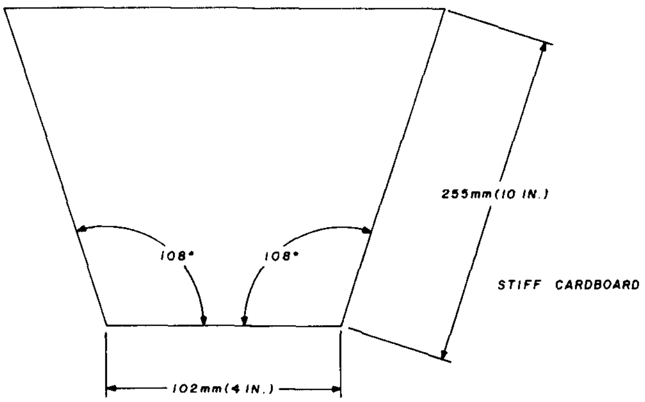


fig. 3. Template used for forming spreader-to-spider angles.

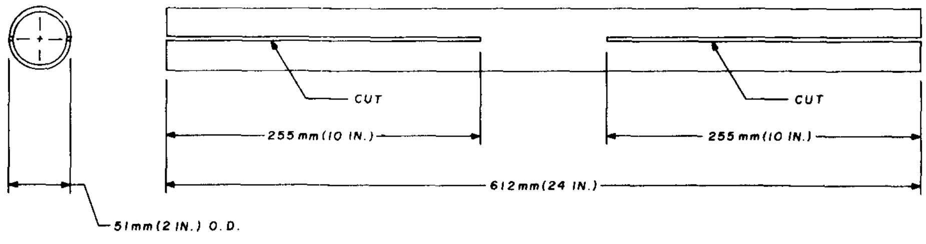
When tube bending has been completed, the spider should look as shown in the photo. The photo also shows how the spreaders are attached to the spider with stainless-steel 7.5-cm (3-inch) hose clamps.

To strengthen the spider, four pieces of 12.5-mm (1/2-inch) conduit was welded between each bent arm, so that the 108-degree angle, or whichever angle you choose, is maintained. See **fig. 4**. The drawing is simplified for clarity.

The spider can either be used as is, with only the addition of a mast-to-spider plate, or you can do as I did and weld a 0.9-meter (3-foot), 51-mm (2-inch) diameter pipe onto the spider, as shown in **fig. 5**. The mast is welded to the spider, depending on the shape quad desired.

Spreaders. Spreaders can be made from any of the conventional materials. In the tropics bamboo is the most available and is gratis; however, fiberglass, aluminum, or wood can also be used. This, of course, will depend upon where you live and what materials are most available. I had a few lengths of aluminum, so these were used. However, to prevent the spreaders from resonating, the horizontal spreaders on the driver and reflector elements were broken with insulators. For years I used wood, and at least one commercial company uses Bakelite. I decided to use rubber from old car tires cut into small strips and laminated together with contact cement. Incidentally, the same idea can be used to make standoff insulators or center insulators. Eight insulators were also

fig. 2. Method of cutting the galvanized tubing used for the spider.



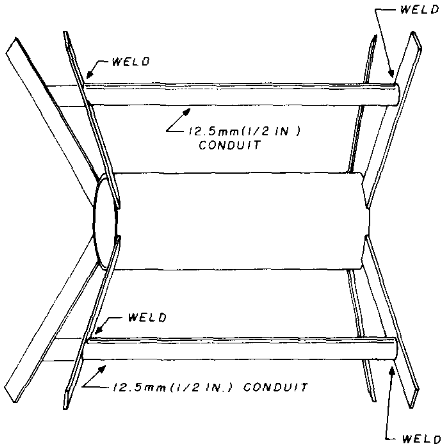


fig. 4. Galvanized conduit, 12.5 mm (1/2 inch) in diameter, is welded between spreader attachments for structural strength.

made to put into the end of the aluminum tubing (**fig. 6**). This practice proved to be well worth the time spent in making them, as the flexible rubber moves with the wind and precludes broken elements on the quad. The three holes spaced 51 mm (2 inches) apart are for the driven-element spreaders only (**fig. 6**).

The per-side dimensions I used for the quad were:

three driven elements	5.3 meters (17.3 feet)
reflector 1	5.4 meters (17.8 feet)
reflector 2	5.6 meters (18.3 feet)

The three driven elements (**fig. 7**) were made up and passed through the holes in the end of the spreader insulator. The middle wire was open at the top and

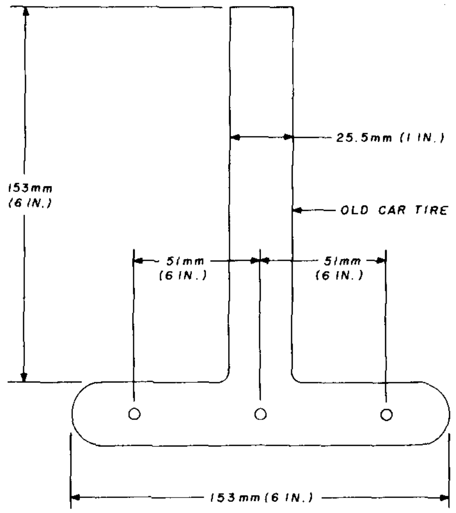


fig. 6. An old auto tire, which moves with the wind and eliminates broken elements, can be used for insulation material. Small strips of tire rubber were cut and laminated together with contact cement.

one of my car-tire insulators inserted. This was also done on the number-one reflector only. The feedpoint was connected with 450-ohm open-wire transmission line to a universal transmatch, thence to a standing-wave-ratio meter, thence to the transmitter.

performance

The quad was mounted on a 12-meter-high (40-foot) mast and vswr checks were made. Having satisfied myself that all systems were go, I tuned up to 20 meters, pointed the antenna toward Europe and called CQ DX. I called only once, and all Europe seemed to call me! The first callsign I picked out was my longtime radio friend Paul, SM7CMC, who gave me a 5-9 + 20 report, and since it has been ever thus. That night I pointed the beam toward Australia and

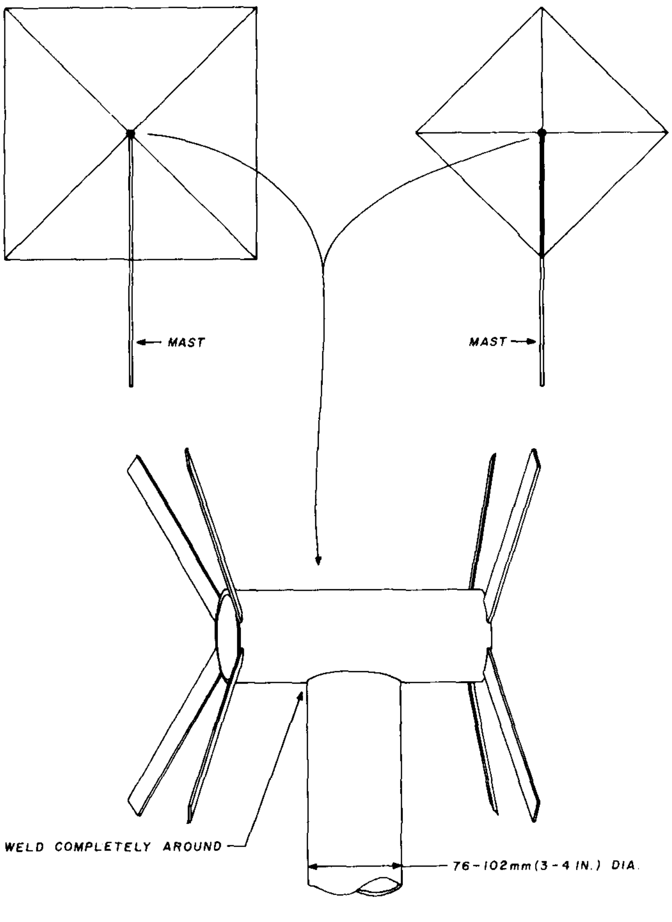


fig. 5. Method of welding spider-to-mast section to obtain a square or diamond-shaped quad.

the same thing happened. It seemed that all the Pacific stations were lining up to say what a great signal I had, including ZL and VK, but also P26, DU, FO8, and others. At this time I ran tests with some of these stations. From their observations the following antenna performance figures were deducted:

	20 meters	15 meters	10 meters
Gain	8.5 - 9 dB	9.5 - 10 dB	10.5 - 12 dB
Front-to-side ratio	40 - 45 dB	35 - 40 dB	40 dB
Front-to-back ratio	30 - 35 dB	25 - 30 dB	25 dB

The next morning at about 4:30 AM I crawled into bed, tired but contented, and next day I tried the beam first on 15 then on 10 meters. Needless to say, the results were even better than those received on 20 meters.

Since that time, whenever I get on the air on any of these bands, there's a pileup. So many amateurs have asked about my antenna system that I decided to write about it, and this is the story.

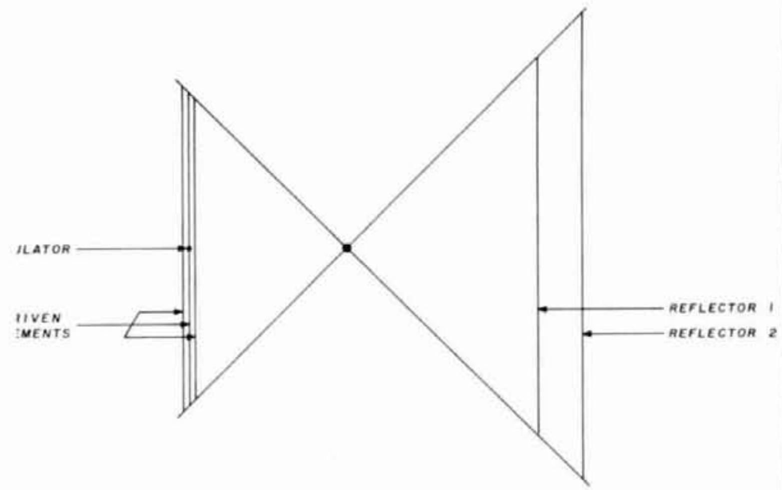


fig. 7. View looking down on the quad elements. Three driven elements are used; the center element is separated with an insulator to which a 450-ohm open-wire transmission line is connected. Reflector 1 is 3 per cent longer than the driven elements; reflector 2 is 6 per cent longer than the driven elements.

closing comments

I'd like to thank the many amateur radio operators around the world who have helped in testing this antenna. It's my hope that any amateur who decides to build this antenna will have as much pleasure with it as I've had.

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2. J. R. Fisk, W1HR, *Ham Notebook Volume 1*, Communications Technology, 1975.
3. *Radio Handbook*, 20th Edition, 1976, Editors and Engineers.

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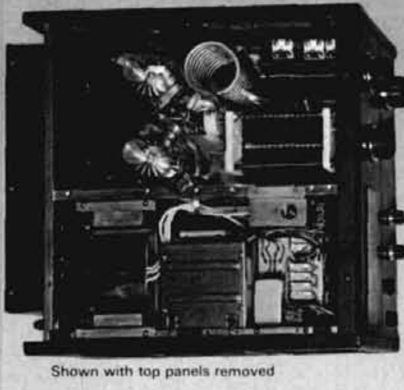

Shown with top panels removed

Frequency Range: Amateur bands, 160-15 meters
Drive Power Required: 80 W nom., 120 W max.
Mode and Duty Cycle: SSB, cont for 30 min CW and RTTY, key-down cont for 10 min
RF Input Power: SSB: 2,000 watts PEP; CW, RTTY: 1,000 watts DC
Plate Voltage: (at idle) 3.1 kV SSB, 2.2 kV CW, RTTY
Circuit Type: Class AB_2 grounded *grid linear amplifier*
Input Impedance: 50 Ω, unbalanced at better than 1.5:1 SWR
Output Impedance: 50 to 75 Ω, unbalanced.
Harmonic Suppression: min 40 dB, depending on exciter used
Fan Motor Delay Time: 140±30 seconds (at room temperature)
ALC: *Negative going, adjustable threshold.* −8 VDC max output (typ)
Tubes: Two Eimac 3-500Z
Semiconductors: 18 diodes, 1 Zener diode
Power Requirements: 120 V, 28 A; 220/240 V, 14 A, 50/60 Hz: for maximum SSB input
Dimensions: 390 mm (15⅜") x 190 mm (7½") x *407 mm (16")*
Weight: Net 31 kg (68 lbs) Shipping 38 kg (83 lbs)

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fm demodulator using the phase-locked loop

Another application of the PLL for fm circuits, including design notes and theory of operation

The phase-locked loop has been around for some time and has many applications including frequency synthesis, clock synchronization, and a-m detection. IC technology has made the design of PLLs available at low cost and in small packages. This article provides some nonmathematical background on PLL theory and describes its application as an fm demodulator.

operation

A PLL is a loop circuit with feedback. It may be viewed as an electronic servo with the ability to lock onto and track a reference signal. The lock-and-track process is accomplished through phase-comparing circuits. However, because frequency is the rate of change of phase with respect to time ($\Delta\omega = d\theta/dt$), the PLL lock-and-track mechanism is meaningful in terms of frequency.

Basic PLL operation is as follows (**fig. 1**). The voltage-controlled oscillator (vco) output frequency depends on dc-voltage value from the phase detector and loop filter. As long as the phase difference between vco output and the reference signal is constant, the vco control voltage will be constant and its output frequency won't change. However, when the phase difference between vco output and reference signal begins to change (as would happen as the vco output frequency changes), the phase detector and loop filter provide a dc error voltage, which shifts the vco frequency to re-establish the original phase relationships. In this manner the vco output frequency is maintained at the value of the reference frequency. This is the lock condition of the PLL.

Even during lock a finite phase difference exists between output frequency and reference frequency because each PLL has a characteristic free-running frequency. That is, with no reference voltage applied to the PLL, some quiescent output frequency exists at which it rests. Hence, with a reference signal,

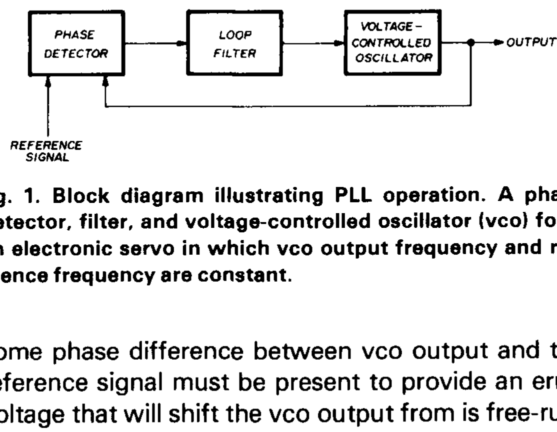

fig. 1. Block diagram illustrating PLL operation. A phase detector, filter, and voltage-controlled oscillator (vco) form an electronic servo in which vco output frequency and reference frequency are constant.

some phase difference between vco output and the reference signal must be present to provide an error voltage that will shift the vco output from is free-running value to the reference value. Often, terminals on the IC package are included for an external capacitor, which can be used to trim the free-running frequency

By Tim Daneliuk, KL7IPS, Room 0-408A, 820 North LaSalle Street, Chicago, Illinois 60610

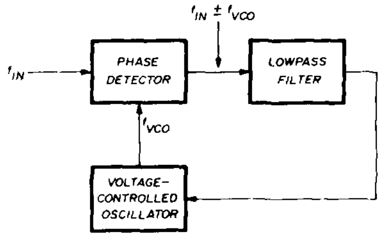

fig. 2. Example of a PLL with a phase detector used as a mixer so that $f_{in} \pm f_{vco}$ applied to a lowpass filter results in an output with a dc component that drives the vco so that loop lock is established.

as close as possible to the reference frequency. This action reduces pull-in time — i.e., the total time required for the PLL to establish the locked condition.

a different perspective

Fig. 2 shows the phase detector as a mixer whose output is $f_{in} \pm f_{vco}$. At lock, f_{vco} is such that the difference between the two frequencies is zero. The lowpass filter (LPF) attenuates the sum frequency and passes the difference frequency. Hence, at lock, the LPF output is a dc voltage (since the difference frequency is zero at lock). From this point of view it's seen that, if the PLL is not in lock but the difference frequency is within the LPF passband the filter output will not be dc but will be an ac beat frequency. This ac voltage is applied to the vco control terminal and, in effect, frequency modulates the vco output frequency. During the time f_{vco} is modulated so that it's closer to f_{in}, the error between the two signals decreases and the resulting beat frequency at the LPF output is lower. Thus the amplitude at the filter output is greater because, in a lowpass filter, less attenuation occurs for increasingly lower frequencies (**fig. 3**).

This entire process results in a filter output that is sinusoidal but decreases in frequency as a function

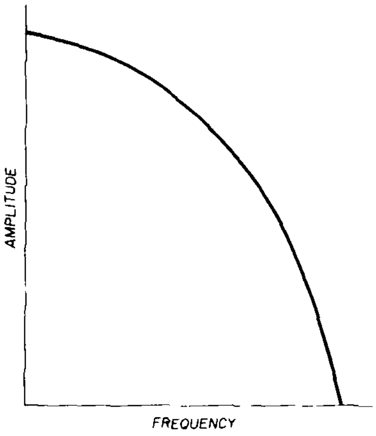

fig. 3. Amplitude as a function of frequency in a lowpass filter.

of time while increasing in amplitude (**fig. 4**). This waveform has a net dc component that drives the vco frequency to establish lock in the loop, which in turn results in a continuous dc output level from the filter. If the pull-in time is shorter than the period of the beat note appearing at the LPF output, the loop can lock without this oscillating error transient.

capture and lock range

It's important to understand the terms *capture* and *lock* and their mutual relationship. Consider the situation where the loop is not locked and the difference frequency is outside the LPF bandpass. The vco remains at its initial free-running frequency, and no real change occurs in the loop. However, as the difference frequency becomes smaller (as f_{in} approaches f_{vco}), a point is reached where an error voltage is passed by the LPF to the vco control terminal, which in turn shifts f_{vco} so that the difference frequency is even lower. This is a *positive feedback* mechanism, which causes the loop to become locked.

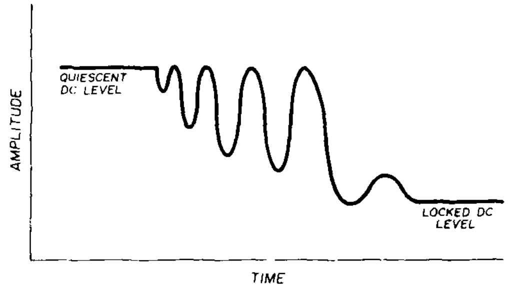

fig. 4. Lowpass-filter output response with time. The signal is sinusoidal but decreases in frequency while increasing in amplitude.

The capture range, then, is "the frequency range centered about the vco initial free-running frequency over which the loop can acquire lock with the input signal."[1] It is determined primarily by the LPF band edge and the system closed-loop gain. This action is contrasted with the loop lock range, which is "the frequency range usually centered about the vco initial free-running frequency over which the loop can track the input signal once lock has been achieved."[1]

The limiting factor of the lock range is the maximum amount of error voltage available and the corresponding maximum frequency swing the vco can produce. Because, in lock, the error voltage is a dc voltage, the lock range is not a function of the LPF bandpass characteristics. Note that the capture range is never greater than the lock range and is, in fact, often less. That is, a PLL may be able to track a signal and maintain lock over a greater frequency range than over which it was initially able to acquire lock.

table 1. Characteristics of several PLL ICs used for fm detection.

device	distortion (per cent)	upper frequency (MHz)
NE 560	0.3	30.0
NE 562	0.5	30.0
NE 565	0.2	0.5
NE 567	5.0	0.5

fm detection using the PLL

The basic circuit of a PLL fm detector is shown in **fig. 5**. Here, instead of a constant reference frequency, a frequency modulated signal is applied to the phase detector. The PLL is locked to the fm carrier frequency. With no modulation no frequency deviation occurs and the LPF output is a constant dc voltage. However, as soon as the wave is modulated and frequency deviation occurs, an error voltage appears at the LPF output which is proportional to the frequency deviation. The circuit demodulates the incoming fm signal. It's essential that the filter have a bandpass characteristic that doesn't attenuate the highest expected modulating frequency — i.e., for a high-fidelity system, a bandpass all the way to 20 kHz would be desirable.

linearity

Another important consideration (particularly in high-fidelity systems) in the design of PLL fm detectors is linearity. The loop must detect the signal without introducing excessive distortion. Also, the PLL must operate at a frequency equal to the carrier frequency plus the *maximum positive frequency deviation* encountered. With modern devices this is usually not a great problem, since detection occurs after mixing and i-f amplification. For example, common i-fs are 455 kHz and 10.7 MHz. **Table 1** shows the distortion and upper frequency limits of several common PLLs used in fm detectors.

response in noise

One of the side benefits of this system of fm demodulation is its ability to detect signals in noise. Since the error voltage is filtered, the control voltage to the vco is "devoid of phase deviations produced by noise."[2] The main requirement is that the incoming signal be strong enough to activate the phase detector. This is not, perhaps, overly critical in the fm broadcast situation, where the receiver is in an area of fairly high signal strength (since fm broadcast is intended primarily for local coverage). However, incoming signal amplitude becomes exceedingly important, for example, in high-frequency RTTY FSK demodulation. Here, the incoming signal is often plagued by atmospheric noise and other disturbances. Unless the demodulated signal is an *exact* reproduction of the transmitted signal, the resulting printout will be gibberish. A similar application would be in the vhf fm telemetry systems.

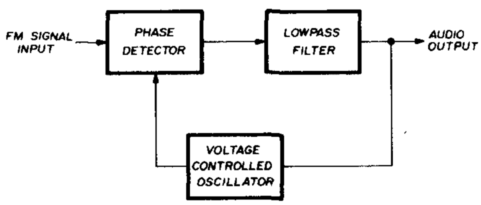

fig. 5. Fm detector using the PLL principle.

conclusion

Since the introduction of the initial IC PLL, technology has produced complete fm stereo demodulators available on one IC. **Fig. 6** shows one of these

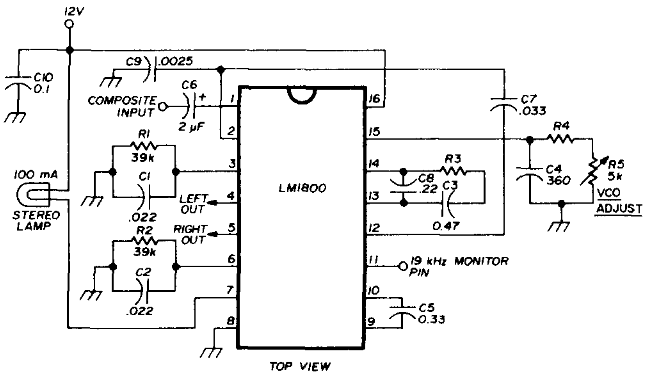

fig. 6. Typical fm detector using an IC chip from National Semiconductor. Additional data is available from their *Linear Applications Handbook*, Vol. II.

circuits. It's from National Semiconductor's *Linear Applications Handbook Vol. II*. This approach decreases parts count and improves reliability. It's safe to assume that this approach will be the industry trend in the future for such applications.

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1. "Phase-Locked Loops," *Signetics Application Notes*, Signetics Corporation, Sunnyvale, California, page 6-5.
2. Nash and Garth, "Locking in on Phase-Locked Loops," Motorola *Monitor*, Vol. VIII, No. 2, page 23.

bibliography

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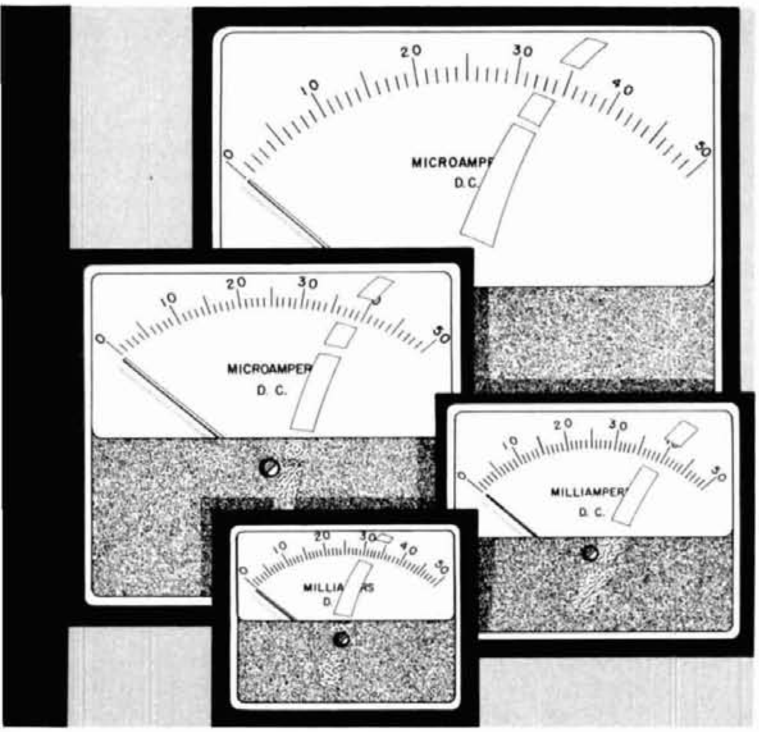
More Details? CHECK—OFF Page 142



calibrating meter amplifiers

Meter amplifiers help provide increased sensitivity for high-current meters, but not without the need for a final accurate calibration

Meter-amplifier circuits have been around for several years, generally using conventional transistors, field-effect transistors, or operational amplifiers. If you want increased meter sensitivity in a wavemeter or grid dip meter configuration, then calibration may not be of much concern. In these cases you're more apt to want sensitivity (in the microampere range) to detect small radio-frequency currents.

When using meter amplifiers for absolute readings, however, several questions arise. How much amplification is expected, and in conjunction with what meter? What will be the final calibration of the new meter?

The data presented in **tables 1**, **2**, and **3** should provide an indication of what to expect from a meter amplifier, as it relates to current measurements.

The circuit used is shown in **fig. 1**. It is a common-source configuration using an MPF102 field-effect transistor.[1] For testing purposes, I constructed the circuit in a mini-box, with six insulated binding-posts for the input, output, and 9-volt supply to the circuit. The amplifier was mounted on a small printed-circuit

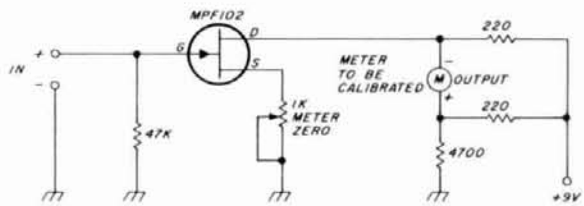


fig. 1. Schematic diagram of the simple meter amplifier. The pot connected to the fet's source is used to zero the meter to be calibrated.

board. The 1k pot was mounted in the center of the front panel. **Fig. 2** shows a block diagram of the interconnections used to calibrate the meters.

As can be seen from **table 1**, you should expect a seven- to eight-time increase in the readings of a

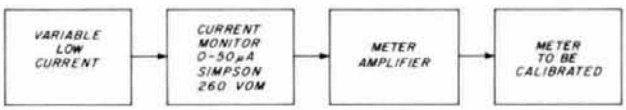


fig. 2. Test set-up for calibrating a meter movement. Using this system, the final calibration and accuracy will be determined by the current monitor.

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table 1. Calibration for a COMCO 50μA meter.

Simpson 260	meter readings μA	reduced to unity μA
1 μA	7.0	7.0
2 μA	14.0	7.0
3 μA	24.0	8.0
4 μA	33.5	8.37
5 μA	44.0	8.8

50μA meter. The popular 1 mA meter is more likely to be used with an amplifier to raise its sensitivity. Not having a 1 mA meter available, I calibrated two identical 1.5 mA meters made by Marion Electric Company. **Table 2** shows the results of the calibration.

table 2. Calibration readings for the Marion Electric 0-1.5mA meters.

meter 1			
Simpson 260	meter reading	divisions on scale	μA per scale division
10 μA	48	8	1.25
20 μA	90	19	1.05
30 μA	128	28	1.07
meter 2			
Simpson 260	meter reading	divisions on scale	μA per scale division
10 μA	43.0	8.5	1.17
20 μA	93.0	18.5	1.08
30 μA	135.5	27.0	1.11

The significant points to note are that 30 μA produced near full-scale deflection on the meters and that each division was slightly more than 1μA. As a final step, I checked Simpson 500 μA meter (see **table 3**).

table 3. Simpson 0 to 500 μA meters calibration.

Simpson 260	meter readings 0-500 μA	divisions on scale	μA per scale division
5 μA	127	17	.29
10 μA	325	35	.28
14 μA	500	50	.28

If the meter amplifier is to become a permanent part of the metering system, some relabeling of the face will be required to reflect the increased sensitivity. When using an amplifier with other meters, the basic resistance of the meter will effect the final sensitivity and calibration.

reference

1. Doug DeMaw, W1FB, editor, *ARRL Electronics Data Book*, American Radio Relay League, Newington, Connecticut, 1976, page 22.

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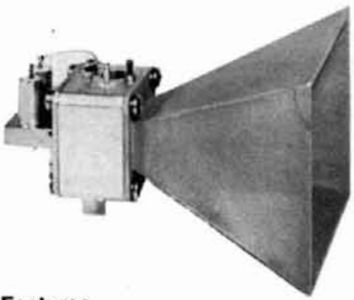

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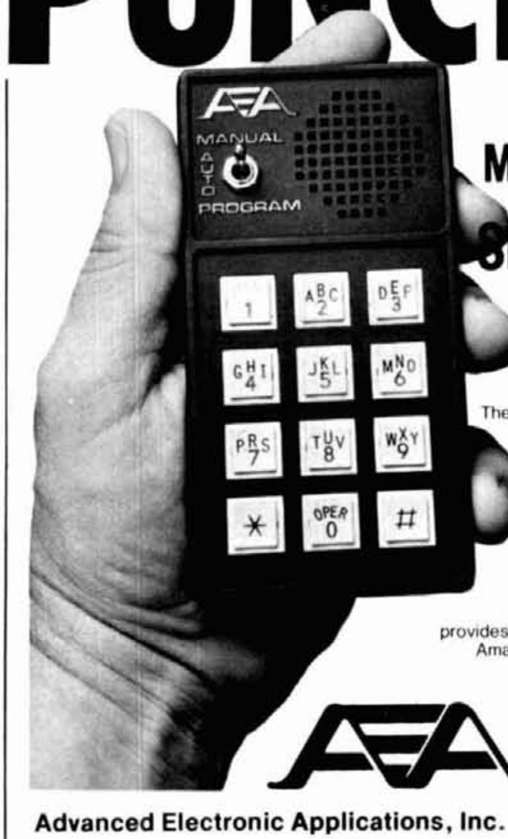

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the **weekender**

1-GHz prescaler for frequency counters

Amateurs fall into many categories — operators, experimenters, contesters, and so on. In addition, they may be full- or part-time mobile radio service or television technicians. These technicians, as well as the experimenters, often find themselves unable to measure frequencies in the low uhf region, especially between 500 and 1300 MHz.

While the 1-GHz prescaler described in this article will not quite reach 1300 MHz, it can be of considerable use in the range just above the limits of many of the inexpensive frequency prescalers available commercially. Although the Fairchild 11C05 used in this prescaler is guaranteed only to 1000 MHz, two that I have used have functioned well above 1200 MHz but couldn't make it to 1300.

In addition to possible application in the new 900-MHz mobile band, the prescaler may help you if you have to repair your TV set. The FCC's requirement for positive-detent tuning of the uhf TV channels has resulted in a proliferation of exotic front-end circuits. The use of digitally tuned oscillators and frequency synthesizers no longer permits us to check oscillator output by means of an electronic voltmeter. This will indicate only that the circuit is oscillating — but at what frequency? One of the solutions to this problem is this 1-GHz frequency prescaler, which can be used with virtually any counter and costs but a fraction of the price of a complete counter capable of operating at that frequency.

The prescaler will accept a signal between 25 and 1000 MHz, probably as high as 1200 MHz, and scale (divide) its frequency by either 10 or 100, depending on the position of a front-panel SCALE switch. Thus the frequency to be measured can be converted to one within the range of the counter which is connected to the prescaler. The accuracy of the measurement remains a function of the counter's accuracy multiplied by the scale factor.

If the prescaler is used with a 30-MHz counter, for example, frequencies between 30 and 300 MHz can be read on the counter by scaling by 10, which will result in read-outs between 3 and 30 MHz. Frequencies above 300 MHz can be scaled by 100, so that a 1-GHz signal can be read as 10 MHz on the counter. Obviously, it is necessary to multiply the counter reading by the scale factor to determine the input frequency, but multiplying by 10 or 100 should not tax anyone's mathematical prowess.

By Robert S. Stein, W6NBI, 1849 Middleton Avenue, Los Altos, California 94022

circuit operation

A block diagram of the prescaler is shown in **fig. 1**, and the overall schematic appears in **fig. 2**. U1 is an Amperex ATF417 broadband hybrid amplifier designed to operate from 40 to 860 MHz, and is usable from below 25 MHz to over 1200 MHz. Because the amplifier has a nominal input impedance of 75 ohms, a minimum-loss pad consisting of resistors R1 and R2 is incorporated to convert the prescaler input to 50 ohms. R2 also affords overload protection in conjunction with hot-carrier diodes CR1 and CR2. As shown in **fig. 3**, the input vswr (referenced to 50 ohms) is less than 1.5:1 below 1 GHz, and is less than 2:1 at 1.2 GHz. The sensitivity of the overall prescaler also appears in **fig. 3**.

The amplified signal is applied to U2, a Fairchild 11C05* divide-by-four circuit. The output of U2 feeds U3, a Fairchild 95H91 divide-by-five/six which is arranged to divide by five. Thus, the input frequency has been divided by twenty at the output of U3. To scale by 100, the frequency is again divided by five, this time in the quinary section of U5, a 10138 bi-quinary counter whose output is connected to the 100 position of SCALE switch S2. Gate U4B buffers the output of U3 from the loading effect of U5.

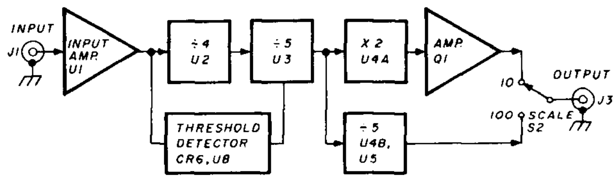
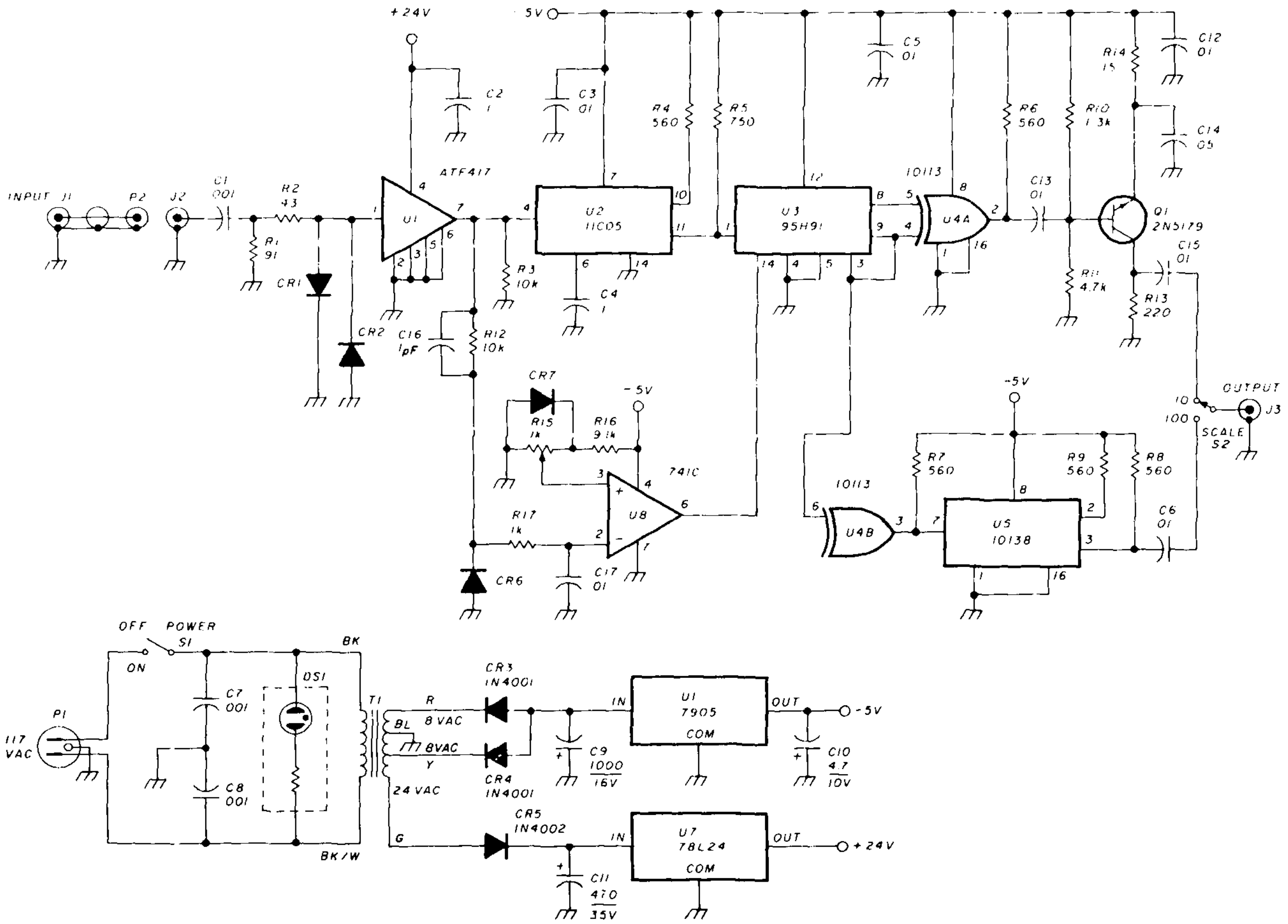


fig. 1. Block diagram of the 1-GHz prescaler.

Since the input frequency has been divided by twenty in U2 and U3, it is necessary to multiply it by

*The Plessey SP8610 is a recently announced pin-for-pin replacement for the Fairchild 11C05.

two to obtain a scale factor of 10. This is accomplished in U4A, one section of a 10113 quad exclusive-OR gate. Frequency doubling is achieved by taking advantage of the finite rise and fall transition times of the complementary outputs of U3, as well as the slight difference in the propagation delays from input to each output. Because an exclusive-OR gate produces an output only when one, but not both, of



C1	0.001 μF, 50 V ceramic capacitor (Erie 8121-100-W5RO-102K, Centralab CY15C102M)
C2, C4	0.1 μF, 50 V ceramic capacitor (Erie 8131-100-651-104M, Centralab CY20C104P)
C3	0.01 μF, 50 V ceramic capacitor (Erie 8121-050-651-103M, Centralab CY15C103P)
C5, C6, C12, C13, C15, C17	0.01 μF, 50 V disc ceramic capacitor
C7, C8	0.001 μF, 1000 V disc ceramic capacitor
C9	1000 μF, 16 V electrolytic capacitor
C10	4.7 μF, 10 V tantalum capacitor
C11	470 μF, 35 V electrolytic capacitor
C14	0.05 μF, 50 V disc ceramic capacitor
C16	1 pF, 50 V disc or tubular ceramic capacitor
CR1, CR2, CR6, CR7	hot-carrier diode (Hewlett-Packard 5082-2835)
DS1	117 V pilot light assembly (Radio Shack 272-328)
J1	Amphenol 86350 or Kings KC-19-54 BNC connector
J2	Amphenol 27-800 or Sealectro 50-051-0000 miniature coax connector
J3	UG-1094/U BNC connector
P2	UG-1465/U miniature coax connector (Amphenol 27-106, Sealectro 50-007-0000)
R15	1k trimmer potentiometer (CTS X-201-R102B, Radio Shack 271-227)
S1	SPST slide switch
S2	SPDT slide switch
T1	Triad F-91X transformer
U1	Amperex ATF417 amplifier
U2	Fairchild 11C05 divide-by-4 (or Plessey SP8610)
U3	Fairchild 95H91 divide-by-5/6
U4	10113 quad exclusive-OR gate
U5	10138 bi-quinary counter
U6	7905 negative 5-volt regulator, TO-220 case
U7	78L24 or National LM340L-24 positive 24-volt regulator, TO-92 case
U8	741C op amp, 8-pin mini-DIP case

fig. 2. Prescaler schematic diagram. All fixed resistors are 1/4 watt, 5% composition or carbon film.

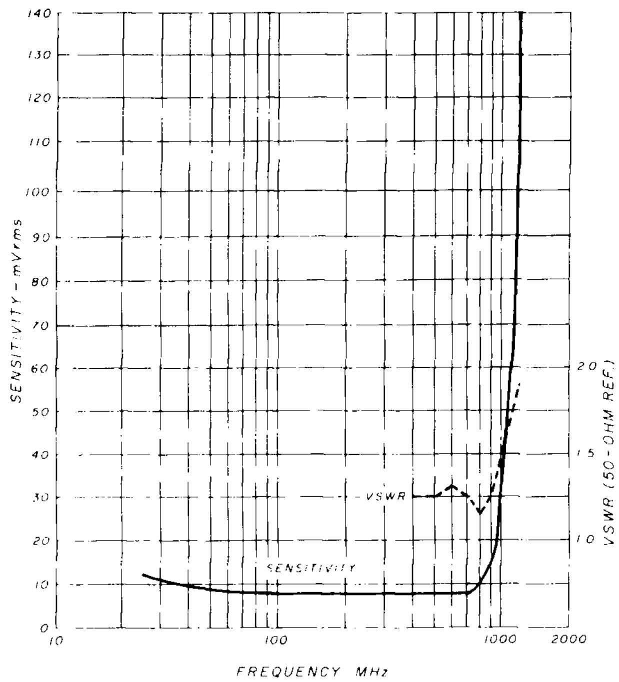


fig. 3. Prescaler sensitivity and vswr, plotted against frequency. Test equipment limitations precluded vswr measurements below 400 MHz.

its inputs is high, there is a very short period of time during the input transitions when *both* inputs are high or low, resulting in the output of the gate going low for this brief time. This is shown in **fig. 4**, as is the fact that two output pulses are generated for each cycle of the input frequency.

The extremely short time period during which the output pulses are developed prevents them from reaching full ECL-output level. Therefore, they are amplified by Q1 to a peak voltage level of at least 300 millivolts before being routed to the 10 position of switch S2. When S2 is set to the 10 position, the 25- to 1000-MHz input range is scaled to 2.5 to 100 MHz. When S2 is set to 100, the same input frequency range is scaled to 0.25 to 10 MHz.

As with all logic devices, U2 has a minimum input level below which it will not clock. However, at frequencies below 50 MHz, it may also divide by two or three just below this critical input voltage. To prevent this from appearing as a false reading on the counter, a threshold detector comprising CR6 and U8 is incorporated, which inhibits the output of U3 whenever the input voltage to the prescaler is below a predetermined level.

The output of amplifier U1 is sampled and rectified by diode CR6. The resultant dc is filtered and applied to the inverting input of U8, a 741C op amp configured as a dc comparator. The non-inverting input is connected to a voltage divider (R15 and R16) across the negative 5-volt supply; R15 establishes the reference voltage for the comparator. If the prescaler input level is insufficient for proper operation of U2, the voltage applied to the inverting input of U8 will be less than the reference voltage at the non-inverting input. This will cause the output of the op amp to go high, activating the master reset (pin 14) of U3 and inhibiting its output. As soon as the input signal reaches the required threshold, the op amp input conditions reverse, and the resultant low output enables U3.

construction

Except for power transformer T1, the primary power circuit, the INPUT and OUTPUT connectors, and the SCALE selection switch, the entire prescaler is built on a printed-circuit board measuring 8.9 x 7.9 cm (3-1/2 x 3-1/8 inches).* The board is two-sided; one side contains the printed-wiring traces, while the opposite side, on which the various components are mounted, provides a ground plane. I chose to mount the board vertically, parallel to the front of the cabinet, with the component side of the board facing the front. Two small right-angle brackets were used for mounting feet, as shown in the parts layout, **fig. 5**.

The first step in assembling the board is to mount connector J2. A complete bead of solder must be made to the ground plane around the entire periphery of the connector. Next, capacitor C1 must be soldered between the center pin of J2 and the adjacent trace, as shown in **fig. 6**. This arrangement is necessary to keep the lead inductance of C1 to an absolute minimum. The capacitor leads must be carefully bent and trimmed as shown. Then the shorter lead is soldered to the trace so that none of the wire is visible, and the longer lead is wrapped around the center pin of J2 and similarly covered with solder.

To keep the cost of the printed-circuit board

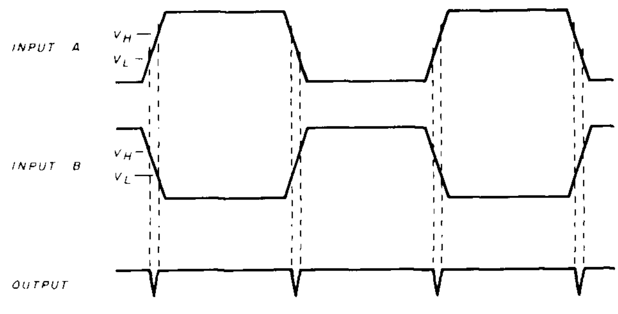
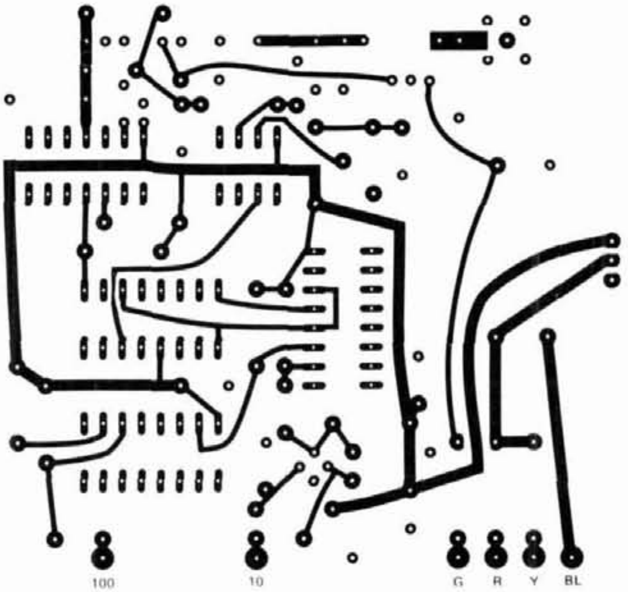


fig. 4. Waveforms showing operation of the exclusive-OR frequency doubler.

*If there is sufficient interest, the author will supply PC boards at nominal cost. Please enclose a SASE with all inquiries.

down, plated-through holes were not used. Instead, ground connectors are made by soldering the applicable component leads directly to the ground plane.

Before installing regulator U6 on the board, attach a TO-220 type heatsink to the tab of the regulator. Use a thin layer of silicone heat-transfer compound between the heatsink and the tab. The heatsink must not be grounded to the board, since the tab is internally connected to the input terminal of the device.



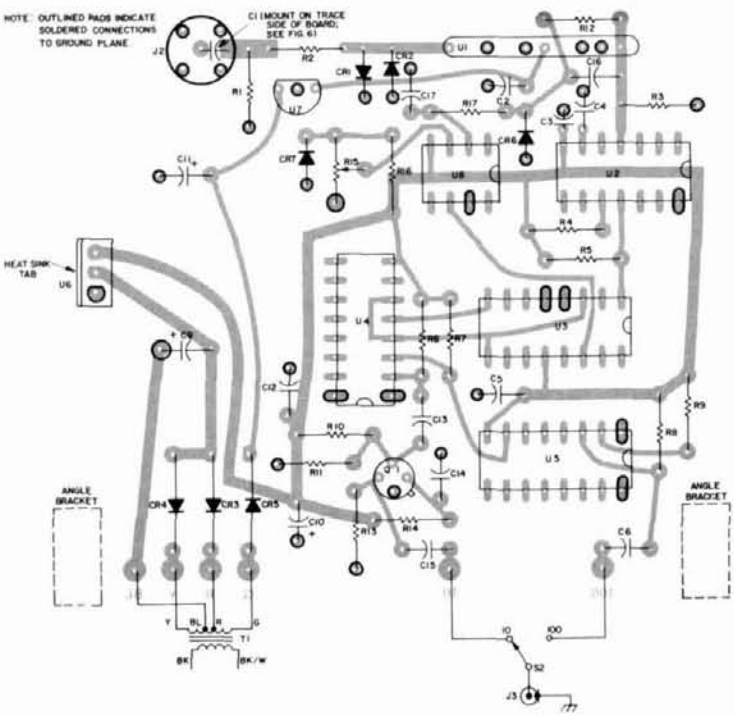


fig. 5. PC board component layout and wiring to transformer and output circuit.

Be sure that the polarities of the electrolytic capacitors and diodes are correct, and that none of the integrated circuits are reversed. After completing the board assembly, examine it carefully for solder bridges between traces or for any other foreign matter that might cause a short circuit.

Next, fabricate the input cable assembly which runs between the board and the front panel. Using a 7.6-cm (3-inch) length of RG-174/U coaxial cable, terminate one end with INPUT connector J1 and the other end with connector P2. Instructions for assembling the connectors to the cable appear in **figs. 7** and **8**.

A recommended arrangement of the overall prescaler is shown in **fig. 9**. OUTPUT connector J3, POWER switch S1, SCALE switch S2, pilot light DS1, and the input cable assembly (terminated by INPUT connector J1) are mounted on the front panel. Transformer T1 is mounted directly behind the printed-circuit board, and capacitors C7 and C8 are wired to a terminal strip located near the transformer.

Before mounting the circuit board in the cabinet, solder a short length of insulated wire to each of the output pads, designated *10* and *100*, on the board. Then solder the secondary leads from transformer T1 to the pads marked *G*, *R*, *Y*, and *BL* on the board, matching the wire colors to the appropriate pad. Mount the board in the cabinet and connect the wires from the output pads to the corresponding terminals of SCALE switch S2. Finally, connect the input cable assembly between the front panel and J2 on the board.

operating considerations

It would appear obvious that after the prescaler has been wired and checked, all that remains is to connect it to the counter and plug it in. Maybe — and maybe not! Unfortunately *no* prescaler is all things to all counters. This one produces outputs of two types: the scaled-by-10 output is a train of very short, fast positive pulses having a peak-to-peak amplitude of 300 to 400 millivolts; the scaled-by-100 output is a square wave of approximately 800 millivolts peak-to-peak amplitude. Both are supplied from low-impedance sources.

Without going into a detailed explanation of transient response and reflections from improperly terminated transmission lines, it can be stated that what appears at the counter end of a coaxial cable connected to the prescaler output depends on the characteristic impedance of the cable, the length of the cable, the input impedance of the counter, and the frequency and waveform of the prescaler output signal. Since only the last of these factors is established (and varies over the prescaler's range), there may be considerable differences as to how the pre-

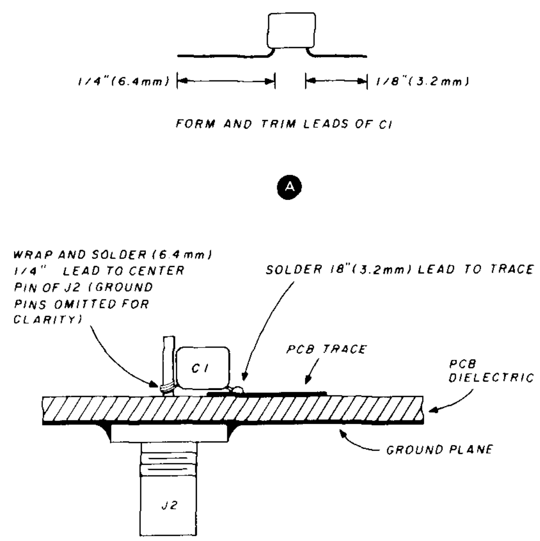


fig. 6. Method of installing capacitor C1 on PC board.

scaler will perform in conjunction with different counters and different cable lengths.

Now for the good news. Although you cannot tell how the prescaler will perform with your counter until you try it, there is a simple remedy if it does not appear to work properly. And that is merely to terminate the connecting cable in its characteristic impedance. Assuming that the connecting cable is 50-ohm coax (RG-58/U or equivalent), you need only to terminate it with a 50-ohm load at the *counter* end. If the counter already has a 50-ohm input impedance, the cable will automatically be properly terminated. However, most low- and medium-frequency counters have a high input impedance. Therefore an external termination may be required.

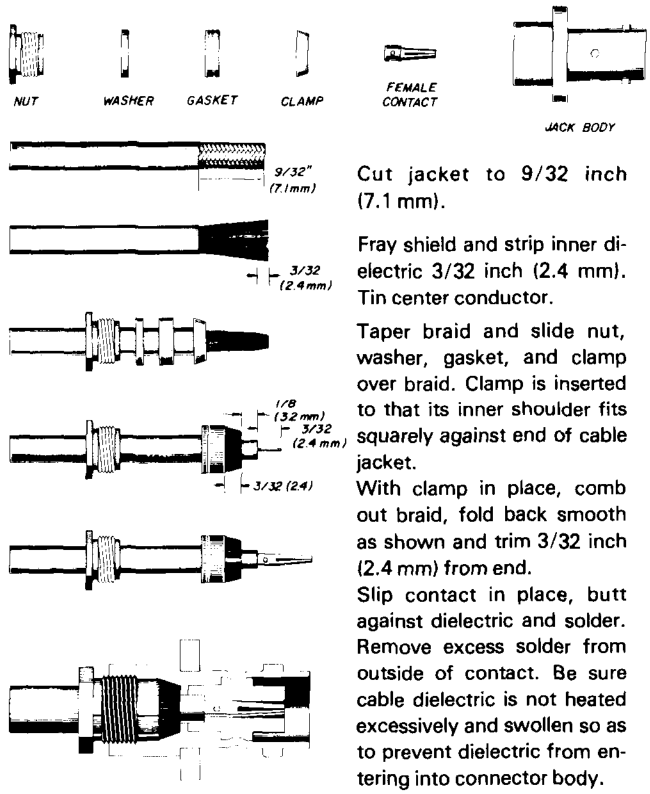
The simplest way of terminating the cable is to use a 50-ohm feedthrough termination, such as the Heath SU-511-50, Tektronix 011-0049-01, Hewlett-Packard 10100C, or Systron-Donner 454. An alternate method is to use a tee-connector at the counter input, with the connecting cable on one side of the tee and a 50-ohm termination on the other side. Or if you are ingenious, you can fabricate a cable with a 51-ohm composition resistor shunted across the counter end.

Another factor which enters into the picture is the characteristic behavior of the counter's input signal processor. All counters must convert the input signal to an appropriate logic level over the specified frequency range of the counter. Of the infinite variety of signals that can be applied to a counter, a symmetrical waveform is the easiest to process. Thus, your counter may exceed its specified maximum frequency when measuring the sine-wave output from a signal generator, but may not perform as well when counting an asymmetrical pulse train. Therefore, even if the counter's frequency range appears to be better than the published specifications, do not expect it to be so on the scaled-by-10 output from the prescaler.

As an example, on two different 80-MHz counters (one home-built, the other a Hewlett-Packard Model 5381A), the upper frequency limit when checked using a signal generator was well over 120 MHz for each. However, the maximum scaled-by-10 count from the prescaler which could be measured was between 80 and 90 MHz, corresponding to a prescaler input between 800 and 900 MHz. Of course, switching to the scaled-by-100 output permitted measurements to the limit of the prescaler. On the other hand, a counter *specified* to perform at 120 MHz should permit use of the scaled-by-10 output over the entire frequency range of the prescaler, as did a 500-MHz counter used to verify the prescaler output.

threshold-level adjustment

Before initially operating the prescaler, fully rotate the thumbwheel of potentiometer R15 toward the top of the board. This effectively disables the thresh-



Cut jacket to 9/32 inch (7.1 mm).

Fray shield and strip inner dielectric 3/32 inch (2.4 mm). Tin center conductor.

Taper braid and slide nut, washer, gasket, and clamp over braid. Clamp is inserted to that its inner shoulder fits squarely against end of cable jacket.

With clamp in place, comb out braid, fold back smooth as shown and trim 3/32 inch (2.4 mm) from end.

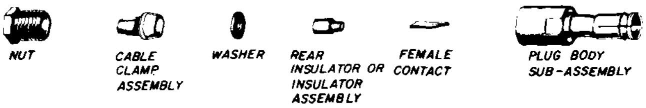
Slip contact in place, butt against dielectric and solder. Remove excess solder from outside of contact. Be sure cable dielectric is not heated excessively and swollen so as to prevent dielectric from entering into connector body.

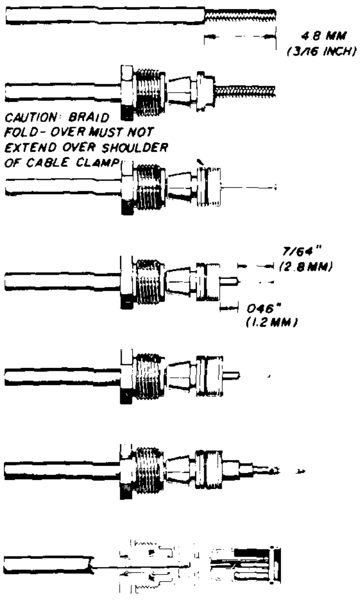
Push assembly into body as far as it will go. Slide nut into body and screw in place with wrench until tight. For this operation, hold cable and shell rigid and rotate nut.

fig. 7. Assembling connector J1 to input cable (courtesy Amphenol).

old detector and will permit a check of the prescaler in conjunction with the counter. Apply signals of known frequencies to the prescaler INPUT connector (noting the approximate minimum levels required, as shown in **fig. 3**) and check the counter readings in both the *10* and *100* positions of the SCALE switch. **Caution**: Although U1 will withstand a 10-volt peak-to-peak input without damage, it is recommended that inputs to the prescaler be limited to 1 volt peak-to-peak (approximately 350 millivolts rms, or 2.5 milliwatts across 50 ohms) to prevent clipping by diodes CR1 and CR2.

To adjust the threshold level, apply a 25- to 30-MHz input to the prescaler using a signal generator or any other signal source whose output level can be controlled. Feed enough signal to the prescaler to obtain a properly scaled reading on the counter, then slowly reduce the signal level until that reading is lost; as the signal level is reduced, readings of two, three, or four times the correct scaled reading will appear. Bring the input-signal level back up to the point where the last false reading is obtained, just before the correct reading appears, and adjust potentiometer R15 carefully to make the counter





Cut end of cable even. Trim jacket to 3/16 inch (4.8 mm). Be careful not to nick braid.

Slide nut over jacket. Place cable clamp assembly over braid and push back against cable jacket as shown.

Comb out braid and fold evenly over cable clamp assembly and trim braid wires as shown, avoiding bunching.

Cut cable dielectric to .046 inch (1.2 mm). Cut must be sharp and square. Do not nick center conductor. Dimension of bared center conductor should be as shown; trim if necessary. Tin center conductor and remove excess solder.

Place washer over core.

Slide rear insulator or insulator washer over center conductor.

Make sure rear insulator or insulator washer butts flush against washer and cable core. Solder contact to center conductor — contact must butt against rear insulator as shown. Do not get any solder on outside surfaces of contact.

Insert prepared cable termination into connector body. Secure by wrench-tightening body while holding nut stationary.

fig. 8. Assembling connector P2 to input cable (courtesy Amphenol).

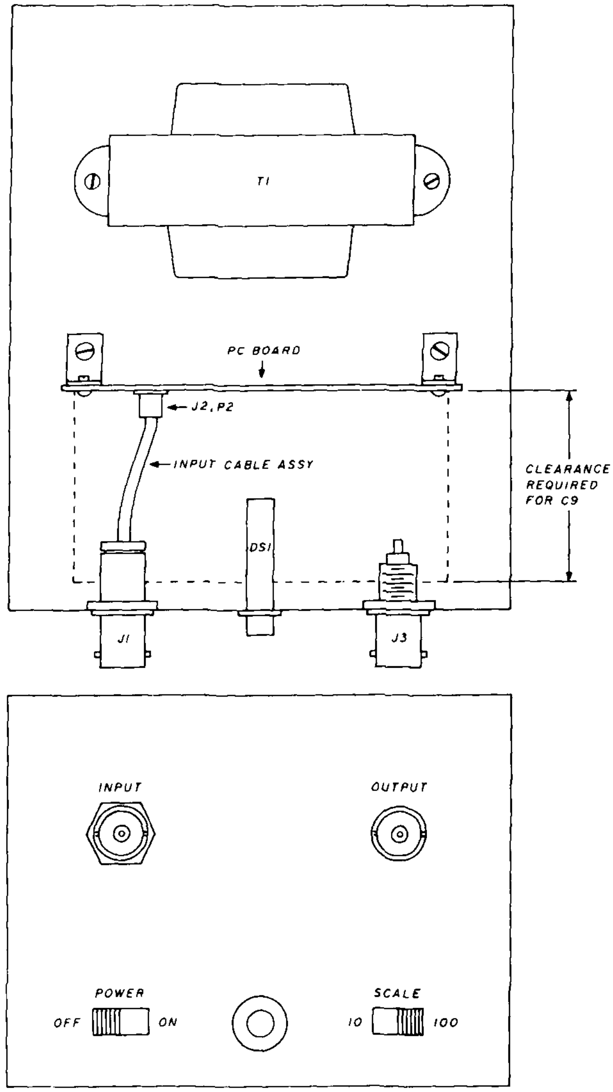


fig. 9. Suggested layout for complete prescaler. Wiring to and from the PC board is shown in fig. 5.

read zero. Then increase the signal level slightly to be certain that a true reading can be obtained. This is a critical adjustment, in that it establishes the sensitivity of the prescaler from 25 to 900 MHz. If the potentiometer is set past the position which just eliminates the false counts, the prescaler sensitivity will be reduced.

If you have no need to use the prescaler below 50 MHz or so, the overall sensitivity of the prescaler can be improved below 900 MHz by simply keeping the arm of R15 rotated fully toward the top of the board, thereby disabling the threshold detector. For those who desire maximum sensitivity above 900 MHz, a slight improvement will result from omitting C16 and R12 (in which case all other parts associated with U8 can also be eliminated).

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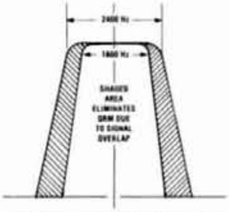

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		31F600	CW	3179.3	6	600 Hz	Same as standard XF-30C unit, $40
		31H1.8	SSB	3180	8	1.8 kHz	For narrow SSB
		31H2.4	SSB	3180	8	2.4 kHz	Substitute for XF-30A(6 pole) in early units
		31F6.0	AM	3180	6	6.0 kHz	Same as standard XF-30B unit, $40
	FT-301	89H250	CW	8999.3	8	250 Hz	Sharp unit for DX and contest work
		89H500	CW	8999.3	8	500 Hz	Use instead of standard 600 Hz unit
		90H1.8	SSB	9000	8	1.8 kHz	For narrow SSB
		90H2.4	SSB	9000	8	24 kHz	For use in speech processor
KENWOOD	TS-520 R-599	33H250	CW	3395	8	250 Hz	Sharp unit for DX and contest work
		33H400	CW	3395	8	400 Hz	Use instead of standard 500 Hz unit
		33H1.8	SSB	3395	8	1.8 kHz	For narrow SSB
	TS-820	88H250	CW	8830.7	8	250 Hz	Sharp unit for DX and contest work
		88H400	CW	8830.7	8	400 Hz	Use instead of standard 500 Hz unit

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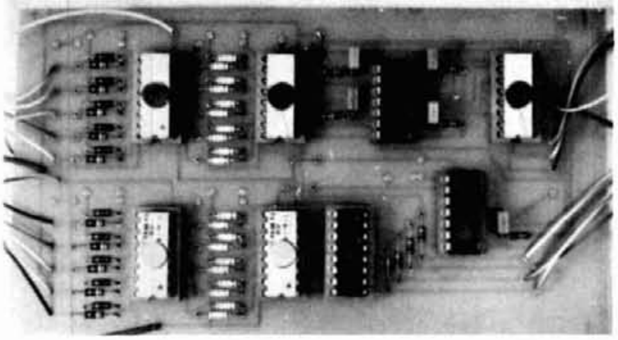
More Details? CHECK—OFF Page 142

digital keyboard entry system

By sampling the signals from an inexpensive pocket calculator, you can build a complete data entry system

While working on a recent synthesizer project, it became apparent that the conventional methods used to enter the frequency control information, such as thumbwheel or rotary switches, are generally cumbersome. Keyboard entry has become popular with the widespread use of *Touch-Tone** phones and hand-held calculators — so, it seemed to be a natural choice for a new design. This same choice has been made by a few manufacturers of digitally controlled signal generators and vhf/uhf scanning receivers. The advantage of a keyboard entry device is that, while providing a means of frequency control (as in our case), other digital information can be entered. If plans for the system change, new functions can be added by assigning a code to that particular function and inputting the code via the keyboard. In our keyboard-synthesizer system, we have incorporated the ability to step the frequency up or down by a fixed increment at the touch of a switch.

**Touch-Tone* is a registered trademark of the American Telephone and Telegraph Company.



The complete data entry system, with the exception of the 74175 latches.

After giving the keyboard-system problem some thought, the solution became a standard four-function calculator with a programmable automatic constant capability. At this point it should be stressed that our application was a frequency synthesizer, but any system that requires digital information in binary coded decimal (BCD) format could use the ideas presented in this article.

theory of operation

There are several problems when trying to build a keyboard encoder. First, the information from the keyboard is presented in 1-out-of-10 format; that is, you must encode the operation of 1-of-10 switches. Second, the keys will be presented in some sequence, and you must store the information as each new key is pressed. Finally, there is the problem of key bounce. As you actuate or de-actuate a key, the contacts of the switch bounce, giving a fairly noisy signal as illustrated in **fig. 1**.

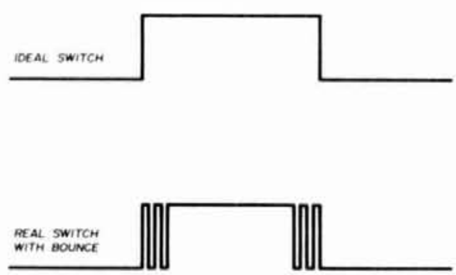


fig. 1. Waveforms generated by the ideal switch and a real switch which exhibits bounce.

A four-function calculator, of course, uses a key-

By Bruce McNair, N2YK, and **Glenn Williman, N2GW.** Mr. McNair's address is 12 Marion Avenue, Howell, New Jersey 07731; Mr. Williman's address is 145 Whalepond Road, Oakhurst, New Jersey 07755.

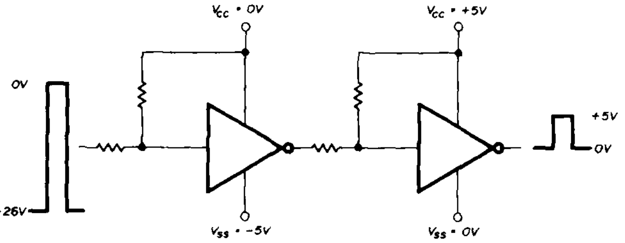


fig. 2. Level translators used to transform the signal voltages from the display to the standard TTL voltage levels.

board for information entry and has all the necessary circuitry to decode, remember the inputs, and debounce the keys. An added benefit of the calculator is the fact that it also displays the entered information. You can take advantage of this fact by using the calculator display as a display for the synthesizer or system you are controlling.

However, there are certain problems associated with the use of a calculator. The information that you need is only present at the calculator display terminals. The information is not BCD encoded, but has been encoded to drive seven-segment displays. Further, to save pins on the calculator chip, the information is multiplexed. Seven lines carry the segment information to all the digits while (in the case of the calculator we used) eight lines enable the correct digit at the proper time.

To use the data from the calculator there are three steps to go through:

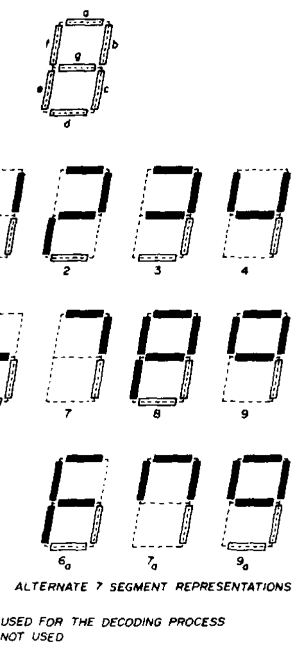


fig. 3. Segments used for the input to the 8223 PROM to convert between the 7-segment display information and the BCD code. As can be seen, segments c and d are not needed for code conversion. Each character is unique, regardless of whether c or d are present.

1. Shift the voltage levels of the display signals to that of the logic devices used in the decoder, and buffer these signals to prevent the calculator from being loaded down.

2. Decode the seven-segment information to BCD.

3. Demultiplex the BCD data and store the data.

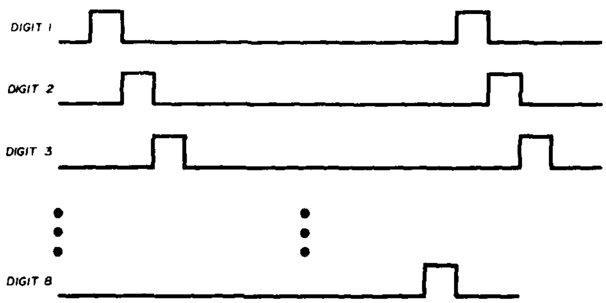


fig. 4. Timing diagram for the digit enable lines.

Each of these operations is accomplished as described in the following sections.

level shifting and buffering

The calculator we chose to use was a TI 1265. This is a simple, four-function calculator with automatic constant, non-blanking display, and low cost (in the $10 price range). Automatic constant is a convenient

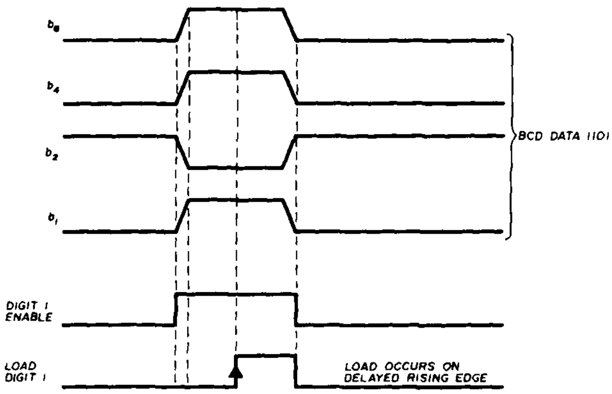


fig. 5. The latches will load the information on the leading edge of the respective digit's load pulse.

feature because by continually adding the fixed constant to the display, you can increment the synthesizer frequency by a constant amount. In 2-meter operation, for example, it would be best to store 0.015 as the fixed constant. Each time you press + the frequency goes up by 15 kHz, the channel spacing on 2 meters. To step down by a fixed amount, make the constant positive and the display negative (or vice versa), each time you press + you will be subtracting a fixed amount.

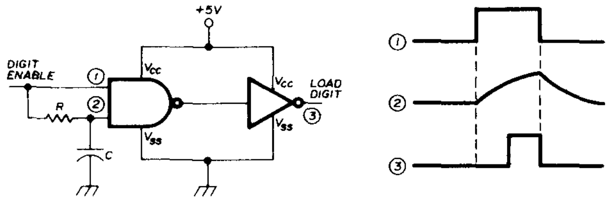


fig. 6. The time-constant formed by the R and C values provide a delay before the gate is enabled. This allows time for the data to settle.

A non-blanking display is an important feature to look for. Some of the calculators on the market will shut off the display, or even the entire calculator, after a period of inactivity to conserve battery power. Since the display conveys all the important information, this is unacceptable. If you already have a calculator with this feature, it may be possible to "fool" the calculator into thinking that there is always activity. Find a key that when pressed does not alter the memory of the display. If this key is regularly "pressed" by an added circuit the calculator will be under the impression that the operator is still there.

Finally, some calculators display the minimum number of digits to accurately represent the stored information. For example, 25. may represent the sum of *21.58* and *3.42*. To be usable for this system, the calculator must retain the same number of decimal places at all times. That is, *21.58 + 3.42 = 25.00*; the two zeros after the decimal place remain.

table 1. Truth table for the outputs of the 8223 PROM.

	prom address 7-segment code					prom outputs BCD output			
number	a	b	e	f	g	b_8	b_4	b_2	b_1
0	1	1	1	1	0	0	0	0	0
1	0	1	0	0	0	0	0	0	1
2	1	1	1	0	1	0	0	1	0
3	1	1	0	0	1	0	0	1	1
4	0	1	0	1	1	0	1	0	0
5	1	0	0	1	1	0	1	0	1
6	0	0	1	1	1	0	1	1	0
7	1	1	0	0	0	0	1	1	1
8	1	1	1	1	1	1	0	0	0
9	1	1	0	1	1	1	0	0	1
6_a	1	0	1	1	1	0	1	1	0
7_a	1	1	0	1	0	0	1	1	1
9_a	1	1	0	1	1	1	0	0	1

Now, consider the type of display the calculator uses; two of the more popular are LED and fluorescent. Most of the LED displays consume a great deal of battery power and blank the display after some period of time. The TI 1265 has a fluorescent display and is not blanked. Other TI calculators that are worth considering are the TI 1200 (very similar to the TI 1265) and the TI 1000 (a low cost calculator that uses an LED display but meets most of the other requirements). Since we did use a calculator with a fluorescent display, this is the type of interface we will describe. Interface with an LED-type display would actually be easier.

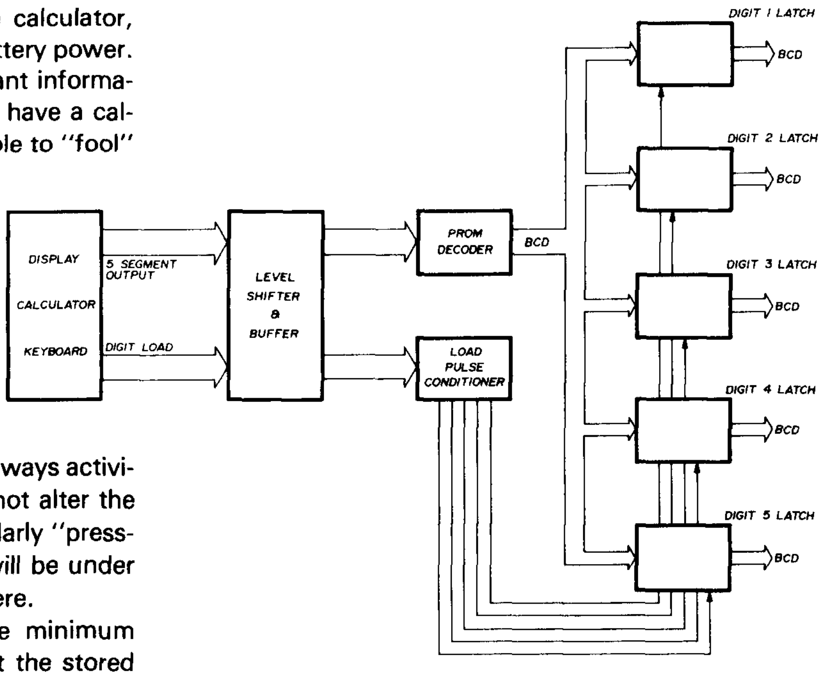
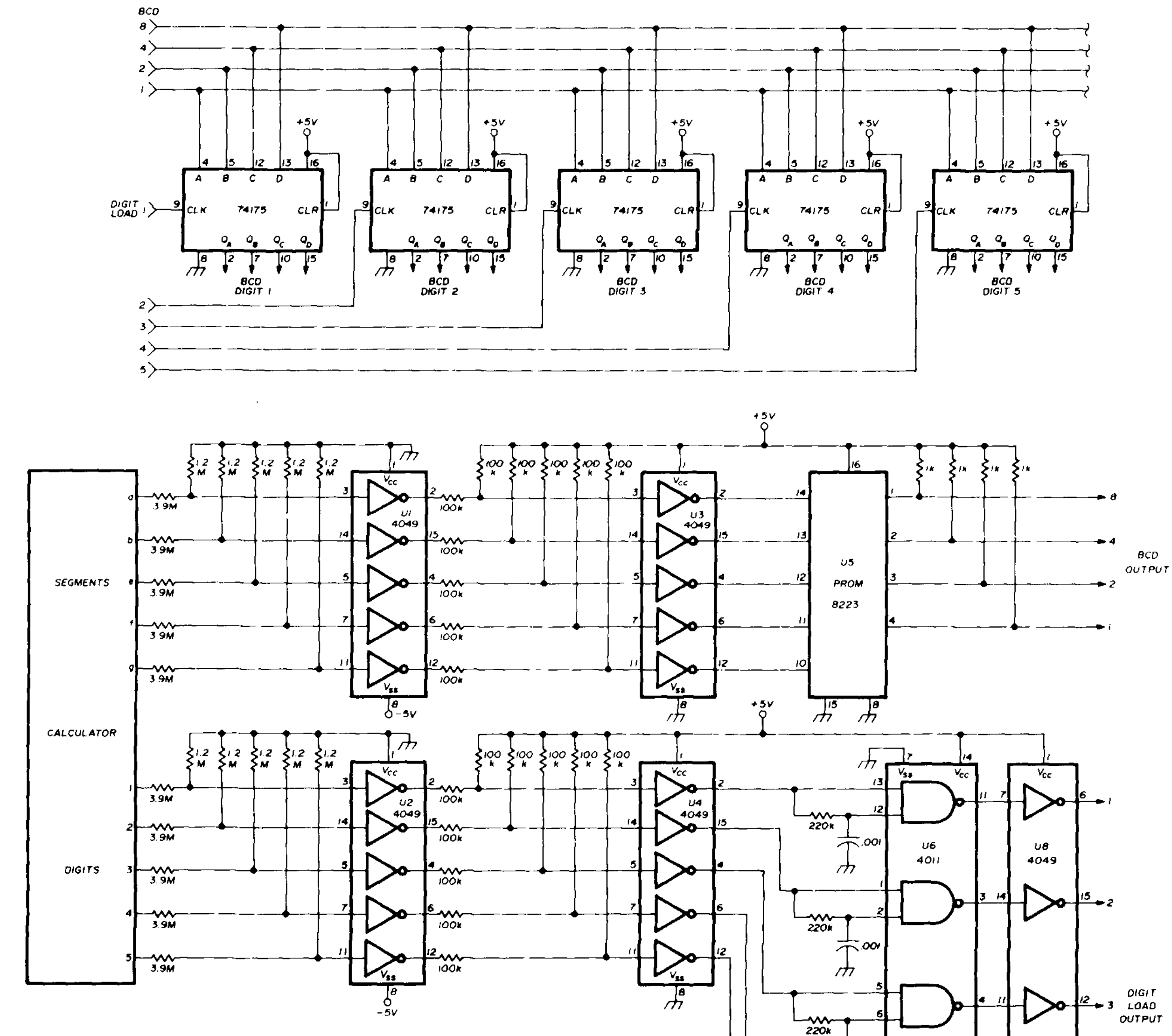


fig. 8. Block diagram of the complete system for using a calculator keyboard as a data entry system.

The display voltage levels in the TI 1265 are 0 and −26 volts. This nonstandard signal can be translated to CMOS/TTL levels of 0 and +5 volts with the circuit shown in **fig. 2**. CMOS 4049 inverters are used to minimize loading on the calculator outputs. The same circuit is used in each data line for seven-segment as well as digit information. All resulting signals will drive CMOS or a single TTL load.

segment decoding

The information generated by the calculator chip is coded as a seven-segment signal to be directly used by the calculator display. To make use of this data, it is necessary to translate it to BCD. At first, it would appear that a complicated circuit with seven inputs and four outputs would be necessary. As it turns out, this will take four chips. Another possibility would be to use a special IC to perform the decoding (a 74C915). Unfortunately, these chips are not readily



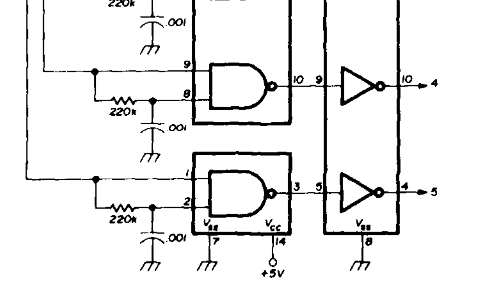


fig. 9. Schematic diagram of the complete keyboard entry system.

obtainable from the common parts suppliers amateurs deal with.

The approach chosen was to program a 74S188 (8223) PROM. This device is readily obtainable, low-cost, and easily programmed. If you examine **table 1** you'll see the code conversion table that must be burned into the PROM. It is also interesting to note that only five of the segments are needed to decode the information displayed. Segments c and d convey no new information. This is shown in **fig. 3**.

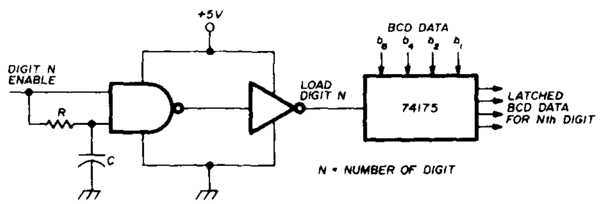


fig. 7. Overall diagram of the circuit necessary to demultiplex the BCD data for each digit.

demultiplexing

To minimize the number of outputs on the calculator chip, most manufacturers multiplex the display information. The segment lines go to the same segments in each digit while the digit lines enable each digit in turn. For example, to light segment g of digit 1 (a minus sign in the first digit) this combination of digit and segment lines would be simultaneously ena-

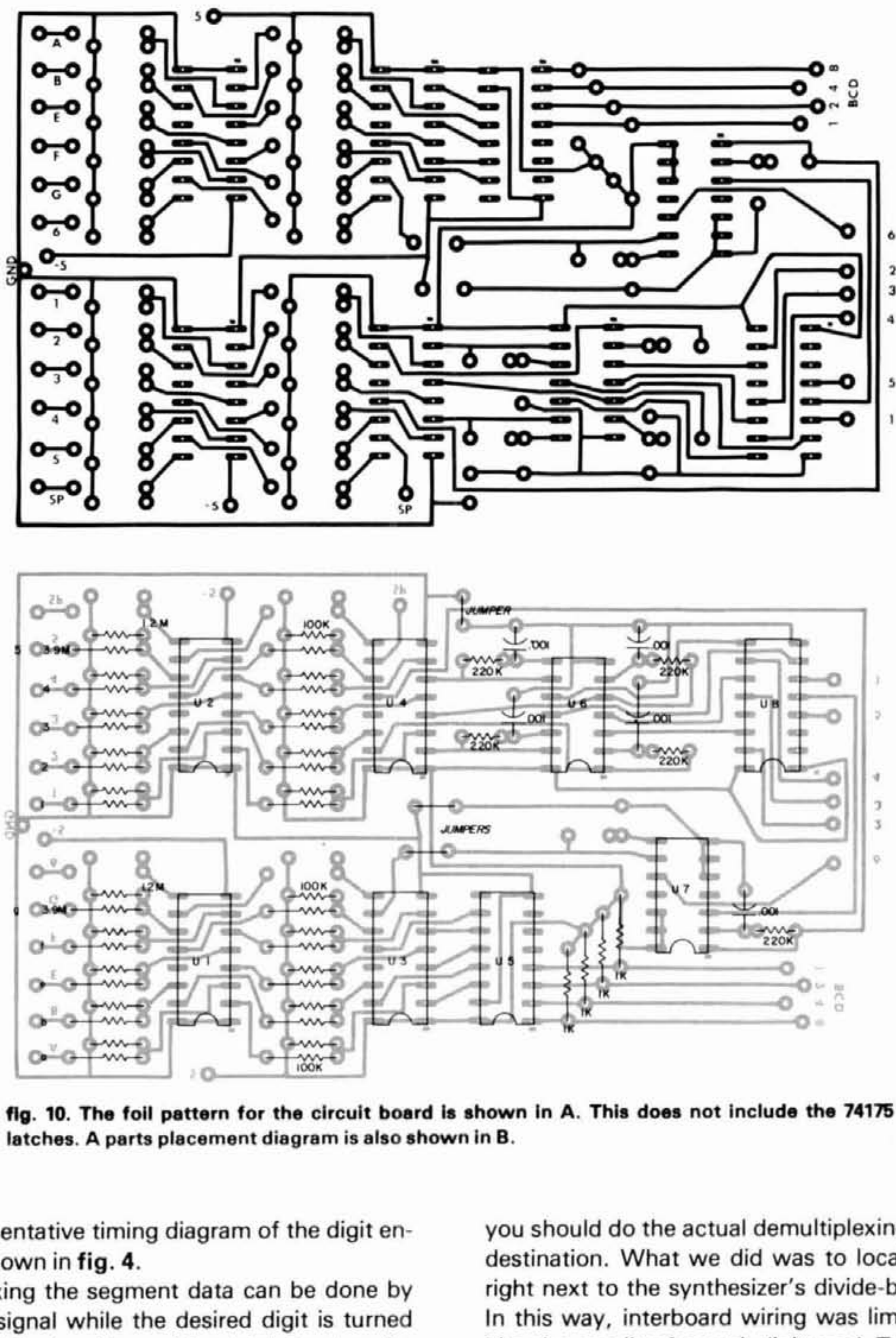


fig. 10. The foil pattern for the circuit board is shown in A. This does not include the 74175 latches. A parts placement diagram is also shown in B.

bled. A representative timing diagram of the digit enable lines is shown in **fig. 4**.

Demultiplexing the segment data can be done by generating a signal while the desired digit is turned on and using this signal to enable a latch to store the data. For this circuit 74175s are used. These ICs are four D-type flip-flops in one package, or one for each BCD bit. The timing diagram for this circuit is shown in **fig. 5**. The latch load signal is generated by the circuit shown in **fig. 6**. The RC time-constant delays the load pulse, so that data will be valid for any calculator that might be used. The overall demultiplexing circuit is shown in **fig. 7**.

If you are going to be transmitting the data from one board to another in your system (as we were), you should do the actual demultiplexing at the data's destination. What we did was to locate the 74174s right next to the synthesizer's divide-by-N counters. In this way, interboard wiring was limited to 4 BCD bits plus one line for each digit used. Tying the whole system together results in the block diagram shown in **fig. 8**, with its schematic shown in **fig. 9**.

construction

As shown in the photographs, our original circuit was patched together on a number of breadboards. For our final system, and this article, a PC board was designed and is shown in **fig. 10A**, with the parts placement shown in **fig. 10B**. This board is designed for five segment lines, six digit lines, and a spare line.

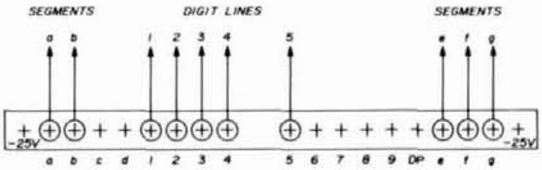
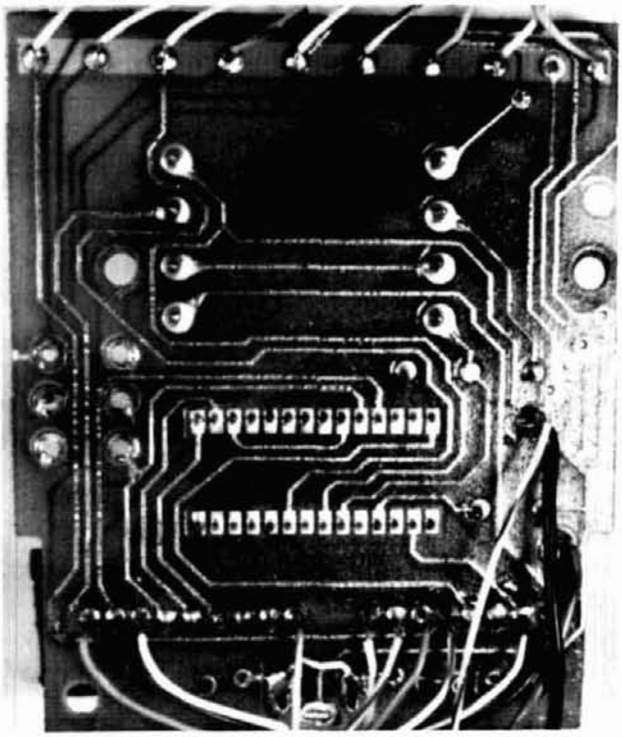


fig. 11. Connecting points on the calculator display board.

In general, construction is not critical. Just try to keep the connections to the calculator as neat as possible to prevent crosstalk and avoid loading down the calculator outputs. For those who choose to build this project with the TI 1265, the photographs also show the location for obtaining the necessary signals. A PC board and the 74S188 PROM are available from the authors; send a self-addressed, stamped envelope for details.



Connections on the calculator board.

What we have shown in this article is a simple, inexpensive system for using a calculator and its keyboard to control a digital system via BCD signals. Of course, if your system is not using BCD coding, you could devise your own programming for the code-converter PROM.

Once your system is designed, it would be a good idea to remount the calculator board, display, and perhaps use a different keyboard tailored to your individual needs, eliminating extra keys and labeling those with special functions.

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the ham notebook

constant pitch monitor for cathode or grid-block keyed transmitters

After acquiring my old cathode-keyed Heath DX-40 transmitter and a new Novice ticket, WD4MNR found he needed a CW monitor. He didn't want to bother with either an rf-activated device that required connection to the coax or a separate signal pickup wire. Some published monitor circuits have obtained their operating voltage across a small dropping resistor connected in series with the key. This approach was tried, but we found that the final tube in his DX-40 keyed erratically if more than a few ohms were inserted in the cathode circuit. Even if this had not happened, the voltage drop across the resistor would have varied and changed the oscillator pitch every time the transmitter was loaded. A similar problem exists when rf pickups are used.

The circuit shown in **fig. 1** was developed to avoid problems. It keys reliably and at absolutely constant pitch, regardless of transmitter loading or band, and works equally well with other cathode keyed or grid-block keyed transmitters and transceivers. The open-circuit voltage across the key (about 75 volts in our case) turns on an optocoupler which gates a 555 oscillator circuit. Operation of the monitor is unchanged, even for manyfold variations in key-up voltage, as long as enough is there to turn on the MCT-2.

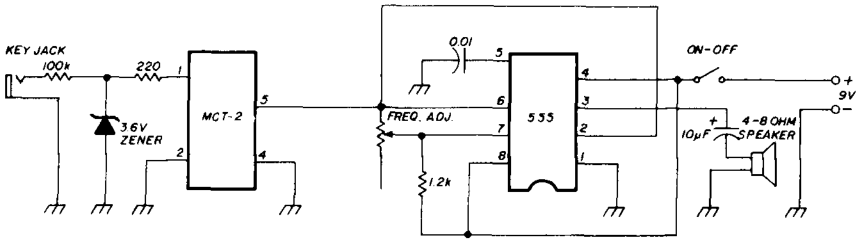

fig. 1. Schematic diagram of the constant-pitch CW monitor. The optical coupler is used to isolate the 555 from the actual transmitter circuitry.

To use this monitor with rigs having different key-up voltages, temporarily substitute a 500k-ohm potentiometer for the 100k resistor connected to the key. With the monitor connected, the transmitter turned on, and the pot at maximum resistance, the monitor should produce a tone. Reduce the resistance of the pot until the oscillator just turns off; remove and measure the pot, and substitute a fixed resistor of the next lowest standard value. The monitor will now produce a tone when the key is closed.

Bill Clements, K4GMR

direct-conversion receivers

I read with interest Dick Rollema's article on direct-conversion receivers (DCR) in your November, 1977, issue of *ham radio*. Since Dick also mentioned some previous work of mine, I feel compelled to give some additional information concerning DCRs.

It seems that the balanced transistor mixer which I used (as shown in **fig. 2** on page 46 of *ham radio*) has been surpassed through the work of a Soviet amateur, V. Polyakov (RA3AAE). So I must draw your attention to his basic article published in the December, 1976, issue of the Soviet magazine *Radio* (later articles appeared in the November, 1977, and December, 1977, issues). Using the first article, I built an experimental receiver and obtained excellent results, which I published in the September, 1977, issue of our Yugoslav radio amateurs' magazine, *Radioamater*. I enclose partial copies of all those articles; however, I suppose you cannot read Russian or Yugoslav — so I shall give you a summary of the texts.

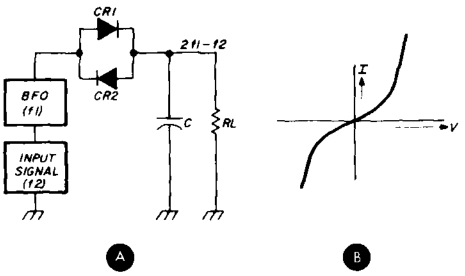

fig. 2. Mixer circuit for double-conversion receivers suggested by RA3AAE, and its characteristic curve.

On page 46 Dick Rollema rightly concludes that a good mixer for DCR should be a switching-type detector. Polyakov's solution is based on two matched silicon or germanium high-frequency diodes, connected in parallel and back-to-back. The local oscillator (in fact, bfo) must work on half of the received frequency, and the output from the detector is CW or ssb audio frequency. The integrated characteristic of the two diodes is represented with an inverted S-shaped curve (**fig. 2A**). Theoretically, the characteristic is similar to a cubical parabola ($I = AV + BV^3$), which means that this detector does not use square functions — thus making a-m detection impossible.

For popular explanation refer to the following. The lower cutoff points of the two diodes are used to obtain a switching device that can be opened and closed by the high-frequency voltage of the local oscillator (bfo). The so-called potential barrier for silicon diodes is about 0.5V and for germanium diodes about 0.1V. Therefore, in the middle part of the characteristic, neither of the two diodes conducts — which makes the switching function possible. The switching point occurs when the high frequency voltage of the bfo passes through zero and comes to one of the cutoff points. (Therefore the bfo's high frequency voltage, brought to the diodes through coil L-4, must exceed the potential barrier twice or more.) Since there are two zeroes in each cycle, it becomes obvious that the bfo must work on half of the received frequency. It can be equally said that the diodes CR1 and CR2 are closed sequentially when positive and negative half-waves of the bfo high frequency voltage reach their peaks. In those moments, the received signal — fed through coil L2 — will pass through one of the diodes and beat against the bfo voltage. At the same time the matched pair of diodes — connected back-to-back — cancel any a-m detection or a-m breakthrough, so this switching mixer is exceptionally insensitive to a-m detection.

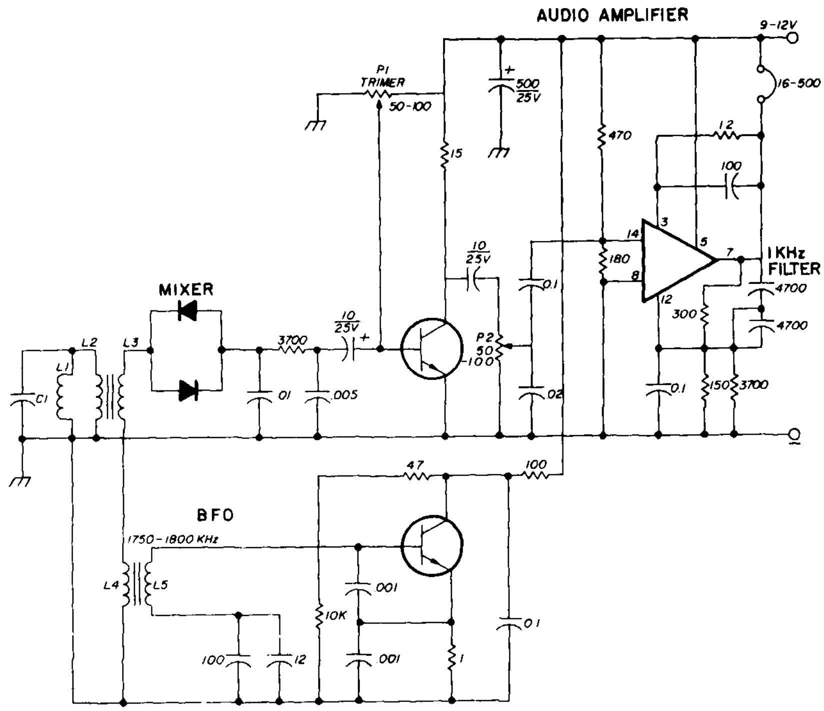

fig. 3. Experimental direct-conversion receiver built by YU2HL that uses the improved diode-mixer circuit.

In addition to simplicity, this mixer has several other qualities. Because the bfo works on half of the received frequency, it is easier to obtain good stability and to prevent unwanted radiation through the antenna. It is also very resistant to cross-modulation and overloading. Although Polyakov recommends silicon diodes — because of their higher potential barrier — I found germanium diodes to be more sensitive without losing other qualities of the mixer.

In the experimental receiver I built the rf resonant circuit C1-L2, for simplicity, was set on the middle of the 80-meter band once for ever (see **fig. 3**). The number of turns of the secondary coils L3 and L4 is one-fourth that of their primary coils, L2 and L5. Because there is no dc component after detection, the usual loading resistor was omitted and the high frequency components are shorted to ground through a 0.01 μF capacitor. I found it essential to use a low-noise audio preamplifier after detection — and one BF 173 did the job. The audio amplifier can be any integrated circuit or operational amplifier with possibility to include negative feedback through C_x and R_x — thus peaking the resonant frequency of the amplifier at 1 kHz. Later I added also an rf stage ahead of the mixer — by using an fet — which made this little receiver a real marvel of clean CW reception, selectivity, stability, sensitivity, and resistance to cross-modulation and over-loading.

Because I am too busy for it at the moment, I hope that Dick Rollema and others will have some more time to experiment with this type of mixer.

Bozidar Pasric, YU2HL

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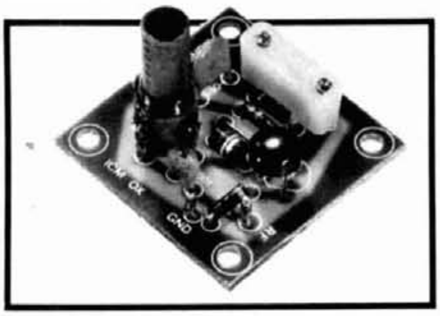

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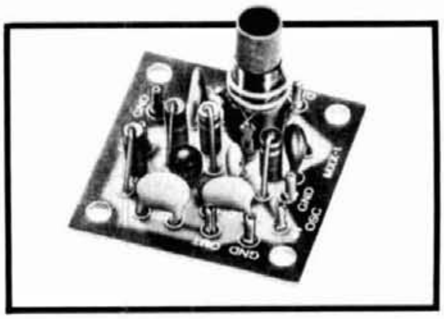

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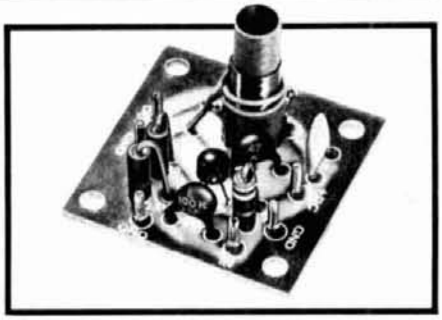

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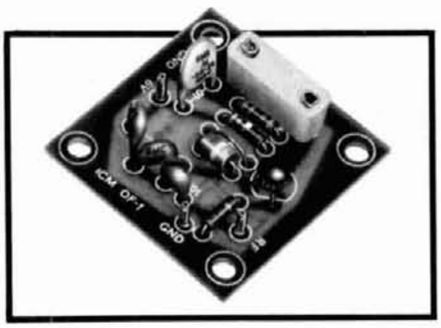

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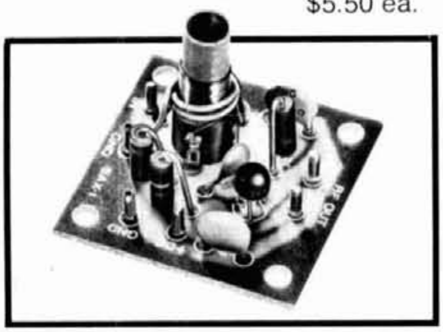

SAX-1 TRANSISTOR RF AMP

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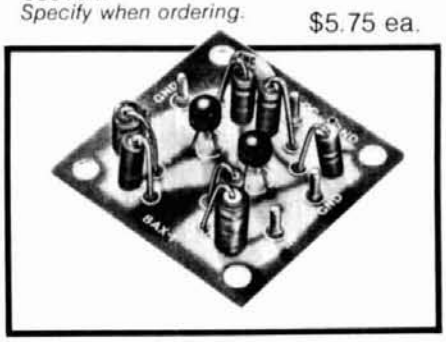

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Cat. No.	Specifications	
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031300	3 to 20 MHz — For use in OF-1L OSC *Specify when ordering*	$4.75 ea.
031310	20 to 60 MHz — For use in OF-1H OSC *Specify when ordering*	$4.75 ea.

Shipping and postage (inside U.S., Canada and Mexico only) will be prepaid by International. Prices quoted for U.S., Canada and Mexico orders only. Orders for shipment to other countries will be quoted on request. Address orders to:
M/S Dept., P.O. Box 32497,
Oklahoma City, Oklahoma 73132.

ICM

International Crystal Mfg. Co., Inc.
10 North Lee
Oklahoma City, Oklahoma 73102

NEW products

For literature on any of the new products, use our *Check-Off* service on page 142.

Triplett 100-T pocket VOM

Two very useful measurements are beyond the capability of most amateur and commercial workshops: temperature and ac current. The temperature of a device can be an important indicator of proper or improper operation. For instance, the relative temperatures of a transistor and its heatsink can tell you if the thermal path between the two is adequate, or whether or not the transistor is operating within its safe dissipation rating. The same is true of resistors and other components in a circuit — too often the extra dissipation is detected by the "scorched finger" method.

The need to measure the amount of current flowing in ac circuits comes up often enough that most amateurs and engineers wish they had an instrument designed for that purpose. A clamp-on ammeter will do the job, if it is available.

The new Triplett model *100-T VOM* is a welcome addition to the lab or workbench because it includes the capability of measuring temperature and ac current in addition to the standard VOM functions that you would expect from this fine instrument.

A first in versatility and temperature sensitivity for its size, the new model *100-T* features a hand-size VOM with −50° to +300°F temperature ranges. It is contained in a handy leather carrying case that includes the temperature probe, VOM leads, a clamp-on ac ammeter, plus a plug-in line separator for current readings on standard line cords. The *100-T* is designed for checking motors, ac and dc lines, machinery, electronic circuitry, appliances, and temperature.

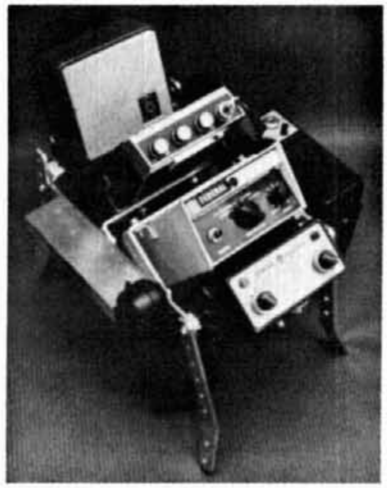
The basic Model 390 "shirt pocket" VOM includes five ac/dc voltage ranges from 0-1200 volts, four dc milliamp ranges from 0.6-600mA, and four resistance ranges from 10k to 10 megohms. Two direct-reading temperature scales from −50°F to +150°F and +50°F to +300°F are also included for use with the temperature probe.

The Triplett Model 10 Clamp-on ac ammeter permits current readings in 6 ranges (up to 300 amps) to be performed without circuit interruption. And, the Model 101 plug-in line separator "divides" a standard line cord to permit clamp-on ac current measurements at directed and extra-sensitive 0.6 and 0.3 amp full scale readings. An extension for the ac clamp-on probe is also included.

Temperature readings are accomplished by using the Triplett thermistor probe. The bare probe is used for surface temperature measurements. An aluminum shield is provided to protect the sensitive probe from damage when taking air temperature measurements, or when the probe is stored in the VOM case.

For further information on this new ultra-compact, versatile, model *100-T*, priced at $120 complete with accessories, contact Triplett Corporation, Department PR, Bluffton, Ohio 45817, or ask your local electronic distributor for a demonstration.

Wayne Bracket



The Wayne Bracket Communications Command Console provides a way to mount and install expensive communications equipment in any vehicle. The rugged, solid-aluminum bar-stock frame and crossmembers allow you to position all sorts of electronic equipment for convenience and safety. An investment in this infinitely practical bracket makes the installation neat, quick, easy, and economical. It fastens over the drive shaft tunnel in any nonconsole, column-shift vehicle using only four sheet-metal screws. Models are available for flat-surface installations.

The bracket provides an ideal place for a first-aid kit, fire extinguisher, and flashlight. It completely eliminates dash-mount hassles and mickey-mouse floor rigs. The Wayne Bracket's low center of gravity and central location protects expensive equipment while providing maximum front-seat room. For more information, request our "10 basic benefits" brochure at no obligation. Write to E. Lee Reid, Wayne Communications, Inc., Post Office Box 57, Doctors Inlet, Florida 32030.

tunable ATV converter

Science Workshop has introduced a new tunable ATV converter, which connects between an ordinary uhf antenna and the vhf input of any television set.

Features and specifications of the model ATVC-10 are a low-noise, high-gain rf amplifier stage with varactor-tuned input and outputs, an active mixer with varactor-tuned input, a varactor-tuned oscillator stage, and adjustable rf gain control.

The built-in ac power supply uses a transformer for power line isolation and a full-wave bridge, supplying a regulated voltage for the four tuning varactors. The converter is electrically tuned from 420 to 450 MHz, with outputs on vhf TV channels 2 through 6.

The ATVC-10 comes completely wired and tested and guaranteed for two years. It is housed in an attractive two-tone (walnut and beige) finished aluminum cabinet which measures only 4.75 × 10.85 × 10.5 cm (1-7/8 × 4-1/4 × 4-1/8 inches).

The prices: factory wired, only $49.95; semi-kit (critical circuits prewired and aligned), $39.95. Full instructions are included.

For additional information write to Science Workshop, Box 393, Bethpage, New York 11714.

Hiram Percy Maxim — a biography

Probably Hiram Percy Maxim has contributed more to amateur radio than any other single person. Historically, he founded *QST Magazine*, the American Radio Relay League, and the International Amateur Radio Union. He pleaded the amateur's cause very successfully

More Details? CHECK—OFF Page 142

before American and international forums bent on abolishing the hobby, and he held one of the most famous ham callsigns of all time: W1AW. Taken together, he organized, nurtured, defended, and disciplined the hobby in its critical formative years; amateur radio still bears the distinctive stamp of his gentlemanly personality.

Maxim is best known outside the world of amateur radio for his inventions and pioneering work in the development of the automobile and noise-control devices. A holder of 49 patents, he was also a pioneer in aviation, air conditioning, motion pictures, and radio astronomy. He was an accomplished international diplomat, screen writer, urban ecologist, and nationally-syndicated newspaper columnist. In short, he was a true Renaissance man; the embodiment of the line from *The Amateur's Code*, "an amateur is balanced."

This is the only available biography of a great and unique American character. It is a fascinating and painstakingly well-researched account that brings his personality to life. The author, Alice Clink Schumacher, avoids dull scholarship and makes the reader feel that he is overhearing a collection of treasured family anecdotes told by close friends and relatives.

The book provides a unique insight into one man's life and an era of unprecedented technological progress in dozens of fields. Perhaps the feature which most commends this book to every amateur's library is the lengthy excerpting from Maxim's incomparable series of "The Old Man" editorials. Printed anonymously in early issues of *QST*, they are amusing, humorous yet thought-provoking carictures of radio amateurs and their foibles. They are still amazingly accurate today.

Certainly few men were as well-liked and respected, nor did as much to make amateur radio the most gentlemanly of hobbies, than The Old Man — Hiram Percy Maxim.

More Details? CHECK — OFF Page 142

Soft cover, 153 pages, $4.50 from Ham Radio's Communications Bookstore, Greenville, New Hampshire 03048. Order catalog HR-HPM.

Bristol electronics 10-meter transceiver

Bristol Electronics of New Bedford, Massachusetts, now offers two mobile transceivers for the amateur 10-meter band. The HAM-10 is a 10-watt, 40-channel unit that covers 40 channels with 10-kHz spacing, starting at 28.965 for channel 1. The HAM-100 is a 100-watt version of the same synthesized transceiver.

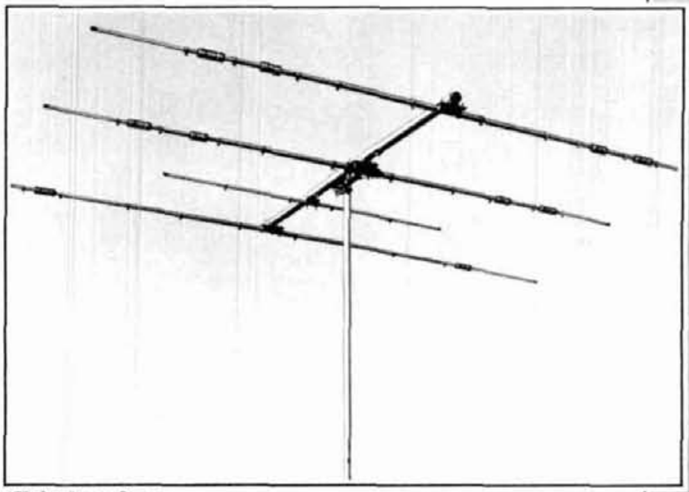
Frequency control is by means of a patented Phase-Lock Loop synthesizer, and the receiver may be tuned between channels for better reception of off-frequency stations.

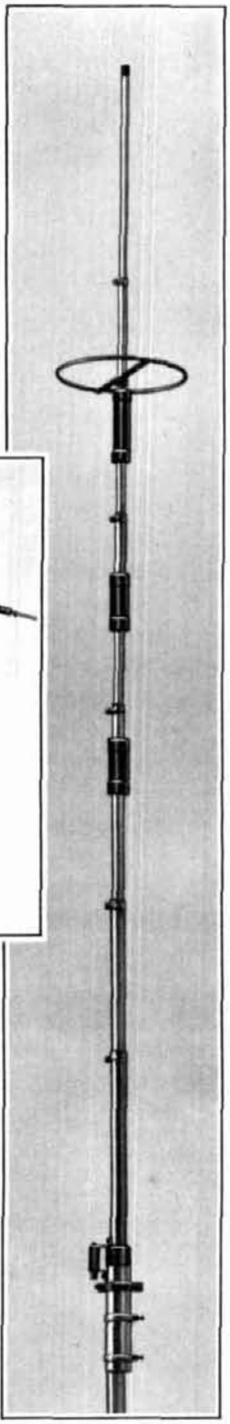
These transceivers are not worked-over CB units, but are, according to Bristol Electronics, designed and engineered for amateur 10-meter band use. The equipment is of the same lightweight and compact style that amateurs are accustomed to using in the vhf part of the spectrum.

Additional features include an automatic noise-limiter, combined S- and rf-power meter, LED modulation monitor, and a jack for an external speaker. A microphone and all mounting hardware are included.

The modulation system is a-m, with a capability of 95 to 100 per cent modulation. Spurious signals are suppressed better than 60 dB, and harmonics are suppressed better than 45 dB. The HAM-100 has a selector switch for either full power or a 10-watt level for local work.

For more information, contact Bristol Electronics, Inc., 651 Orchard Street, New Bedford, Massachusetts 02774.





More Details? CHECK—OFF Page 142

standard C-6500 general-coverage receiver

The Model C-6500 is a synthesized, general-coverage, communications receiver; a new "Standard" with high-quality, low-cost performance that will please the most critical listener. Reception capability is provided for a-m, CW, and ssb. Unusual stability is achieved by using a synthesized, drift-cancelling injection system in 30 tunable ranges, covering the entire broadcast band starting at 500 kHz through 30 MHz. A 10-MHz reference oscillator provides the frequency stability necessary for excellent ssb reception. Dial accuracy is better than 5 kHz, which is sufficient to locate and identify stations on known frequencies.

There are two separate detectors, product and diode, to provide excellent performance for both ssb and a-m signals. A mode switch provides wide or narrow selectivity. A tunable preselector allows the user to adjust for maximum sensitivity and interference rejection. Completely solid-state in design, the Standard C-6500 operates from ac mains as well as eight internal type "D" flashlight cells. Automatic switchover to battery operation is accomplished if the ac power should fail. For information write Standard Communications Corporation, Post Office Box 92151, Los Angeles, California 90009.

two-volume course on microcomputer programming

A two-volume course that integrates introductory experiments in digital electronics with programming and interfacing an 8080A-based microcomputer is now available. *Bugbooks V and VI* by D. G. Larsen, P. R. Rony, and J. A. Titus are lab experiment-oriented texts that are intended for study and guidance in the performance of "hands on"

More Details? CHECK—OFF Page 142

experiments with the aid of a low-cost microcomputer, breadboarding kits, and readily available components. The books may be purchased individually.

The course material is organized for teaching microcomputer programming and the interfacing of a microcomputer to external digital devices for practical applications. The course content is derived from the authors' experience in teaching the subjects to college students, scientific researchers, and engineers with a need for mastery of microcomputers but no formal background in either digital electronics or computer programming. The student or hobbyist is expected to perform the suggested experiments to obtain the most benefit from the course material.

Integrated circuits and the microprocessor are treated as functional black boxes with specific electrical characteristics; semiconductor physics and mathematical analysis is omitted. Laboratory experiments and text review questions and answers are included to test reader understanding of the subjects covered.

Bugbook V, with 15 units in 493 pages covers the basics of 8080A microcomputer programming and instructions as well as digital codes, register, logic gates, and truth tables. An introduction to breadboarding is followed by instructional units and experiments covering 7400 series TTL integrated circuit chips, including flip-flops and latches, decoders, counters, digital signal gates, and multivibrators.

Bugbook VI has eight units in 490 pages; it integrates the digital concepts discussed in *Bugbook V* into a treatment of 8080A microcomputer interfacing and programming. Detailed instructions and related laboratory experiments cover select pulses, the 8080A instruction set, three-state bussing techniques, and introductions to accumulator and memory-mapped input/output techniques. Other topics in *Bugbook VI* include

More Details? CHECK—OFF Page 142

advanced input/output concepts and interrupt servicing. Complete appendixes for both volumes at the back of *Bugbook VI* include references, definitions, and descriptions of available breadboarding accessories and microcomputer recommended for use in the experiments.

Bugbook V and *Bugbook VI* are priced at $9.50 each from Ham Radio's Communications Bookstore, Greenville, New Hampshire 03048.

feather touch keyer

The new Kantronics Feather Touch Keyer is the world's first commercially available keyer with no moving parts. The Feather Touch responds to your lightest touch, not to mechanical connections or switches. No moving parts means the end of slapping and bouncing. There are no adjustments to be made before each contact, and no mechanical parts to wear out.

Feather Touch sends self-completing dots and dashes, with a speed range of 7-1/2 to 50 words per minute. The keyer operation is semi-iambic, with dot priority. This keyer is great for portable or field-day use, where it can be powered by a single 9-volt internal battery. An extra-life battery can provide 24 hours of reliable keying under average conditions. At home, the unit can operate from any 5- to 15-volt dc power source.

The attractive design and compact size make the Feather Touch a professional addition to any ham station. Price: $69.95 from Kantronics, Inc., 1202 East 23rd St., Lawrence, Kansas 66044. For more information, write to them.

More Details? CHECK—OFF Page 142

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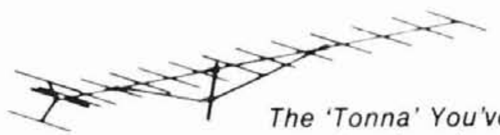

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17.8 dBi	Wt. 4.4 kg.
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Great for OSCAR, SSB, FM, ATV. Over 10,000 in use throughout the world on all types of receivers.

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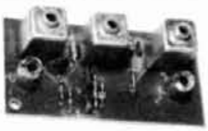

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Miniature VHF model for tight spaces - size only 1/2 x 2-3/8 inches.

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P8-220	220-230 MHz
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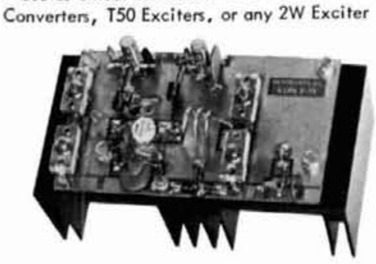

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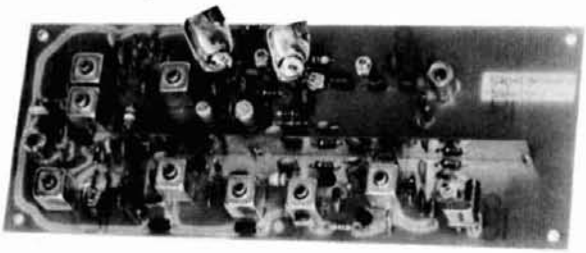

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C145	145-147 (OSCAR)	28-30
C146	146-148	28-30
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Special	Other i-f & rf ranges available	

MODEL	RF RANGE (MHZ)	I-F RANGE
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$495

GENERAL SPECIFICATIONS

Semiconductors:	39 diodes, 23 transistors, 11 integrated circuits
Power Requirements:	Nominal 13.8 VDC input at 15 amps, *negative ground only*
Power Consumption:	Receive — 5.5 watts (includes dial and meter lamps); Transmit — 260 watts
Dimensions:	3-1/4" high x 9" wide x 12-1/2" deep (82.55 mm x 228.6 mm x 317.5 mm)
Weight:	8-1/4 lbs. (3.66 kg)

PERFORMANCE SPECIFICATIONS

Frequency Range:	80 meter band — 3.5 to 4.0 MHz 40 meter band — 7.0 to 7.5 MHz 20 meter band — 14.0 to 14.5 MHz
Modes:	CW, USB, LSB
RF Input Power:	SSB — 250 watts PEP nominal CW — 250 watts DC maximum (adjustable)
Transmitter:	
Antenna Impedance:	50 ohm, unbalanced
Carrier Suppression:	Better than −45 dB
Side-Band Suppression:	Better than −55 dB at 1000 Hz
Distortion Products:	Better than −26 dB
AF Response:	500 to 2500 Hz
Spurious Radiation:	Harmonics better than −45 dB below 30 MHz; better than −60 dB above 30 MHz
Frequency Stability:	Less than 100 Hz drift per hour (from a cold start at room temperature)
Microphone:	High impedance 3000 ohm
Receiver:	
Sensitivity:	Better than 0.5 watts audio output for 0.5 μV input
Signal-to-Noise Ratio:	Better than 10 dB S+N/N for 0.5 μV input
Image Ratio:	Better than −60 dB (typical with respect to 0.5 μV input: 80 meters — −130 dB; 40 meters — −100 dB; 20 meters — −75 dB)
IF Rejection:	Better than −70 dB (typical with respect to 0.5 μV input: 80 meters — 110 dB; 40 meters — 80 dB; 20 meters — 75 dB)
Intermodulation Intercept Point:	Better than 10 dBM
Selectivity:	2.5 kHz — 6 dB; 5.0 kHz — 60 dB
Audio Output Power:	More than 3 watts
Audio Distortion:	Less than 5% at 3 watts

OPTIONS & ACCESSORIES

Noise Blanker — Model No. PC 701 .... **$39.95**

100 kHz and 25 kHz Dual Crystal Calibrator — Model No. PC 801 .... **$19.95**

Portable Power Supply — Model No. ALDA PS 115: average duty 15 amp unregulated; input — 115/230 VAC, 50/60 Hz; output — 13.8 V *nominal* at 15 amps ... **$84.95**

Heavy Duty Power Supply — Model No. ALDA PS 130: output — regulated 30 amp at 13.8 VDC; input — 115/230 VAC, 50/60 Hz **$149.95**

alda communications, inc. 215 Via El Centro Oceanside, CA 92054 (714) 433-6123

EUROPE: Contact Datacom, Box 442, S-194 04 Upplands Vasby, Sweden

EXCEPT FRANCE: Poussielgues Diffusion Electronique Sarl, 89 Bis Rue De Charenton — 75012 Paris

ALDA 103 is completely manufactured in the U.S.A.

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BUY 1 AT SALE PRICE, GET 2ND FOR 1C MORE!!!

THIS SPECIAL ONE CENT SALE IS FOR MAGAZINE ADS ONLY

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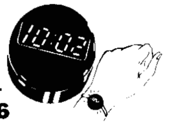

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Factory "lay-arounds." Do they work? Who knows! A micro digital technicians bonanza. The complete guts are there. With black case and leatherette band. 5 functions: HOURS, MINUTES, SECONDS, MONTH, & DATE. Sorry, no specs.
Cat. No. 9H5267 Wt 4 oz.

IMAGINE GETTING A CALCULATOR REJECT FOR ONLY A PENNY!!!!

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LED OR FLUORESCENT CALCULATOR GAMBLE!

PARTS ALONE ARE WORTH MORE THAN PRICE!

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□ 9H5292 Flourescent
□ 9H5291 LED

Choose from 2 styles: GREEN fluorescent .5" digits or RED all-LED .125" digits. Both styles feature 8 digits, 22 keys, 4 arithmetic functions, 4 memory functions, percent, equals, clear. All units complete, and include operation manual. (Batteries not included) Wt. 6 ozs.

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Quan. Description (Order by Cat. No. in parenthesis)	Sale	1¢SALE
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□ 10-IC "DICE", microscopic circuits, teaches theory (#9H5065)	1.19	2 for 1.20
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□ 1-LED WATCH GUTS, men's, how good? We don't know (#9H5267)	1.95	2 for 1.96
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□ 5-PANCAKE PHOTOCELLS, 600 to 15K ohms (#9H2939)	1.00	10 for 1.01
□ 1-100KHZ MARKER CRYSTALS, approx for marker gen. (#9H3896)	1.95	2 for 1.96
□ 1-MOTHERBOARD EDGE CONNECTOR, 106 pins, .125" (#9H3967)	3.50	2 for 3.51
□ 1-46-PIN EDGE CONNECTOR, .156" spacing (#9H3963)	1.95	2 for 1.96
□ 1-METER, 50uA, 1½" square, 0-20db (#9H3705)	1.19	2 for 1.20
□ 1-SPST RELAY, norm, open 12-24 VDC, 1250 ohms, dip style (#9H5175)	1.00	2 for 1.01
□ 1-VEEDER ROOT COUNTER, 000-999, resettable, panel mt. (#9H5081)	1.49	2 for 1.50
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□ 1-JOYSTICK, four 100K pots, with knob (#9H3806A)	4.95	2 for 4.96
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□ 1-PLESSEY TV SIDEBAND FILTER, for chan, 3 or 4 (#9H3975)	1.95	2 for 1.96
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□ 20-DATA ENTRY PUSH-SWITCHES, spst, norm open, for keyboards (#9H5279)	2.00	40 for 2.01
□ 75-SN7400 TTL ICs, untested 50%+ yield, pop types (#9H2415)	2.00	150 for 2.01
□ 100-MINI DIP ICs, linears, untested 50%+ yield, pop types (#9H3245)	2.00	150 for 2.01
□ 30-LM380 AUDIO IC's, 2 watts on-a-dip 50%+ yield (#9H5284)	2.00	60 for 2.01
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□ 150-GLASS ZENERS, 400 MW, untested, better than 50% yield (#9H2740)	2.00	300 for 2.01
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□ 30-PC TRIM POTENTIOMETERS, thumbwheel, screwdriver ass't. (#9H3345)	2.00	60 for 2.01
□ 15-SLIDE VOLUME CONTROLS, asst'd values, duals, singles (#9H3057)	2.00	30 for 2.01
□ 75-4" CABLE TIES, plastic, like "Ty-wrap" (#9H5218)	2.00	150 for 2.01
□ 10-CRYSTALS, may include CB, Ham & more (#9H3250)	2.00	20 for 2.01
□ 100-TERMINAL STRIPS, from 2 lugs up (#9H3136)	2.00	200 for 2.01
□ 30-NE-2NEON LAMPS, all 100% good (#9H2613)	2.00	60 for 2.01
□ 40-ft. SHIELDED CABLE, 1 cond, mikes, phones, (#9H3577)	2.00	80 ft. for 2.01
□ 3-SOUND TRIGGERS, sound triggers scr w/amp (#9H3625)	2.00	6 for 2.01
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□ 100-DISC CAPACITORS, long leads, marked, asst'd (#9H2596)	2.00	200 for 2.01
□ 100-CAPACITOR SPECIAL, discs, mylar, lytics, more (#9H2738)	2.00	200 for 2.01
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□ 30-PANEL SWITCHES, slides, rotaries, mod, etc (#9H3268)	2.00	60 for 2.01
□ 200-RESISTOR SPECIAL, ¼ to 1W, carbon, metal (#9H3054)	2.00	400 for 2.01
□ 200-HALF WATTERS, resistors, carbon, metal (#9H3046)	2.00	400 for 2.01
□ 100-NATIONAL IC BONANZA, linears, 7400s ROMS (#9H2860)	2.00	200 for 2.01
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□ 100-POLYSTYRENE CAPS, asst'd values, voltage, hi-Q (#9H2729)	2.00	200 for 2.01
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□ 20-BRIDGES, untested, 2, 4, 6, amp, full wave (#9H4022)	2.00	40 for 2.01
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□ 15-MIXED READOUTS, hobby, untested, .127, .3, .5, etc. (#9H3619)	2.00	30 for 2.01
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□ 100-PLASTIC TRANSISTORS, untested, TO-92 (#9H2604)	2.00	200 for 2.01
□ 200-PREFORMED RESISTORS, ¼, ½, 1W, marked, asst'd (#9H2606)	2.00	400 for 2.01
□ 200-PRECISION RESISTORS, ¼, ½, 1W, 1%, 2% marked (#9H2428)	2.00	400 for 2.01
□ 60-DIPPED MYLARS, shiny finish, asst'd values (#9H2597)	2.00	120 for 2.01
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□ 30-CLOCK CHIPS, National, hobby & untested, alarm (#9H5069)	2.00	60 for 2.01
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□ 1-CONDENSER MIKES, sensitive, 500 ohms 1.5 Volts (#9H3178)	4.95	2 for 4.96

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		ONE CENT SALE
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□ SPERRY FLAT NIXIES, orange, .3", 1½-dig (#9H5015)	3 for 1.19	6 for 1.20
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□ MAN-4 READOUTS, bubble, red, com. anode, .19" (#9H1503)	2 for 1.00	4 for 1.01
□ FND-10 BLOCK READOUT, .122" com cathode (#9H2082)	2 for 1.19	4 for 1.20
□ 8-DIGIT READOUT, led, com cathode, red (#9H5190)	1 for 1.95	2 for 1.96
□ FND-503, .5" red, com cathode, 7-seg. (#9H2949)	1.50	2 for 1.51
□ FND-500, .5" red, com anode, 7 seg. (#9H2950)	1.50	2 for 1.51
□ FND-800, .8" red, common anode, (#9H3030)	3.95	2 for 3.96
□ FND-803, .8" red, common cathode, (#9H3327)	3.95	2 for 3.96

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	Each	2 for
□ 1-SPST 24V REED RELAY, norm open, dip style, 1250 ohms (#9H5175)	1.49	1.50

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	Each	2 for
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□ 3 WATTS ON A CHIP, G-E PA 263 (#9H1522)	1.50	1.51

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	Each	2 for
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IC SOCKETS!

□ 8-PIN MINI-DIP (#9H2123)	4 for $1.19	8 for $1.20
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□ 18-PIN DIP (#9H3378)	6 for 1.19	12 for 1.20
□ 24-PIN MSI/DIP (#9H3886)	2 for 1.19	4 for 1.20
□ 28-PIN MSI/DIP (#9H3887)	2 for 1.19	4 for 1.20

FULL WAVE BRIDGE 10 AMP RECTIFIERS!

Order by Cat. No. 9H2447 & voltage

PRV	Sale	2 for
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□ 100	1.49	1.50
□ 200	1.69	1.70
□ 400	1.99	2.00
□ 600	2.25	2.26
□ 800	2.50	2.51
□ 1000	2.75	2.76

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Retail: 16-18 Del Carmine St., Wakefield.

MINIMUM ORDER — $6.00

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1¢ SALE 10 for $1.01

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□ #9H1795	JUMBO TAPER CLOUDY
□ #9H1802	MICRO SINGLE PIN RED
□ #9H1946	MICRO YELLOW
□ #9H2135	JUMBO RED
□ #9H2136	JUMBO TAPER RED
□ #9H2137	MICRO RED
□ #9H2790	JUMBO RED CLEAR

TTL'S AT "CENT-CIBLE" PRICES

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□ SN7401	.19	.20	□ SN7470	.19	.20	□ SN74154	1.75	1.76
□ SN7403	.25	.26	□ SN7471	.35	.36	□ SN74155	.79	.80
□ SN7404	.19	.20	□ SN7472	.19	.20	□ SN74156	.39	.40
□ SN7405	.19	.20	□ SN7474	.59	.60	□ SN74157	.99	1.00
□ SN7406	.19	.20	□ SN7475	.69	.70	□ SN74158	.99	1.00
□ SN7407	.39	.40	□ SN7480	.19	.20	□ SN74161	1.25	1.26
□ SN7409	.39	.40	□ SN7482	.29	.30	□ SN74163	1.39	1.40
□ SN7410	.25	.26	□ SN7483	.99	1.00	□ SN74164	.79	.80
□ SN7416	.35	.36	□ SN7484	.49	.50	□ SN74165	.99	1.00
□ SN7417	.35	.36	□ SN7486	.79	.80	□ SN74166	1.99	2.00
□ SN7420	.32	.33	□ SN7489	3.49	3.50	□ SN74173	.99	1.00
□ SN7421	.49	.50	□ SN7490	.99	1.00	□ SN74174	1.79	1.80
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□ SN7426	.19	.20	□ SN7492	.79	.80	□ SN74177	.79	.80
□ SN7430	.29	.30	□ SN7493	.69	.70	□ SN74179	1.99	2.00
□ SN7437	.19	.20	□ SN7494	.79	.80	□ SN74180	.49	.50
□ SN7438	.25	.26	□ SN7495	.59	.60	□ SN74182	.49	.50
□ SN7440	.19	.20	□ SN7496	.79	.80	□ SN74190	1.99	2.00
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□ SN7446	1.25	1.26	□ SN74113	.39	.40	□ SN74193	.99	1.00
□ SN7450	.19	.20	□ SN74114	.29	.30	□ SN74194	1.25	1.26
□ SN7451	.19	.20	□ SN74121	.39	.40	□ SN74197	.75	.76
□ SN7453	.19	.20	□ SN74123	.69	.70	□ SN74199	1.50	1.51
□ SN7454	.29	.30	□ SN74126	.99	1.00	□ SN74200	3.50	3.51
□ SN7455	.35	.36	□ SN74136	.49	.50	□ SN74251	.79	.80
□ SN7460	.35	.36	□ SN74140	.49	.50	□ SN74284	5.99	6.00
□ SN7462	.35	.36	□ SN74145	.69	.70	□ SN74298	3.75	3.76
□ SN7464	.19	.20						

POP-AMPS AT "CENT-CIBLE" PRICES

Case code: T=TO-220 Power Tab; V=Mini dip; K=TO-3; H=TO-5; N=DIP.

Type No.	Each	2 for	Type No.	Each	2 for	Type	Each	2 for
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□ LM300N	.49	.50	□ LM340T-6	1.49	1.50	□ LM704H	.19	.20
□ LM301V	.45	.46	□ LM340T-8	1.49	1.50	□ LM709H	.19	.20
□ LM301H	.45	.46	□ LM340T-12	1.49	1.50	□ LM709N	.49	.50
□ LM307V	.45	.46	□ LM340T-15	1.49	1.50	□ LM733N	.79	.80
□ LM308V	.29	.30	□ LM340T-18	1.49	1.50	□ LM741V	.25	.26
□ LM308H	.69	.70	□ LM340T-24	1.49	1.50	□ LM741H	.30	.31
□ LM309K	1.49	1.50	□ LM350N	.49	.50	□ LM747H	.59	.60
□ LM311V	.29	.30	□ LM376V	.29	.30	□ LM1304	1.49	1.50
□ LM311H	1.49	1.50	□ LM377N	2.25	2.26	□ LM1310	1.79	1.80
□ LM318V	.99	1.00	□ LM380N	1.39	1.40	□ LM1312	2.49	2.50
□ LM320H-5	.99	1.00	□ LM381N	1.99	2.00	□ LM1414V	.19	.20
□ LM320H-12	.99	1.00	□ LM386N	1.49	1.50	□ LM1458V	.39	.40
□ LM320H-15	.99	1.00	□ LM531H	1.49	1.50	□ LM1800N	.79	.80
□ LM320T-6	1.49	1.50	□ LM532N	.25	.26	□ LM3028H	.65	.66
□ LM322N	1.19	1.20	□ LM532H	.25	.26	□ LM3900N	.49	.50
□ LM324N	1.79	1.80	□ NE540H	5.95	5.96	□ LM3909V	1.25	1.26
□ LM339N	1.79	1.80	□ LM555V	.75	.76	□ LM4250	1.20	1.21
□ LM340K-5	1.49	1.50	□ LM556N	1.79	1.80	□ LM75451	.69	.70
□ LM340K-6	1.49	1.50	□ LM558V	.39	.40	□ LM75453	.69	.70
□ LM340K-8	1.49	1.50	□ LM558H	.39	.40	□ LM75491	.80	.81
□ LM340K-12	1.49	1.50	□ LM561N	1.00	1.01	□ LM75492	.80	.81
□ LM340K-15	1.49	1.50	□ LM565N	1.00	1.01	□ LM75494	.60	.61
□ LM340K-18	1.49	1.50	□ LM565H	1.00	1.01	□ PA263	1.50	1.51
□ LM340K-24	1.49	1.50	□ LM566	2.49	2.50	□ DM8864N	1.29	1.30
			□ LM567	2.39	2.40			

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Type	Description	Sale	1¢ Sale!
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□ 5202	2K Prom	2.95	2.96
□ 5262	2K x 1 Dynamic RAM	.99	1.00
□ 1702A	256 x 8 EPROM	4.95	4.96
□ MMS280*	4K x 1 Dynamic RAM	3.95	3.96

Order by Cat. No. 9H3489 & Type No.

*Removed from new tested equipment

1 AMP SCR'S

TO-92 Case. 2N5060 series.
Order by Cat. No. 9H2367 and voltage

□ 30	4 for $1	8 for 1.01
□ 60	3 for $1	6 for 1.01
□ 100	3 for $1	6 for 1.01
□ 150	2 for $1	4 for 1.01
□ 200	1 for $1	2 for 1.01

1N4000 Epoxy Rectifiers

Order by Cat. No. and Type No.

Cat. No.	Type	Volts	Sale	1¢ SALE!
□ 9H2377	1N4001	50	10 for $ .75	20 for $ .76
□ 9H2378	1N4002	100	10 for .85	20 for .86
□ 9H2379	1N4003	200	10 for .95	20 for .96
□ 9H2380	1N4004	400	10 for 1.19	20 for 1.20
□ 9H2381	1N4005	600	10 for 1.39	20 for 1.40
□ 9H2382	1N4006	800	10 for 1.49	20 for 1.50
□ 9H2383	1N4007	1000	10 for 1.59	20 for 1.60

• 1.5 Amp!
• Miniature!

25 AMP BRIDGE RECTIFIERS

Order No. 9H2273 & voltage

V	Each	1¢	SALE
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□ 100	1.49	2 for	1.50
□ 200	1.69	2 for	1.70
□ 400	1.99	2 for	2.00
□ 600	2.25	2 for	2.26
□ 800	2.50	2 for	2.51

BULLET RECTIFIERS!

Order by Cat. No. 9H60B84 and voltage
1.5 AMP

□ 50V	10 for $.59	20 for $.60
□ 100V	10 for .69	20 for .70
□ 200V	10 for .79	20 for .80
□ 400V	10 for .89	20 for .90

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Your Choice 2 for $1.50 4 for $1.51

(m) – multiturn
(s) – single turn

□ 10(m) □ 20(m) □ 50(m) □ 100(m) □ 200(m) □ 500(m) □ 750(m) □ 1K(m) □ 2K(m) □ 2.5K(s) □ 5K(s) □ 10K(s) □ 20K(s) □ 200K(m) □ 250K(m) □ 500K(m) □ 1 Meg(m)

Order No. 9H5336 and value

RIBBON CABLE!

Order by Cat. 9H3939 and Conductors

Cond.		Sale		1¢ Sale
□ 26	4-ft.	1.98	8-ft.	1.99
□ 34	3-ft.	1.98	6-ft.	1.99
□ 40	3-ft.	1.98	6-ft.	1.99

10 AMP - POWER TABS!

9H1730 - SCR'S
9H1448 - TRIACS
9H1590 - QUADRACS

PRV	Sale	2 for
□ 50	$ .55	$ .56
□ 100	.69	.70
□ 200	1.10	1.11
□ 400V	1.60	1.61

LYTIC KLINIC

Order No. 9H3269 and value — Electrolytic capacitors

UF	V	Style	Sale	1¢ SALE
□ 10	15	P.C.	10 for $1.00	20 for $1.01
□ 50	15	P.C.	8 for 1.00	16 for 1.01
□ 15	25	P.C.	8 for 1.00	16 for 1.01
□ 50	25	P.C.	6 for 1.00	12 for 1.01
□ 100	25	P.C.	5 for 1.00	10 for 1.01

CONDENSER MIKE

"TIE-PIN" TYPE

It's a little giant in sound quality. Metal encased with built-in FET circuit, omni-directional, freq. resp. 20-12,000Hz. Less tie pin or lapel clip. 600 ohm impedance. 1.5VDC.

7/16" x ⅞" long

No. 9H3178 4.95

2 for $4.96

ZENERS!

Order by Cat. No. 9H5210A & voltage & wattage

1 Watt	Sale	1¢ SALE
□ 7.5V	5 for $1.	10 for $1.01
□ 8.2V	5 for 1.	10 for 1.01
□ 9.1V	5 for 1.	10 for 1.01
□ 10.V	5 for 1.	10 for 1.01
□ 11.V	5 for 1.	10 for 1.01
□ 12.V	5 for 1.	10 for 1.01
□ 15.V	5 for 1.	10 for 1.01

Order by Cat. No. 9H5210B

5 WATTS	Sale	1¢ SALE
□ 6. V	3 for 1.	6 for 1.01
□ 8.2V	3 for 1.	6 for 1.01
□ 15. V	3 for 1.	6 for 1.01
□ 18. V	3 for 1.	6 for 1.01
□ 24. V	3 for 1.	6 for 1.01
□ 30. V	3 for 1.	6 for 1.01

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RATES Non-commercial ads 10¢ per word; *commercial ads 60¢ per word both* payable in advance. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing). Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (not all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue

DEADLINE 15th of second preceding month.

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

WANTED: Magnum 6 Speech Processor for Drake Separates. K1XX, 603-899-5621

WANTED: Skyneedle or equivalent crank-up tower, *minimum 75 feet. Must support 16 square feet unguyed.* N1GL, 136 Knob Loch Lane, Stamford, CT 06902. (203) 348-1331 (eves); (212) 953-5943 (days).

ELECTRONIC BARGAINS, CLOSEOUTS, SURPLUS! Parts, equipment, stereo, industrial, educational. Amazing values! Fascinating items unavailable in stores or catalogs anywhere. Unusual FREE catalog. ETCO-012, Box 762, Plattsburgh, N.Y. 12901. SURPLUS WANTED.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 93862.

HAPPY BIRTHDAY! Now ten years fighting TVI. The RSO low pass filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada MIS 3B4.

Foreign Subscription Agents for Ham Radio Magazine

Ham Radio Austria
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio Belgium
Stereohouse
Brusselsesteenweg 416
B-9218 Gent
Belgium

Ham Radio Canada
Box 114, Goderich
Ontario, Canada N7A 3Y5

Ham Radio Europe
Box 444
S-194 04 Upplands Vasby
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Ham Radio France
Christiane Michel
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France

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Holland

Ham Radio Italy
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Italy

Ham Radio Switzerland
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio UK
P.O. Box 63, Harrow
Middlesex HA3 6HS,
England

Holland Radio
143 Greenway
Greenside, Johannesburg
Republic of South Africa

CANADIANS: 1,000,000 surplus electronic parts. Hundreds of fantastic bargains! Good deals on Yaesu & Icom. Free catalog. ETCO-HR, 183G Hymus Blvd., Pointe Claire, Quebec H9R 1E9.

UNLIMITED VHF/UHF EQUIPMENT is at Radios UNlimited. From transverters to specialized transceivers, from mobile whips to E-M-E arrays. Plus all accessories. Authorized dealer for top manufacturers. (Also all your needs from 160 to 10) RUN in, write or phone — Radios UNlimited, 1760 Easton Avenue, Somerset, New Jersey 08873, 201-469-4599 — Hours 1 to 8 Mon-Fri; 10 to 8 Sat.

BUY-SELL-TRADE. Send $1.00 for catalog. Give name, address and call letters. Complete stock of major brands new and reconditioned equipment. Call for best deals. We buy Collins, Drake, Swan, etc. SSB & FM. Associated Radio, 8012 Conser, Overland Park, KS 66204. 913-381-5900.

ELECTRONIC EQUIPMENT HOTLINE *is a new classified* advertising newsletter for buying and selling professional, industrial, and surplus electronic equipment. Subscriptions $6/year, ads 50¢/word. Prepublication offer: $1 off subscriptions and 20% off all ads postmarked by October 1, 1978. Electronic Equipment Hotline, P.O. Box 4768, Panorama City, CA 91402.

PORTA PAK the accessory that makes your mobile really portable. $67.50 and $88.00. Dealer inquires invited. P.O. Box 67, Somers, Wisc. 53171.

HAM RADIO HORIZONS, a super new magazine for the Beginner, the Novice and anyone interested in Amateur Radio . . . What it's all about, How to get started, The fun of ham radio. It's all here and just $10.00 per year. HURRY! HURRY! Ham Radio HOIRZONS, Greenville, NH 03048.

FREE CATALOG of new merchandise. Resistors, capacitors, IC's, semiconductors, and more. Send to: Key Electronics, Box 3506H, Schenectady, New York 12303.

MOTOROLA HT220, HT200, and Pageboy service and modifications performed at reasonable rates. WA4FRV (804) 320-4439, evenings.

AUTHORIZED DEALER for DenTron, KLM, Larsen, Bearcat, etc., Big Catalog 201-962-4695 Narwid Electronics, 61 Bellot Road, Ringwood, N.J. 07456.

RECONDITIONED TEST EQUIPMENT for sale. Catalog $.50. Walter, 2697 Nickel, San Pablo, Ca. 94806.

TELETYPEWRITER PARTS WANTED: for all machines manufactured by: Klienschmidt Corp., Teletype Corp. and Mite. Any quantity, top prices paid send list for my quote. Phil Rickson, W4LNW, Rt. 6, Box 1103G2, Brooksville, Fl. 33512.

VERY in-ter-est-ing! Next 3 issues $1. "The Ham Trader", Sycamore, IL 60178.

QSL CARDS 500/$10. 400 *illustrations, sample.* Bowman Printing, Dept. HR, 743 Harvard, St. Louis, MO 63130.

HOMEBREWERS: Stamp brings component list. CPO Surplus, Box 189, Braintree, Mass. 02184.

CREATIVE QSL CARDS — New designs. Send 50¢, receive catalog, samples. WILKINS CREATIVE PRINTING, Box 787-2, Atascadero, CA 93422.

SELL: *Tektronic 545B with manual $495. Plug-ins and* calibration equipment also available. WB0JGP. (303) 722-2257.

DRAKE SPR-4 RECEIVER. Mint condition. Includes noise blanker, calibrator and crystals for 10-80M, foreign broadcast, CB. $455. K4KZE, 2337 3rd Place NW, *Birmingham, AL 35215.*

CENTRAL ELECTRONICS 100V $295.00, National NC300 with Johnson 6 & 2 Converter $150.00, TT-16/FG Reperforator $25.00, Tape Reader $15.00, HB 2kW 2 Meter *Linear with three 4 x 150s $75.00,* K0PUX. (308) 254-6330.

ROHN TOWERS — Buy Wholesale from National Distributor — 48′ Foldover Tower $471.50 freight paid — 25G sections $33.86 each — 45G sections $54.89 each — 48′ BX free standing $240.67. Order now and beat August 1 price increase. Hill Radio, 2503 G.E. Road, Bloomington, IL 61701. (309) 663-2141.

YAESU EQUIPMENT OWNERS — Present or Prospective — Join the seven-year-old 3500 member, 46 country, International Fox-Tango Club. Members receive valuable monthly Newsletter, money-saving purchasing service, technical committee consultation, free ads, FT net, more. Back issues of Newsletter available from 1972. To join, send $6 for calendar year (includes all 1978 issues of Newsletter) or $1 creditable towards dues, for complete information and sample Newsletter. Milton Lowens, WA2AOQ/N4ML, 248 Lake Dora Drive, W. Palm Beach, FL 334111.

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CQ AND QST 1950-1975 issues for sale. Send SASE if ordering Ham Radio, 73, or other CQ and QST issues. One dollar minimum order and all issues cost 25¢ each, including USA shipping. Send chronological list and full payment to W6LS, 2814 Empire, Burbank, CA 91504.

TECH MANUALS for Govt. surplus gear — $6.50 each: SP-600JX, URM-25D, OS-8A/U, TS-173/UR. Thousands more available. Send 50¢ (coin) for 22-page list. W3IHD, 7218 Roanne Drive, Washington, DC 20021.

CUSTOM printed and photo QSL's, very economical; free samples. Stamp appreciated. Stu, K2RPZ, Box 412, Rocky Point, NY 11778. (516) 744-6260.

TELETYPE EQUIPMENT for beginners and experienced operators. RTTY machines, parts, supplies. Beginner's special: Model 15 Printer and demodulator $139.00. Dozen black ribbons $6.50; case 40 rolls 11/16 perf. tape $17.50 FOB. Atlantic Surplus Sales, 3730 Nautilus Ave., Brooklyn, N. Y. 11224. Tel: (212) 372-0349.

THE "CADILLAC" of QSL's! Samples: $1.00 (Refundable) — W5YI, Box #1171-D; Garland, Texas 75040.

TELETYPEWRITER PARTS, gears, manuals, supplies, tools, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, FL. 33310. N4TT Buy parts, late machines.

EXCLUSIVELY HAM TELETYPE *24th year, RTTY Journal, articles, news, DX, VHF, classified ads. Sample 35.. $3.50 per year. 1155 Arden Drive, Encinitas, Calif. 92024.*

MANUALS for most ham gear made 1937/1970. Send only 25¢ coin for list of manuals, postpaid. HI, Inc., Box H864, Council Bluffs, Iowa 51501.

QSL FORWARDING SERVICE — 30 cards per dollar. Write: QSL Express, 30 Lockwood Lane, West Chester, PA. 19380.

RECEIVE PARTS LISTS regularly for $4/yr. Surplus Parts, P.O. Box 7057, Norfolk, VA 23509.

WANT UP-TO-DATE INFORMATION? Radio-Hobbyist Newsletter issued every 2 weeks. Only $5.00 year. W5YI, Box 1171-D, Garland, Texas 75040.

EZ deals are the best! Try me and see for Yaesu, Drake, KLM, Swan, Cushcraft, DenTron, VHF Eng, ICOM, CDE, Hustler, Wilson and more. Call, see or write WØEZ, Bob Smith Electronics, RFD 3, Hwy 169 & 7, Fort Dodge, IA 50501. (515) 576-3886.

THE MEASUREMENT SHOP has used/reconditioned test equipment at sensible prices; catalog. 2 West 22nd St., Baltimore, MD 21218.

RADIO MUSEUM NOW OPEN. Free admission, 15,000 pieces of equipment from 1850 telegraph instruments to amateur and commercial transmitters of the 1920s. Amateur station W2AN. Write for information: Antique Wireless Assn., Main St., Holcomb, NY 14469.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz ± 20 ppm Coldweld crystals. 1 ppm/yr. 32 pF. C_o 6 pF. $4.25 ea. postpaid. Savoy Electronics, Inc., P.O. Box 5727, Ft. Lauderdale, FL 33310. 305-563-1333.

AUTHORIZED DISTRIBUTOR F9FT Antennas, Microwave Modules, RIW Products' new tandem reflector, 19 element, 432 MHz Yagi — Radio Clinic — N2MB (formerly WA2BIT) 212-327-4952.

SEE SST ANTENNA TUNERS — Large ad this issue. Builders also send for our catalog of hard-to-find components and much more. SST Warehouse Outlet, 1215 Manhattan Ave., Hermosa Beach, CA 90254. (213) 376-5887.

HENRY 4K-2 Linear 4kW SSB, 2 kW CW, 3.5/30 MHz floor model, used little, mint $700 K6PS, 4211 Beresford Way, Flintridge, CA 91011.

SWAN 500C w/ac supply, good cond., $400; Swan 350 w/ac, mint, $300; 12 V supply for either $35, Johnson kW match box $75; SWR bridge for above $25, 150 acres water front near Baddeck, Nova Scotia, $20,000; K6PS, 4211 Beresford Way, Flintridge, CA 91011.

HAM RADIO HORIZONS, a super new magazine for the Beginner, the Novice and anyone interested in Amateur Radio . . . What it's all about, How to get started, The fun of ham radio. It's all here and just $10.00 per year. HURRY! HURRY! Ham Radio HOIRZONS, Greenville, NH 03048.

TEST EQUIPMENT CATALOG listing used Tektronix, HP and GR eqiupment at bargain prices. PTI, Box 8699, White Bear Lake, MN 55110. Price $1.00 refundable with first order.

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QSL CARDS. Design your own and have printed for less than 3¢ each! Complete instructions. $1.00. Lionel Industries, Box 64, Lincoln, MA 01773.

STOP LOOKING for a good deal on amateur radio equipment — you've found it here — at your amateur radio headquarters in the heart of the Midwest. We may not have a toll free number but we'll save you more in the long run! We are factory-authorized dealers for Kenwood, Drake, Yaesu, Collins, Wilson, Ten-Tec, Atlas, ICOM, DenTron, MFJ, Tempo, Regency, Hy-Gain, Mosley, Alpha, CushCraft, Swan, and many more. Write or call us today for low quote and try our personal and friendly Hoosier service. HOOSIER ELECTRONICS, P.O. Box 2001, Terre Haute, Indiana 47802. (812) 238-1456.

WANTED — manuals, info, schematics, for: TS-1871 Spectrum analyzer, 881-M1 EEC VLF Receiver, R-839/FLR-2 Receiver, TPG-2 Pulse Generator, R-1037E Receiver, R-1010 AC Regulator. Kernaghan, P.O. Box 17688, Honolulu, HI 96817.

QUARTZ CRYSTAL CONTROLLED Clock Movements — $15.95. Transistorized Movement — $7.95. Hands included use 'C' cell. Peko, Box 5476, Sherman Oaks, CA 91413.

SWAN 350 TRANSCEIVER, power supply, speaker and home brew RF power meter. All good condition $250. You ship. Ray Foster WA2OOH, Cranford, N. J. 07016. (201) 276-8429.

40' ROHN TOWER, Galv. Steel, HAM-M rotator, Kirk 2-element tri-band Super Quad for 10, 15 and 20 meters — fiberglass. All in excellent condition, $300. Ray Foster WA2OOH, Cranford, N. J. 07016. (201) 276-8429.

COLLINS 75S3B (SN 17952), 32S3 (SN 13555), 312B4, AC supply, DX Engr Speech Processor, 2.1 and 500 kHz filters, and Hallicrafters "TO" Keyer. $1200.00 firm, will ship. Richard Somers W6NSV, 9197 Crescent Drive, Los Angeles, CA 90046. (213) 654-7481.

ATLAS 215X All Factory Mods (SN 5476) w/noise blanker, MBK mobile mount with cable, MT-1 antenna matching transformer, SWAN #45 All Band antenna w/mount, $550.00, will ship. Richard Somers W6NSV, 9197 Crescent Drive, Los Angeles, CA 90046. (213) 654-7481.

MOTOROLA L-53 & L-43 VHF FM 30 & 30 watt base stations less cabinets, 5 units available, $75.00 each firm, will ship; GENERAL ELECTRIC UHF FM Pre Prog. Base less cabinet, $50.00, will ship; MOTOROLA FSATR 250BRA low-band 250 watt base in cabinet, pick up only, $185.00; MOTOROLA 60 watt VHF Base w/homemade rack mount AC supply less cabinet, will ship, $50.00; Richard Somers W6NSV, 9197 Crescent Drive, Los Angeles, CA 90046. (213) 654-7481.

HALLICRAFTERS FPM-300 80-10 Meter SSB/CW Transceiver w/built-in 12/110/220V supply, will ship, $285.00 firm. Richard Somers W6NSV, 9197 Crescent Drive, Los Angeles, CA 90046. (213) 654-7481.

Coming Events

BYTE, Drink and be merry at the Tidewater Hamfest, Flea Market and Computer Show, Norfolk, Virginia. September 23-24. Over 60,000 sq. ft. of exhibit and flea market space. All indoors. All air-conditioned. Write TRCI, P.O. Box 9371, Norfolk, Virginia 23505.

ILLINOIS: The Sangamon Valley Radio Club of Springfield, Third Annual Hamfest Sunday, September 24th, Sangamon County Fairgrounds in New Berlin, 16 miles west of Springfield. Hear Hugh Vandegrift WA4WME talk on the Clipperton DX-pedition! Various exhibits, kids activities and food. Camping. First Prize — Bearcat 210; Tickets: $1.50 advance, $2.00 at gate. Information — Al K9QFR; Tickets — Carole WB9QWR, write C/O 1025 S. Sixth, Springfield, Illinois 62703.

OHIO: 42nd Annual Cincinnati Hamfest — Sunday, September 17, 1978 at Stricker's Grove on State Route 128, one mile west of Ross (Venice) Ohio. Exhibits, Prizes, Good Food, Refreshments, Flea Market (radio related products only) Music, Good Fellowship, Hidden Transmitter Hunt and Sensational Air Show. No increase in cost, same as last year — $7.50 in advance. For further information: Lillian Abbott, K8CKI, 1424 Main Street, Cincinnati, Ohio 45210.

ELMIRA, NEW YORK HAMFEST — September 30th from 9-5. Door prizes, grand prize, Free Flea Market, tech talks, and more! Contact WA2-FJM, John Breese, 340 West Avenue, Horseheads, New York 14845 for tickets and info.

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LANSING, MI CMARC Swap-Shop. Oct. 1, 1978. Grand Ledge High School. Prizes — Food — Tables. CMARC Box 10073, Lansing, MI 48901.

ILLINOIS: Rockford ARA Hamfest and ARRL State Convention, September 10, 1978, Winnebago County Fairgrounds, Pecatonica, 10 miles west of Rockford on U.S. 20. Large inside and outside display areas; inside tables available $3. Snack bar/free camping (electrical hookup $4). Prizes, microcomputer seminar, ARRL technical discussion, OSCAR presentation, contest talk, Midwest Country Cousins meeting, many others. Come one, come all for FUN. Talk-in on 146.01/61 and 146.52 simplex. Tickets $1.50 advance, $2 at door. SASE to Rockford County Amateur Radio Association, P.O. Box 1744, Rockford, Illinois 61110.

WASHINGTON, DC — 1978 ARRL Technical Symposium Saturday, September 16, 1978 at the Tysons Corner Ramada Inn, Falls Church, Virginia in conjunction with the National Capital DX Association's DXPO 78. The Symposium is managed by the Amateur Radio Research and Development Corporation (AMRAD) and sponsored by the Northern Virginia Amateur Radio Council (NOVARC). Previously unpublished papers are invited on all technical subjects relating to amateur radio. Prospective contributors are asked to forward informal summaries along with a photo of the author and a one-page bio sketch of the author's amateur/electronic background by July 15. Manuscripts are due by August 15. Please write or call: Paul Rinaldo, W4RI, 1524 Springvale Ave., McLean, VA 22101, (703) 356-8918 eves. or weekends.

NINTH ANNUAL DELTA QSO Party sponsored by the Delta Division of the American Radio Relay League, from 1800Z Sept. 23 to 2400Z Sept. 24, 1978. No time or power restrictions. Amateurs outside of the Delta Division will attempt to contact as many amateurs inside of the Delta Division (Ark-La-Miss-Tenn) as possible. Delta Division Amateurs will attempt to contact as many amateurs as possible both inside of and outside of 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 worked, exchange, band, emission, and multiplier. Stations may be worked on each band/mode. Portables and mobiles may be reworked on the same band/mode if they change counties. Suggested Frequencies: CW 50 kHz from low end and SSB 10 kHz from high end, 28590; Novice center of each novice band. Logs must be postmarked no later than Oct. 21 to be eligible for award consideration. Logs will be returned if requested. Send logs to Malcolm P. Keown, W5RUB, 213 Moonmist, Vicksburg, Miss. 39180.

WESTERN ELECTRIC KEARNY RADIO CLUB will host its 19th annual CQ-WE contest October 28-29, 1978. All amateurs employed by or retired from Western Electric, Bell Labs, Teletype Corporation, and AT&T, as well as their club stations, are invited to participate. The phone sessions are Saturday, October 28th from 1700 to 2200, and 2300 to 0300 GMT. CW and RTTY sessions are Sunday, October 29th from 1800 to 2200 and 0000 to 0300 GMT. The *first hour* of each CW session is reserved for contacting Novices and Technicians *only on at least one end* of the two-way QSO. Detailed information and log sheets from the local WORKS COORDINATOR: At Kearny: John Markunas, W2JVJ, Bill Rodney, W2IKH or write Amateur Radio Club, WEKEARNY Club Office, Western Electric Company, 100 Central Avenue, Kearny, New Jersey 07032.

LOUISIANA: New Orleans Hamfest/Computer Fest, September 16th and 17th, Airport Hilton Inn, Kenner, Louisiana. DX Forums, antenna discussions, computer seminars, satellite demonstrations, Navy MARS meeting, FCC exams Sunday morning (make reservations through the committee in advance), Saturday-night *luau* for 300 persons. Special amateur radio information for CBers. Reserve early because the Ali-Spinks fight is the same weekend. Talk-in on 34/94. Details from New Orleans Hamfest/Computerfest, P.O. Box 10111, Jefferson, Louisiana 70181.

OHIO: 36TH ANNUAL FINDLAY HAMFEST — Riverside Park, Findlay, Ohio — Sept. 10th. One of Ohio's Finest Hamfests, Giant Flea Market, Two Meter Xmitter Hunt, MARS, P.O., Buckeye Belles, SSB, Net Meetings, Talk-in — 75/15 and 52/52. Advance tickets $1.50 at the gate $2.00. For tickets and additional information send a SASE to Clark Foltz W8UN, 122 W. Hobart, Findlay, OH 45840.

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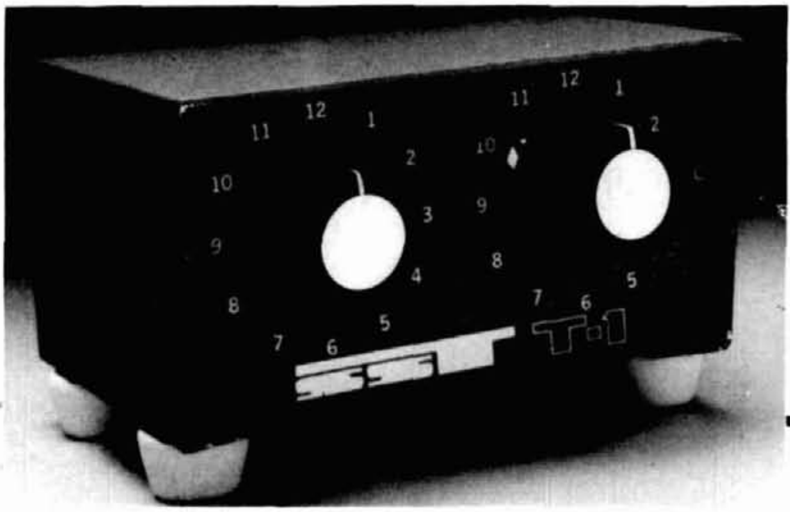
SST T-1 RANDOM WIRE ANTENNA TUNER



All band operation (160-10 meters) with any random length of wire. 200 watt **output** power capability—will work with virtually any transceiver. Ideal for portable or home operation. Great for apartments and hotel rooms—simply run a wire inside, out a window, or anyplace available. Efficient toroid inductor for small size: 4-1/4" x 2-3/8" x 3", and negligible loss. Built-in neon tune-up indicator. SO-239 connector. Attractive bronze finished enclosure.

only $29.95

THE ORIGINAL Random Wire Antenna Tuner. . . in use by amateurs for 6 years.

SST T-2 ULTRA TUNER

Tunes out SWR on any coax fed antenna as well as random wires. Works great on all bands (80-10 meters) with any transceiver running up to 200 watts power **output**.

Increases usable bandwidth of any antenna. Tunes out SWR on mobile whips from inside your car.

Uses efficient toroid inductor and specially made capacitors for small size: 5-1/4" x 2-1/4" x 2-1/2". Rugged, yet compact. Negligible line loss. Attractive bronze finished enclosure. SO-239 coax connectors are used for transmitter input and coax fed antennas. Convenient binding posts are provided for random wire and ground connections.

only $39.95

only $19.95

SST T-3

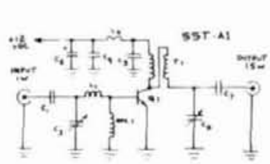
Mobile Impedance Transformer

Matches 52 ohm coax to the lower impedance of a mobile whip or vertical. 12-position switch with taps spread between 3 and 52 ohms. Broadband from 1-30 Mhz. Will work with virtually any transceiver—300 watt **output** power capability. SO-239 connectors. Toroid inductor for small size: 2-3/4" x 2" x 2-1/4". Attractive bronze finish.

GUARANTEE

master charge — VISA

All SST products are guaranteed for 1 year. In addition, they may be returned within 10 days for a full refund (less shipping) if you are not satisfied for any reason. Please add $2 for shipping and handling. Calif. residents, please add sales tax. COD orders OK by phone.



only $29.95

$49.95 wire and tested

SST A-1 VHF Amplifier Kit

1 watt input gives you 15 watts output across the entire 2 meter band without re-tuning. This easy-to-build kit (approx. 1/2 hr. assembly) includes everything you need for a complete amplifier. All top quality components. Compatible with all 1-3 watt 2-meter transceivers. Short and open protected—not damaged by high SWR.

Kit includes:

- Etched and drilled G-10 epoxy solder plated board.
- Heat sink and mounting hardware. All components—including pre-wound coils.
- Top quality TRW RF power transistor.
- Complete assembly instruction with details on a carrier operated T/R switch.

SST ELECTRONICS

P.O. BOX 1 LAWNDALE, CALIF. 90260 · (213) 376-5887

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NEW HAMPSHIRE: Evans Radio, Inc., of Concord, New Hampshire, celebrates its' 45th anniversary as a wholesale distributor of electrical and electronic equipment and components, as well as radio and electronics supplies. An open house will take place September 15, 16 from 9:00 to 4:30 at the firm's headquarters at Route 3A, Bow Junction, and a trade show at the New Hampshire Highway Hotel will feature some 85 displays of electrical and electronic manufacturers products. Buses carrying guests will run continually between the headquarters and trade show throughout the two day celebration. One of the highlights of the day will include a trip for two to a vacation paradise as yet not disclosed.

MICHIGAN: BLOSSOMLAND Annual Swap-Shop, Sunday, October 1st, Berrien County Youth Fair Grounds, Berrien Springs. Large facilities. Prizes, refreshments. Open all night for set-up. Table space restricted to radio and electronic items. Advance ticket $1.50. Tables $2. Write: John Sullivan, P.O. Box 345, St. Joseph, Mich. 49085. Make checks payable to Blossomland Hamfest.

GEORGIA: August ARCA Hamfest, Sunday, September 17 at Julian Smith Casino. Hospitality room Saturday. Bar-B-Q Sunday. Bingo, flea market, prizes. Prize tickets $1.00, 6 for $5.00. For info: ARCA, Box 3072, Augusta, GA 30904.

GEORGIA: Lanierland ARC fifth annual Hamnic Lanier Islands Dogwood Pavilion, Gainesville. September 24. Swap-shop, exhibits. Food. $2.00 per car. Picnic, hiking, swimming for kids. First prize: KDK FM2015R. Other prizes. Talk-in on W4IKR on .07/.67. For info write: Bob Cochran, W4DNX, 607 East Lake Dr., Gainesville, GA 30501.

PENNSYLVANIA: Central Pennsylvania Repeater Association's 5th annual Electronic Swap Fest. Sunday, September 17, Harrisburg. Gates open 8:00 AM. Park-N-Shop garage, Walnut St. Registration: $3.00, spouse and children free. Free tailgating. Talk-in 146.16/.76, 146.34/.94, WA3KXG .52/.52. Refreshments. For info: WB3HXH, (717) 944-7017.

PENNSYLVANIA: Third annual HamJam sponsored by the Radio Association of Erie, Sunday, September 24 from 9 AM to 4 PM at Waldameer Park in Erie. Admission $1.50 advance, $2.00 at the gate. Refreshments, prizes, talk-in on 34/94, 22/82 and 52. Write HamJam '78, Radio Association of Erie, Box 844, Erie, PA 16512.

IOWA: Cedar Valley ARC ARRL Hamfest, Sunday, October 8. Hawkeye Downs Exhibition Building. Doors open 7:00 AM. Tickets: $1.50 advance, $2.00 door. Tables: 1st — $3.00, others $5.00. Overnight camping, picnic area, movies. Many prizes. Talk-in 146.16-.76, 146.52, 223.5, 3.970. Early birds: 2 meter XMTR Hunt, 2:00 PM Saturday, October 7. 2 free steak dinners to winner. For info write: CVARC Hamfest, P.O. Box 994, Cedar Rapids, IA 52406.

SOUTH TEXAS SWAPFEST — Corpus Christi, Texas. Saturday, September 30, 1978. 9 to 5. Texas National Guard Armory, 1430 Horne Rd. Free admission and tables. Dealer displays, contests, door prizes. Talk-in 34/94, 28/88. Jointly sponored by Corpus Christi ARC and So. Texas Amateur Repeater Club. Additional info from J. E. Rehler, W5KNZ, 526 Pasadena, Corpus Christi, Texas 78411.

FLORIDA: The 13th Annual Melbourne Hamfest, Saturday and Sunday, September 9-10, 9 AM to 5 PM at the Melbourne Civic Auditorium, Hibiscus Boulevard. Donation is $3.50 per family. Forums, meetings, swap tables, commercial exhibits, awards, prizes. Talk-in on 25/85 and 52. Sponsored by Platinum Coast ARS. For more info write P.O. Box 1004, Melbourne, FL 32901.

ARIZONA: The Cochise Amateur Radio Association's 4th Annual Round-Up, September 9. Sierra Vista Community Center, starting at 0900. Talk-in on 16/76 and 52/52. First prize is Atlas 210X, plus many others. For tickets and more info, write CARA, P.O. Box 1855, Sierra Vista, AZ 85635. Tickets are $3.00.

OHIO: Cincinnati Hamfest, Sunday, September 17, Stricker's Grove, Venice (Ross). Exhibits, flea market, prizes, air show. $7.50 advance. For info request Hamfest issue of "The Mike and Key", W8ALW, 3965 Harmar Ct., Cincinnati, OH 45211, WA8STX, 10615 Thornview Dr., Cincinnati, OH 45241, K8CKI, 1424 Main St., Cincinnati, OH 45210.

INDIANA: 21st annual Peoria Hamfest, Sept. 17, Exposition Gardens, W. Northmoore Rd. Admission: $1.50 advance, $2.00 door, grounds free. Ladies free bus trip to shopping mall. 100 stores. 2-meter talk-in 146.76. Local repeaters 16-76, 25-85, 37-97. Write: John Sutton, WD9BJJ, 608 W. Teton Dr., Peoria, IL 61614.

More Details? CHECK—OFF Page 142

flea market

CALIFORNIA: 1978 Region 6 AFCS MARS Conference. Hosted by Mather Air Force Base Support Team, 29 September — 1 October 1978, at The Mansion Inn, Sacramento. Tours of Mather AFB, Seminar by Command MARS Director, Regional and State reports, Emergency exercise highlights, Open forum discussions, Banquet, Awards, Equipment drawings; Reports on MTS program, equipment issue, emergency operations, improvements; papers on switching power supplies, becoming a frequency monitor, and much more. Specially selected location brings lots for XYL and kids to see and do within walking distance. Details from Jack Bayha, 23009 Vanowen St., Canoga Park, California 91304. Tel: (213) 887-4568 evenings or call on 6S1.

NEW YORK: Ham-O-Rama "78", Saturday, September 16, 9:00 AM to 5:00 PM, Erie County Fairgrounds just south of Buffalo, NY. Flea markets, women's programs, contests, prizes. Admission: $3.00 advance, $4.00 gate, Children under 12 free. Recreational parking with hookup $4.00. Talk-in on WR2ABU 146.31/91. For further info: Bert Jones, W2CUU, 143 Orchard Dr., Kenmore, NY 14223, (716) 873-3984 or Jim Ciurczak, WB2IVO, 10404 Cayuga Dr., Niagara Falls, NY 14304, (716) 297-0539.

PENNSYLVANIA: Butler County ARA Hamfest Sunday, September 10, from 11 AM to 4 PM, Butler County Farm Show Grounds adjacent to Butler Roe Airport with a paved runway for fly-ins. Check-ins on 90/30 and 52 simplex. For further info contact John, K3HJH, or Cliff, WB3CDA.

PENNSYLVANIA: 2nd annual Mid-Atlantic States VHF conference Saturday, September 30, Treadway Inn on Easton Rd., Willow Grove. Advance registration includes admission to Hamarama '78. — Mt. Airy VHF Radio Club Hamarama '78 at Bucks Co. Drive-In Theater, Route 611, Warrington, Sunday, October 1, 8:00 AM to 4:00 PM. Registration $2.00, tailgating $2.00/space (own table). Talk-in via W3CCX/3 on 146.52. Information for both events: Ron Whitsel, WA3AXV, Chairman, P.O. Box 353, Southampton, PA 18966. (215) 355-5370.

PENNSYLVANIA: Skyviews annual swap and shop, Saturday, September 17, new location, Sokol Camp, Lower Burrell. Registration $1.00 at gate. First prize: Icom IC22S. CW contest. Talk-in 146.04/64. For info write: Jim Jackson, Jr., K3VRU, Rt. #1, Box 7A, Apollo, PA 15613.

ILLINOIS: Peoria Area ARCs 21st Annual Hamfest, Sunday, September 17th at the Exposition Gardens. Free coffee and donuts 8:30 to 9:00 AM. Camping space available Saturday night. Smorgasbord dinner Heritage House Restaurant at 7:00 PM Saturday, no reservations. Free bus trip to Northwoods Mall for the ladies. Talk-in .16/.76, call W9UVI. Advance tickets $1.50, Door tickets $2.00. Write John Sutton, WD9BJJ, 608 W. Teton Drive, Peoria, Illinois 61614.

KENTUCKY: The Eighth Annual Greater Louisville Hamfest Saturday, Sept. 30th and Sunday, Oct. 1st at the West Hall of the Kentucky Fair and Exposition Center in Louisville. Air conditioned indoor exhibitors area and flea market, a ladies program. Camping is free on grounds (no hook ups). For more information contact Greater Louisville Hamfest, P.O. Box 34444, Louisville, KY 40232 or phone (502) 634-0619.

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RADIO EXPO '78. Special late dates for this year only are September 30, October 1. Dozens of exhibits. Indoor/outdoor flea market, open Friday for set-up. Free camping. Thousands of dollars in door prizes. The convention center is the Holiday Inn, Mundelein, IL. Tickets: $2 advance, $3 gate. The Lake County IL Fairgrounds at Routes 45 and 120 in Grayslake, IL. For info or tickets, write Chicago FM Club, P.O. Box 305, Maywood, IL 60135.

MICHIGAN: L'Anse Creuse ARC's 6th annual swap and shop. September 17, L'Anse Creuse High School, Mt. Clemens 0900-1500. Prizes. Talk-in 14769.09 and 146.52. $1.50 door, $1.00 advance. SASE to WB8ZME, 35751 Dunston, Sterling Heights, MI 48077.

MICHIGAN: Adrian Hamfest Sept. 24, Lenawee County Fairgrounds, Adrian. Tickets: $1.50 advance, $2.00 gate. Tables: $4.00 full table, $2.00 half. Trunk sales: $1.00 per space. Write: Adrian ARC, P.O. Box 26, Adrian, MI 49221. (517) 265-8016. Talk-in W8TQE on 146.31/91 or 146.52 MHz.

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SKL24	24 pin	3/ 1.10
SKL36	36 pin	5/ 2.75
SKL40	40 pin	2/ 1.25

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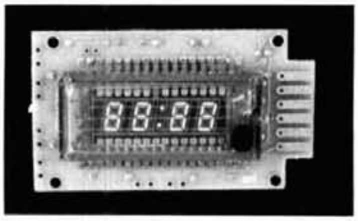

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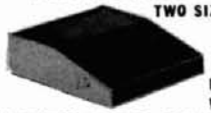

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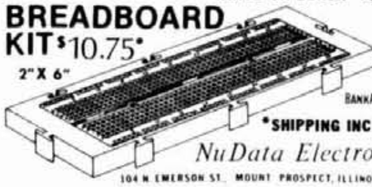

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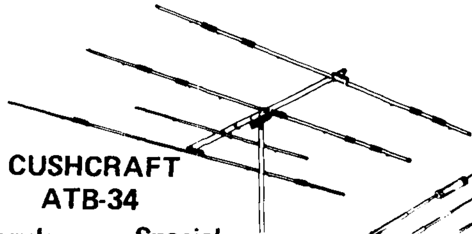

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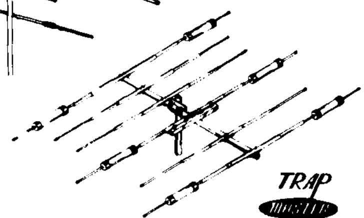

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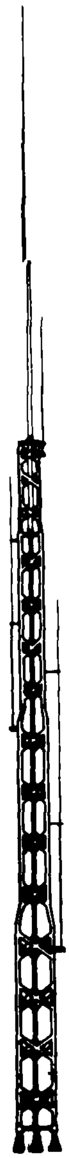

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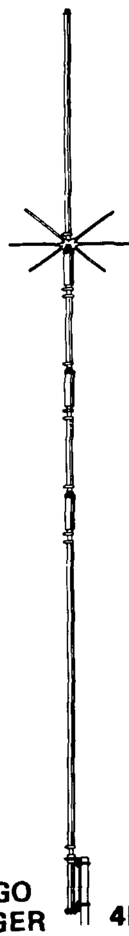

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Oklahoma

RADIO STORE, INC.
2102 SOUTHWEST 59th ST.
(AT 59th & S. PENNSYLVANIA)
OKLAHOMA CITY, OK 73119
405-682-2929
New and used equipment — parts and supply.

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PORTLAND RADIO SUPPLY CO.
1234 S.W. STARK STREET
PORTLAND, OREGON 97205
503-228-8647
Second location, 1133 S. Riverside Avenue, Medford, OR 97501.

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ARTCO ELECTRONICS
302 WYOMING AVENUE
KINGSTON, PA 18704
717-288-8585
The largest variety of semiconductors in Northeastern Pennsylvania

ELECTRONIC EXCHANGE
136 N. MAIN STREET
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Demonstrations, Sales, Service
New/Used Amateur Radio Equip.

"HAM" BUERGER, INC.
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Delaware Valley's Fastest Growing Amateur Radio Store

HAMTRONICS, DIV. OF TREVOSE ELECTRONICS
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Same Location for 30 Years.

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AGL ELECTRONICS
3068 FOREST LANE, SUITE 309
DALLAS, TX 75234
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Out-of-State, Call our toll-free number 800-527-7418.

HARDIN ELECTRONICS
5635 E. ROSEDALE
FT. WORTH, TX 76112
817-461-9761
Your Full Line Authorized Yaesu Dealer.

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AMATEUR ELECTRONIC SUPPLY, INC.
4828 WEST FOND du LAC AVENUE
MILWAUKEE, WI 53216
414-444-4200
Open Mon & Fri 9-9, Tues, Wed, Thurs, 9-5:30, Sat, 9-3.

Washington

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First in Ham Radio in Washington
Northwest Bird Distributor

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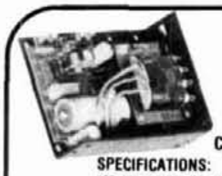


ELPAC POWER SUPPLIES

Completely Assembled

SPECIFICATIONS:

105-125/210-250 Vac, 47-440 Hz input:

Line Regulation	±0.1%
Load Regulation	±0.1%no-load to rated-load
Output Ripple and Noise	±0.1%p-p,dc to 10 MHz
Input/Output Isolation	100 megohm dc, 900 Vac
Short Circuit Current	35% rated current

PART NO.	WATTS	VOLTS	AMPS	PRICE
SOLV15-5*	15	5	3	$36.95
SOLV15-12*	15	12	1.5	36.95
SOLV30-5	30	5	6	59.95
SOLV30-12	30	12	3	59.95
OVP1	over voltage protection for SOLV30-5,-12			9.95

*SOLV15-5, 12 includes OVP installed

NEW! BULB-ENERGY SAVER

BULB-ENERGY SAVERS used for years by major industrial users — now available for home or office use. Bulb Savers can cut electrical bills by as much as 3%. BULB-SAVERS lengthens light life by:

1. Acting as an electrical "shock absorber" turns the bulb on slowly, eliminating the "thermal shock". Bulb life increases 300 percent.
2. Banishes Current "Surges". Cushions line voltage surges when other loads cut power line.
3. Reduces Energy Consumption.

Bulb lasts 3 or more times longer. Fits Standard Socket 6 watts to 200 watts

	1-9	10+
BES-1	1.39 ea.	1.20

CRYSTALS

THESE FREQUENCIES ONLY

PART NO.	FREQUENCY	CASE	PRICE
CY1A	1.000MHz	HC33	5.95
CY1.84	1.8432MHz	HC33	5.95
CY2A	2.000MHz	HC33	5.95
CY2.01	2.010MHz	HC33	1.95
CY2.50	2.500MHz	HC33	4.95
CY3.27	3.2768MHz	HC33	4.95
CY3.57	3.579545MHz	HC33	4.95
CY3A	4.000MHz	HC18	4.95
CY4.91	4.916MHz	HC18	4.95
CY7A	5.000MHz	HC18	4.95
CY5.18	5.185MHz	HC18	4.95
CY6.14	6.144MHz	HC18	4.95
CY6.40	6.400MHz	HC18	4.95
CY6.55	6.5536MHz	HC18	4.95
CY12A	10.000MHz	HC18	4.95
CY14A	14.31818MHz	HC18	4.95
CY19A	18.000MHz	HC18	4.95
CY18.43	18.432MHz	HC18	4.95
CY22A	20.000MHz	HC18	4.95
CY30A	32.000MHz	HC18	4.95

TRIMMERS

10MM size trimmers - .394" Dia.

Part No.	1-9	10-24	25-49	100+
TR-11(valve)	.35	.30	.25	.20

Resistance values - 100, 500, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1 meg

TRIMPOTS

Single-Turn - 1/2 Watt

Square - Top Adjust - 3/8" Size

Part No.	1-9	10-24	25-49	50-99
840P(value)	.99	.89	.80	.70

Resistance Values - 50, 100, 500, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 500K, 1 meg

15-Turn - 3/4 Watt

Rectangular Side Adjust 3/4" x 1/4" Size

Part No.	1-9	10-24	25-49	50-99
830P(value)	1.35	1.25	1.20	1.15

Resistance Values - 50, 100, 500, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 500K, 1 meg

1/16 VECTOR BOARD

0.1 Hole Spacing

	Part No.	P Pattern L	W	Price 1-9	10 up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062WE	4.50	6.50	2.07	1.86
	84P44 062WE	4.50	8.50	2.56	2.31
	169P44 062WE	4.50	17.00	5.04	4.53
	169P84 062WE	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062WEC1	4.50	17.00	6.80	6.12

CONNECTORS

25 Pin-D Subminiature

DB25P(as pictured)	PLUG	$3.25
DB25S	SOCKET	4.95
DB51226-1	Cover for DB25 P or S	1.75

MOLEX CONNECTOR PINS

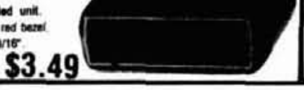
M-530-1 $1.95/100 pins (minimum order) $16.00/1000 pins

Pre-packaged in strips

INSTRUMENT/CLOCK CASE

Injection molded unit. Complete with red bezel. 4½" x 4" x 1-9/16"

$3.49



MICROPROCESSOR COMPONENTS

P8085	CPU	$29.95	CDP 1802	CPU	$19.95
8080A	CPU	10.95	Z80	CPU	24.95
8212	8-Bit Input/Output	4.95	2650	MPU	26.50
8214	Priority Interrupt Control	7.95	MC6800	MPU	19.95
8216	Bi-Directional Bus Driver	4.95	MC6810API	128 x 8 Static Ram	5.95
8224	Clock Generator/Driver	5.95	MC6820	Periph. Interface Adapter	7.95
8228	System Controller/Bus Driver	5.95	MC6821	Periph. Interface Adapter	11.50
8251	Prog. Comm. Interface	9.95	MC6830L8	1024 x 8 Bit ROM	14.95
8255	Prog. Periph. Interface	10.95	MC6850	Asychronous Comm. Adapter	14.95

RAM'S

1101	256 x 1	Static	$1.49
1103	1024 x 1	Dynamic	.99
2101	256 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107/5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
2112	256 x 4	Static	5.95
2114	4K x 1	Static 450ns	9.95
2114L	4K x 1	Static 450ns Low Power	10.95
2114-3	1K x 4	Static 300ns	10.95
2114L-3	1K x 4	Static 300ns Low Power	11.95
7489	16 x 4	Static	1.75
8101	256 x 4	Static	5.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
21L02	1024 x 1	Static	1.95
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MM5262	2K x 1	Dynamic	3/1.00
MK4027 (UPD414)	4K	DYNAMIC 16 PIN	5.95
MK4116 (UPD416)	16K	DYNAMIC 16 PIN	29.95
TMS4044-45NL	4K	STATIC	14.95

ROM'S

2513(2140)	Character Generator (upper case)	$9.95
2513(3021)	Character Generator (lower case)	9.95
2516	Character Generator	10.95
MM5230N	2048 Bit Read Only Memory	1.95

USER MANUALS

1802M	CDP1802 Manual	$7.50
Z80M	Z80 Manual	7.50
2650M	2650 Manual	5.00

PROMS

1702A	2048 x 1	Famous	$5.95
5203	2048 x 1	Famous	14.95
82S23	32 x 8	Open C	5.00
82S115	4096 x 1	Bipolar	19.95
82S123	32 x 8	Tristate	5.00
74S287	1024 x 1	Static	7.95
2708	8K	EPROM	10.95
2716 T.I.	16K	EPROM	29.95
2716 Intel (2516 T.I.)	16K	EPROM	59.95
6301-1	1024 x 1	Tri-State Bipolar	3.49
6330-1	256 x 1	Open C Bipolar	2.95
74186	512 x 1	TTL Open Collector	9.95
74188	256 x 1	TTL Open Collector	3.95

SHIFT REGISTERS

MM5013N	1024 BitAccumulator Dynamic	2.95
MM5016H	500/512 Bit Dynamic	.89
MM5017N	Dual 500/512 Bit Dynamic	2.95
25047	1024 Dynamic	3.95
2518	Hex 32 Bit Static	4.95
2519	Hex 40 Bit Static	4.00
2522	Dual 132 Bit Static	7.95
2524	512 Dynamic	.99
2525	1024 Dynamic	2.95
2527	Dual 256 Bit Static	2.95
2528	Dual 250 Static	4.00
2529	Dual 240 Bit Static	4.00
2532	Quad 80 Bit Static	2.95
2533	1024 Static	2.95
3341	Fifo	6.95
74LS670	4 X 4 Register	1.95

UART'S

AY-5-1013	30K BAUD	$5.95

SPECIAL REQUESTED ITEMS

TELEPHONE KEYBOARD CHIPS

AY-5-9100	$14.95
AY-5-9200	14.95
AY-5-9500	4.95
AY-5-2376	14.95
HD0165	7.95
74C922	9.95

ICM CHIPS

ICM7045	$24.95
ICM7205	19.95
ICM7207	7.50
ICM7208	19.95
ICM7209	6.95

NMOS READ ONLY MEMORIES

MCM6571	$13.50
MCM6574	13.50
MCM6575	13.50

TV GAME CHIP SET
AY-3-8500-1 Chip and 2.010 MHZ Crystal **$7.95**

MISCELLANEOUS

11C90	$19.95	MK40240	$17.50
MC3061P	11.95	DS0026CH	3.75
MC1408L7	4.95	TIL308	10.20
MC1408L8	5.75	95H90	11.95
LD110/111	$25.00/set		
MC4016(74416)	7.50		
4N33	3.95		

NEW

The Sinclair PDM35. A personal digital multimeter for only $59.95

Now everyone can afford to own a digital multimeter

A digital multimeter used to mean an expensive, bulky piece of equipment.

The Sinclair PDM35 changes that. It's got all the functions and features you want in a digital multimeter, yet they're neatly packaged in a rugged but light pocket-size case, ready to go anywhere.

The Sinclair PDM35 is supplied completely assembled with test leads and prods, protective wallet and Operator's Manual.

The Sinclair PDM35 is tailor-made for anyone who needs to make rapid measurements. Development engineers, field service engineers, lab technicians, computer specialists, radio and electronic hobbyists will find it ideal.

Technical specification

DC Volts (4 ranges) Range: 1mV to 1000 V. Accuracy of reading 1.0% ± 1 count. Note: 10 MΩ input impedance

AC Volts (40 Hz-5 kHz) Range: 1V to 500 V. Accuracy of reading 1.0% ± 2 counts

DC Current (8 ranges) Range: 1nA to 200 mA. Accuracy of reading 1.0% ± 1 count. Note: Max resolution 0.1 nA

Resistance (5 ranges) Range: 1Ω to 20 MΩ. Accuracy of reading 1.5% ± 1 count. Also provides 5 junction-test ranges

Dimensions: 6 in x 3 in x 1½ in.

Weight: 6½ oz

Power supply: 9 V battery or Sinclair AC adapter (battery not incl.)

Sockets: Standard 4 mm for resilient plugs

Options: AC adapter for 117 V 60 Hz power. De-luxe padded carrying wallet.

PART NO.	DESCRIPTION	PRICE
PDM35	Digital Multimeter (Completely Assembled)	$59.95
PDM-AC	117volt AC Adapter	6.95
PDM-DP	Deluxe padded carrying case	6.95

B&K PRECISION 3½-Digit Portable DMM

- Overload Protected
- .3" high LED Display
- Battery or AC operation
- Auto Zeroing
- 1mv 1Va 0.1 ohm resolution
- Overange reading
- 10 meg input impendence
- DC Accuracy 1% typical

Ranges: DC Voltage - 0-1000V. AC Voltage 0-1000V. Freq. Response 50-400 HZ. DC/AC Current 0-100mA. Resistance 0-10 meg ohm. Size 6.4" x 4.4" x 2"

Model 2800 $99.95

Comes with test leads, operating manual and spare fuse

Accessories:

AC Adapter BC-28	$9.00
Rechargeable Batteries BP-26	20.00
Carrying Case LC-28	7.50

CSC 100 MHz 8-Digit Counter

- 20 Hz-100 MHz Range
- .6" LED Display
- Crystal-controlled timebase
- Fully Automatic
- Portable — completely self-contained
- Size — 1.75" x 7.38" x 5.63"
- Four power souces, i.e. batteries, 110 or 220V with charger, 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 $134.95

ACCESSORIES FOR MAX 100:

Mobile Charger Eliminator use power from car battery — **Model 100 — CLA $3.95**

Charger/Eliminator use 110 V AC — **Model 100 — CAI $9.95**

KEYBOARDS

63-Key Unencoded — Hexadecimal Encoder

This is a 63-key, terminal keyboard newly manufactured by a large computer manufacturer. It is unencoded with SPST keys, unattached to any kind of PC board. A very solid molded plastic 13 x 4" base suits most application. IN STOCK **$29.95/each**

19-key pad includes 1-10 keys, ABCDEF and 2 optional keys and a shift key. **$10.95/each**

$5.00 Minimum Order – U.S. Funds Only
California Residents – Add 6% Sales Tax

Spec Sheets – 25¢
1978 A Catalog Available—Send 41¢ stamp

NEW NAME

Jameco ELECTRONICS

A Division of JAMES ELECTRONICS of California

PHONE ORDERS WELCOME (415) 592-8097

MAIL ORDER ELECTRONICS – WORLDWIDE

1021 HOWARD AVENUE, SAN CARLOS, CA 94070

Advertised Prices Good Thru September

The Incredible "Pennywhistle 103"

$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications for the deaf. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable)
Maximum Data Rate	300 Baud
Data Format	Asynchronous Serial (return to mark level required between each character)
Receive Channel Frequencies	2025 Hz for space, 2225 Hz for mark
Transmit Channel Frequencies	Switch selectable: Low (normal) – 1070 space, 1270 mark; High – 025 space, 2225 mark
Receive Sensitivity	-46 dbm acoustically coupled
Transmit Level	-15 dbm nominal. Adjustable from -6 dbm to -20 dbm
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar)
Power Requirements	120 VAC, single phase, 10 Watts
Physical	All components mount on a single 5" by 9" printed circuit board. All components included

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align.

The Original the 3rd Hand

$9.95 each

- Leaves two hands free for working
- Clamps on edge of bench, table or work bench
- Position board on angle or flat position for soldering or clipping
- Sturdy, aluminum construction for hobbyist, manufacturer or school rooms

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One: Times Single Event — Split & Taylor
- Size 4.5 x 2.15 x .90 (4½ ounces)
- Uses 3 Penlite Cells

Kit — $39.95
Assembled — $49.95
Heavy Duty Carry Case $5.95

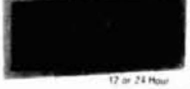
Stop Watch Chip Only (7205) $19.95

imc 3½ DIGIT DPM KIT

- New Bipolar Unit
- Auto Zeroing
- .5" LED
- Auto Polarity
- Low Power
- Single IC Unit

Model KB500 DPM Kit	**$49.00**
Model KB503 5V Power Kit	**$17.50**

JE700 CLOCK



The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2¼" x 1". It utilizes a MAN72 high brightness readout and the MM5314 clock chip.

12 or 24 Hour

115 VAC

KIT ONLY **$16.95**

JE803 PROBE

The Logic Probe is a unit which is for the most part indespensible in trouble-shooting logic families, TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols: (HI) 1 (LOW) 0 (PULSE) P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit

printed circuit board

T²L 5V 1A Supply

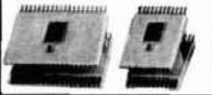
This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only **JE225 $9.95 Per Kit**

CSC PROTO BOARDS

PROTO BOARD 6 $15.95 (6" long X 4" wide)

PB100 - 4.5" x 6"	$19.95
PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6½ x 2¾	80.00
PB203A - 9.75 x 6½ x 2¾ (includes power supply)	129.95

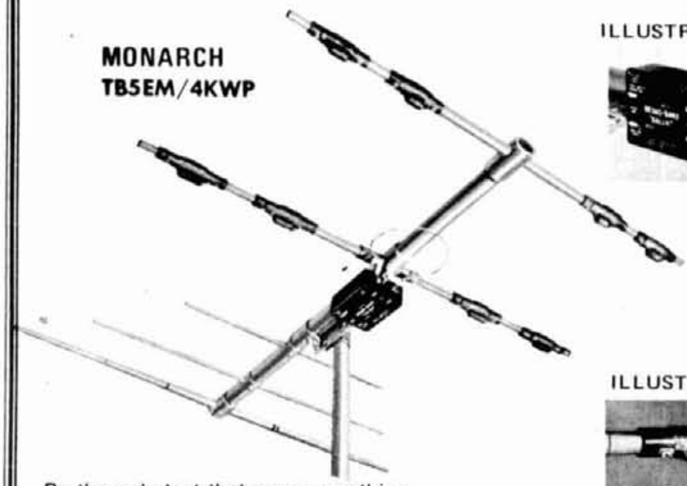
PROTO CLIPS

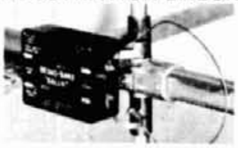


14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50
40 PIN	13.75

More Details? CHECK—OFF Page 142

More Details? CHECK—OFF Page 142



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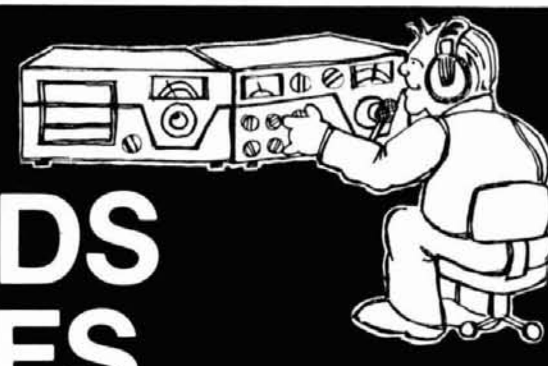

CALL TOLL FREE! 1-800-633-3410

Lumitime CC-24 24 hour digital clock

The CC-24 is the perfect addition to any ham shack. Large 2 inch digital display makes telling time easy at a glance. • 24 hour alarm with 8-10 min. snooze button can also be used as a station ID buzzer. • 110 volts A/C operation.

29.95 Call for yours today.

KENWOOD MC-50 desk microphone

The MC-50 dynamic mike has been designed expressly for amateur radio operation. • Complete with PTT & LOCK switches. • Easy conversion from HI to LOW impedance • Unidirectional • Mike plug on coil cord for instant hook-up to any Kenwood rig.

39.50
Call for quote.

DENTRON Big Dummy Load

Tune-up off the air with Dentron's Big Dummy Load. A full power dummy load, it has a flat SWR, full frequency coverage from 1.8 to 300 MHz. A high grade industrial cooling oil is furnished with the unit. Fully assembled and warrantied. Help cut out the QRM factor NOW!

29.50 Call for yours today.

YAESU SP-101PB speaker / phone patch

The SP-101PB features a response speaker from 300 to 3000 Hz • Built-in hybrid phone patch • VU meter • Full VOX phone patch operation • Receiver input impedance: 4 or 600 ohm • Output impedance: 600 ohm or high impedance.

64.00 Call for yours today.

AEA AD-1 automatic dialer

You get 18 numbers from a 1-2 punch. Make quick and safe auto patch calls. The AD-1 features: • Key-Pad programmable memory • Built in speaker • MOS micro-processor • Crystal controlled • Mates with virtually all amateur FM transceivers.

129.95 List. Call for quote.

VISA **Long's Electronics** master charge

MAIL ORDERS: P.O. BOX 11347 BIRMINGHAM, AL 35202 • STREET ADDRESS: 2808 7TH AVENUE SOUTH BIRMINGHAM, ALABAMA 35233

Remember, you can Call Toll Free: **1-800-633-3410** in the U.S.A. or call **1-800-292-8668** in Alabama for our low price quote. Store hours: 9:00 AM til 5:30 PM, Monday thru Friday.

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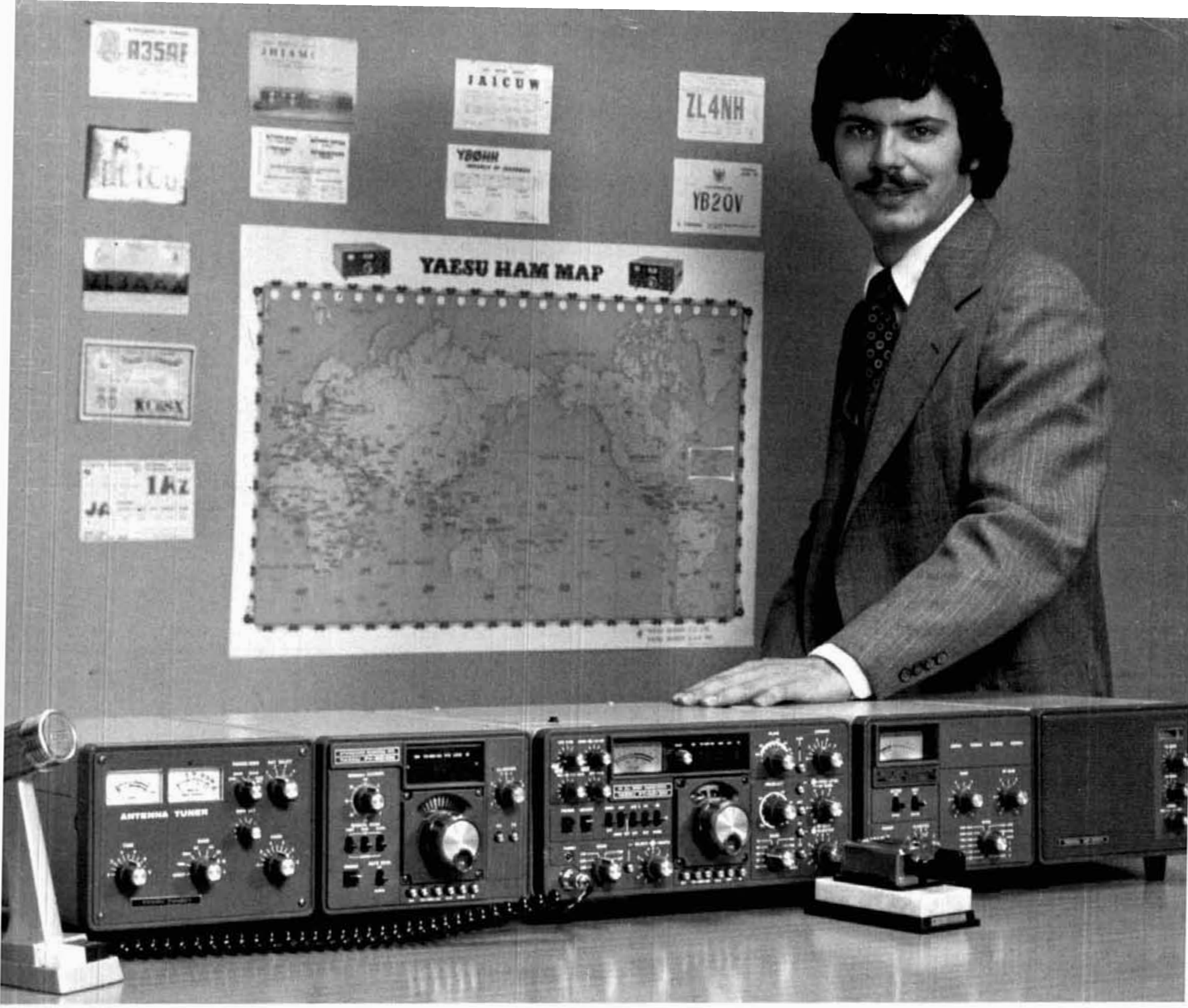
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