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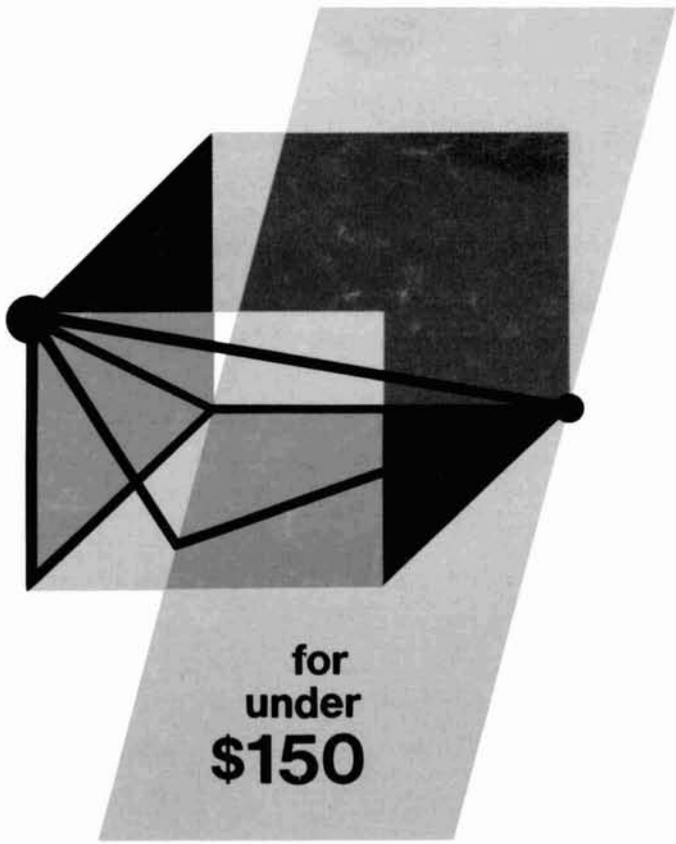
ham radio magazine

MARCH 1980

SATELLITE COMPUTER



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* With touch tone pad $399.00

Shown with optional touch tone pad

SPECIFICATIONS

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Current Drain:	17 ma-standby 500 ma-transmit
Antenna Impedance:	50 ohms
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More Details? CHECK—OFF Page 94

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magazine

MARCH 1980

volume 13, number 3

contents

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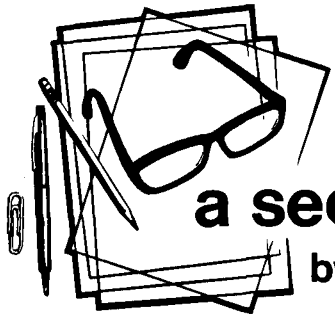

a second look

by Jim Fisk

Just as we were about to go to press with this issue, the FCC adopted rules permitting the use of ASCII (American Standard Code for Information Interchange) on the Amateur bands; at press time the FCC had not yet set a date when Amateur ASCII transmissions would be permitted, but early March was suggested, so it's quite likely that you will hear some ASCII signals on the ham bands by the time you receive this issue of the magazine. If you don't have a terminal unit, however, you probably won't be able to tell any difference from the Baudot code used until now for Amateur RTTY! ASCII is more versatile than Baudot, and is capable of handling 2½ times more individual characters (or unified commands), so it's much more powerful; it will be especially popular with Amateurs who are also computer hobbyists and wish to link their computers and exchange programs over the air.

For those readers who are not familiar with ASCII, it is a standard code used extensively in digital data transmission, and is commonly used when computers "talk" to each other. RTTY and computer enthusiasts have been trying for some time to obtain ASCII authorization for use not only in conventional communications, but also for exchanging digital data, computer control of repeaters and remote stations, and even for exchanging digitized voice and video on the high-frequency bands.

The new FCC rules permit the use of ASCII transmissions (carrier-shift keying, F1) on the same frequencies presently authorized for RTTY between 3500 kHz and 21.25 MHz at a maximum rate of 300 baud. On the RTTY frequencies between 28 and 220 MHz transmission rates up to 1200 baud may be used with carrier-shift keying (F1), AFSK (F2), or amplitude tone-modulated keying (A2); above 420 MHz these modes may be used with rates up to 19.6 kilobaud.

There is also considerable interest in *packet* radio, a digital mode used since 1978 by Canadian Amateurs on the 220-MHz band. Packet radio is basically a time-shared use of the same frequency channel that results in a tremendous savings of spectrum. Look at it this way: it might take you 20 seconds to type a line on your terminal — and only a few thousandths of a second for the computer to process that line and enter it into storage. If the line is not transmitted character by character as you typed it but is sent as a short, high-speed burst at the end of each line, you have packet radio.

At the keying rates permitted on 80 through 15 meters, the typical transmission time for a one-line packet would be something less than 2 seconds, a 10:1 savings over the time required to enter the line into the terminal in the first place. Therefore, up to 10 different stations could communicate on the same packet channel; the significantly higher keying rates permitted at vhf would permit 100 stations or more on the same frequency! You'll be hearing a lot more about packet radio in the months ahead, but in the meantime you may want to read VE2BEN's excellent "Introduction to Packet Radio" which appeared in the June, 1979, issue of *ham radio*.

Jim Fisk, W1HR
editor-in-chief

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Hellschreiber

Dear HR:

The December issue of *ham radio* describes the Hellschreiber typing keyboard machine, and the article mentioned that the shortest pulses are 8.16 ms, producing a speed of 122.5 baud and a minimum bandwidth of 61 Hz.

Unfortunately for the system, the abrupt rise and fall times involved are quite broad. A similar system that has been on 14140 kHz from the Hsinhua News Agency in Peking for years (but now possibly removed at the request of the Intruder Match), is more like 3 or 4 kHz wide at a distance 6241 miles; it was hard to live with. There continue to be other signals here in the mornings on 3577, 3595, and 3845 kHz just before the 80-meter band closes to China.

The system I heard during WW2 was used by German fighter aircraft in interception, and directed from ground by this equipment. That was not so bad because vhf was used, and at some distance in frequency from other communications circuits. I think that it is a mistake to encourage the use of this system of 14 emission, which is *not* authorized by FCC Regulations, Section 97.61, except on frequencies of 51.1 MHz and higher.

My tape of the Hsinhua transmissions was printed by G5XB, who thought that it was difficult for Chinese to read, and shows what would be expected when there may be as many as thirty or so strokes in one character. Obviously, that requires rather good facsimile definition or it might not be possible to read.

E. H. Conklin, K6KA
La Canada, California

Dear HR:

The December issue of your magazine arrived this morning and as usual I sat down to skim it — saving the serious stuff for later.

I was surprised at the Hellschreiber article. You see, I have one of these machines, sitting above the rafters of the shack, waiting until someone came up with the other one.

That last remark is deliberate: It relates to the time of WWII when I was working with the Signal Service Section of the Signal Corps in Liege, Belgium. We were located in rear of the 15th Army; they were sending back captured German equipment to our depot, and we had no orders how to process it. We were very busy reworking our own equipment. I was acting as senior officer in charge of salvage and incoming equipment.

Among the items coming in on the rail cars was this type of equipment. I intercepted three of these Hellschreibers and shipped two home complete and one in parts less the case. Luckily, the case size just fit the maximum package size that could be shipped home. I was also depot security officer, and as such knew what could be shipped and what couldn't. Numerous articles were shipped at my personal expense to the Signal Corps Laboratories at Fort Monmouth, where I had spent several weeks in 1942.

Thanks to the poor work of the Army mail, and over-emphasis on what could, and could not, be received within a country still at war, only one of the Hellschreibers arrived at my father's home address. The other and the parts were not received, but I did receive some papers telling me that it was illegal to ship this stuff (our orders stated that souvenirs could be shipped only if certain papers were put on the outside of the package).

To say I was disgusted and angry is to put it mildly, but having only one Hellschreiber and no spare parts, I simply put it away until I could find use for it. I arrived home in December, 1945, and with a new wife and setting up a home and finding work, it was forgotten for many months.

Therefore, there is at least another of these machines in the United States. It will be marked inside with my call W6DKZ. The parts were not identified, as I thought no one would be interested in them. I am still looking for the missing machine, and would like to get in contact with anyone who might be saving it, as I intended it for a museum. If it turns up, I'll try out the two between some friends here in Santa Clara Valley.

The Hellschreiber machines are all that the writer says they are, although I did not know they would work well through QRM. They were made to work on wire lines as simplex or duplex, with isolating coils, and since they employ a tone and amplifier, they don't interfere with speech on the lines.

Henry B. Plant, W6DKZ
San Jose, California

Apparently the German Wehrmacht was not alone in their use of the Hellschreiber system during World War II. Ed King, WA8PFB, of Louisburg, West Virginia, reports that he has a U.S. Signal Corps BC-918B which has a similar ink pad and worm gear mechanism for "writing" on paper tape, but a photo-cell is used for the input. Ed's BC-918B has a 20-pin plug so it's part of a larger system, but Ed has been unable to locate the matching unit, or even to find a technical manual. Does anyone have any more technical details on this equipment or any ideas how it was used, or know where there might be a technical manual? ***W1HR***

More Details? CHECK—OFF Page 94

presstop

RULES PERMITTING ASCII for U.S. Amateurs were adopted at an FCC Agenda meeting in late January, with its use on Amateur bands likely as soon as early March. In adopting the third Report and Order on Docket 20777, the Commission specified that Amateur ASCII transmissions must conform to ANSI Standard X3.4-1968, with F1 (only) used on frequencies presently authorized for RTTY use between 3.5 and 21.25 MHz at a maximum rate of 300 baud; on RTTY frequencies between 28 and 225 MHz, F1, F2, and A2 may be used, at a transmission rate up to 1200 baud; and above 420 MHz, F1, F2, and A2 are all permitted, with a baud rate up to 19.6 kilobaud.

Under The New Rule Section 97.69(b), ASCII will be permitted not only for conventional communications but also for such purposes as computer-to-computer communications, computer controls of repeaters and other Amateur stations, and packet communications. No changes were made in present bandwidth limitations, however, and further action on Docket 20777 appears unlikely at this time.

RULES FOR AN AMATEUR RADIO SATELLITE Service have been proposed by the Commission as a Notice of Proposed Rule Making on Docket 19852, which dates back to 1973. Under the NPRM a new Subpart H would be added to Part 97 to cover the new Amateur Satellite Service (AMSS), which would be open to all Amateurs subject to the restrictions of their licenses. "Space Operations," defined as "Space-to-Earth Amateur Radio Communications from a station which is beyond...a major portion of the Earth's atmosphere," would be limited to those Amateurs holding Extra Class licenses, however.

Other Provisions of the proposed AMSS rules would require capability for immediate shutdown of an Amateur station operating in space, but would permit stations in space to operate as repeaters and to operate without I.D. Bands proposed for the new AMSS are 7.0-7.1, 14.0-14.25, 21.0-21.45, 28.0-29.7, 144-146, 435-438, and 24000-24050 MHz. Detailed requirements for international coordination and registration are also included in the NPRM.

PHOTOCOPIES ARE NOW ADEQUATE substitutes for an Amateur's original license. The rules change, which was okayed by the FCC in early December, became effective December 21.

"NO PERMIT" RECIPROCAL operation by U.S. Amateurs in Canada and Canadian Amateurs in the U.S. went into effect on January 21st. The Department of Communications agreed with the FCC to make the rules relaxation effective on that date, so Amateurs of either country can operate as freely across the border as they do at home.

Novices And Techs will be able to operate under the new rules, but they'll be limited to the operating privileges they enjoy with their license class when operating in the United States.

RULES PROTECTING FCC MONITORING stations were announced in early January in a Report and Order on General Docket 78365. Amateurs received considerable leeway in making their own determinations as to whether their operations would be likely to disrupt the monitoring stations, though a new section, 97.41(d), was added to the Amateur rules.

Specifically, The New Rules simply "advise" applicants for Amateur station licenses to "give consideration" to the possibility of such interference, and "suggest" prior consultation with the Commission "if the proposed station will be located within one mile" of the FCC's monitoring facilities.

Monitoring Stations to be protected are located at Allegan, Michigan; Anchorage; Belfast, Maine; Douglas, Arizona; Grand Island, Nebraska; Kingsville, Texas; Laurel, Maryland; Livermore, California; Powder Springs, Georgia; Sabana Seca, Puerto Rico; and Waipahu, Hawaii.

NOAA WEATHER BROADCASTS may not be picked up from VHF stations and rebroadcast over local or even by an individual Amateur station, despite some lingering confusion over this point of law. FCC rules — 97.61(c) — specifically prohibit the retransmission of any broadcast picked up outside the allocated Amateur sub-bands. This ban also applies to other broadcast material such as WWV's time and propagation reports.

The Use Of Autopatches for dialing local weather reports is not, despite recent published reports, illegal. Since these weather reports are not originated as "broadcasts," their transmission by Amateur stations is not a violation of the FCC rules.

75-METER BROADCAST STATIONS planned by the Canadian Broadcasting Corporation may be on the air by June, 1981; the 250 kW transmitters will be used in CBC's arctic service with two stations planned for New Brunswick. Amateurs in the Northeast United States will be most susceptible to interference, but it is not expected to be severe.

W6GO, JAY O'BRIEN, was the one ACAR member we found we slighted in last month's list of contributors to Amateur Radio's success at WARC. His call was typoed as W6GD. Sorry, Jay!

THE OLYMPIC EDGE

During the XIII Olympic Winter Games in Lake Placid, New York, a complete amateur radio network communicates to the world emergency and personal messages for participants in the games.

HF transceivers used by the Winter Olympic Radio Amateur Network (WORAN) at Olympic Village are Ten-Tec OMNI models loaned by Ten-Tec, Inc., Sevierville, TN 37862.

The OMNI all-HF-band coverage and 100% duty cycle offers SSB, CW, RTTY, TELETYPE, and SSTV capability directly from the Olympic Village. The elaborate network, staffed by nearly 200 amateur radio operators, is one of the most extensive in recent amateur radio history.

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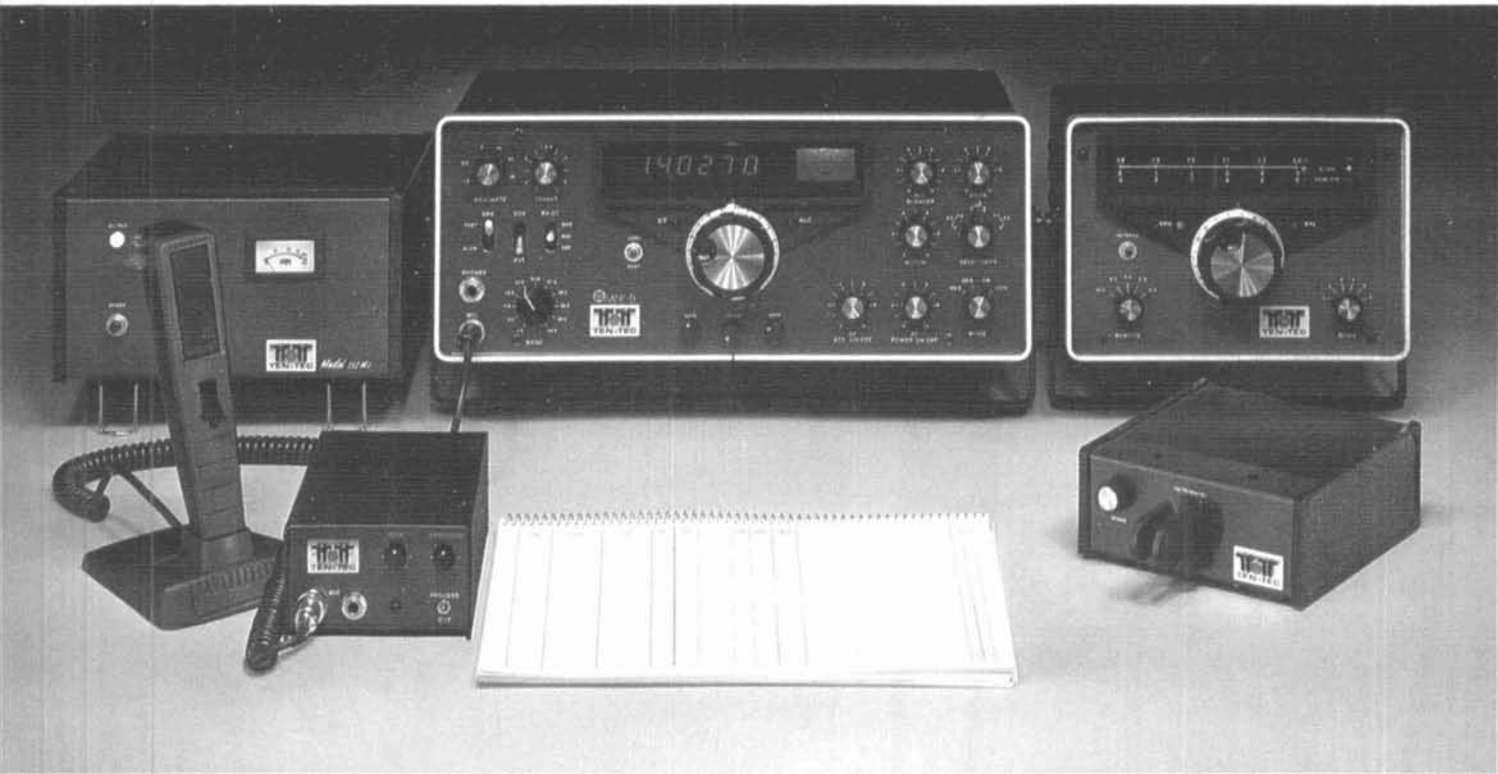

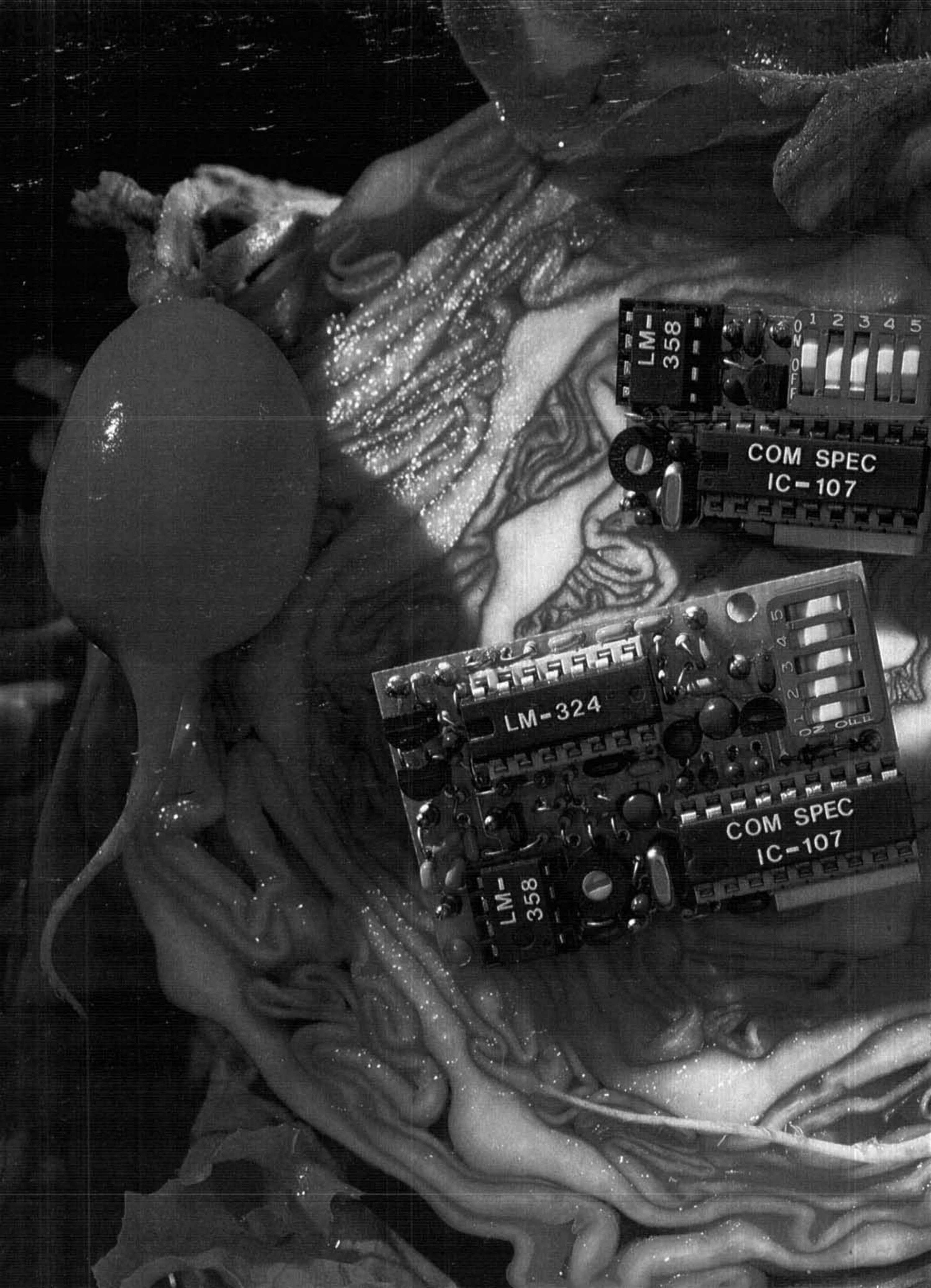

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77.0 XB	100.0 1Z	131.8 3B	173.8 6A
79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
85.4 YA	110.9 2Z	146.2 4B	192.8 7A
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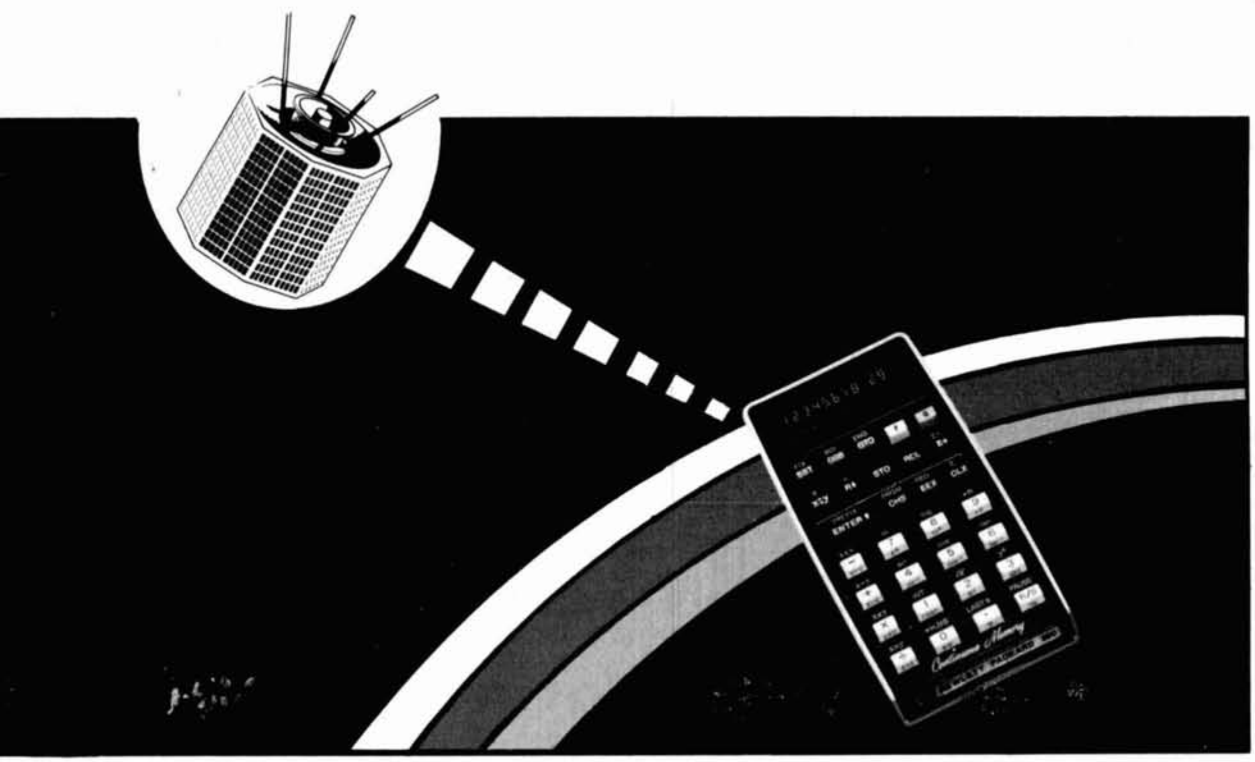

satellite computer
for under $150

The Hewlett-Packard HP-29C is put to work for OSCAR enthusiasts in computing orbital geometry

The availability of card-reading calculators, such as the Hewlett-Packard 67 and SR-52, has made it possible for satellite users to track OSCAR without so much as using a pencil and paper. Fine programs for both machines have been written and published,[1] but there's one pitfall associated with the two systems — cost. For those who bought one of the $400 gems for purposes other than satellite tracking, keying in the appropriate OSCAR program is certainly worth the effort. However, it's not likely that an Amateur Radio operator will spend that much money on a calculator for just satellite tracking, since an entire ground station needn't cost more than a few hundred dollars.

the calculator

A more realistically priced programmable calculator that can serve the OSCAR community as well as the geosynchronous-satellite enthusiasts is the Hewlett-Packard Model HP-29C. Although the HP-29C doesn't have the luxury of a card reader, it does have continuous-memory capability, which, in my opinion, matches and in some instances outweighs the virtues of those card-readers that are dumbfounded when power is interrupted. The HP-29C may be purchased at college bookstores for as little as $135 — a modest sum compared with the price of automatic keyers that send CQ and little else! Even if purchased only for OSCAR purposes, the HP-29C's price is worth considering when you realize its full potential as an SWR calculator, dipole-length computer, or grocery-bill adder. Truly it's a good investment.

the program

Developing an OSCAR program that fits within the 98-step memory limit of the HP-29C demanded a

By Richard Cleis, WB6POU, 438 South Havenside Avenue, Newbury Park, California 91320

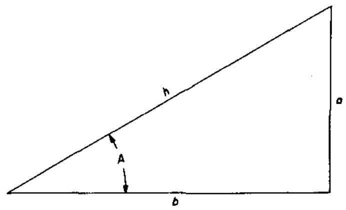

fig. 1. Pertinent to the program is the coordinate-conversion feature of the HP-29C calculator. When solving a right triangle, given h and A, the P-R key yields a and b. Conversely, given a and b, the R-P key yields h and A.

process far removed from the popular memory-gobbling Napier's Rule formulas of expensive calculators. My method requires no discrete trigonometric functions, but depends on the HP-29C's ability to perform rectangular-to-polar coordinate conversions and the reverse operation. The program does the following:

1. Calculates azimuth and elevation to satellite

2. Calculates slant range

3. Runs in real time

4. Displays real time

5. Can be set backward or forward any number of minutes

6. Can be set backward or forward any number of orbits

7. Can be set to start at any time

8. Works for any ground-station location

9. Uses only 11 seconds per calculation

10. Calculator can be turned off without losing track of OSCAR's position

11. Program can be used to find azimuth, elevation, and slant range to a prescribed synchronous satellite

The polar-rectangular (P-R) conversion key of the HP-29C is valuable because it yields the length of two sides of a right triangle when given the hypotenuse and the angle included in the hypotenuse and one side. The rectangular-polar (R-P) key does the operation in reverse (see **fig. 1**). Nearly every aspect of the program uses these two functions.

finding the rectangular coordinates of OSCAR

One portion of the program determines the movement of the satellite by incrementing the number of degrees that the satellite travels in its approximate circular orbit. Assume OSCAR travels arc distance T degrees from an arbitrary point as shown in **fig. 2**. After the program recalls T and the radius r, of the orbit, values s and d are calculated with the P-R function. Recalling the inclination of the satellite, and performing a P-R conversion in conjunction with s, yields z and v. The next portion of the program finds angle A and distance e through an R-P operation on v and d.

During the period that OSCAR takes to travel arc distance T, the earth will have rotated beneath the satellite. The x and y axes have thus rotated counterclockwise, as shown by the dotted line. The angle of rotation, R, is added to angle A, obtaining the system shown in **fig. 3**. Performing a P-R conversion on e and the new angle, $A+R$ yields y and x, while z remains as calculated earlier.

What's been accomplished during the previous calculations is the assignment of the satellite to a three-dimensional rectangular coordinate system. When the position of the tracking station is assigned to its rectangular coordinates on the same system as that of the satellite, the relative rectangular position of the satellite is determined by subtracting the corresponding x, y, and z values (**fig. 4**).

finding azimuth, elevation, and slant range

After the subtraction operations, the new x, y, and z values are used to set up the final coordinate system (**fig. 5**). Length g and angle B are calculated by converting z and x to their polar equivalents. The complement of the tracking station's latitude is then added to B, since we want to know the azimuth and elevation according to the earth's surface at the station rather than with reference to the x/y plane parallel to the equator. Next, a P-R conversion is performed on g and $B+$ (90-latitude) to obtain t and u.

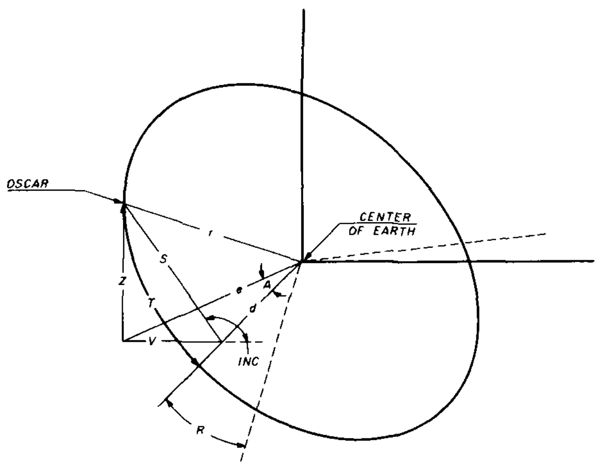

fig. 2. Geometry for determining satellite movement in its orbit. Values s and d are calculated with the calculator P-R function.

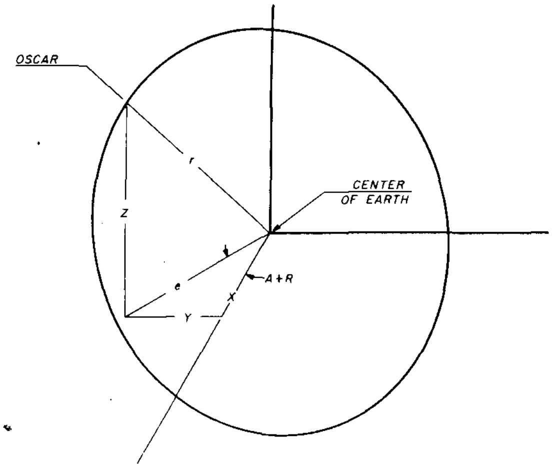

fig. 3. Accounting for earth rotation after the satellite has traveled arc distance *T*.

Azimuth is derived by an R-P operation on the *u* and the *y* value calculated earlier. Since distance *v* is also found during the previous step, elevation and slant range can be derived by performing an R-P conversion on *t* and *v*.

preparing the program

The first time the calculator is to be used for tracking a satellite, the program must be keyed in. Twelve data registers have to be filled. Since the HP-29C remembers when it's turned off, only half of the memories must be entered again so long as the station location is not altered. Registers 1 and 2 will change daily because they're the reference orbits' equatorial times and crossings respectively.

Four other registers (.1, .2, .3, and 3) must be changed when you want to track a satellite other than the one for which the calculator is set up. In other words, if OSCAR 8's progression, inclination angle, orbit radius, and arc rate are stored in the data registers, they must be changed to represent OSCAR 7's parameters.

tracking a satellite

Suppose the calculator is set for tracking OSCAR 7 and you want to work it on December 20. The first step is to look up the *reference node data* for that date. Turn on your HP-29C, punch in the time in H.MS format. Store the data in register 1. Next key in the longitude. Store it in register 2.

You must now guess the number of orbits that will pass before acquisition will occur. If you think three orbits will suffice, **3** should be entered and **GSB 1** depressed (see program, **fig. 6**). The calculator will then display the time at which the satellite crosses the equator after three passes beyond the reference node.

Press the **x-y** *key to display the crossing longitude* relative to the station. If the crossing is 15 degrees east of the station, the displayed result is **−15**, since the difference between station longitude and satellite longitude decreases on successive orbits.

If the node is 15 degrees west of the station, **+15** will be displayed, because successive nodes are further away from the station.

You must guess with the **GSB-1** function until you find an appropriate node that will produce an orbit likely to pass through the station window. Nodes between −45 and +25 are likely candidates for stations with a latitude near that of Los Angeles.

If you want to begin tracking the satellite from a nodal point, wait until the calculated crossing time arrives, then push **GSB 2**. The HP-29C does about 10 seconds of number crunching, then displays the time for about a second, displays the slant range for a second, displays the azimuth for a second, displays the elevation for a second, then repeats the cycle until 1 minute is used up. During each minute, the time is incremented, so that the calculator is tracking in real time.

The ascending nodes of OSCAR 7 are often too far south for North-American stations to see, and they may occur during the middle of the window for southern Florida stations. Also, the descending passes aren't visible until the satellite travels up the back side of the earth — a 40-minute wait.

Getting to the point, few operators will desire to begin tracking the satellite from the time it crosses the equator. The program is equipped with solutions to this problem.

notes on calculator subroutines

Two subroutines permit the track to be started at

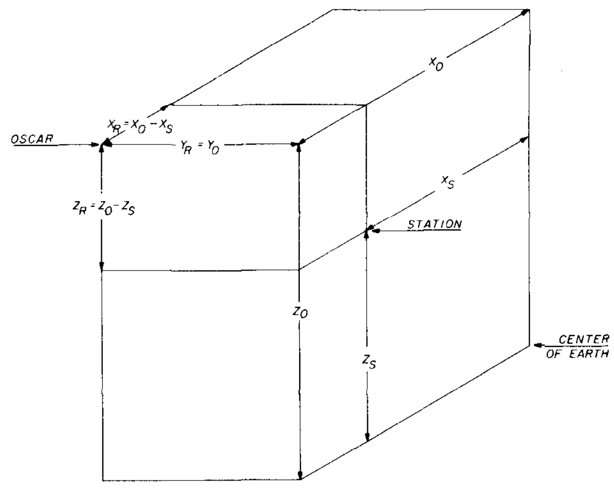

fig. 4. The relative rectangular position of the satellite is determined by subtracting the corresponding *x, y,* and *z* values.

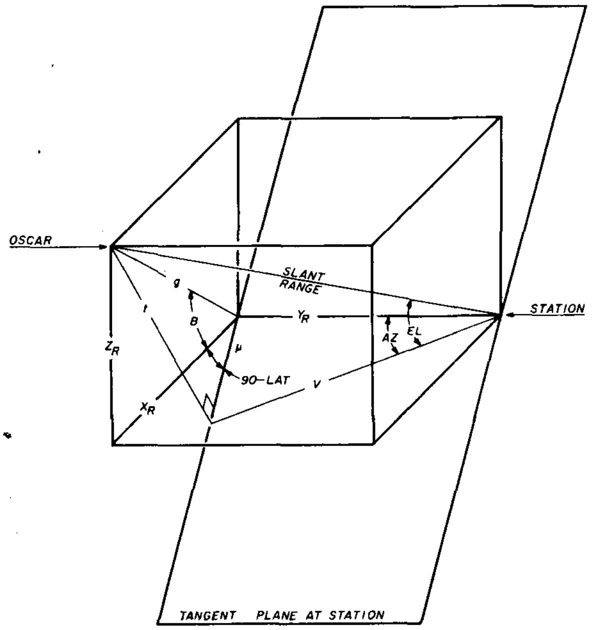

fig. 5. Geometry for determining final coordinates of the satellite (azimuth, elevation, and slant range).

any time and enable the time of acquisition to be easily found. Keying in any number of minutes and pressing **GSB 3** will advance the time to the prescribed value. If a negative number is used the time will be back-tracked. This subroutine is similar to **GSB 2**; so after **GSB 3** is called, the time will be altered, then the program will run in real time as if **GSB 2** had been used.

The other time-altering subroutine is **GSB 4**: By entering any time in H.MS format, then pressing **GSB 4**, the program will begin tracking at the prescribed time.

To enhance your search for the acquisition time, the satellite elevation will be displayed as a negative number if it's below the horizon. If you make a guess that produces an elevation of, say, −45 degrees, *then you can immediately assume that many minutes* must be added. If an elevation of −3 degrees is discovered, then acquisition is only a few minutes away.

To realize the usefulness of the features offered in this program, it must be stressed that the program is time based. The only register that changes is the time register, so the calculator may be turned off at *any time* during *any* subroutine without losing track of the satellite's position. If the calculator is turned off, turning it on and pressing **GSB 2** will start it tracking at the time it was last calculating. The other subroutines will also function as if the calculator were never turned off.

It's also important to note that the subroutine **GSB 1** is independent of the number of times that any other subroutines are used. In other words, whatever

User Instructions

Program Title HP-29 OSCAR PROGRAM
Name RICHARD A. CLEIS Date MARCH '80
Address
City State Zip Code

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	INITIALIZING PROGRAM			
1	Keyin program			
2	360	Degrees	STO 7	
3	1/60	Hrs/Min	STO 6	
	ENTERING TRACKING STATION LOCATION			
1	Longitude of tracking station	Deg. W	STO 4	
2	90-Latitude of tracking station	Deg. N	STO 5	
3	Latitude of tracking station	Deg. N.	ENT	
4	Radius of earth: 3964	Miles	f R	X_{ts}
5			STO .4	
6			x/y	Z_{ts}
7			STO .5	
	ENTERING SATELLITE DATA			
1	-60^{x} increment/period in minutes	Deg/Hr	STO .1	
2	Inclination of orbit	Degrees	STO .2	
3	Radius of orbit	Miles	STO .3	
4	Arc rate of satellite: 21600/period in minutes	Deg/Hr	STO 3	
	ENTERING DAILY OSCAR DATA			
1	Time of equatorial crossing	H. MS	STO 1	
2	Longitude of equatorial crossing	Deg. W	STO 2	
	FINDING DAY'S EQUATORIAL CROSSINGS			
1	Key in number of orbits to skip after reference		GSB 1	Xing time
2	Longitude with respect to station yielded here:		x/y	Xing long.
	CHANGING MINUTES: Keyin ± # of minutes		GSB 3	New data
	SETTING NEW TIME: Keyin desired time		GSB 4	New data
	STARTING TRACK WITHOUT CHANGES		GSB 2	
	FINDING SYNCHRONOUS SATELLITE DATA			
1	0		ENT	
2	Station longitude-satellite longitude	Deg. W	ENT	
3	*Radius of synchronous orbit*	*Miles*	GSB 5	Sat.data

STEP	KEY ENTRY	KEY CODE	COMMENTS	STEP	KEY ENTRY	KEY CODE	COMMENTS
001	g LBL 1	15 13 01			RCL .5	24.5	
	RCL 7	24 07			-	41	
	RCL 3	24 03			x/y	21	
	/	71		060	g P	15 44	
	X	61			x/y	21	
	RCL 1	24 01			RCL 5	24 05	
	g H	15 72			+	51	
	+	51			x/y	21	
	STO .0	23.0			f R	14 44	
010	GSB 8	12 08			CHS	32	
	CHS	32			RCL 9	24 09	
	RCL .0	24.0			x/y	21	
	f H.MS	14 72			g P	15 44	
	g RTN	15 12		070	x/y	21	
	g LBL 8	15 13 08			g x> 0?	15 51	
	3	03			GTO 9	13 09	
	7	07			RCL 7	24 07	
	STO 0	23 00			+	51	
	RCL .1	24.1			g LBL 9	15 13 09	
020	RCL .0	24.0			STO 9	23 09	
	RCL .1	24 01			ROLL	22	
	g H	15 72			g P	15 44	
	-	41			RCL .0	24.0	
	X	61		080	f H.MS	14 72	
	STO 8	23 08			RCL 9	24 09	
	f LAST x	14 73			g LBL 7	15 13 07	
	RCL 3	24 03			ROLL	22	
	X	61			*f PAUSE*	14 74	
	RCL .3	24.3			g DSZ	15 23	
030	f R	14 44			GTO 7	13 07	
	STO 9	23 09			1	01	
	ROLL	22			g LBL 3	15 13 03	
	RCL .2	24.2			RCL 6	24 06	
	x/y	21		090	X	61	
	f R	14 44			STO + .0	23 51 .0	
	RCL 9	24 09			GTO 2	13 02	
	g P	15 44			g LBL 4	15 13 04	
	x/y	21			g H	15 72	
	RCL 8	24 08			STO .0	23 .0	
040	+	51			GTO 2	13 02	
	RCL 4	24 04					
	+	51					
	RCL 2	24 02					
	-	41		100			
	g RTN	15 12					
	g LBL 2	15 13 02					
	GSB 8	12 08					
	x/y	21					
	g LBL 5	15 13 05					
050	f R	14 44					
	x/y	21					
	STO 9	23 09					
	ROLL	22					
	RCL .4	24.4		110			
	-	41					
	x/y	21					

REGISTERS

0 used	1 Time Eq X	2 Long. Eq. X	3 Arc d / Hour	4 Long QTH	5 ___ / Lat.QTH	6 1/60	7 360	8 used	9 used
S0 Time	S1 60 Inc. / period	S2 Inclin.	S3 Radius Orbit	S4 x_{QTH}	S5 y_{QTH}	S6	S7	S8	S9
A	B	C	D	E	I				

fig. 6. User instructions for the satellite-tracking program using the HP-29C calculator.

the calculator is doing (on or off), if a number, *n*, is keyed in and **GSB 1** is depressed, the time and longitude of the *n*th node before or after the reference node will be calculated. Analogous independence rules can be applied to the other subroutines.

program versatility

Suppose the satellite's fourth orbit after the reference node has just been tracked, and the time is 0300. You want to work the following pass, so you can choose one of three alternatives:

1. Enter **5** then **GSB 1**
2. Enter **100** then **GSB 3**
3. Enter **4.40** then **GSB 4**

The first choice calculates the node of the next orbit. From that point you may start looking for the acquisition time with the other subroutines. The second choice adds 100 minutes to the time; an orbit lasts about 100 minutes, so the program is positioned somewhere near the window of the following orbit. From inside the window, it's easy to find the acquisition time. The third choice is almost exactly the same as the second, except you must mentally add the 1-hour, 40-minute orbit period to the time (0300).

synchronous satellites

Finding azimuth, elevation, and slant range of a synchronous satellite requires entering a zero, the difference between the satellite and station longitudes, then the radius of a synchronous orbit. After pressing **GSB 5**, the calculator will display the time of the last satellite orbit (meaningless for this purpose), then it will display slant range, elevation, and azimuth in that order.

credibility

The methods used in this program should work for any near-circular orbit and any ground-station location. I've successfully used the program for OSCAR 7 and OSCAR 8 on ascending and descending passes. Although I've never worked with the Russian satellites, I feel confident that the program will work as well for them.

reference

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Burke, Art, W6UIX, "Track Oscar with Your SR-52," *73*, November, 1977, page 58.

ham radio

More Details? CHECK—OFF Page 94

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★ Multi-function antenna selector/50 ohm splitter for dual receive with the TR7.
- 100% solid state broadband design, synthesized with PTO.
- Covers range 0 to 30 MHz. Both digital and analog readout.
- Special front-end circuitry with high level mixer and 48 MHz 1st i-f.
- Complete front-end bandpass filters operate from hf thru vlf.
- 10 dB pushbutton-controlled broadband preamp for ranges above 1.5 MHz.
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• 160 thru 10 meters frequency coverage — plus MARS, future expansions, etc. • Matches antennas fed with coax, balanced line, or random wire. (Use Drake Balun for balanced line.) • Antenna by-pass switching also selects various antennas. • Extra harmonic reduction to help fight TVI — "pi-network" low-pass filter type circuitry is a Drake exclusive. • Accurate rf wattmeter/VSWR bridge. • 2000 watts PEP, 1000 watts average. Continuous duty.

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More Details? CHECK—OFF Page 94

new class of coaxial-line transformers

Coreless 4:1 and 1:1 balun transformers are described with a systematic design procedure for making your own — Part 2 of a two-part series

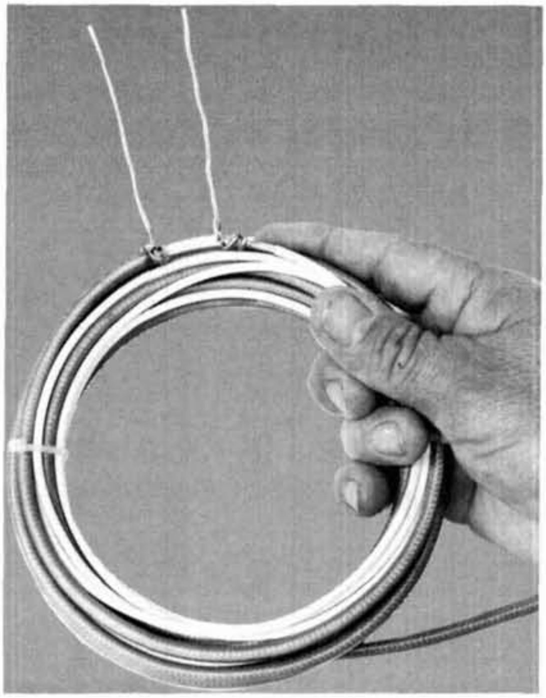
Part 1 of this article reviewed the theory of *transmission-line transformers and baluns,* as well as problems with magnetic cores such as arcing, distortion, and harmonics. A simple balun that doesn't depend on magnetic materials was described. A new *class of coaxial transmission-line transformers* based on the same principles as the coreless balun was introduced. Also described were two specific transformer designs with experimental performance data.

In this article I will describe additional 4:1 and 1:1 balun transformers, including one for vhf. Impedance, VSWR, and balance data on these specific designs and on commercially available balun transformers are compared. I have included data on baluns working into various loads, with information on how to build and modify balun transformers. A systematic design procedure, evolved during the development of these transformers, is summarized.

how to make coreless baluns

While the balanced-to-balanced 4:1 *transformers* described in Part 1 are interesting, more useful configurations are 50-ohm unbalanced to 12.5-ohm balanced, and 50-ohm unbalanced to 200-ohm balanced, *balun transformers*. These were made in two stages using coreless baluns together with the balanced-to-balanced coreless transformers of **figs. 5** and **6** described in Part 1.

The first step in making these balun transformers was to arrive at an optimum 50-ohm 1:1 balun design. I tried many lengths of coax and many configurations before choosing the design shown in **fig. 1**. A length of RG141/U* Teflon coaxial transmission line longer than 127 cm (50 inches) was used. A dummy length of line 127 cm (50 inches) long was soldered to the outer conductor of the Teflon coax 127 cm (50 inches) from the end as shown in **fig. 1**.



How to add a simple compensating winding to the W1JR balun to provide superior balance. Thanks to W6ZO for building the balun and suggesting the easy modification. Low reactance adjustable load shown is connected with 1.27-cm (0.5-inch) copper strap for match and balance measurements.

*Available from Radiokit, Box 429, Hollis, New Hampshire 03049. RG-142B/U (Belden 83242-100) may also be used.

By George Badger, W6TC, 341 La Mesa Drive, Portola Valley, California 94025

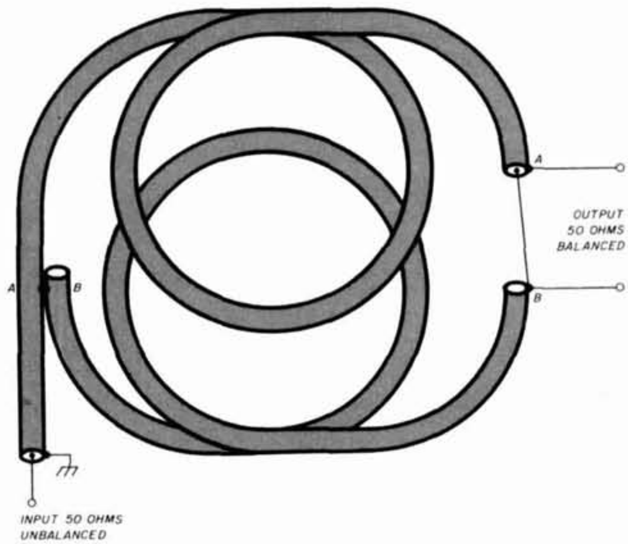


fig. 1. 50-ohm unbalanced to 50-ohm balanced coaxial balun. From the common point (system ground) to the output terminals, coax line A and compensating line B are each 127 cm (50 inches). The lines were wound into a seven-turn random-wound coil of 11.5 cm (4.5 inch) nominal diameter. For clarity, only three turns are shown. Performance data are shown in table 1.

The resulting 254 cm (100 inches) of line was then random wound into a nominal 11.5-cm (4.5-inch) diameter seven-turn coil. **Fig. 1**, for clarity, shows only three turns of coaxial line. The dummy length of line used for the compensating winding was made with RG-58A/U. The advantage of using small coax is that the balun is compact and results in a convenient configuration for mounting on beam antennas. Performance is shown in **table 1**. Note the excellent balance data. Balance was determined by measuring the rf voltage with respect to the common point (ground) at each of the output terminals when terminated with a floating matched load. The difference between the readings taken at each frequency was divided by the sum of the readings expressed as a percentage . The rf voltage was measured with an HP model 410C rf voltmeter.

Rather than use coax for the compensating winding, to save money and space I decided to try a length of hookup wire. I tried some surplus no. 12 (2.1-mm) Teflon insulated wire. Hookup wire instead of coax for the compensating winding results in an excellent design. The balun is shown in the photo. A balun made this way was compared with one made entirely of coax. The two designs used for this comparison were optimized for the low bands. Data taken on these designs are shown in **table 2**. This table compares the use of Teflon coated no. 12 (2.1-mm) wire with coax for the compensating winding. VSWR performance of the Teflon wire version was at least equal to that of the all-coax balun, and the balance was actually better.

The balun design optimized for the 80 through 10 meter bands (**table 1**) was made with 127-cm (50-inch) lines. The balun designs optimized for the 160 through 20 meter bands (**table 2**) were made with 254-cm (100-inch) lines.

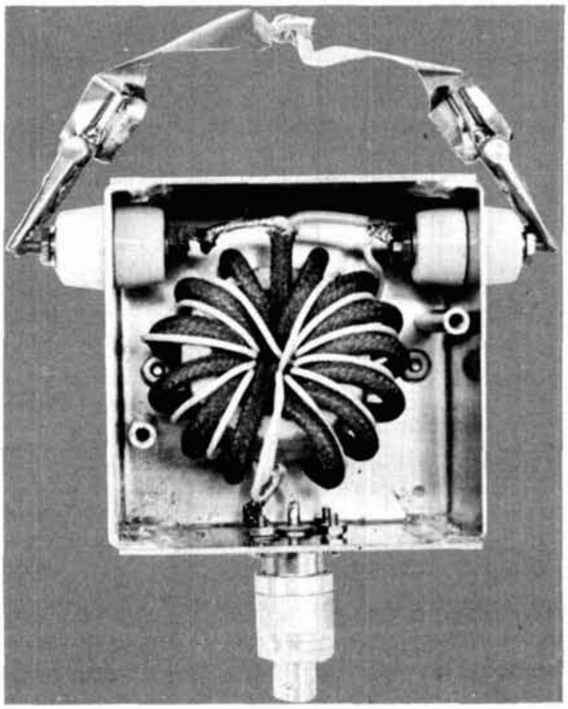
vhf balun

A vhf version of the coreless 1:1 balun is shown in **fig. 2**. The balun has a nominal diameter of 5.8 cm (2.25 inches). The length of coax from the output to the common point is 45.7 cm (18 inches). An equal length of coax line is used for the dummy. The lengths of RG-58A/U were wound into a five-turn coil. **Table 3** shows the performance of this balun.

two-stage balun transformers

After the 50 to 12.5 ohm and 50 to 200 ohm balanced-to-balanced transformers (Part 1) and the 50-ohm unbalanced to 50-ohm balanced balun (see **fig. 1**) were optimized, I combined them into two-stage 50 to 12.5 ohm and 50 to 200 ohm unbalanced-to-balanced configurations. These two-stage transformers are shown in **figs. 3** and **4**. **Tables 4** and **5** show performance data.

The first stage converts from 50-ohm unbalanced



Compact broadband 1:1 balun. The only materials used are a short length of RG-141/U and insulated hookup wire. The balun provides excellent match, balance, and several kW reserve power-handling capability.

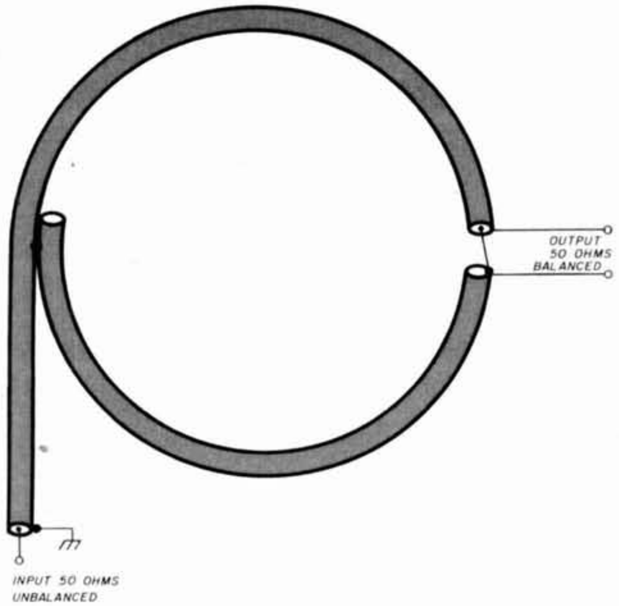


fig. 2. Vhf version of the coreless balun. Length of each line from the common point to the output terminals is 45.7 cm (18 inches). The lengths of RG-58A/U were wound into a five-turn coil of about 5.8 cm (2.25 inches) diameter. For clarity, only one turn is shown. The center conductor of the compensating coax line winding may be left floating or shorted to the outer conductor at both ends. Performance data are shown in table 3.

to 50-ohm balanced; the second stage converts from 50-ohm balanced to 12.5-ohm or 200-ohm balanced loads. Note that the bandwidth of these two-stage balun transformers is somewhat less than that of the individual stages.

When the two stages are coiled together into one compact bundle of coax, the way in which connections are made between the two stages is important. Note the lead crossover between the first and second stage (**fig. 4**). Performance was significantly better when the leads between stages were cross-connected because of the magnitude and direction of rf current flow over the coaxial-line outer conductors. The leads between the two stages must be short. The length of grounding wire, **AB**, was not critical.

a 50/12.5-ohm unbalanced-to-unbalanced transformer

A transformer particularly useful for matching low-impedance unbalanced loads, such as a mobile whip or short ground plane antenna, is shown in **fig. 5**. Note that this configuration differs from the designs described earlier because the line lengths aren't random wound into a common coil and, therefore, aren't coupled together. Because of the unbalance-to-unbalance connection, both ends of the outer conductors of line **CD** are grounded. Thus, line **CD**, if coiled with and therefore coupled to coil **AB**, would act like a shorted turn, reducing the common-mode impedance of coil **AB**. Both ends of line **CD** are at the same potential so no isolation impedance is required. Thus the line may be positioned in any convenient way that doesn't couple to coil **AB**. The line is shown folded in the drawing to minimize coupling. The line may be twisted and taped to the incoming 50-ohm line. Line **CD** must be the same length as line **AB** so that the two rf paths are equal, thus preserving the phase relationship. Lines **AB** and **CD** are each 127 cm (50 inches) long and are made of two paralleled lengths of RG-58A/U.

Performance data on the 50/12.5-ohm unbalance/unbalance transformer is shown in **table 6**. The VSWR data show the harmful effect of the shorted turn when **CD** is coiled and coupled to **AB**. The VSWR curve could be centered to improve the match at the low end by adding length to lines **AB** and **CD** by the design techniques described later.

efficiency and power

The power-handling capability and efficiency of these new transformers made with RG-58/U coaxial cable were analyzed in Part 1. The 4:1 baluns shown in **figs. 5** and **6** of Part 1 and **fig. 5** of Part 2 can handle 1 kW at 30 MHz. This is twice the rating of RG-

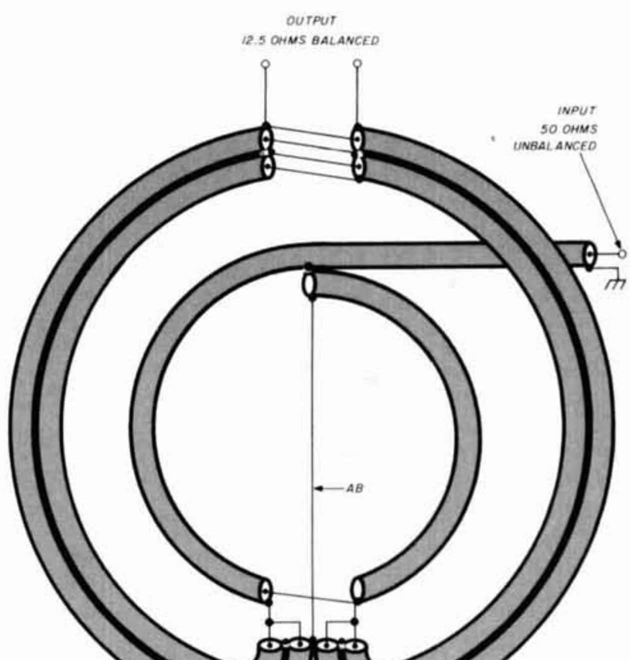


fig. 3. This 50-ohm unbalanced to 12.5-ohm balanced balun transformer is a two-stage design combining the transformer of fig. 5 (Part 1) with the balun of fig. 1. Performance data are shown in table 4.

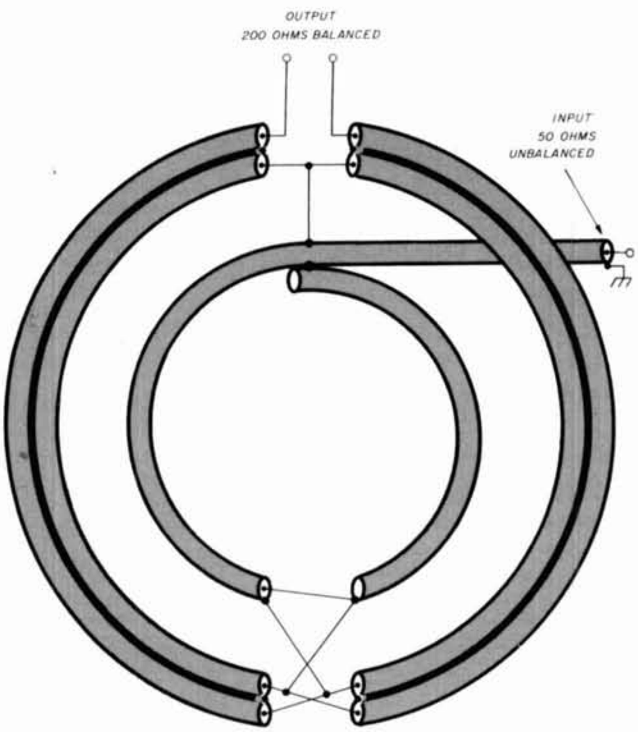


fig. 4. This 50-ohm unbalanced to 200-ohm balanced balun transformer is a two-stage design combining the transformer of fig. 6 (Part 1) with the balun of fig. 1. Performance data including balance are shown in table 5.

58A/U cable because the line pairs are connected in series or parallel.

In the case of the coreless 1:1 baluns, all of the power is transmitted through a single coax. Therefore, for high-power applications, the 1:1 baluns must be made with RG-8/U or RG-141/U transmission line. RG-141/U is the same size as RG-58A/U but it's about four times as expensive. The dielectric used in this coax is Teflon; therefore, the baluns can handle about 5 kW at 30 MHz. Using RG-141/U or RG-142B/U results in a rugged balun of reasonable size. From my experience, these compact baluns made with Teflon coax are virtually indestructible in Amateur use.

Efficiency of the Teflon coax balun shown in the photo was tested by the method described in Part 1.

table 1. Performance of the 50-ohm balun shown in fig. 1. Balance expressed as a percentage is shown. This design was optimized for 80 through 10 meters.

F_0 (MHz)	Z (ohms)	θ degrees	VSWR	balance (per cent)
3.5	48	16	1.33	2.8
4.0	49	14	1.28	2.1
7.0	50	10	1.19	1.3
14.0	50	8	1.15	2.5
21.0	51	8	1.15	4.2
28.0	52	9	1.18	1.3
30.0	53	9	1.18	1.3

Efficiency was better than 95 per cent over the useful bandwidth shown in **table 2**.

comparison with commercial products

Just how good are these balun transformers regarding match and balance? The best way to answer this question is to compare them with popular, commercially available products. The devices described here were compared with a commercial ferrite rod core 1:1 balun and a commercial toroid-wound 1:4 balun transformer. Performance comparisons are summarized in **tables 7** and **8**. **Table 7** shows the comparison between the commercial 1:1 ferrite-core balun and the corless balun of **fig. 1**. **Table 8** compares the performance of the commercial 1:4 toroid balun transformer with the two-stage 50/200 ohm balun transformer shown in **fig. 4**. On the average, the VSWR and balance are

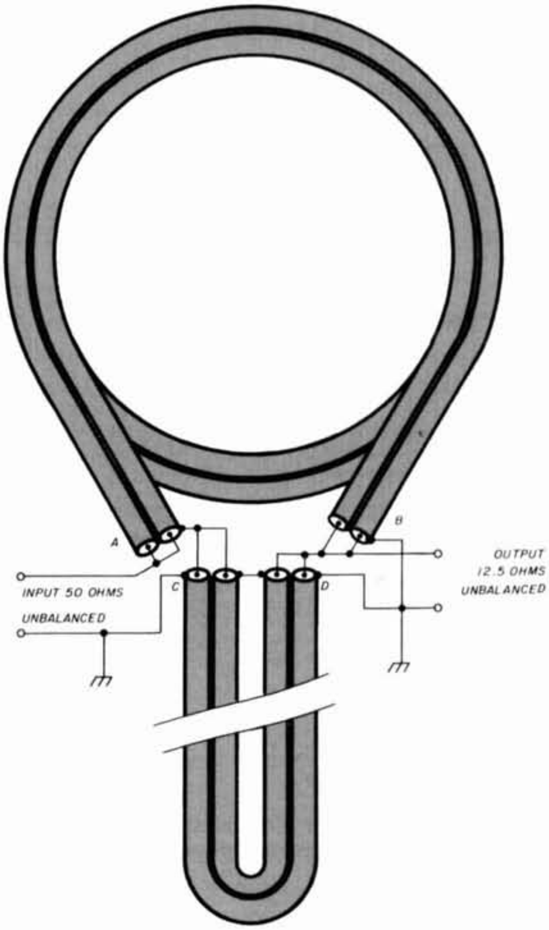


fig. 5. This 50/12.5-ohm unbalanced-to-unbalanced transformer consists of two 127-cm (50-inch) parallel pairs of RG-58A/U coaxial cable connected in series at the input and in parallel at the output. Line CD must be the same length as line AB and should not be coupled to AB. Data comparing the coupled and uncoupled cases are shown in table 6.

table 2. Comparison of two baluns optimized for the low bands. Balun A was made entirely of coax as shown in fig. 1 but with 254-cm (100-inch) lines. Balun B is identical except for the dummy compensation line, which was made with an equivalent length of insulated no. 12 (2.1-mm) wire. These baluns are optimized for the low bands, so performance is good on 160 meters and poor on 10 meters.

	balun A				balun B			
F_0 (MHz)	Z (ohms)	θ (degrees)	VSWR	balance (per cent)	Z (ohms)	θ (degrees)	VSWR	balance (per cent)
1.8	53	10	1.20	3.8	51	6	1.11	1.90
2.0	53	9	1.18	4.7	51	5	1.09	1.40
3.5	53	4	1.10	4.5	51	2	1.04	.68
4.0	53	3	1.08	4.5	51	1	1.03	.67
7.0	53	0	1.06	5.1	49	1	1.05	2.00
14.0	53	1	1.02	6.1	46	5	1.13	4.00

better for the devices described here than for the commercial balun transformers tested. I evaluated only two commercial balun products, which were selected at random.

balun performance with varying loads

All the test data were taken with terminations for which the balun transformers were designed. In the real world, balun transformers are connected to antennas. Antennas are rarely ideally matched; as operating frequency is changed across the band, both resistive and reactive components of the antenna impedance change. It is therefore important to understand the influence of the balun when terminated with other than the characteristic impedance of the line and balun.

I tested the coreless balun of **fig. 1** and a commercial 1:1 balun at 3.5 and 14 MHz with loads varying from 16 to 150 ohms. These measurements are summarized in **table 9**. Impedance magnitude, phase angle, and calculated VSWR of the loads are listed. Measurements taken through the balun of **fig. 1** and the commerical balun are also recorded. Both resistive and reacitve components of the impedance looking through the baluns varied widely from the data taken on the loads alone. In general, however, the resulting VSWR was not significantly altered.

table 3. Performance of the vhf balun shown in fig. 2.

F_0 (MHz)	Z (ohms)	θ (degrees)	VSWR
21	60	10	1.29
28	60	5	1.22
30	60	15	1.22
50	53	−1	1.06
56	52	−1	1.05
70	48	3	1.07
80	49	6	1.11
90	50	8	1.15
100	54	12	1.25

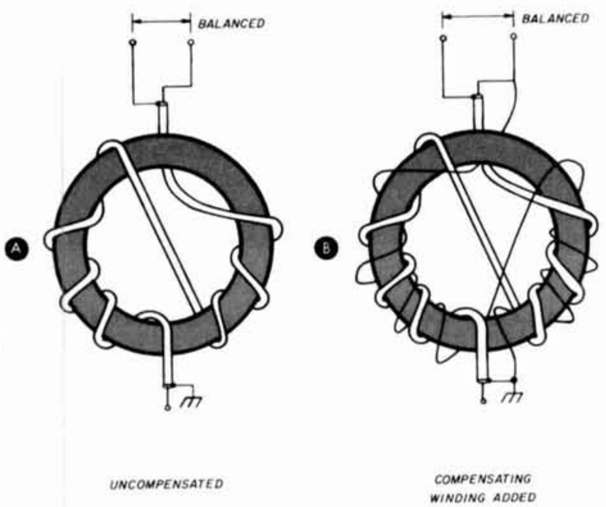


fig. 6. Compensating winding added to W1JR balun[2] for improved performance. A length of no. 16 (1.3-mm) Teflon insulated wire equal to the coax line, wound and connected as shown, improves balance and VSWR of the uncompensated balun.

balun rf distortion measurements

Saturation effects in magnetic-core materials in balun transformers may contribute to nonlinearity and cause generation of harmonics with attendant TVI problems. However, to my knowledge, this problem has not been addressed in the literature and no measurements have been made to lend experimental validity to these concerns. For this reason a popular commercially available rod magnetic core 1:1 balun was measured for nonlinearity at a power level of 2 kW PEP.

The two-tone test method[1] offers a convenient means for measuring harmonic distortion. It's the method commonly used for determining the linearity of power tubes and solid-state devices. If two rf signals are linearly combined and are equal in amplitude, the resultant envelope varies periodically from zero to maximum. When a two-tone rf signal is passed through a nonlinear device, many new signals are produced, including harmonics and products resulting from harmonics and the original signals. Products that fall near the original signals in frequency are known as odd-order products (3rd, 5th, 7th, 9th, 11th). The measurement of the amplitude of these products with respect to the amplitude of one of the original signals is an excellent method for evaluating the harmonic distortion products generated by a nonlinear device.

The two-tone method was used to measure the harmonic distortion contribution of the commercial ferrite balun. In this experiment, the two rf signal sources were 2000 Hz apart at 2.001 and 2.003 MHz. The signals were combined and amplified to 2 kW PEP and fed through the balun to the load. The distortion products were measured with a modified HP310A Wave Analyzer. Power output at the 50-ohm load was measured with an HP3400A rms Volt-Meter. **Table 10** summarizes the results of the measurements. Note the 3rd-order distortion product increased from 43 to 39 dB below one of the two original signals, a 4-dB deterioration. Under the set of power-amplifier operating conditions chosen, the 5th- and 7th-order products decreased, and the 9th-order distortion product again increased.

table 4. Performance characteristics of the two-stage 50/12.5-ohm transformer of fig. 3 consisting of the balun of fig. 1 combined with the 4:1 transformer of fig. 5 (Part 1).

F_0 (MHz)	Z (ohms)	θ (degrees)	VSWR	balance (per cent)
3.5	53	22	1.49	3.5
4.0	53	20	1.44	2.7
7.0	56	9	1.21	2.1
14.0	55	−1	1.10	3.3
21.0	47	−1	1.07	0.0
28.0	45	10	1.23	4.3
30.0	47	12	1.25	6.5

It's clear from these measurements that you can't assume that a magnetic-core device, such as a ferrite core balun, is perfectly linear at all power levels. Unless flux density is held below the saturation threshold for the core material used, magnetic-core baluns and transformers can affect the linearity of your equipment and may cause TVI through the generation of harmonics.

W1JR balun improvement

Joe Reisert, W1JR, made an excellent contribution to the state of the art in his article, "Simple and Efficient Broadband Balun," in the September, 1978, issue of *ham radio*.[2] An improvement in the balance of the W1JR balun can be made by the very simple addition of a length of insulated hookup wire wound on the toroid as a continuation of the coax winding.

*Also proposed by K4KJ and discussed in the February, 1980, issue of *ham radio*, page 28.

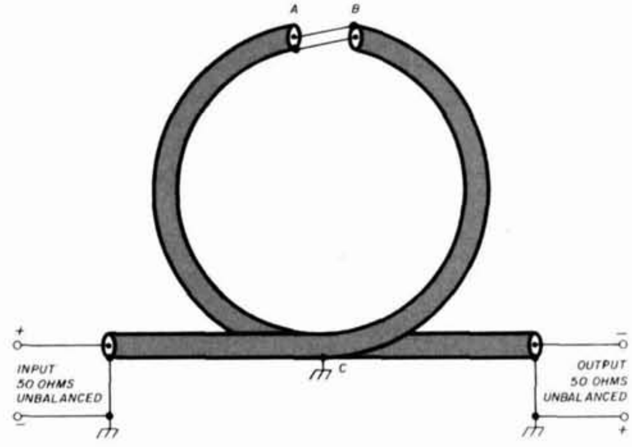


fig. 7. Phase inverter based on the same principles as the coreless balun. This useful coaxial line component changes the phase of an rf signal applied at the 50-ohm input terminal by 180°; the phase reversal is produced by the cross connections between the two coaxial lines at A-B. Connections at A-B are isolated from ground by the self-resonance of the coiled coax lines. Construction, dimensions, and connections are the same as the coreless balun shown in fig. 1. From the common point C (system ground) to the output terminals, coax lines A and B are each 127 cm (50 inches) long. The lines are wound into a seven-turn random wound coil of 11.5 cm (4½ inches) nominal diameter. For clarity, only one turn is shown. Performance data is shown in table 12.

See **fig. 6** and the photo. The length of the compensating winding must, of course, be equal to the coax length. This modification was made at the suggestion of Ray Rinaudo, W6ZO.* It's based on the principles described in Part 1, showing how the length of coiled coaxial line of **fig. 2** (Part 1) is evolved into the compensated balun of **fig. 3** (Part 1).

Data showing VSWR and inherent balance of the compensated and uncompensated baluns are shown in **table 11.**. The balance measurement was made by terminating the balun with 50 ohms, driving at the frequencies shown, and measuring the voltage with respect to ground (enclosure) at each of the output terminals. Note the very significant variations in balance shown for the uncompensated balun, compared with the reasonably good inherent balance shown in the right-hand column. Balance is defined

table 5. Performance characteristics of the two-stage 50/200-ohm transformer of fig. 4 consisting of the balun of fig. 1 combined with the 4:1 transformer of fig. 6 (Part 1).

F_0 (MHz)	Z (ohms)	θ (degrees)	VSWR	balance (per cent)
3.5	60	25	1.63	1.3
4.0	60	25	1.63	0.6
7.0	60	3	1.21	0.6
14.0	48	0	1.04	0.6
21.0	51	10	1.19	0.0
28.0	60	2	1.20	3.3
30.0	60	−1	1.20	3.3

table 6. Performance of 50/12.5-ohm unbalanced-to-unbalanced transformer of fig. 5. The two right-hand columns compare VSWR of coupled and uncoupled configurations as explained in the text. VSWR on the 80-meter band can be improved by increasing the length of the coax lines as explained in the design procedure.

F_0 (MHz)	Z (ohms)	θ (degrees)	VSWR (uncoupled)	VSWR (coupled)
3.5	49	20	1.4	1.6
4.0	50	19	1.4	1.6
7.0	54	14	1.3	1.5
14.0	58	11	1.3	1.5
21.0	61	6	1.2	1.6
28.0	55	4	1.1	1.4
30.0	53	4	1.1	1.4

as the difference between the rf voltage readings at each of the two output terminals to ground (enclosure) divided by the sum of the two readings, expressed as a percentage.

Fig. 7 shows how to build a useful component for reversing the phase of an rf signal in a coaxial line. This phase inverter is useful for coaxial-fed W8JK antennas and other close-spaced phased arrays. The phase reversal takes place at the cross connection of two coax lines at terminals **A** and **B**. Terminals **A** and **B** are isolated from ground by the self-resonance principles described last month (**fig. 3**) and in **fig. 12**. Terminals **A** and **B** are not shorted by the grounded common connection between the coax outer conductors at **C** because of the high impedance over the outer conductors of the coiled coax lines. Of course, 180-degree phase shift can be accomplished in coax with a half-wavelength line; phase shift by this method, however, depends on frequency. The simple device shown in **fig. 7** inverts phase by 180 degrees independent of frequency; it inverts rf phase by exactly 180 degrees, with respect to equivalent length of coaxial cable, over a very broad band of frequencies. Measured broadband VSWR performance of the phase inverter is shown in **table 12.**

Phase inverters optimized for other frequency ranges may be designed according to the systematic design procedure for balun transformers detailed at the conclusion of this article.

summary of results

Of the various coreless rf devices made during the project, eleven are described in Parts 1 and 2 of this article. For convenience, they are summarized in Table 13, which correlates the construction of each device with measured performance data.

The transformers described in this article were, for the most part, designed with a combination of intuition and practical experience with coax baluns. However, as the project evolved, I gathered information that can be organized into a systematic design procedure. For example, N6AIG suggested a method of analysis starting with diagramming all of the possible ways to connect the ends of two or more coaxial cables.

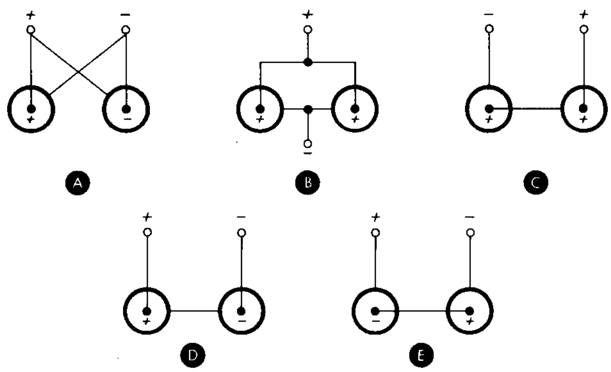


fig. 8. Various connections for pairs of coaxial lines. Polarity is arbitrarily assigned to the terminals, and the resulting polarity of the center conductors with respect to the outer conductors is indicated.

The diagram of **fig. 8** shows most of the connections possible with a pair of lines, and **fig. 9** shows some of the combinations for four lines. Similar diagrams can, of course, be drawn for any number of lines. Polarities are then assigned to the network terminals.

Next, assign polarities to each of the coax center conductors with respect to the outer conductors. Ex-

table 7. Performance of the 50-ohm coreless balun shown in fig. 1 compared with a commercial ferrite-core balun. VSWR was calculated from the impedance magnitude and phase data and is referred to 50 ohms.

	coreless balun				ferrite-core commercial balun			
F_0 (MHz)	Z (ohms)	θ (degrees)	VSWR	balance (per cent)	Z (ohms)	θ (degrees)	VSWR	balance (per cent)
3.5	48	16	1.33	2.8	49	11	1.21	11.8
4.0	49	14	1.28	2.1	49	9	1.17	12.0
7.0	50	10	1.19	1.3	50	9	1.17	11.6
14.0	50	8	1.15	2.5	55	11	1.24	7.9
21.0	51	8	1.15	4.2	63	12	1.37	1.4
28.0	52	9	1.18	1.3	72	5	1.46	3.9
30.0	53	9	1.18	1.3	75	8	1.54	1.6

table 8. Performance characteristics of a popular commercial 1:4 toroid balun transformer compared with the two-stage 50/200-ohm balun transformer of fig. 4.

	coreless balun transformer				commercial toroid balun transformer			
F_0 (MHz)	Z (ohms)	θ (degrees)	VSWR	balance (per cent)	Z (ohms)	θ (degrees)	VSWR	balance (per cent)
3.5	60	25	1.63	1.3	53	6	1.12	1.8
7.0	60	3	1.21	0.6	53	8	1.16	2.5
14.0	48	0	1.04	0.6	54	16	1.34	12.0
21.0	51	10	1.19	0.0	57	27	1.66	18.0
30.0	60	−1	1.20	3.3	69	44	2.53	21.0

amples of these assignments are shown in **figs. 8** and **9**.

Now make a table similar to **table 14.** This table will be an aid in analyzing each of the possible end-connection combinations. Construct the table by choosing the input and output connections you want for your application, taking into account balance/unbalance and impedance. Show these connections in columns 1 and 2.

Next, determine whether there is a polarity match. The input connection must be compatible with the output connection. This is determined by inspecting the polarities assigned to the inner conductors. For example, **A** cannot be matched with **B** in **fig. 8** because **A** has one + and one − center conductor polarity, whereas **B** has two + polarities. **A** and **D** are compatible because both have + and − polarities. Indicate whether there is a polarity match in column 3.

Whether the connection is balanced or unbalanced can be determined by inspection; this information is entered in columns 4 and 5. For example, **A** is balanced and **B** is unbalanced. An unbalanced connection can be converted to a balanced connection by the addition of one or more compensating lines. For example, unbalanced connection **F** or **fig. 8** may be converted to a balanced configuration by connecting the outside conductor of a dummy length of coax to the positive terminal. Wind the coax as a continuation of the line connected to the negative terminal.

Part 1 explained how the compensating winding creates balanced terminals by showing how the isolated terminals of **fig. 2** (Part 1) evolve into the balanced terminals of **fig. 3** (Part 1).

Input and output impedances of transformers made with 50-ohm lines are shown in **table 14**, columns 6 and 7. For example, for connections **A-D** (third line in **table 14**, the input impedance is 25 ohms, because two 50-ohm lines are connected in parallel at the input. The output impedance is 100 ohms, because the two 50-ohm lines connected in series at the output are properly terminated with 100 ohms.

The transformation ratio (column 8) is simply determined from columns 6 and 7. If the transformer in this case had been made with 75-ohm line, the input impedance would be 37.5 ohms, and the output

table 9. This table compares the performance of the corless balun of fig. 1 with that of a typical 1:1 commercial ferrite core balun with varying loads. VSWR is calculated with respect to 50 ohms from the impedance magnitude and phase-angle data.

	load			coreless balun			commercial ferrite balun		
F_0 (MHz)	R (ohms)	θ (degrees)	VSWR	R (ohms)	θ (degrees)	VSWR	R (ohms)	θ (degrees)	VSWR
3.5	16.0	7	3.1	22.0	34	2.9	17	25	3.2
3.5	20.0	4	2.5	25.0	28	2.4	22	20	2.5
3.5	25.0	3	2.0	28.5	25	2.1	26	18	2.1
3.5	33.0	2	1.5	37.0	21	1.6	35	15	1.6
3.5	50.0	1	1.0	54.0	20	1.3	51	13	1.3
3.5	75.0	0	1.5	77.0	20	1.8	75	14	1.6
3.5	100.0	0	2.0	98.0	25	2.0	97	25	2.3
3.5	125.0	−1	2.5	127.0	24	2.9	122	18	2.6
3.5	150.0	−1	3.0	140.0	31	3.4	144	20	3.1
14.0	16.5	22	3.3	53.0	60	3.7	33	60	4.1
14.0	21.0	20	2.6	54.0	48	2.6	36	51	3.0
14.0	25.0	18	2.2	54.0	34	1.9	38	46	2.6
14.0	32.0	14	1.7	57.0	30	1.8	43	35	2.0
14.0	51.0	7	1.1	56.0	2	1.1	61	15	1.4
14.0	75.0	5	1.5	62.0	−20	1.5	80	0	1.6
14.0	100.0	3	2.0	62.0	−36	2.0	100	−13	2.1
14.0	125.0	1	2.5	65.0	−46	2.6	117	−21	2.6
14.0	150.0	1	3.0	66.0	−50	2.9	126	−26	2.9

table 10. Summary of the distortion contribution of a typical commercial ferrite core balun at 2 kW PEP. The linearity of a high-power linear amplifier was measured with and without the balun connected between the amplifier and the load.

	odd order products				
	3rd	5th	7th	9th	11th
distortion products, amplifier without balun (dB)	43	43	52	63	60
distortion products, amplifier with balun (dB)	39	48	56	60	60

impedance would be 150 ohms. Incidentally, the transformer of this example (**A-D, table 14**) is the same configuration as that shown in **fig. 4** of Part 1 except that input and output connections are reversed. All the possible connections are not listed in **table 14**, as indicated by the dashed lines. Completing the list of possible combinations is left as a challenge to the reader.

The next step is to determine how the lines are to be coiled and to determine the coupling between the coils. Draw a schematic diagram similar to **fig. 1** of Part 1. A sample drawing of the example **A-D** in **table 14** is shown in **fig. 10**. For analysis, assign an arbitrary input rf voltage of 100 volts. In this case, the input is balanced, so a balanced input voltage of ±50 volts is assigned. A total of 100 volts is applied to each line, so the output voltage is 200 volts (± 100 volts with respect to ground). Note that 50 volts appears along the outside conductor across the length of each of the lines.

Determine the magnitude and polarity of the voltage along the outer conductors by tracing the applied voltage. Current will tend to flow over the outside of the outer conductors in the direction shown by the arrows. Sufficient impedance must be provided to prevent shorting the applied voltage. Another example of this technique for analysis is shown in the schematic of the unbalanced-to-unbalanced 50/200-ohm transformer of **fig. 11**.

The required common-mode impedance is provided by coiling the coaxial lines. The lines of **fig. 10**

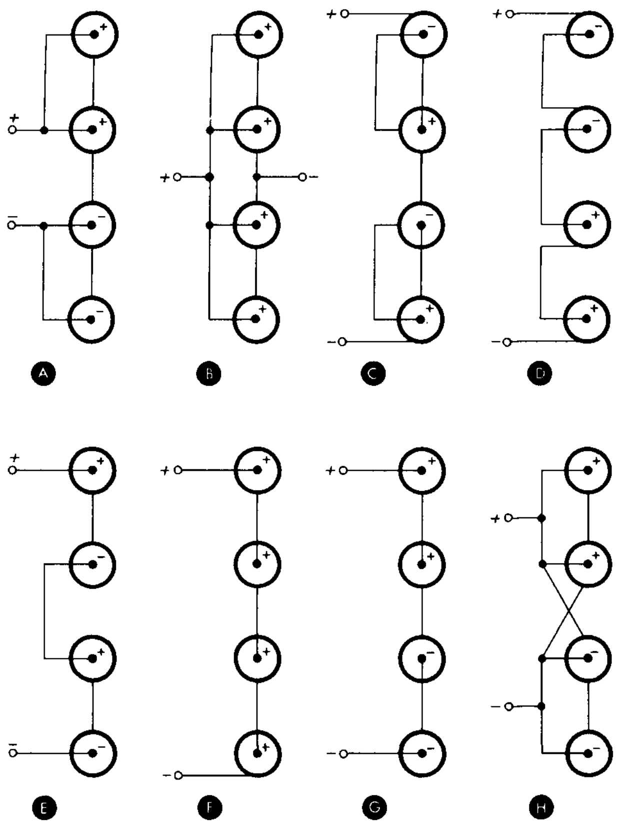


fig. 9. Some of the many possible connections for four coaxial lines. Polarity of the network terminals as well as the polarity of the coax center conductors is shown.

may be coiled together (closely coupled), because the voltage across the two lines is the same. The direction of current flow dictates that the lines must be coiled together as shown in **fig. 4** of Part 1. If the lines are coiled in opposite directions so that the current flow, as indicated by the arrows, is in the same direction, the coils will have positive mutual coupling and maximum common-mode impedance (input/output isolation). This is the reason the lines are coiled together into a continuous winding as shown, for example, in **fig. 4** of Part 1.

table 11. Comparison of W1JR Balun[2] with and without compensating winding. Additional winding of insulated hookup wire on the toroid shown in the photograph and the drawing (fig. 6B) substantially improves balance as shown below. Because of lead length, load VSWR is high at 14 MHz and above. See load data below.

	load			W1JR balun,[2] uncompensated				W1JR balun,[2] compensated			
F_0 (MHz)	Z (ohms)	θ (degrees)	VSWR	Z (ohms)	θ (degrees)	VSWR	balance (per cent)	Z (ohms)	θ (degrees)	VSWR	balance (per cent)
1.8	49	1	1.03	48	1	1.05	99.0	49	7	1.13	1.5
3.5	49	2	1.04	49	4	1.08	93.0	50	6	1.11	1.5
4.0	49	3	1.06	49	4	1.08	92.0	50	7	1.13	1.5
7.0	49	5	1.09	51	8	1.15	71.0	52	8	1.16	0.0
14.0	49	10	1.19	63	11	1.35	3.7	61	8	1.28	0.0
21.0	50	15	1.30	76	4	1.35	38.0	68	0	1.36	7.1
28.0	52	19	1.41	79	−12	1.66	47.0	51	−11	1.21	15.0
30.0	52	21	1.46	67	−17	1.53	48.0	36	−1	1.39	39.0

Depending on the choice of the many input/output configurations partially listed in **figs. 8** and **9**, the coaxial lines may or may not have current flow similar to that in example **A-D**. In some configurations, the direction of current flow on two lines is the same, in which case the lines must be wound together in the same direction. In other configurations, the voltage drops are not the same, so the coils should not be *tightly coupled. The configuration shown in* **fig. 11** is an example. In a number of unbalanced-to-unbalanced configurations, the voltage drop in one or more of the lines is zero (zero current flow). These lines should not be coupled with lines having voltage drop, because lines with zero voltage drop act like shorted turns. The unbalanced-to-unbalanced transformer of **fig. 5** is an example of this.

The outer conductor of coax **CD** (**fig. 5**) has the *same potential at both ends. It should not, therefore,* be coupled to the coiled length **AB**. The effect of trying to couple incompatible coils together is shown in the two right-hand columns of data in **table 6**.

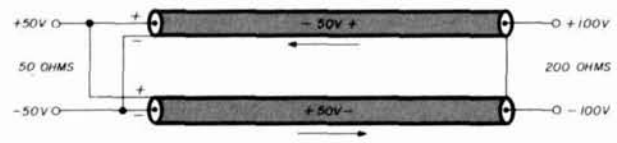


fig. 10. Schematic of the example A-D table 13 and fig. 4 of Part 1. A balanced input voltage of 100 volts (±50 volts) is assigned for analysis. 50 volts appears across the outer conductor along the length of each line, causing current to flow in the direction of the arrows. Enough impedance must be provided along the outside of the lines to prevent shorting the applied voltage.

Fig. 9 shows some of the many possible input and output connections for a group of four coax lines. Terminal and coax center-conductor polarities are indicated in the same format as in **fig. 8**. *A number of* the four-line connections are shown in **table 15** to *serve as examples.* Transformers consisting of any number of lines may be analyzed in this way. The highest transformation ratio depends on the number of coax lines. **Table 14** shows that two lines can achieve a transformation of four, and **table 15** shows that four lines can achieve transformation ratios up to sixteen. The highest transformation ratio available is equal to the square of the number of lines.[3] The length of all lines should be the same, to preserve phase relationships.

The final step in the design procedure is to determine the optimum length of coax line and the number of turns in the coil. If the coil has too few turns, performance will be poor at low frequencies; if it has too many turns, performance will be poor at high frequencies. As an example, in the balun described in

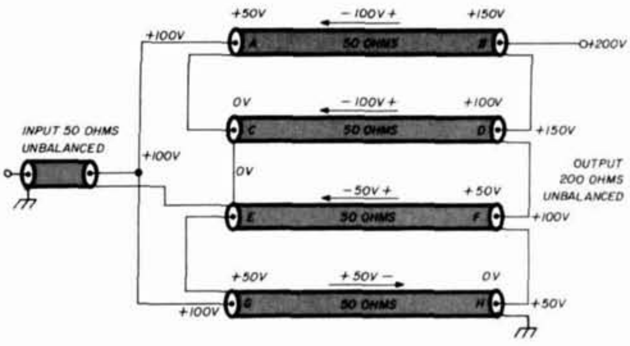


fig. 11. Another example similar to fig. 10 showing how to analyze a transformer configuration for direction and magnitude of voltage drops over the outside conductors of the coax lines. Lines AB and CD should be wound together in parallel and in the same direction for positive mutual coupling, like coiled line AB in fig. 5. Lines EF and GH should be wound together in opposite directions for the same reason.

fig. 1, each RG-58A/U line is 127 cm (50 inches) long. The lines were random wound *into* a 11.5-cm (4.5-inch) nominal diameter coil. VSWR performance *over the useful frequency range* is shown in **table 1**. Note the increase in VSWR at the ends of the frequency range and compare this with **fig. 12**.

Fig. 12 shows the impedance across the output terminals of the balun of **fig. 1** plotted as a function of frequency. When the balun is open circuited; that is, when the center conductor at the output is disconnected from the dummy coaxial line, the self-impedance of the coax coiled outer conductor can be *measured. The vector impedance meter was con*nected from point **A** to point **B** (**fig. 12**), and the impedance magnitude was measured between 1 and 70 MHz. Note that the impedance from **A** to **B** is always greater than 50 ohms, the line surge impedance, over the useful frequency range of the balun (**table 1**).

When designing a balun or transformer to your needs, make the coil self-resonant frequency approximately equal to the average of the upper and lower *frequency limits of the band of interest.* For example, if you want to design a transformer to cover 3.5-30 MHz, the open-circuited coil self-resonant frequency should be about 16 MHz. If you want your balun/transformer to be optimum for 160, 80, and 40 me-

table 12. Broadband VSWR performance of the 50-ohm to 50-ohm coax phase inverter shown in fig. 7.

F_0 (MHz)	Z (ohms)	θ (degrees)	VSWR
3.5	54	16	1.34
4.0	54	14	1.30
7.0	57	4	1.16
14.0	53	−3	1.08
21.0	48	−2	1.06
28.0	46	4	1.11
30.0	46	7	1.16

Table 13. Tabular summary of the balun transformers built and measured by W6TC.

input/output impedance ohms	ratio	input/output balance	bandwidth MHz	construction	measured data
50/12.5	4:1	balanced/balanced	1.8-30	fig. 5, part 1	table 1, part 1
50/200	1:4	balanced/balanced	3.5-30	fig. 6, part 1	table 2A, part 1
50/200	1:4	balanced/balanced	1.8-14	fig. 6, part 1	table 2B, part 1
50/50	1:1	unbalanced/balanced	3.5-30	fig. 1, part 2	table 1, part 2
50/50	1:1	unbalanced/balanced	1.8-14	fig. 1, part 2	table 2A, part 2
50/50	1:1	unbalanced/balanced	1.8-14	fig. 1, part 2	table 2B, part 2
50/50	1:1	unbalanced/balanced	21-100	fig. 2, part 2	table 3, part 2
50/12.5	4:1	unbalanced/balanced	3.5-30	fig. 3, part 2	table 4, part 2
50/200	1:4	unbalanced/balanced	3.5-30	fig. 4, part 2	table 5, part 2
50/12.5	4:1	unbalanced/unbalanced	7.0-30	fig. 5, part 2	table 6, part 2
50/50	1:1 (inverted)	unbalanced/unbalanced	3.5-30	fig. 7, part 2	table 12, part 2

ters, make the resonant frequency about 4.5 MHz. For two or three adjacent band designs, the frequency isn't critical; ± 10 per cent accuracy is sufficient.

I found that a grid-dip meter can be used to make this measurement. Make certain that the balun/transformer is open circuited at the output, as described above. The coil diameter should be 15-20 times the coax line diameter. Remember that these baluns and transformers make use of a broadly resonant circuit consisting of the distributed inductance and capacitance of the coax line outside surfaces. Accordingly, if the device is mounted on a metal plate or in a metal enclosure, the resonant frequency should be determined while in place. I tried extending the low-frequency limit of one of these transformers by adding lumped capacitance to the coiled coax at the output. (For example, between **A** and **B** in **fig. 12.**) This artificial loading does, in fact, lower the frequency of minimum VSWR; however, bandwidth is severly reduced.

design procedure summary

In summary, a systematic design procedure for coreless transformers and baluns is as follows:

1. Select input and output coaxial line connections (see examples in **figs. 8** and **9**).

2. Assign polarities.

3. Make certain the polarities of the input and output connections match (column 3, **tables 14** and **15**).

4. Check input and output balance by inspection (columns 4 and 5).

5. Check input and output impedance by inspection (column 6 and 7).

6. Determine transformation ratio (column 8).

7. Draw a schematic diagram similar to that in **figs. 10** and **11** for analysis.

8. Assign an input voltage, such as 100 volts.

9. Determine the polarity and magnitude of voltage across the length of the lines.

10. Determine the direction of current flow over the outer conductors of the lines.

11. Determine which lines must be coiled, if they can be coiled together, and the sense of the mutual coupling.

12. Select the length of line, coil diameter, and number of turns using a grid-dip meter to resonate the coil near the average between the upper and lower frequencies of the band of interest.

13. Make certain that the rf paths through all coax lines are equal, to preserve phase.

table 14. This table is a partial list of the coax connections shown in fig. 8. It is used as an aid in analyzing the connections.

column 1 connection (in)	2 connection (out)	3 polarity (match)	4 balance (in)	5 balance (out)	6 impedance in (ohms)	7 impedance out (ohms)	8 transformation ratio (in/out)
A	B	no					
A	C	no					
A	D	yes	balanced	balanced	25	100	1:4
B	C	yes	unbalanced	unbalanced	25	100	1:4
B	D	no					
—	—	—					
—	—	—					
—	—	—					

table 15. This table shows some of the connections for four coax lines shown in fig. 9. The impedances listed in columns 6 and 7 assume the use of 50-ohm lines.

column 1 connection (in)	2 connection (out)	3 polarity (match)	4 balance (in)	5 balance (out)	6 impedance (in) (ohms)	7 impedance (out) (ohms)	8 transformation (ratio) (in/out)
A	B	no					
B	C	no					
A	D	yes	balanced	balanced	50	200.0	1:4
F	B	yes	unbalanced	unbalanced	200	12.5	16:1
E	C	yes	balanced	balanced	200	50.0	4:1
B	C	no					

advantages of coreless balun transformers

The advantages of this new class of broadband coaxial line transformers over magnetic-core transformers are as follows:

1. They are inexpensive.

2. They are linear; there are no materials in the system that can saturate.

3. They use readily available materials: only coax and hookup wire.

4. They are lightweight and compact.

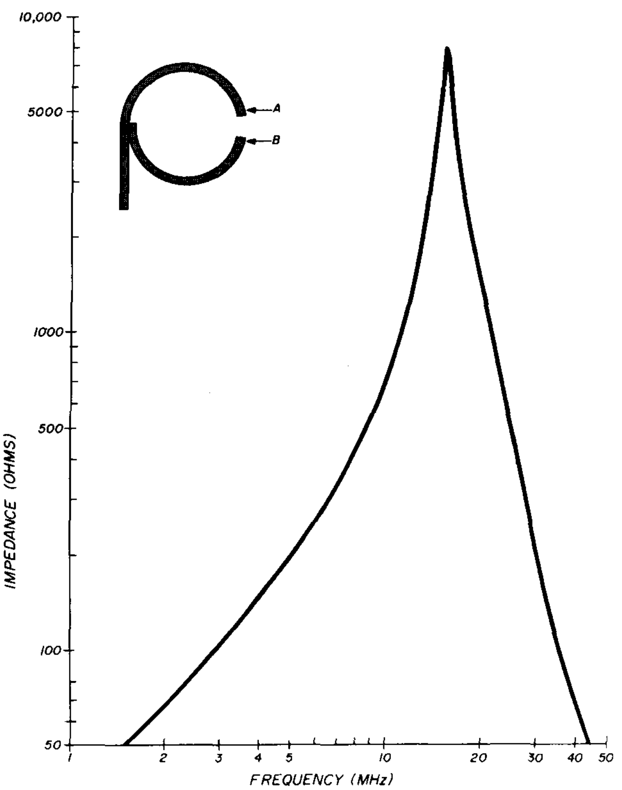


fig. 12. Impedance from point A to point B of open-circuited balun. Impedance at AB is greater than 50 ohms, the line surge impedance over the useful frequency range of the balun.

5. They are weatherproof because of the materials; an enclosure is not required.

6. They have low VSWR.

7. They are inherently balanced.

8. They have high power-handling capability limited only by the coaxial line chosen. When made with Teflon coax, they are virtually indestructible in Amateur service.

9. There are no closely spaced or tightly twisted enameled wires and no ferrite or powdered iron core materials that can result in arcing.

conclusion

The purpose of this article is to show how high-performance balun transformers can be built free of the disadvantages of magnetic core materials. I hope I've presented enough data on this new class of devices for you to be able to reproduce one or more of the designs described here, or to design one of your own to meet your requirements. My goal has been to provide enough information for others to be able to reproduce these useful balun transformers, even though they may not have access to fine instruments such as the Hewlett Packard vector impedance bridge, rf voltmeter, or programmable calculator.

acknowledgment

I am indebted to the EIMAC gang (the laboratory staff at EIMAC) and the staff at CTC for counsel, constant encouragement, and after-hours use of their laboratory facilities.

Note: The HP-67 program for calculating VSWR that should have appeared in the appendix of part 1 of W6TC's article (February, 1980, *ham radio*) can be found on page 70 of this issue.

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ham radio

considerations regarding microphones and simple speech processing

A look at simple homemade microphones and speech processors

This article describes a microphone stand that can be built easily and that's much more convenient to use than the typical commercial unit. Also described are simple preamplifier and clipper circuits that can be added to a phone station between microphone and transmitter.

improved desk microphone

In spite of all the equipment manufactured for sale to Amateurs, many desirable items still can't be readily purchased. Many times these items are simple to build, and many times the item needed is a simplified version of what's commercially available. In any case, it's seldom that the scratch-built item isn't a big cost saver.

In the case that prompted this article, the audio gain in my low-band rig was marginal. Close talking in a moderate voice into a standard crystal microphone was required for full SSB output. This condition may not be unusual based on my own experience and that of others I've talked to. Additionally, standard microphone stands have always left a lot to be desired, to my way of thinking. First, they're seldom adjustable in height; second, they must be placed off to the side if you want to take notes or fill in your log while talking. One of my friends claims the best he can do is get his nose up to the bottom of the microphone; in my case, I have to bend over to speak into a microphone mounted on a typical commercial stand. The solution to this problem is a boom-type microphone stand.

The mechanical end of this kind of project is wide open with respect to cost and complexity. If you have the shop equipment, the boom stand can be a major project for tools such as a lathe and drill press. It's largely a matter of the materials and tools you have and your personal taste.*

My original stand was made from junk-box parts and some pieces of birch dowel.' It looks a bit "Tinker-Toyish," but it serves the purpose very well. The second design, which is shown in the diagram, requires no unusual tools and works better than the original.

building the microphone stand

The base is made from two or more layers of 6.5-mm (¼-inch) tempered Masonite (**fig. 1**). The base should be at least 153 mm (6 inches) in diameter and may be weighted if a heavy microphone is used. The upright section is a "plumber's delight" made from readily available plumbing fittings. The boom is a piece of Greenfield flexible tubing, which is available at electrical supply houses. This type of tubing is smooth and flexible. To stiffen it, use a piece of aluminum clothes line wire inside of it.

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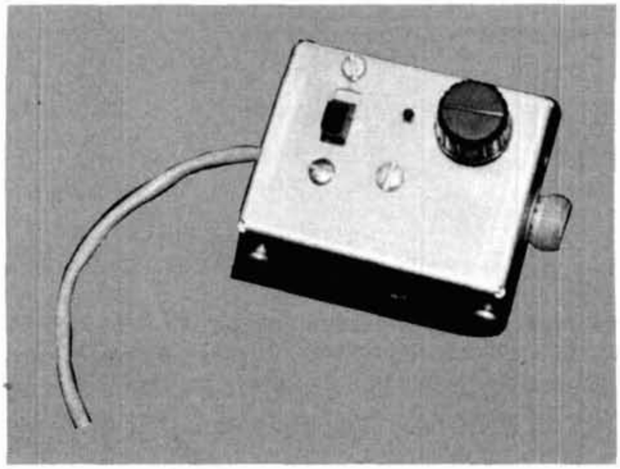
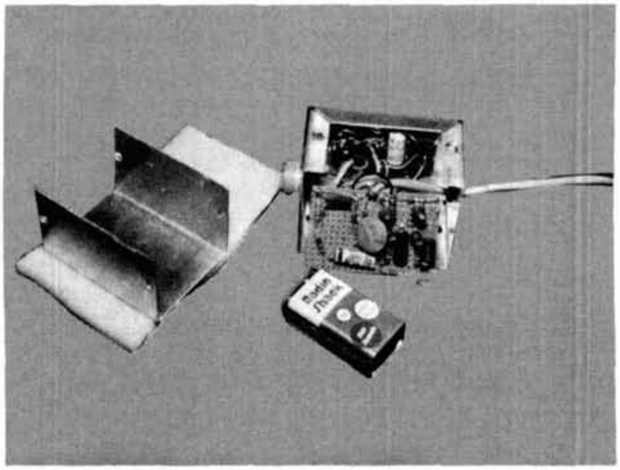
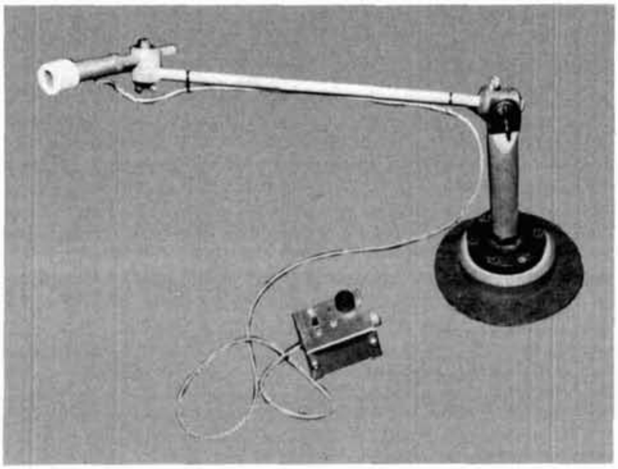
*Metal is recommended for audio and radio-frequency shielding.







Top left, **panel view of the two stage preamplifier/clipper described in the text. The on-off switch is at the left, the LED pilot light is in the center, and the gain control is on the right. The gain setting in the preamplifier controls the amount of clipping, while the gain setting in the transmitter sets the maximum modulation (or audio drive) level. Preamplifier gain will decrease as the battery voltage decreases making it necessary to readjust the gain control. The control in the transmitter should require readjustments only after major tuning changes.** ***Top right,*** **preamplifier circuit built on a perfboard and contained inside a mini box. The circuit is loose-mounted by wrapping it in foam plastic (under the box cover in the picture). The plastic insulates it from terminals and connections, which are part of the box itself, and provides all the mechanical strength needed. The on-off switch is separate from the gain control so that the preamplifier can be turned on and off without changing the gain setting. Input-output connectors can be varied to suit the needs of any transmitter/microphone combination.** ***Bottom left,*** **the first boom microphone built by the author. This type of construction led to a very useful microphone but requires more tools to build than the design in the text. The boom arms and upright section are constructed from birch dowels. This approach doesn't provide the audio and radio-frequency shielding that all-metal construction does. However, it's cost effective, since the parts were all from the junkbox.** ***Bottom right,*** **the microphone design described in the text. It is made of readily available materials easily assembled in the home workshop. If you lack the tools to make a round base, use a square or six-sided base, which will work just as well. This design provides all-metal shielding of the microphone element and that part of the cable inside the stand. The Greenfield flexible tubing is stiffened with an internal piece of aluminum clothesline wire. This approach provides the ultimate in adjustability and convenience.**

pilot light circuit

The LED pilot light in the two-stage circuit is of special interest. If the circuit is left on when not using the rig, the battery will last only a few days, depending on how new it is. Having learned the hard way, I realized that a pilot light with minimum power requirement was needed. Several power-saving techniques were rejected before a friend suggested connecting the pilot light in series with the amplifier. Neat! A pilot light that actually causes a slight *decrease* in the current drain! It's not too bright, but it's adequate for the purpose. (If used with the single-stage preamplifier circuit, it may be necessary to add a resistor* to ground after the LED. This will cause more current to follow through the LED — at least 2 mA is required for most LEDs.)

Another solution to the power problem is an external source powered from the ac line. If the preamplifier is to be built into the rig there's little problem, even if it is a tube rig. In the latter case, a voltage source, such as the well by-passed cathode bias on an amplifier stage, can be used. The circuit will operate over a range of at least 7-15 volts. External supplies intended for calculators and similar devices can be used, or a miniature regulated supply can be built into the amplifier.

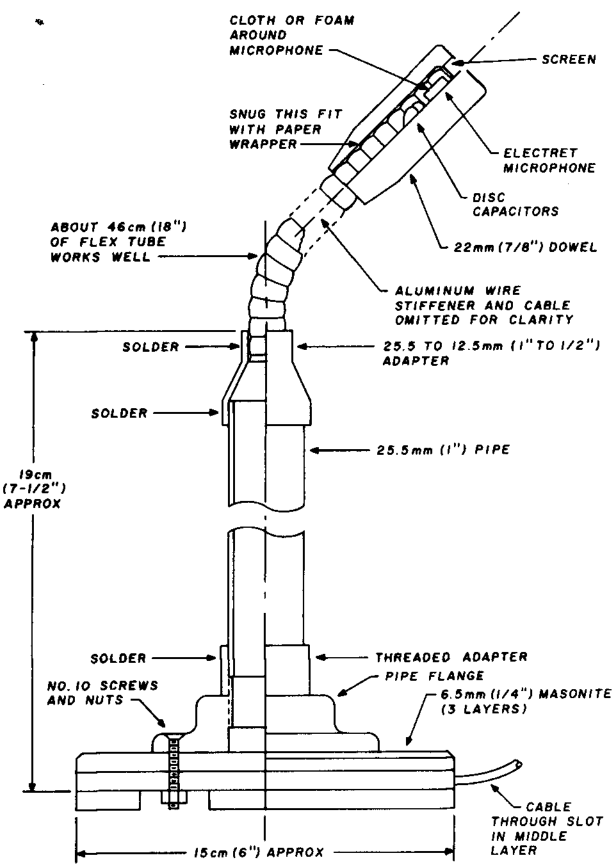


fig. 1. Mechanical layout of the desk microphone described in the text. The construction shown is for guidance only. Most builders will substitute materials on hand and their own techniques of fastening things together. A push-to-talk switch can be mounted on the base if desired.

adapting the Electret cartridge

If an Electret microphone is used, it can be easily adapted to the boom using a short piece of 22-mm (7/8-inch) birch dowel. Drill the dowel to fit the tubing outside diameter (16 mm, or 5/8 inch) but do not go quite all the way through. Turn the dowel around and drill through from the other end with a 12.5-mm (½-inch) diameter drill. Slip in a piece of screening from the 16-mm (5/8-inch) end. Sand the dowel, round the edges to suit yourself, and slip the dowel over the end of the Greenfield tubing. Use a piece of 77 × 128 mm (3 × 5 inch) card stock to "snug" the fit if necessary.

Slip the microphone into the end of the Greenfield tubing and make it snug with a layer or two of cloth, sponge rubber, or plastic foam. Make the connections before putting the microphone element into place. Don't neglect a ground connection to tubing at the microphone end!

I've received many on-the-air compliments on the Electret microphone, which compensate for its low output and the power requirement for its internal amplifier.

Other microphone elements can be adapted in a similar manner or with a little ingenuity. For example, the top of a plastic bottle can be cut off and used to house a larger microphone element. If your workmanship isn't the greatest, a "blast shield" can be purchased (Olson Radio has them). A shield of this type will cover the whole microphone housing and make things look quite professional.

plumbing details

The Greenfield tubing and pipe fittings can be soldered together using a propane torch, standard plumbing flux, and solder. Details of the plumbing lash-up are left to you, since the availability of junkbox material may determine your approach. The stand in the photos has a 128-mm (5-inch) length of 25.5-mm (1-inch) copper pipe with a reducing fitting to hold the Greenfield tubing. A 25.5-mm (1-inch) copper pipe threaded adapter was used to mount the pipe flange at the bottom.

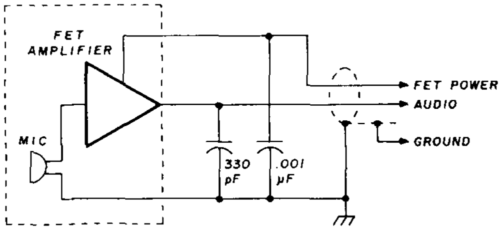
All told, including a Radio Shack Electret microphone element, the microphone cost less than $10.00. Most of the cost was in the plumbing fittings. Not a bad price for an extra convenient microphone!

Unlike mikes, most commercially available speech processing equipment is complex and expensive. Many hams need speech processing for two reasons: a) lack of audio gain in the transmitter, and b) a need to limit the audio level to prevent overmodulation and consequent wide bandwidths. In the first case, we're short-changing ourselves by not using the transmitter's full capability. In the second case, we're causing inconvenience to others by splattering outside our allowed bandwidth. In fact, we're operating illegally in this case. Both of these problems can be resolved by building an outboard solid-state speech processor — or buying one.

*Try resistors in the 2-5 kilohm (¼-watt) range. The lower the resistance, the brighter the LED will be.

simple microphone amplifier

If lack of gain and/or power for an Electret microphone is your problem, the single-stage bipolar transistor amplifier shown in **fig. 2** can be used. The circuit includes a regulated voltage source for an Electret microphone. The zener regulator output is for the microphone's internal amplifier. It reduces the 9-volt battery voltage to about 4 volts, a nominal supply voltage that will satisfy most microphones. Check your microphone and use an appropriate zener if the supply voltage should be higher or lower.



Typical Electret microphone circuit. Output impedances vary but are typically in the order of 1 kilohm. Disc ceramic capacitors tend to short out rf that may be picked up. This type of microphone is inexpensive and provides excellent speech quality. The fet amplifier is built in.

After pricing zeners for the 4-6 volt range, I bought a blister pack full for less than $2.00 and found four usable diodes among them. A test circuit can be made by connecting the diode in series with the 2.2-kilohm resistor specified in **fig. 2**, a voltmeter, and the 9-volt battery. Check the diode in both directions. It will read about 0.6 volt in one direction and the zener voltage (if less than 9 volts) in the other direction. Mark the diode polarity on the diode if it was not marked as received.

The transistor amplifier circuit shown is very

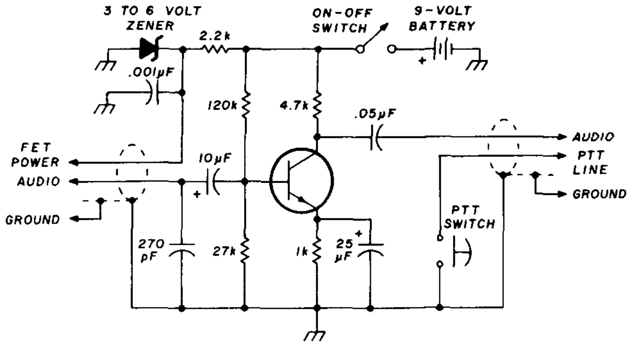


fig. 2. Simple amplifier for use with low-output microphones. A regulated supply for an Electret microphone is included. All resistors ¼ watt. Transistor is 2N2925 or equivalent. Capacitors are disc ceramic except where polarity is marked; these are electrolytics. This circuit is not recommended for microphones with impedances higher than 50,000 ohms. The output is intended to match transmitters with high-impedance microphone inputs.

tolerant of the transistor used. Most any medium- or high-gain (h_{fe} = *100-300*) NPN transistor should do the trick. The 2N2925 is typical of this type and is usually in plentiful supply.

The circuit can be built on a small piece of perfboard. The 9-volt battery and circuit were wrapped in plastic foam to keep them from rattling about and were tucked into the minibox without rigid mounting. The capacitors across the microphone, and at all leads entering or leaving the minibox enclosure, were intended to minimize rf entering the circuit and causing problems.

two-stage speech processor

If you're looking for some gain and would like full audio drive without splattering, the circuit of **fig. 3** is your answer. This circuit includes two stages of gain, a diode clipper circuit, and an RC filter that reduces

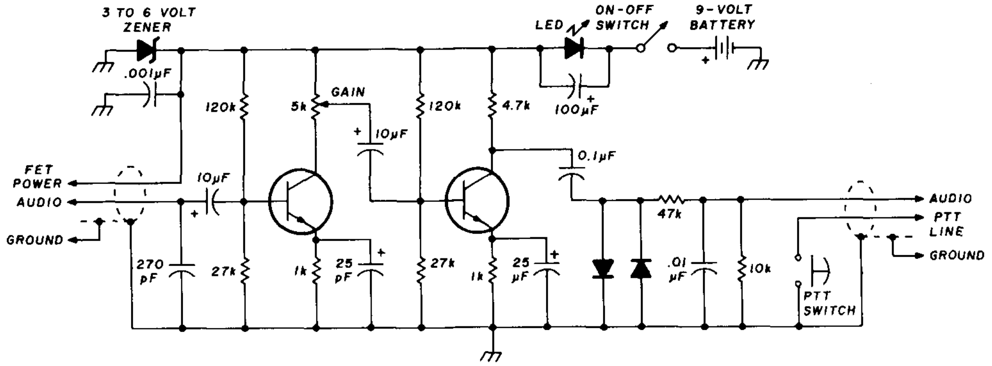


fig. 3. Two-stage amplifier/clipper circuit. A regulated supply for an Electret microphone is included. All resistors ¼ watt. Transistors are 2N2925 or equivalent. Capacitors are disc ceramic except where polarity is marked; these are electrolytics. Diodes are 1N4149/1N914. Input-output impedances are similar to those of the single-stage amplifier of fig. 2.

the distortion introduced by the clipper circuit. It also includes a voltage source for an Electret microphone and a novel pilot-light circuit (described later). This circuit has enough gain to allow the signal to be clipped or flat-topped by the back-to-back diodes. They set a peak-to-peak audio voltage level of 0.6 volt maximum that can't be exceeded by a loud voice or high gain settings in the preamplifier. Because the diodes fix the output level, the transmitter gain control can be used to set a relatively fixed drive level that won't cause splatter.

The diode clipping distorts audio quality by introducing harmonics of the voice frequencies. These harmonics are reduced by the RC filter that follows the diodes. This circuit is far from a cure-all, however, and this clipper-filter circuit must be classified as a rudimentary speech processor.

gain control

The potentiometer in the two-stage amplifier is a gain control and will set the amount of gain ahead of the diode clipper. If set high, the gain will be great. The diodes will clip a great deal, and the ambient background noise will modulate the rig with ease. This setting will also introduce more audio distortion. The peak output level is set by the diodes, and the transmitter modulation level is set by the gain control in the transmitter. Once this control is set for any tune-up condition, the transmitter peak drive level will not be exceeded, even under close-talking conditions.

Some experimentation will be necessary. It will be necessary to readjust the transmitter gain control when major changes in transmitter tuning are made. (This adjustment has to be made even without a speech processor.) In my opinion, a simple processor of the sort shown can be very useful but shouldn't be overworked to the point that your listeners complain about distorted voice quality and the dishes clattering in the kitchen.

On-the-air results with these circuits have been gratifying. Their results-to-simplicity ratio is high!

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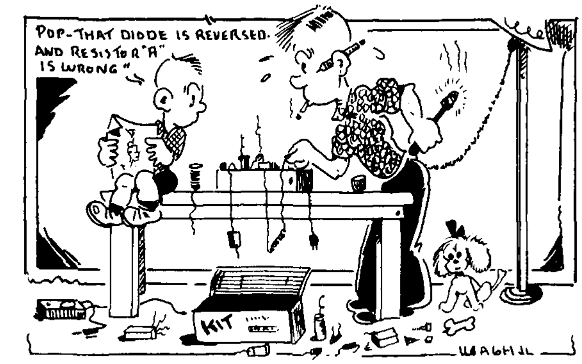

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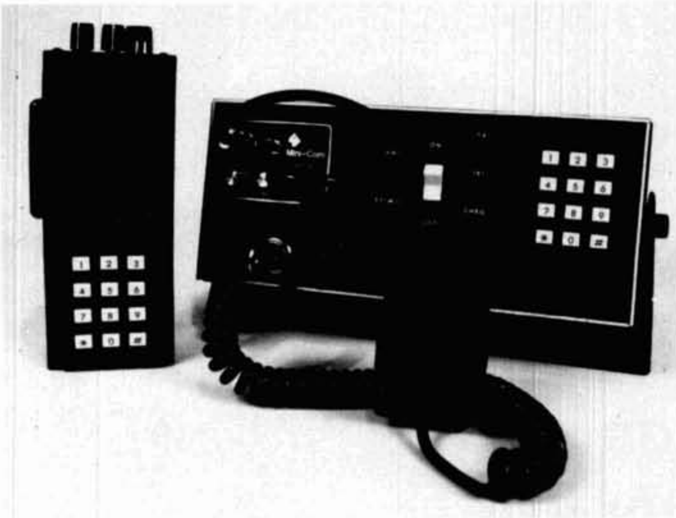

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logarithmic detector

with a post-injection marker generator

A specialized piece of test equipment that provides accurate frequency markers for crystal-filter alignment

The best way to align a crystal filter is to drive it with a swept signal generator that provides horizontal input to a scope, then detect the filter output and display it vertically. The detector should be logarithmic; that is, *linear in dB*. And it's helpful if accurate frequency markers are available on the display. This article describes such a box, which I suppose is properly called a "logarithmic detector with post-injection marker generator." That title seems a little long, so I call it the target for my sweeper.

This is a specialized piece of test gear, so many hams wouldn't consider building it; how many times does one align a crystal filter? The fact is, though, there isn't much in this thing in the way of parts, and it's easy to get running. I'd call it a "longweekender" project, and it sure is fun to play with.

detector speed and dynamic range

In any logarithmic detector there's a tradeoff between speed and dynamic range. Take a peek ahead at **fig. 5**, which shows our box giving a nice account of itself between −60 and −10 dBM. That data alone doesn't guarantee the performance we need because the data in **fig. 5** is static; it doesn't show how long the detector takes to settle down when the input level is changed. To see why this is important, consider a typical test situation. We're running our sweeper at 30 Hz (to get a flicker-free display) and our filter is working great. On the display there's a single hill or blip having a width of, say, one-fifth of the screen (our sweep width is five filter bandwidths).

The scope vertical signal has a bandwidth of at least 150 Hz, probably more if our filter response has steep sides; figure it out yourself. This means that, if the displayed response is to have any meaningful relationship to the filter response, the detector must be fast, very fast as logarithmic detectors go. To get this speed we have to give up range; the 50-dB range of **fig. 5** is poor in comparison with the 100-dB range available in instruments that can take their time about producing a reading.

performance test

Perhaps the best way to specify the performance of the target is to describe the simple test I apply whenever I use it. Required are a signal generator capable of being 50 per cent modulated at 400 Hz, a calibrated step attenuator, and a dc-coupled scope. (You don't have a dc-coupled scope? Neither do I, but I *do* have an electronic switch that chops up an

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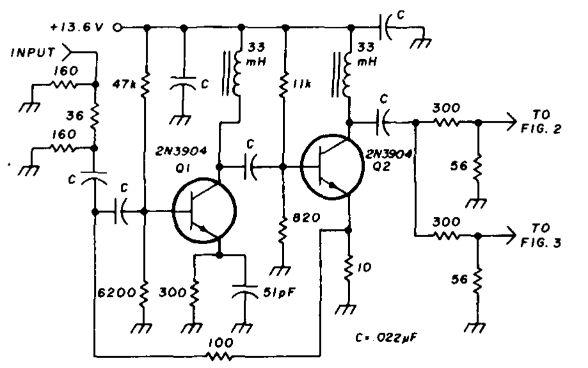

fig. 1. Schematic of the front end showing the input pad, preamplifier, and power divider. The two outputs deliver about 100 mV rms. Output circuit is designed to prevent interaction. The output resistors aren't critical; 330-ohm units could be used.

input to give the same effect; alternatively, you can connect a dc voltmeter along with the scope, although this is not as dramatic.)

Now, the peak-to-trough ratio of the envelope of a 50 per cent amplitude-modulated signal is exactly three; that is, the instantaneous power changes 10 dB over a modulation cycle. Hook up the stuff (using the scope internal sweep) and see what you see. The log of a sine wave isn't that much different from a sine wave, so you'll see a "sort of" sine wave of 400 Hz. Note the peak-to-peak size of the display and the average height.

Now crank in 10-dB attenuation. The shape of the display should be unchanged, because the instantaneous power is still varying 10 dB. The height of the display should have dropped exactly 10 dB; namely, the peak-to-peak size! Run this test over a range of input levels and frequencies.

I find the box works very well from 1-10 MHz and from −10 dBm input to −60 dBm (unmodulated value). At the bottom end of input levels, the display shrinks vertically, indicating loss of linearity, whereas at the highest levels, it first balloons then collapses because of saturation. The bandwidth is well above 400 Hz, because, if it weren't, the displayed waves would "lean" from vertical symmetry. I wish more of my test junk had such a simple "alive-and-well" test.

circuit description

Fig. 1 shows the front end. It's important, of course, that the target present a constant load to the filter. The feedback amplifier is designed for 50-ohm input, and a 6-dB pad makes extra sure.

Levels for operation are arbitrary. I chose −10 dBm as the maximum input because that's about what any old signal generator will produce. The amplifier was chosen so that, at this input level, the two outputs are about 100 mV rms, which is the maximum input level for the following devices.

The 300-ohm resistors keep the two outputs from interacting. All values in all diagrams are the ones I used, mostly because of the Mt. Everest principle (they were there). Obviously, 330 ohms would do as well, and the same goes for many other places where I used values available in 5 per cent tolerance.

Log detector. Fig. 2 shows the logarithmic detector, which uses the agc output from an LM373. The LM373 is connected in the a-m mode precisely as recommended by the manufacturer, with the exception of the 1-μF capacitor at pin 1. Normally, a much higher value is used to prevent the agc from following audio; we *want* the agc to follow audio.

I experimented to find the smallest usable value for this cap; with lower values the agc loop is fast

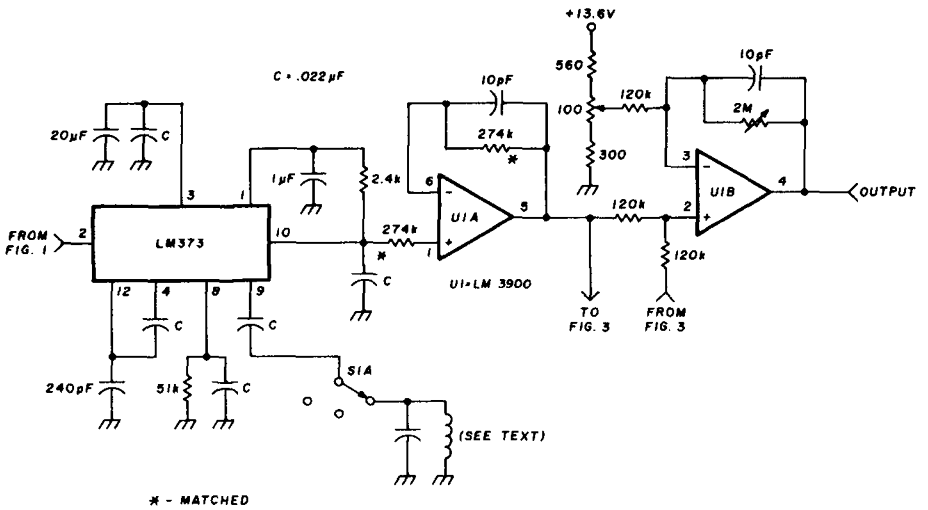

fig. 2. Log detector circuit. The 1-μF capacitor at pin 1 of the LM373 determines respond speed. Useful bandwidth is about 1 kHz.

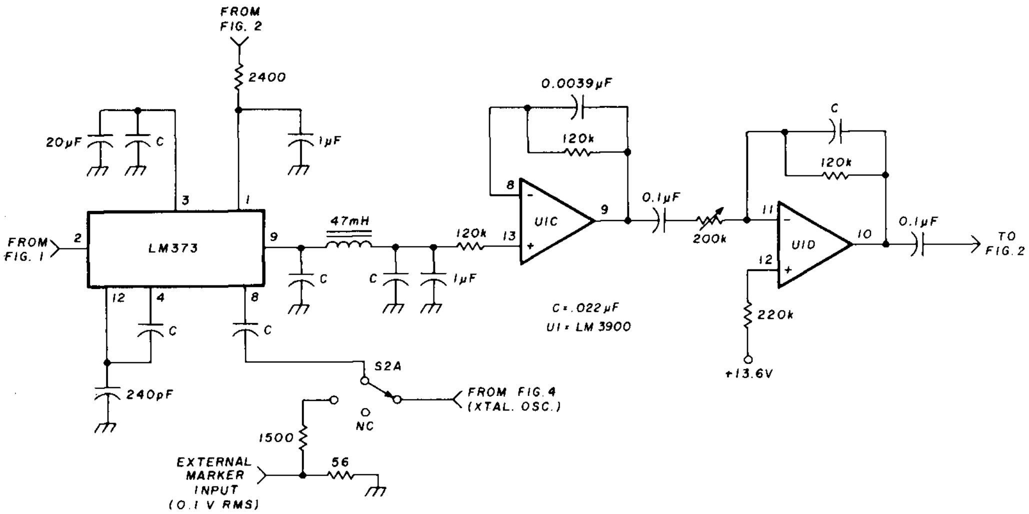

fig. 3. Post-injection marker generator. An LM373 is used in the product-detector mode with BFO input from an external source or crystal oscillator.

enough to lock onto noise and oscillate. This item determines the speed of the whole works. Adding 4 μF in parallel here gives a perceptible effect at 400 Hz, so I expect the useful bandwidth is about 1 kHz.

The tuned circuit at pin 9 could have been eliminated. I set up a bandswitch with circuits at 1.25-, 4.8-, and 10.6 MHz (where I had filters in the works), but I found little difference when I switched to an unconnected position left in reverse. A loss of about 6 dB occurred at the low end, and that's it. Of course, there's a huge difference if I switch to the *wrong* filter.

At about 100 mV rms input, the agc system loses control and the output soars; this is easily spotted and reminds you to cut down the input level.

Op amp U1A is an isolator. I took care to match its two resistors (by using a couple of 1 per cent resistors of the same value) to keep its output very close to the input for reasons discussed later.

Op amp U1B permits adjustment of the output range (my voltmeter has a 3-volt scale, so I selected the range shown on the right of **fig. 5**), and also accepts a "birdie" input from the marker generator. Each op amp has a 10-pF feedback cap to roll off unwanted high frequencies. The units of **figs. 1** and **2** are complete in themselves; the marker (discussed next) is optional.

marker generator

Fig. 3 shows the marker generator. A second LM373 operates in the product-detector mode with BFO input from an onboard crystal oscillator. The agc line of this LM373 is driven by the output of U1A (**fig. 2**) at precisely the level being used on the other LM373. This keeps the marker size independent of where it falls on the filter response curve — just a frill, but the line was available, so why not?

U1C provides a heavy lowpass filter to keep the marker narrow. I selected the 0.0039-μF cap by trial to give a width of about 300 Hz, my personal preference. U1D allows adjustment of the marker height by the 200-kilohm pot. Mine is adjusted for 1 volt p-p, or about 20 dB, which is another item of choice.

I never use markers and filter at the same time; I prefer to precalibrate the horizontal scale, then get the markers out of the way. It used to be that, with a rig like this, one would want several crystal markers available. But nowadays, with counters easy to come by, it seems simpler to connect an external generator and move it around while reading its position from a counter.

I did opt for one internal marker, which is handy for making sure I'm connecting the correct tuned circuit (S1 does both). Switch S2 selects internal, ex-

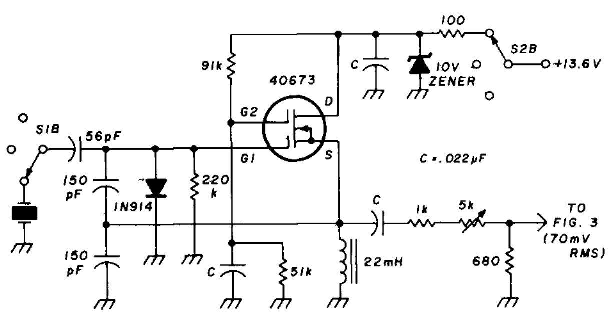

fig. 4. Crystal-oscillator schematic. Circuit is from W2YM. The 1N914 generates "grid-leak" bias.

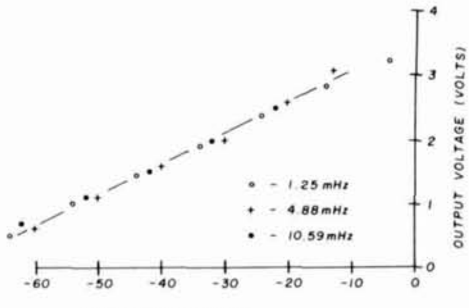

fig. 5. Log detector response showing linearity over its 50-dB range. The absolute level is temperature dependent; relative levels are not (see text).

ternal, or no marker; and, in the internal case, it powers the crystal oscillator, **fig. 4**. This is just the good old W2YM circuit using a diode to generate "grid-leak" bias.

BFO injecton-level is far from critical. The levels shown are what I use, but 10 dB up or 20 dB down from there should be fine. One nice thing about the LM373 is the low level required; this allows a good, solid termination for the external generator without requiring excessive drive. As I mentioned, the marker output goes to U1B for combining with the logarithmic level.

detector response

Fig. 5 shows the linearity of this gadget over its limited range. The absolute level in **fig. 5** is temperature dependent; that is, the curve might go up or down a few tenths of a volt between a cold start and temperature stabilization. The relative levels are not temperature dependent; 10 dB is 0.5 volt hot or cold. All this means is that, if you want to use the target as a "dBm meter," say to measure the output of an oscillator, you must be sure it's warmed up and calibrated. For filter responses you can jump in cold.

concluding remarks

Speaking of secondary uses for the target, note that you don't have to connect a scope to the output. I plugged in a 2000-ohm headset in series with a 0.1-μF blocking cap and used the thing in the external marker mode as a direct-conversion receiver to listen for chirp on the main rig. Worked fine!

I had a small circuit board for the crystal oscillator, having made up a batch of them long ago. I mounted the rest of this thing on a 6 × 6 inch (153 × 153 mm) single-side board, which had room for a second LM3900. Each IC was bypassed at B+ as at pin 3 of the LM373s.

ham radio

log-periodic fixed-wire beams
for 75-meter DX

Extensive tests with overseas Amateurs have resulted in an LP antenna with excellent characteristics and performance

This article describes log-periodic antennas made of wire elements, fixed in position, for the 75-meter Amateur band. It includes test results based on contacts between W4AEO in South Carolina and an Amateur in New Zealand, ZL1BKD. During the test period (late 1975 through early 1976), performance of the 75-meter LP, in various configurations, was compared with that of other antennas including dipoles, delta loops, slopers, and verticals.

background

I first became interested in 75-meter DX while talking to Colin, ZL1BKD. Colin had read some of my articles on LP beams[1-5] and asked if I'd tested one on 75 meters. Most of the referenced articles describe the construction of LPs for 10, 15, and 20 meters, giving test results. In one or two of the articles I'd furnished dimensions for a 5-element monoband LP for 75 meters of the log-periodic dipole (LPD) type, but it was never tested. (The dimensions for the 75-meter LPD were merely scaled up from one that worked well on 40 meters.)

As a result of my on-the-air talks with ZL1BKD and an exchange of correspondence, we agreed to conduct a test program involving a 75-meter LP and several popular Amateur antennas.

reference antenna

The antenna used as a reference in the tests was a log periodic consisting of five elements about 18 meters (60 feet) high. This antenna was modified several times during the tests. It was used as an LP Yagi, then as a 5-element Yagi. Test data in the form of operating-log sheets are provided to show on-the-air results (**table 1**).

environmental test conditions

I'm fortunate to have enough space to erect several 75-meter antennas at the same time. Pine trees abound for supports, with heights of up to 21 meters (70 feet). But my location in South Carolina is subject to severe thunderstorms. Lightning took its toll in the summer of 1976: two test antennas were destroyed.

I have also found that vertical antennas don't perform well at this location. I believe this is because of poor ground conductivity in my area,[14] limited clearance between verticals and trees,[15] and an extremely high noise level.

overseas tests

Between July, 1975, and March, 1976, ZL1BKD and I compared over a dozen different antennas with

The 75-meter LP beam antenna described here requires a considerable amount of real estate as well as many high supports. The minimum area required for the 75-meter antenna suggested by W6PYK (3-element LP plus director) is about 0.3 acre (1500 square meters, or 16,131 square feet). This doesn't include space for running supporting lines between antenna elements and trees, which requires another 988 square meters (10,620 square feet). Thus the antenna isn't practical for Amateurs limited to small city lots. **Editor**

By George E. Smith, W4AEO, in collaboration with **Paul A. Scholz, W6PYK.** Mr. Smith's address is 1816 Brevard Place, Camden, South Carolina 29020. Mr. Scholz's address is 12731 Jimeno Avenue, Grenada Hills, California 91344

the 75-meter LP, which was aimed west from my location. Comparision antennas included:

1. Three 75-meter halfwave dipoles at 15, 18, and 23 meters (50, 60, and 75 feet) above ground

2. Three 75-meter delta loops

3. Several 75-meter slopers and phased slopers using various beam configurations

4. Two quarter-wave 75-meter verticals with various numbers of buried radials

5. One half-wavelength 75-meter vertical suspended from a balloon, voltage fed at the bottom with an antenna tuner

6. Two 75-meter half waves in phase (collinear horizontal dipoles) at 23 meters (75 feet) high, oriented broadside to New Zealand

7. One 2-wavelength 75-meter horizontal quad element up 23 meters (75 feet). One lobe was toward New Zealand

8. A two-element, 75-meter bobtail curtain (two phased quarter-wavelength vertical radiators with one-half wavelength spacing). An inverted groundplane was used. Antenna height was about 21 meters (70 feet). The pattern was bidirectional, broadside to New Zealand

9. One 75-meter long-wire antenna (229 meters, or 750 feet long) mounted on tree tops at about 18 meters (60 feet) high. The main lobe was oriented west.

10. A Shakespeare (commercial marine) vertical antenna, center loaded, 7 meters (24 feet) long covering the 4-MHz marine band. The antenna was tuned to 3808 kHz and mounted at 12 meters (40 feet). Four one-quarter-wavelength sloping radials were used.

a note on delta loops

Delta loops for 75 meters were popular during the time of these tests and were used by several 75-meter DXers. Of the three delta loops used in the tests, two were arranged with the horizontal section at the top and with the apex pointed toward ground (delta loops 2 and 3, **table 1**). The third delta loop (delta loop 1, **table 1**) was in the opposite configuration: apex up and horizontal section about 3 meters (10 feet) above ground.

Two deltas were first fed at bottom or center (horizontal polarization), then changed to corner feed (vertical polarization). The latter configuration was best for the U. S. — VK/ZL path.

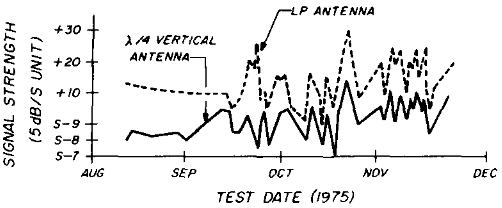

fig. 1. Data showing day-to-day differences between the LP and the quarter-wave vertical used at W4AEO during the test period (August, 1975, through November, 1975.) These data were compiled by W6PYK from reports by ZL1BKD.

Anyone considering a quad or delta loop for 75 or 40 meters is urged to read reference 16, in which the author describes his tests of deltas and quads and shows lobes, radiation angles, and other data. (A reprint of this article appears in reference 17.) Another source appears in the April, 1976, issue of *ham radio*.[18]

test results

Overseas tests began in July, 1975. A condensed reproduction of my log (**table 1**) shows representative data taken while running tests with ZL1BKD. The vertical, delta loops, and quad were first compared directly with the 5-element LP at about 18 meters (60 feet) above ground, aimed west. Note from **table 1** that the quad, erected in October, 1975, and delta loop 3, erected in November, 1975, were mounted over a pond.

The LP, LP-Yagi, and Yagi under test were the only true unidirectional antennas used during the test period. Also note that the LP had been modified several times — it was used as an LP-Yagi for a time, then later modified as a 5-element Yagi.

test note

My first 75-meter LP was completed on August 1, 1975. I made contact with New Zealand stations the following morning. Reports indicated that the LP was at least 10 dB better than the dipole or quarter-wave vertical antenna.

Colin, ZL1BKD, later added an external dB meter to his receiver, which gave more accurate readings. This method was used during the tests between August 21, 1975, and March, 1976, when the tests were completed. Contacts were made several times per week during this period.

Tests were run on 75 meters near 3808 kHz for U.S. and ZL stations, with 350 watts PEP. (VK stations operate split frequency and are received between 3690-3700 kHz.)

During some days there was little if any propagation, so no tests were run because of low signal strength. Little fading was noticed during the test periods. If there was any, it was quite slow in contrast to that on the higher-frequency bands. Signal buildup occurred just before sunrise, usually 5-10 dB. Then a gradual signal-strength decay occurred for about 30 minutes to an hour until the DX signals faded into the noise. We repeated the antenna tests at different times during the 1000-1200 GMT opening.

The unidirectional beams. From reports furnished by ZL1BKD during the 75-meter tests (**table 1**), the LP and LP-Yagi beams showed a 10-15 dB increase over the other antennas tested. This doesn't mean that the 75-meter beams had a 10-15-dB gain. Theoretically, a truncated LP of the type tested, using only three to five elements and a boom length of only 0.35 wavelength, would probably have no more gain than 5 dB over a dipole at the same height. Increasing elements to 9 or 10, and increasing boom length to about 1.3 wavelength, would probably result in a gain of about 10 dB. But the boom length would be about 103 meters (337 feet), which is impractical for most Amateurs.

I believe that the reported differences, 10-15 dB in favor of the unidirectional LP beams, were caused by the inefficiency of the other antennas tested — possibly by power wasted in lobes in undesired directions.

Comparative reports on reception at W4AEO were about the same. However, a high noise level plus heavy interference at times made direct comparison difficult on some days. (World noise charts show that ZLs and VKs generally experience much less noise than I do in my area.)

During high noise conditions I used several Beverage receiving antennas, which helped to improve reception. I am now erecting several Beverage antennas for 160, 75, and 40 meters. They are of the two-wire type with direction-reversing capability.

More on the delta loops. Table 1 shows that the quarter-wave vertical and delta loop 1 (apex up; horizontal portion near ground) were used for most test comparisons during which data were taken. Delta loop 2 (horizontal section up; apex toward ground) was tested only a few times, as it made a poorer showing than delta loop 1. Delta loop 2 was supported at about 23 meters (75 feet) over a pond. I used a 183-meter (600-foot) length of RG-8/U cable to feed this antenna. Here are some additional interesting observations.

table 1. Condensed log of W4AEO showing representative data on antenna tests with ZL1BKD during the latter half of 1975 and early 1976. Delta loop 1: apex up; delta loop 2: apex down; delta loop 3: apex down. Readings taken by ZL1BKD.

date (1975)	time (GMT)	remarks	LP or LP Yagi	quarter-wavelength vertical	delta loop 1	delta loop 2[1]	two-wavelength quad[2]	delta loop[3]
July		First contacts with ZL1BKD using half-wavelength dipole at 15 meters (50 feet) high						
2 Aug		ZL1BKD reports LP ≈ 10 dB better than dipole or vertical						
2 Aug later		ZL1BKD and ZL2BT report LP now ≈ 15 dB better than dipole or vertical						
21 Aug*		dipole S8	+ 10-15 dB	S8	S9-S9 + 10 dB			
25 Aug			+ 10-15 dB	S8	S9-S9 + 10 dB			
6 Sept			+ 12 dB	S8	S9 + 5 dB			
1 Oct		poor conditions	S7 (ref)	− 12 dB	− 8 dB	− 10 dB		
2 Oct			S9 (ref)	− 4 dB	− 2 dB	− 10 dB		
8 Oct	1030		+ 18 dB		+ 4 dB		+ 6 dB	
8 Oct	1200		+ 26 dB	− 8 dB	− 6 dB		− 10 dB	
11 Oct	1115	all sigs. down 10 dB today	5 dB	− 7 dB	− 7 dB		− 8 dB	
9 Nov		reworked LP	30 dB	15 dB	18 dB		12 dB	
19 Nov	1038		24 dB	8 dB	10 dB		4 dB	21 dB
31 Dec	1115		26 dB	21 dB			6-8 dB	
(1976)								
6 Jan	1125		6 dB	0	0 (ref)			4 dB
24 Jan	2120		30 dB	S9				20 dB

Notes: (1) Erected 24 Sept., 1975
(2) Erected 8 Oct., 1975
(3) Erected 29 Nov., 1975
These antennas [(2) and (3)] were erected over a pond 1/10 mile from shack.

*ZL1BKD improved method of taking readings, which was used for remainder of tests.

1. Delta loop 3 (horizontal part up; apex down) was erected over a swimming pool. The transmission-line length to this antenna was 76 meters (250 feet) of RG-8/U cable.

2. Delta loops 1 and 2 were tried using both end-feed and center-feed for vertical and horizontal polarization respectively. The latter was best for short distances; the former was best for DX. Delta loop 3 was used with vertical polarization only. (The ZL reports shown for the delta loops were for vertical polarization.)

3. Each delta loop had the same length of wire, which was cut by formula to resonate at 3800 kHz. However, I noted that, with vertical polarization, the antenna resonant frequency decreased to 3700 kHz. The following table shows SWR readings taken for the delta loops when fed for vertical polarization:

	standing wave ratio		
f(MHz)	DL 1	DL 2	DL 3
3.5	2.8	2.2	2.7
3.6	2.4	2.8	3.0
3.7	2.0	2.3	2.9
3.8	1.2	2.0	2.0
3.9	1.05	1.07	1.05
4.0	1.8	1.1	1.5

notes on the vertical antenna

The quarter-wave vertical used in most of the tests was a 19-meter (61.5-foot) length of wire suspended by a nylon line between two high pine trees. The vertical was fed from a 61-meter (200-foot) length of RG-8/U coax cable buried in the ground. Ten radials were used originally; the number was later increased to thirty.

Another vertical antenna, consisting of a half-wavelength wire suspended from a balloon, was tested several times for comparison with the quarter-wavelength vertical. Little improvement was noted.

the beam antennas

The original 75-m LP beam first erected for the tests was a 4-element LP with one parasitic director in front. This antenna was later modified to an LP-Yagi using one parasitic director, three driven (LP) elements, and a parasitic reflector. Little difference was noted between these two configurations. Later the LP-Yagi was converted to a Yagi using only one driven element. (This beam was soon destroyed by lightning.)

The last beam used during the test was the Yagi. When comparing it with the quarter-wave vertical, the difference between the Yagi and the vertical was less than that in the previous reports covering the LP

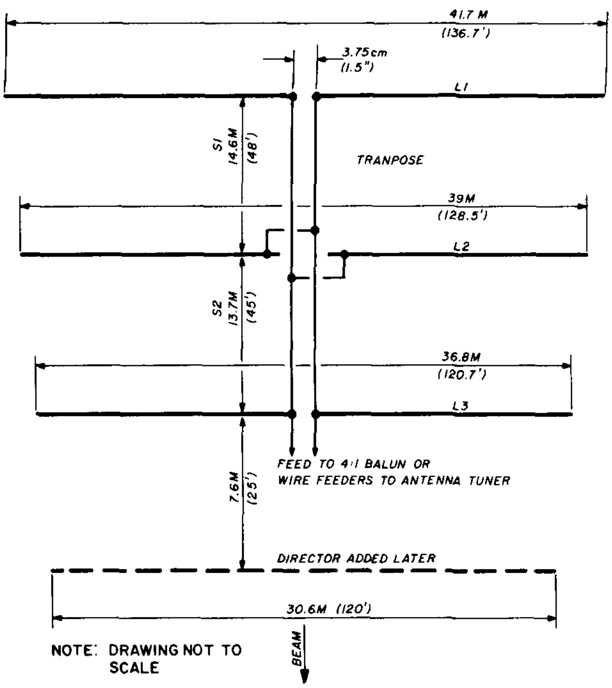

fig. 2. The 75 meter LP design suggested by W6PYK, which is for 3808 kHz. Taper factor, τ, = 0.94; spacing factor, σ, = 0.175.

or LP-Yagi. It's possible that the Yagi gain could have been improved by carefully adjusting the element lengths and spacing, since a Yagi is critical of adjustment. As the Yagi was destroyed by lightning, tests were not completed.

analysis of test results

The beam antennas gave surprisingly consistent day-to-day reports. Average reports were Q5, S9 + 10 dB average, with low readings about S9. At times readings peaked to S9 + 25 dB. These were about the same reports given on the same day to other Eastern U.S. stations running the legal power-input limit, but using only an inverted V or dipole antenna. I therefore feel that the beams did a fair job (especially at a height of 18 meters, or 60 feet). The average report on the beams was about 10 dB better than most of the conventional antennas tested at the same time at my location. I used a coaxial switch for antenna selection, so the readings taken during the tests were made within a second.

Table 1 shows differences among the same three antennas on different days. I believe that this is probably because of the differences in the vertical radiation patterns. **Fig. 1** was compiled by W6PYK from the data taken by ZL1BKD to illustrate the day-to-day difference of the LP antenna and the quarter-wave vertical. The data were taken between August and mid November, 1975. Note that the LP, the LP-Yagi,

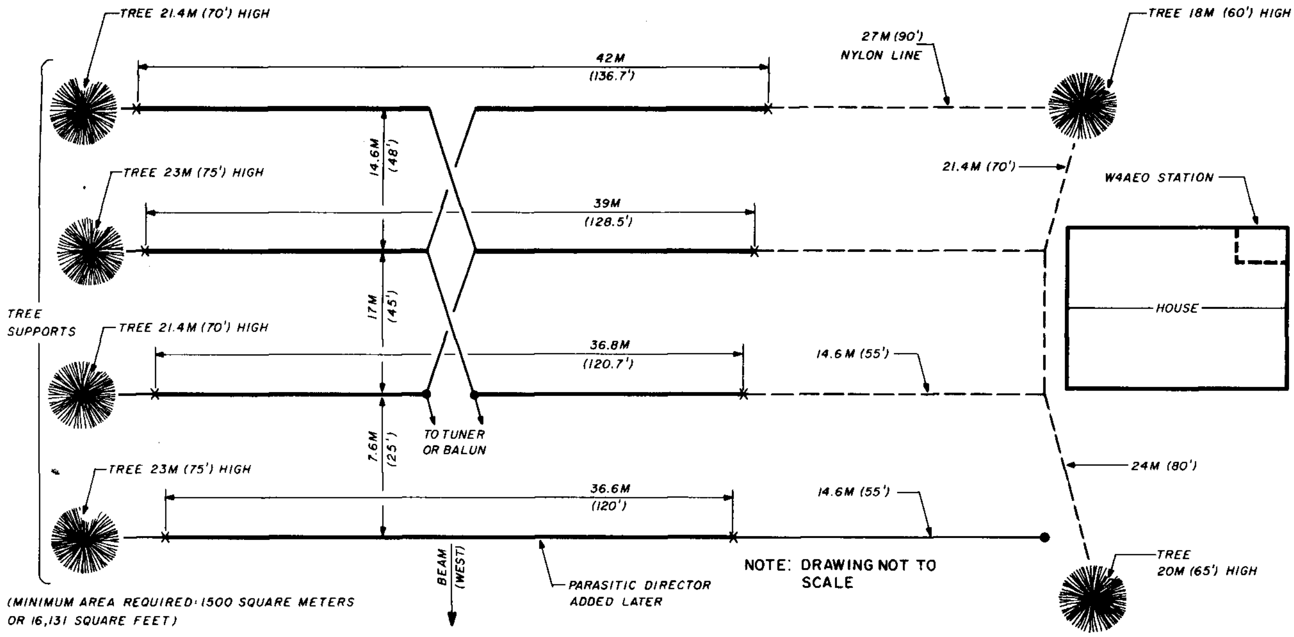

fig. 3. Plan view of the 3-element LP plus director for 3808 kHz (design suggested by W6PYK).

and the Yagi were the only *true unidirectional* beams tested.

Observations:

1. The delta loops (fed at corner's vertically polarized) have bidirectional lobes [plus the smaller high-angle center lobe (90 degrees), straight up]. Thus more than 50 per cent of the radiation is lost in unused lobe(s). Ref. 16, Fig. 10; Ref. 17, Fig. 7; or Ref. 18, Fig. 3.

2. The two-wavelength horizontal quad has four equal-spaced lobes, with only one pointing southwest.

3. The quarter- and half-wavelength verticals are omnidirectional and have maximum radiation at low angles. This may be a doubtful advantage if the antenna is located in a high-absorption environment. Interference from manmade noise was very evident.

a 3-element fixed wire beam LP for 75 meters

The 75-meter Yagi under test was destroyed by lightning in June of 1976. I wanted to replace it with another LP giving more gain, if possible. So Paul, W6PYK, suggested a 3-element, wide-spaced, truncated LP designed with a higher taper factor, τ, and spacing factor, σ. Using only three elements would limit the boom length so that it would fit into the available space previously used for the 5-element antenna.

W6PYK had observed a number of the ZL1BKD/W4AEO tests. As he is also interested in antenna design, we became acquainted on 75 meters. We also had a great deal of correspondence, comparing notes. W6PYK made a number of excellent suggestions during this period.

Paul describes his QTH as a typical California residential lot. He does not have space for a 75-meter beam, but was using a unique 40/75 roof-mounted vertical of his own design (which is quite effective considering its size — see *ham radio*, September, 1979, page 44) for working the ZLs and VKs. I agreed to construct and test some of his LP designs. He has written a number of papers on antennas, his latest being "L/P Antenna Design," which appeared in *ham radio*, December, 1979, page 34.

Paul furnished complete dimensions for the 3-element LP: element lengths and spacing (**fig. 2**)

table 2. Standing-wave ratio as a function of frequency for the beam antennas used in the test.

	standing-wave ratio			
frequency (MHz)	3-element LP (τ 0.94, σ 0.175)*	3-element LP plus director*	5-element LP	5-element Yagi†
3.5	1.35	1.35	1.1	2.9
3.6	1.3	1.2	1.25	2.4
3.7	1.2	1.1	1.1	2.0
3.8	1.1	1.1	1.07	1.4
3.9	1.1	1.05	1.15	1.2
4.0	1.5	1.6	1.15	2.0

*The 3-element LP and LP plus director were the last LPs tested. Design suggested by W6PYK using τ = 0.94 and σ = 0.175. This beam was tested after the tests covered by Table 1, which used the previous 4- and 5-element LPs. The improved 3-element LP was the one Bob Tanner, ZL2BT, reported the best tested here to date.

†Note that the Yagi is much sharper than the LPs.

designed to $\tau = 0.94$ and $\sigma = 0.175$. This design gives an overall array length (boom length) of 28.3 meters (93.0 feet). Paul advised that this configuration should provide good gain for the space available.

Note that the element lengths are slightly longer than those given by the formulas. Paul suggested this to allow for ground effect, since the height of the beam above ground would be limited to about 18.3 meters (60 feet), or less than a quarter wavelength. This was evidently correct from the SWR data (**table 2**), which was taken after the beam was completed. A plan view of the beam, (**fig. 3**), shows method of support — several trees.

During the tests on this new 75-meter beam, the only other antenna available at the time for comparison, was a dipole sloper. The other 75-meter antennas outlined above had been dismantled to make room for several beams needed for 20-meters. Bob Tanner, ZL2BT, reported on this new LP, the best tested to date.

acknowledgment

I especially thank W6PYK for his suggestions on LPs, Beverages, and other antennas. A number have already been tested and several more are still to be tried. I also thank Colin, ZL1BKD, for his many hours of test reports.

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ham radio

More Details? CHECK—OFF Page 94

more conversions of surplus cavity bandpass filters

Follow-up to a previous article in *ham radio* — adapting surplus filters for 220 and 440 MHz

By William Tucker, W4FXE, 1965 South Ocean Drive, 15 G, Hallandale, Florida 33009

In an earlier issue of *ham radio*,[1] I described the procedure for converting surplus cavity bandpass filters for operation in the 2-meter band. These filters are dual-resonant cavities, gold plated for high conductivity, and are available at low cost in the surplus market.*

The previous article thoroughly covered the theory and application of these cavity bandpass filters; therefore, I suggest that you refer to that issue. I'm sure that copies are available.

For convenience, the filters used in the 417/GRC receiver and the frequency ranges covered are:

filter	frequency (MHz)	filter	frequency (MHz)
F-238/U	50.0-58.5	F-196/U	184-205
F-239/U	58.5-67.0	F-197/U	205-226
F-240/U	67.0-76.0	F-199/U	224-254
F-241/U	75.0-84.0	F200/U	254-284
F-242/U	84.0-92.5	F201/U	284-314
F-192/U	100.0-121.0	F202/U	314-344
F-193/U	121.0-142.0	F203/U	344-374
F-194/U	142.0-163.0	F204/U	374-404
F-195/U	163.0-184.0	F-236/U	550-600

For conversion to the 220-225 MHz band, I selected the F-195/U and the F-196/U filter assemblies; both are lower in frequency than the desired band. Likewise, I selected a lower-frequency filter for the 420-450 MHz band: the F-202/U. The advantage of selecting the lower-frequency filters for conversion was discussed in reference 1.

*Fair Radio Sales Co., Inc., P.O. Box 1105, Lima, Ohio 45802.

conversion procedure for 220 MHz

The F-195/U and F-196/U filters can be converted to the 220-MHz band by making the following modifications: remove the rear hex nuts from the dual-cavity assembly and carefully slide out the stationary portion of the cavity and the cylindrical housing.

The stationary portion of the cavity consists of the fixed center conductor, the fixed capacitance cup, and the pickup loops. The fixed capacitance cup provides fixed capacitance with respect to the cavity housing and is also the stator of the variable capacitor provided by the movable plunger capacitor cup (**fig. 1**).

To increase frequency the size of the fixed capacitance cup must be reduced by trimming as indicated by the dotted line in **fig. 1**, thus reducing the fixed capacitance to the cylindrical cavity wall. To increase frequency to the 200-230 MHz range, cut off no more than 7 mm (9/32 inch) on the F-195/U and no more than 5 mm (3/16 inch) on the F-196/U. If a slightly higher range is desired, for example 210-240 MHz, file off an additional amount until the desired range is obtained. A hacksaw or any convenient method can be used. Be sure to remove all burrs for a smooth finish.

Modify one section of the cavity assembly at a time and check with a grid-dip meter at its terminal. About a 12.5-mm (½-inch) loop at the terminal, coupled to the grid-dip meter, should provide a sharp dip at resonance. When the desired frequency is obtained, duplicate the other half of the assembly.

The dual-cavity assemblies can be separated electrically into two individual-bandpass, single-section cavities by removing the connecting jumper and providing two additional terminals using a small BNC type connector.

If two individual series-resonant "suck-out" cavity traps are desired, simply remove the jumper and its pickup loops. You'll then have two single-terminal traps.

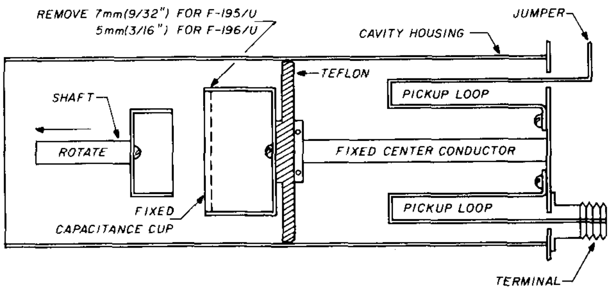

fig. 1. Modifications to the F-195/U and F-196/U filters for 220-225 MHz. The fixed capacitance cup must be trimmed as shown to increase frequency.

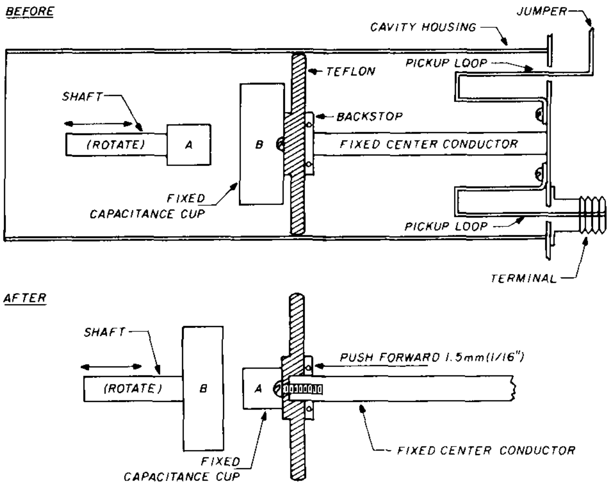

fig. 2. Modifications to the F-202/U filter for 420-450 MHz. Reverse A and B and push forward fixed capacitance cup A as shown.

conversion procedure for 440 MHz

The F-202/U filter assembly can be converted to the 440-MHz band in the following manner. Slide out the stationary portion as previously indicated and refer to **fig. 2** "before" and "after." To increase frequency to the 400-530 MHz range, the fixed-capacitor size must be reduced and the movable section size increased by reversing the **A** and **B** capacitance cups as shown. Note that the small cup, **A**, is pushed forward 1.5 mm (1/16 inch) by loosening the allen set screw in the backstop and pushing it forward.

The frequency range can now be checked by any convenient method such as a transmitter or receiver or a signal generator. You can also use your 2-meter transceiver in the low-power position by feeding the output into either terminal of the dual cavity through a germanium diode to obtain a good third harmonic. You can then read the output as you tune through resonance with a dc microammeter in series with a similar diode at the other terminal of the cavity assembly. Instructions for obtaining two individual bandpass or band reject (suck-out) cavities are the same as previously described.

All the cavities listed for the 417/GRC receiver probably can be converted for use on other frequencies as required. The methods described in this and the preceding article[1] serve as a guide; all that's required is a little patience and some simple test equipment.

reference

1. William Tucker, W4FXE, "How to Modify Surplus Cavity Filters for Operation on 144 MHz," *ham radio*, February, 1980, page 42.

ham radio

TS-120S...A big little rig.

It's a compact, up to 200 watts PEP input, all solid-state HF transceiver with such standard features as built-in digital readout, IF shift, new PLL technology ...and requires no tuning!

Exciting and perfect for car or ham shack use! But, there's more to say about the TS-120S! This unique all solid-state HF, SSB/CW transceiver produces a hefty signal and also offers a lot of other great features in a very attractive, compact package.

FEATURES:

- All solid-state with wideband RF amplifier stages. No final dipping or loading, no transmit drive peaking, and no receive preselector tuning! *Just dial your frequency and operate!*
- Five bands, plus WWV. Transmits and receives on 80/75, 40, 20, 15, and all of 10 meters... and receives WWV on 15 MHz.
- 200 watts PEP (160 watts DC) input on 80-15 meters, 160 watts PEP (140 watts DC) input on 10 meters. LSB, USB, and CW.
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- IF shift (passband tuning), to remove adjacent-frequency interference and sideband splatter.
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- Attractive, compact design. Measures only 3½" high X 9¼" wide X 13½" long, and weighs only 4.9 kg (11.7 lbs.). A perfect size for convenient mobile operation and rugged enough for either mobile or portable use. Also has all the desired features for optimum ham-shack operation at home.
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- Operates with PS-30 base-station power supply, which turns on and off remotely with TS-120S power switch.

See the big little TS-120S rig and matching accessories (VFO-120 remote VFO, SP-120 external speaker, PS-30 AC power supply, MB-100 mobile mounting bracket, AT-120 antenna tuner and YK-88C CW Filter) at your nearest Authorized Kenwood Dealer!

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- All solid-state... including the final. No dipping or loading. Just dial up the frequency, peak the drive, and operate!
- High power... 200 W PEP/160 W DC input on 160-15 meters, and 160 W PEP/140 W DC on 10 meters (entire band provided). Also covers more than 50 kHz above and below each band (MARS, WARC, etc.), and receives WWV on 10 MHz.
- Improved dynamic range.
- Adaptable to all three proposed (WARC) bands.
- Single-conversion system with highly advanced PLL circuit, using only one crystal with improved stability and spurious characteristics.
- Built-in microprocessor-controlled large digital display. Shows actual VFO frequency and difference between VFO and "M1" memory frequency. Blinking decimal points indicate "out of band." Monoscale dial, too.
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- Tunable noise blanker (adjustable noise-sampling frequency).
- RF AGC ("RGC"), which activates automatically to prevent overload from strong, local signals.
- AGC (selectable fast/slow/off).
- Dual RIT (VFO and memory/fix).
- Three operating modes... SSB, CW, and FSK.
- Improved RF speech processor.
- Dual SSB filter (optional), with very steep shape factor to reduce out-of-passband noise on receive and to improve operation of RF speech processor on transmit.
- 13.8 VDC operation.
- Also available is the TS-180S without DFC, which still shows VFO frequency and difference between VFO and "hold" frequencies on the digital display.
- Full line of matching accessories, including PS-30 base-station power supply, SP-180 external speaker with selectable audio filters, VFO-180 remote VFO, AT-180 antenna tuner/SWR and power meter, DF-180 digital frequency control, YK-88 CW filter, and YK-88 SSB filter.

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LED tuning indicator
for RTTY

A novel circuit that takes the guesswork out of tuning RTTY stations

This project was started after I built a modified ST-4 radioteletype (RTTY) demodulator to interface between my EICO 753 transceiver and my model 28 page printer. Since RTTY operation permits only a very small tuning error, and my EICO often drifts freely, my oscilloscope was in constant use to monitor the cross-loop pattern. This pattern shows any drift immediately before the printer starts to garble and therefore was essential for keeping the receiver on frequency.

tuning indicator

It wasn't long before I decided that running my scope just for tuning was a waste of power. It uses 285 watts. Also, the scope's fan is almost as noisy as the teletypewriter. What was needed was something small with low power consumption to provide the tuning indication. This article describes the circuit I used to replace the scope for observing the cross-loop pattern. The display uses two bar graphs, each having seventeen LEDs. The right graph (see photos) shows, bottom to top, the segment **A** to **B** for mark. The left graph shows, from bottom to top, the segment **A** to **C** for space. See **fig. 1**.

As shown in **fig. 1**, each loop crosses each segment once. The points where the segments are crossed is directly related to how well the station is tuned in. This circuit samples these points and displays their relative positions on the bar graphs. This circuit also requires that the oscilloscope display of the demodulator output be loops — not straight lines.

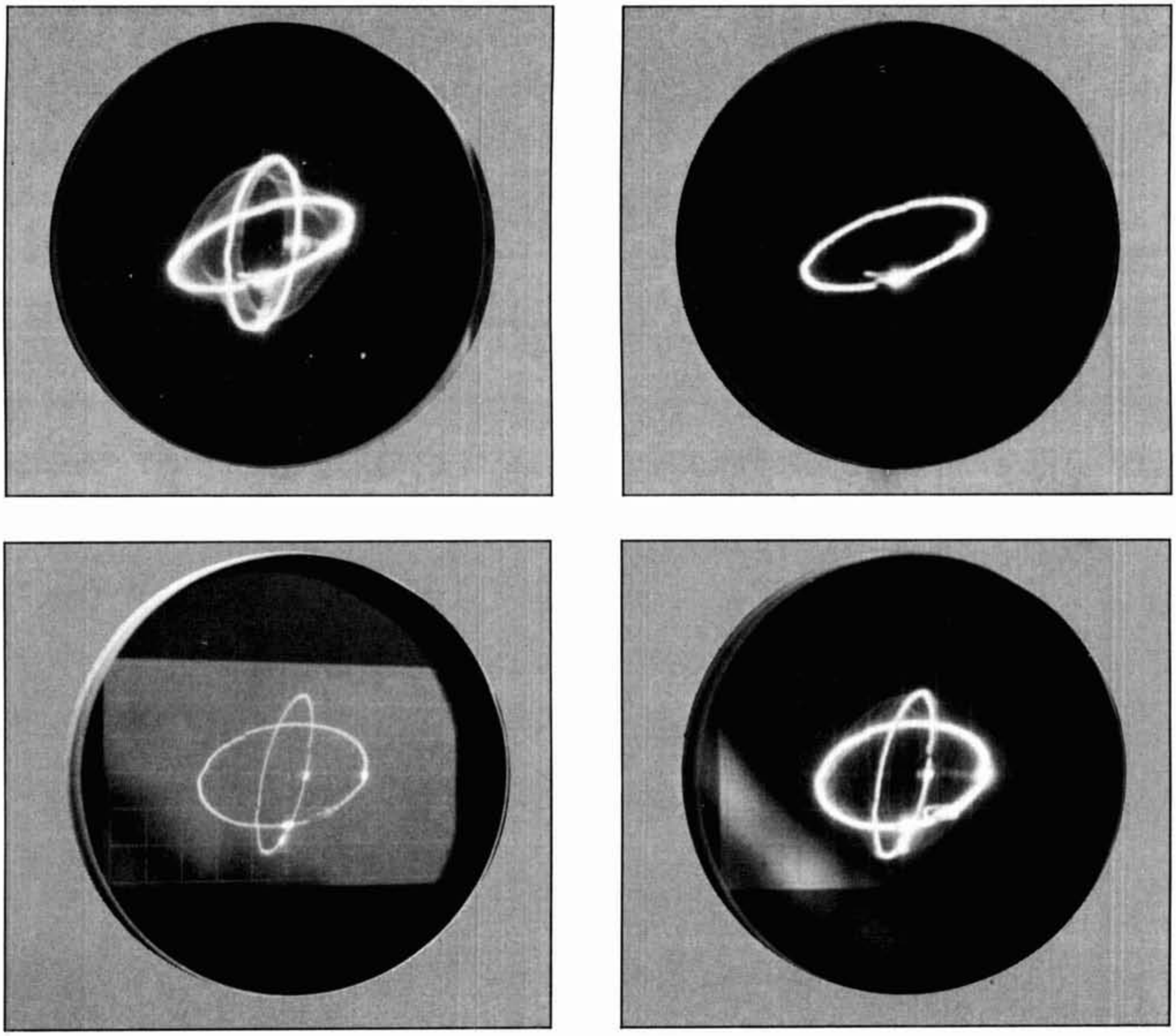
configuration

The circuit is connected as shown in **fig. 2**. The inputs are connected to the same points in the demodulator where an oscilloscope would be connected. U1D, an LM3900N, a unity-gain inverter. (One amplifier in one of the LM3900N quad amps is not used.) Q4 reduces the +12 volts from the demodulator to 6.1 volts to supply the circuit. This voltage is a compromise between LED intensity, system performance, and a desire to reduce power consumption. In the setup shown (**fig. 2**), two identical circuits are used: one for the mark input and the other for the space input.

sample-and-hold circuit

Fig. 3 consists of input buffer amplifier U1A, a zero-crossing detector, U1B and Q1, and a sample-and-hold circuit, Q2, Q3, and U1C. When the input signal goes positive through the zero-voltage point, a low-going pulse at Q1 collector turns on Q2 for 5 to 20 microseconds. The voltage on Q2 emitter, which comes from the second sample-and-hold circuit, is stored in C4. Q3 acts as a buffer between C4 and U1C.

By Loren Jacobson, WA0ELA, Rural Route 1, Box 60, Lennox, South Dakota 57039



***Top left*: A properly tuned-in mark and space signal with the accompanying bar graph indications. *Top right*: A properly tuned-in mark signal with the accompanying bar graph indications. *Bottom left*: The four intensified points on the oscilloscope display indicate where sampling is being accomplished. Both sample pulses were coupled to the Z axis on the oscilloscope to help clarify the sampling points in these photos. *Bottom right*: A slightly mistuned signal and resulting bar-graph display.**

table 1. Parts list for the tuning indicator.

quantity		description
2	C1	0.02-μF, 100V disc
4	C2,C3	0.01-μF, 25V disc
2	C4	0.002-μF, 1000V disc
1	C5	50-μF, 25V electrolytic
1	C6	0.1-μF, 25V disc
2	CR1	silicon diode
34	CR2-CR18	LED
1	CR19	6.8V zener, 1W
2	Q1	2N2222 or equivalent
2	Q2	general-purpose PNP
2	Q3	MPF102, RS276-2035 or equivalent
1	Q4	MPS U01 or equivalent
2	R1	500k pot
8	R2,R13,R15 R17,R18	100k
4	R3,R14	560k
3	R4,R19	1.8M
2	R5	180k
2	R6	2.2M
2	R7	1M
4	R8,R16	25k pot
2	R9	330k
2	R10	1k
2	R11	2.2k
2	R12	10k pot
1	R20	10k
64	R21-R35, R37-R53	470k
4	R36,R54	4.7k
2	U1A-U1D	LM3900N quad op amp
32	U3-U18	LM741CN op amp
1		integrated circuit perfboard 114 × 152 mm (4½" × 6") RS276-1394 or equivalent

resistors are ¼ watt

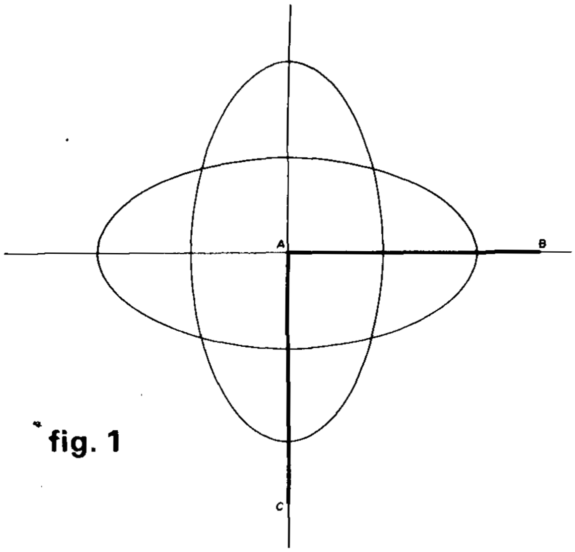


fig. 1

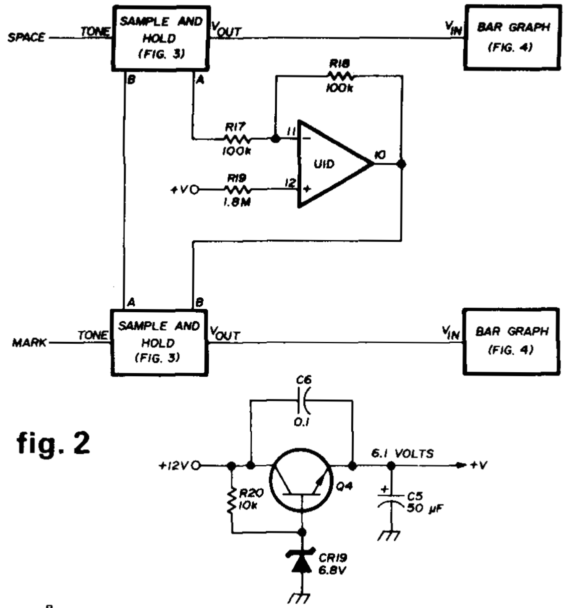


fig. 2

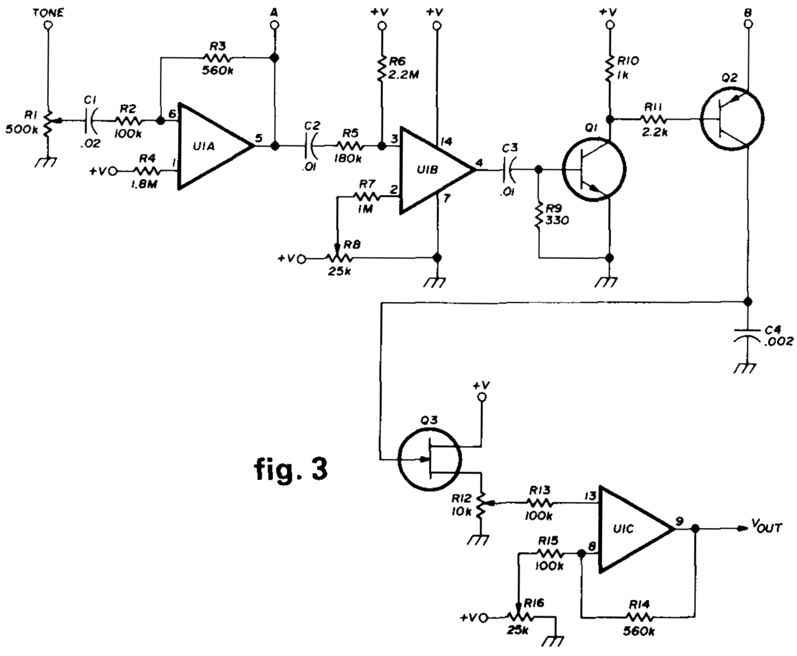


fig. 3

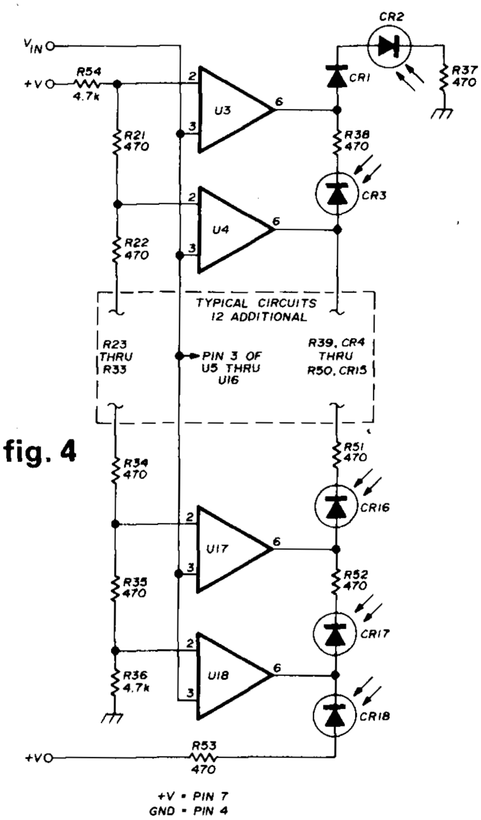


fig. 4

fig. 1. Cross-loop pattern.

fig. 2. Configuration of the complete tuning unit.

fig. 3. Sample-and-hold circuit.

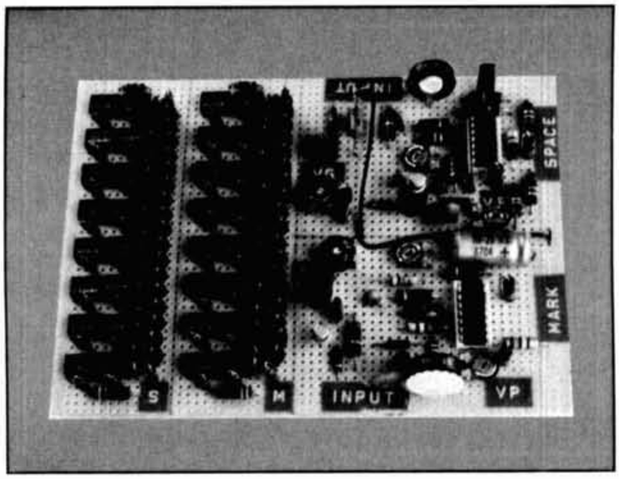
fig. 4. Bar-graph circuit.

bar-graph circuit

Fig. 4 consists of a group of LM741CN comparators that light the appropriate LED, depending on the value of the input voltage at V_{in}. Each 741 has a different reference voltage on pin 2, obtained from voltage divider R21-R36. The sampled voltage is on pin 3. The output of pin 6 of any 741 will depend on the relationship of the reference voltage to the input voltage. When two adjacent 741s have a different output, the LED between them will light. In this way only one LED will be illuminated for any level of input voltage.

construction

A parts list for the tuning indicator is shown in **table 1**. Neither circuit layout nor components were critical in the unit I built. Point-to-point wiring was used throughout. Half-watt resistors may be substi-



The completed project.

tuted if space permits. The power supply voltage can be changed to adjust for LED brightness. Using smaller resistors in series with the LEDs will make possible a lower supply voltage. On my unit, at 5 volts, the upper and lower LEDs could not be lit by adjusting R16 and R12. Using different values of R54 and R36 or adjusting U1C gain will compensate for insufficient or excessive voltage swing from U1C. Using only thirteen or fewer LEDs in each bar graph will still provide a good display if cost is a factor.

adjustments

An oscilloscope is needed in adjusting and troubleshooting the circuit. Adjust R1 so that U1A puts out a maximum voltage swing with little distortion. Adjust R8 for a symmetrical square-wave output of U1B at maximum input signal. A compromise adjustment may be needed to get a square wave at low input-signal conditions. If Q1 doesn't go low enough, increase either C3 or R9 until Q1 produces a low-going pulse of 5 to 20 microseconds. R12 is the display amplitude control, while R16 is the display position control. Note that R12 also affects the display position.

The displayed pattern on the LED is of sufficient quality to tune in an RTTY station by observing the LEDs alone. Another possible use for the circuit is to interface the LEDs with a computer and have the computer tune the receiver.

bibliography

Fredriksen, T.M., et al, *The LM3900 — A New Current-Difference Quad of ± Input Amplifiers*, National Semiconductor Application Note AN-72, September, 1972.

Hoff, Irvin M., W6FFC, "The Mainline ST-3 RTTY Demodulator and the ST-4 for 170 Hz Shift," *QST*, April, 1970, page 11.

ham radio

More Details? CHECK—OFF Page 94

improvements to the simplified capacitance meter

Repackaging and improved circuitry make a cap meter published previously even better

I've always been suspicious of capacitance meters. They were difficult to read accurately, had extraneous readings, and were nearly useless below 100 pF. But the meter described by WA5SNZ[1] is different. After building the meter, I found that it was easy to read and it measured to 0.5 pF. All those unmarked caps, variable caps, and even my homemade bypass caps could be measured easily. It was fun to put a variable cap on the meter, swing the cap from end-to-end, and watch the meter read from minimum to maximum value. WA5SNZ's cap meter is as easy to use as an ohmmeter.

After discovering what a remarkable meter it was, I designed a packaging scheme so that the meter could be built as a club project. The packaging worked out so well I decided to pass it on to those interested in building this valuable piece of test equipment.

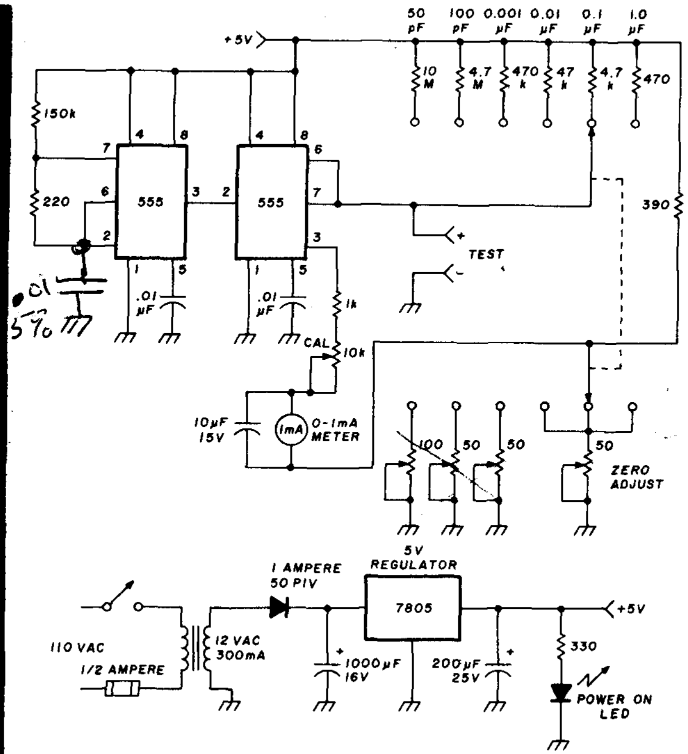


fig. 1. Capacitance meter schematic. All components mount on a single PC board except for the power supply and test terminals.

By Tom Varmecky, WA3CPH, 859 Goucher Street, Johnstown, Pennsylvania 15905

construction

The cap meter schematic is shown in **fig. 1**. All components mount on a single circuit board (**fig. 2**) except for the power supply and test terminals. The cap meter was built into a box measuring 134 × 76 × 149 mm (5-1/4 × 3 × 5-7/8 inches), available from Radio Shack (catalog no. 270-253).

Wiring the switch on my prototype unit presented the biggest problem. There were just too many parts hanging from it. So I mounted the switch directly to the circuit board with small lengths of bare wire. I attached the wires to the switch first, fed the wires through the holes in the board, and then soldered the switch to the boards. Be very careful to orient the switch correctly, as it's easy to get it out of place by one position. The switch is mounted on the copper side of the board opposite the components. Holes were provided in the board for mounting the meter directly to the circuit board so that the unit can be checked out before it's mounted in the box. A bench power supply is used.

The front panel (**fig. 3**) was drilled and labeled. The power supply was then built into the box. An LED indicates when power is on.

The meter was removed after tests and mounted onto the front panel. The circuit board was then placed over the meter. The switch was extended through the front panel and bolted on (photo). A small length of bare wire was soldered to the + **unknown** terminal then soldered to the board hole marked (?). The ground-side test terminal was connected to both the circuit board and box to prevent ground loops.

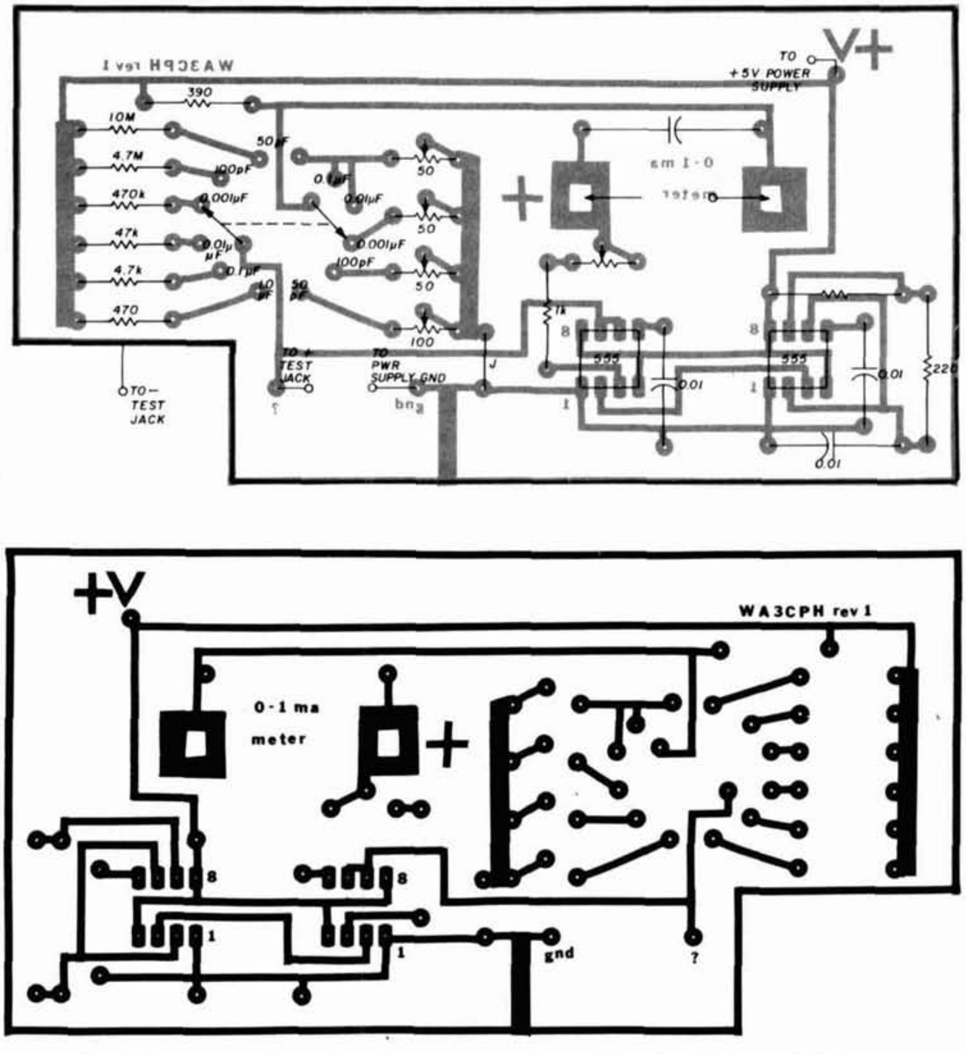


fig. 2. Component layout for the cap meter, above. Foil side of PC board, below.

modifications to the original unit

The switch I used had six positions (it's available

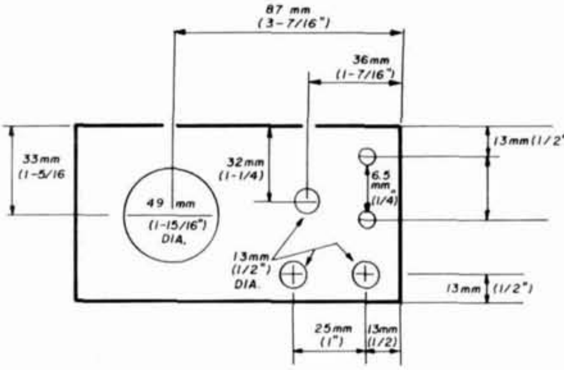


fig. 3. Layout of the cap meter front panel.

from Radio Shack). Rather than leave one switch position blank, I added a 0-50 pF range. On this range, meter readings are divided by two, which is useful when testing small vhf and uhf components.

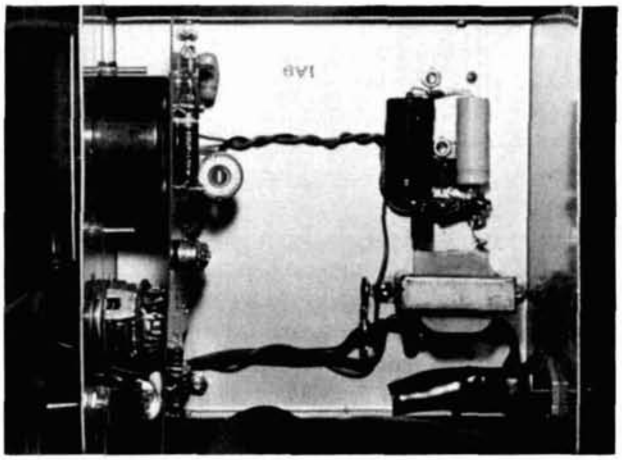
The 500-ohm, zero-adjust pots on the original unit were difficult to set, so they were changed to 50-ohm pots, which made adjustments easier. I used a 100-ohm pot for the 0-50 pF range. I used a 5-volt regulated power supply (**fig. 1**) rather than the original supply, which was 6 volts. No effect was noted on meter operation.

calibration

Calibration is the same as for the original unit. Set each range to zero with its respective pot. Then place a 0.001-μF, 5 per cent or better capacitor across the unknown terminals. Set the calibration pot so that the meter reads full scale on the 0.001-μF range. Calibration is then complete.

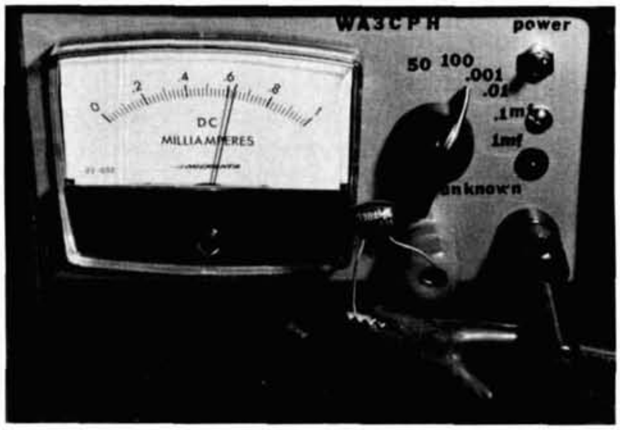
operation

The easiest method of operation is to place a test



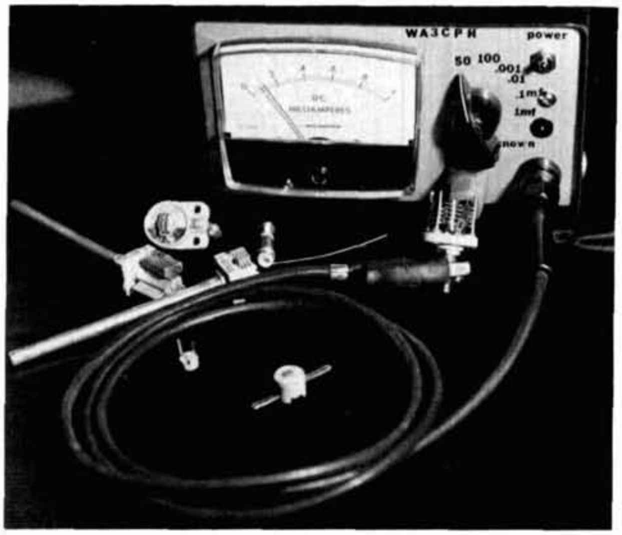
Underside of chassis showing component layout in the modified version of the simplified cap meter.

lead in the ground side test terminal and clip it to the unknown capacitor. Then touch the other side of the capacitor to the plus test terminal (photo). In this



Cap meter with an unknown fixed cap connected to test terminals.

way, transient capacitances are minimized and readings are most accurate. Always start on a high range and work down until the best reading is obtained. With variable caps, clip the ground lead onto the cap



A variable capacitor connected to the cap meter.

shaft and touch the other side to the plus test terminal. Vary the cap from minimum to maximum while reading the meter.

reference

1. Courtney Hall, WA5SNZ, "Simplified Capacitance Meter," *ham radio*, November, 1978, page 78.

ham radio

auto-product detection of double-sideband

Novel system for DSB detection which automatically generates the correct reinserted-carrier frequency

The detection of carrierless signals requires very careful control of the transmitter and receiver oscillator frequencies. Mobile communication equipment has the added problems associated with mechanical stability, widely varying supply voltage, and even Doppler shift, which is more troublesome at higher frequencies. Automatic means of correcting to the reinserted carrier frequency in voice single-sideband suppressed carrier systems have met with limited success.[1] In terms of power, a suppressed-carrier double sideband (DSB) transmission offers a highly efficient means of communication, and with DSB you know that the carrier should be halfway between the two sidebands.[2]

double-sideband carrierless detection

The carrier frequency for a pair of sidebands is one half their sum; to derive the carrier, it is necessary to select its twice-frequency component from the second-order products obtained from a nonlinear amplifier (detector). The relationship of the second-order products to an amplitude-modulated signal with carrier is shown in the appendix.

The block diagram, **fig. 1**, shows the essentials of a system for generating the reinserted carrier to a double-balanced modulator. The carrierless DSB input signal is centered around the typical receiver i-f frequency, 455 kHz, and is applied to two groups of circuits: a nonlinear amplifier or detector, and a balanced modulator or product detector. The nonlinear amplifier is followed by a filter to select the desired sideband-sum component. The waveforms of signals at these points are shown in **fig. 2**.

The input signal at point **A** is shown at the top of

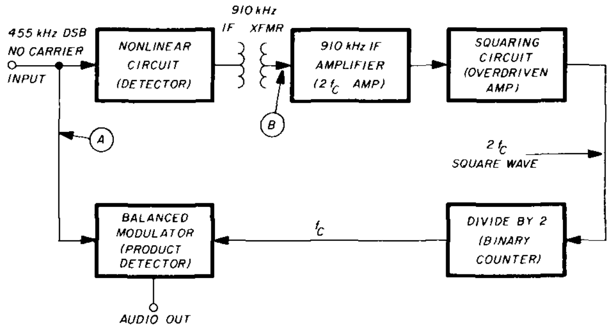
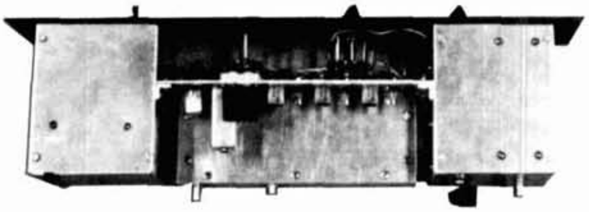
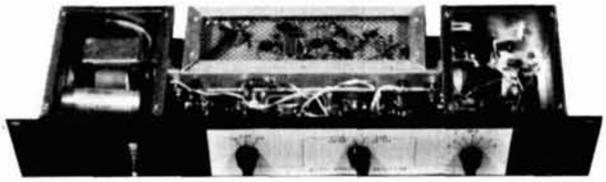
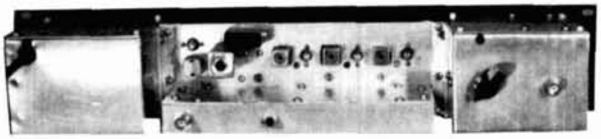


fig. 1. Block diagram of the double-sideband no-carrier demodulation system or auto product detector. Waveforms at points A and B are shown in fig. 2; a schematic diagram of the system is presented in fig. 3.

By H. F. Priebe, Jr., K4UD, 5040 Wickford Way, Dunwoody, Georgia 30338







Left: Top, the auto product detector built by K4UD and used with a Collins R-390A receiver. Directly beneath is a bottom view of the auto product detector showing the twice-carrier frequency amplifier circuit. Above: Top view of the auto product detector with shield covers removed. The power supply is to the left, and balanced modulator with squaring circuit and binary counter are in the center. The BFO for SSB reception is at the right. Directly beneath is rear view of the unit. The twice-carrier circuits are located in the center along the bottom; the knob on the left is a BFO calibration adjustment.

fig. 2 (the time-domain display is the familiar two-tone signal used for testing SSB transmitters). The output of the nonlinear amplifier following the tuned circuit is shown at the bottom. This signal is a 100 per cent modulated amplitude-modulated 910 kHz carrier with sidebands at twice the input sideband frequencies. The 910 kHz i-f amplifier and crystal filter supply additional selectivity to reduce the amplitude of the sidebands and thus reduce the resultant equivalent modulation percentage. The remaining sidebands or modulation is reduced by the squaring circuit in **fig. 1** which provides an output square wave at twice the carrier frequency. This $2f_c$ signal is divided by two in the binary counter stage and supplied as the demodulating carrier to the balanced modulator product detector.

Detection of signals with carrier is similar because the level of the demodulating carrier has several times the amplitude of the original. Reversing the phase of the 910-kHz signal is equivalent to shifting the phase of the carrier by 90 degrees; therefore, a simple phase-reversing switch permits copying amplitude or phase-modulated signals.

circuit diagram

The schematic of the carrierless double-sideband detector is shown in **fig. 3**. The nonlinear input amplifier is based on a dual-gate MOSFET with a double-tuned circuit load. A three-stage tuned amplifier with a crystal filter provides selectivity to reduce the amplitude of the second harmonics of the input sidebands; this ensures that an amplitude squaring circuit will extract the sideband sum component. The amount of selectivity required is related to the squaring circuit sensitivity and the lowest frequency sideband separation.

For voice signals with a low frequency component of a few hundred hertz the 910 kHz i-f is approximately 1.5 kHz wide; this permits a tolerance to signal instability of approximately 1000 Hz.

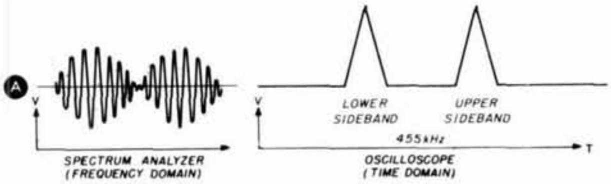
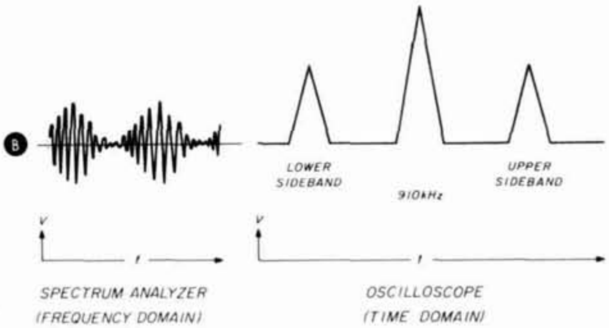


fig. 2. Auto product detector waveforms as displayed in the time domain (oscilloscope) and frequency domain (spectrum analyzer). Signal at point A (fig. 1) is similar to a two-tone SSB test signal; signal at point B has 910 kHz carrier.



The balanced modulator (product detector) uses a MC1496L IC; the type 5596A is similar but the pin-out is different. A diode and transformer balanced modulator could also be used, of course. All three were tested in the circuit and performed about the same.

The BFO operates at 910 kHz and uses the familiar Colpitts circuit; its output is divided by two as was done with the derived carrier for DSB detection.

conclusion

The double-sideband no-carrier detector provides auto product detection of double-sideband signals with or without a carrier. There is no reinserted carrier oscillator — the reconstructed carrier is derived automatically from the two sidebands of the incoming signal. This makes receiver tuning of no-carrier DSB signals as easy and simple as tuning in a-m signals.

The detector is compatible with a-m and provides exalted-carrier a-m detection with none of the disadvantages of carrier oscillator control. The detection of phase-modulated signals is accomplished with a switch position that alters the phase of reconstructed carrier.

A BFO is included so that SSB signals can also be detected. Thus, the described circuit can demodulate all the popular modulation modes as well.

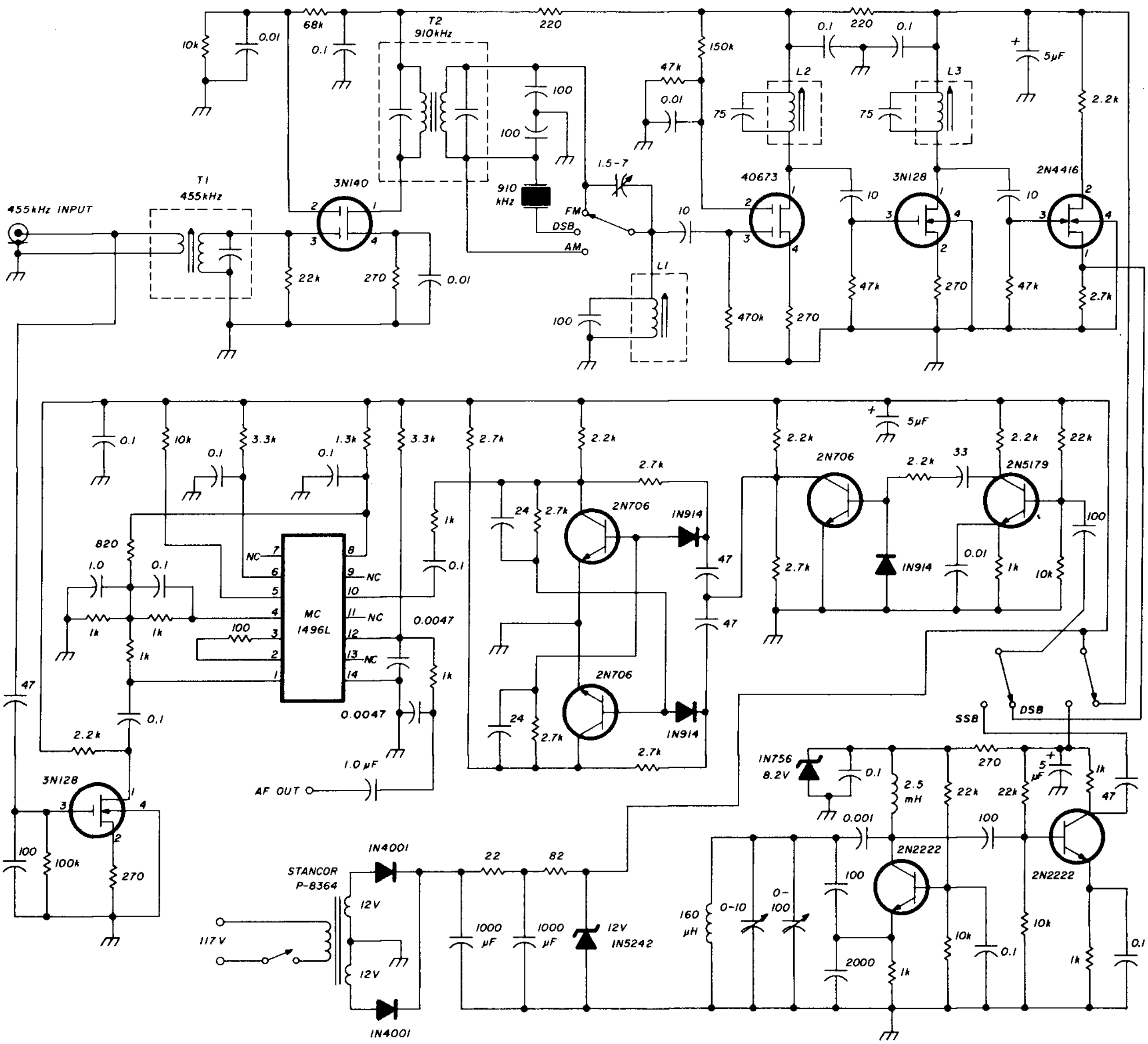


fig. 3. Schematic diagram of the auto product detector for DSB and a-m; an optional BFO is provided for the detection of SSB signals. Inductors L1, L2, and L3 are 290-650 μH (J. W. Miller 9057). Transformer T1 is a 455-kHz i-f transformer; T2 is a tube-type 455-kHz i-f transformer with turns removed.

references

1. O.G. Villard, Jr., "Sideband-Operated Automatic Frequency Control for Reception of Suppressed-Carrier SSB Voice Signals," *IEEE Transactions on Communications Technology*, October, 1971.

2. W.K. Squires and E. Bedrosian, "The Computation of Single-Sideband Peak Power," *Proceedings of the IRE*, January, 1960.

appendix

The output of the nonlinear amplifier stage is analyzed from the curvature of the transfer characteristic as expressed in terms of a power series.* Such a curvature is characteristic of rectifiers and detectors. When the input e_g is made up of two sine waves E_a and E_b:

$$e_g = E_a \sin \omega_a t + E_b \sin \omega_b t \tag{1}$$

The second-order components are:

$$e_g^2 = \frac{E_a^2 + E_b^2}{2} - \frac{E_a^2}{2} \cos 2\omega_a t$$

$$- \frac{E_b^2}{2} \cos 2\omega_b t$$

$$+ E_a E_b \cos (\omega_a + \omega_b)t$$

$$+ E_a E_b \cos (\omega_a - \omega_b)t$$

With a filter circuit tuned to twice the i-f, the dc term $\frac{E_a^2 + E_b^2}{2}$ is of no concern to this mode of operation, nor is the difference term, $E_a E_b \cos (\omega_a - \omega_b)t$. The important components are then:

$$e_g^2 \cong E_a E_b \cos (\omega_a + \omega_b)t$$

$$\frac{E_a^2}{2} \cos 2\omega_a t$$

$$- \frac{E_b^2}{2} \cos 2\omega_b t$$

let $\omega_a + \omega_b = 2\omega_c, \quad \omega_a = \omega_c + p, \quad \omega_b = \omega_c - p, \quad E_a = E_b = E$

then $e_g^2 = E^2 \cos (2\omega_c)t$

$$- \frac{E^2}{2} \cos 2 (\omega_c + p)t$$

$$- \frac{E^2}{2} \cos 2 (\omega_c - p)t$$

And, for an amplitude modulated wave:†

$y = A_o \cos \omega_o t$ — carrier

$+ \frac{a_m}{2} \cos (\omega_o + p_m)t$ — upper sideband

$+ \frac{a_m}{2} \cos (\omega_o - p_m)t$ — lower sideband

where p_m = the angular frequency of the modulating signal
a_m = degree of modulation
$a_m = A_o$ for 100 per cent modulation

Therefore, the output of the two-times i-f filter is a 100 per cent modulated a-m signal with a modulating frequency of twice the original.

*F.E. Terman, *Electronic and Radio Engineering*, McGraw-Hill, New York, 1955, page 332.

†*Reference Data for Radio Engineers*, 3rd edition, Federal Telephone and Radio Corporation, New York, 1953, page 276.

ham radio

More Details? CHECK—OFF Page 94

7400 TTL

SN7400N	.16	SN7470N	.29	SN74160N	.89
SN7401N	.18	SN7472N	.29	SN74161N	.89
SN7402N	.18	SN7473N	.35	SN74162N	1.95
SN7403N	.18	SN7474N	.35	SN74163N	.89
SN7404N	.18	SN7475N	.49	SN74164N	.89
SN7405N	.20	SN7476N	.35	SN74165N	.89
SN7406N	.29	SN7479N	5.00	SN74166N	1.25
SN7407N	.29	SN7480N	.50	SN74167N	1.95
SN7408N	.20	SN7482N	.99	SN74170N	1.59
SN7409N	.20	SN7483N	.59	SN74172N	6.00
SN7410N	.18	SN7485N	.79	SN74173N	1.25
SN7411N	.25	SN7486N	.35	SN74174N	.89
SN7412N	.25	SN7489N	1.75	SN74175N	.79
SN7413N	.40	SN7490N	.45	SN74176N	.79
SN7414N	.70	SN7491N	.59	SN74177N	.79
SN7416N	.25	SN7492N	.43	SN74179N	1.95
SN7417N	.25	SN7493N	.43	SN74180N	.79
SN7420N	.20	SN7494N	.65	SN74181N	1.95
SN7421N	.29	SN7495N	.65	SN74182N	.79
SN7422N	.39	SN7496N	.65	SN74184N	1.95
SN7423N	.25	SN7497N	3.00	SN74185N	1.95
SN7425N	.29	SN74100N	.89	SN74186N	9.95
SN7426N	.29	SN74107N	.35	SN74188N	3.95
SN7427N	.25	SN74109N	.59	SN74190N	1.25
SN7429N	.39	SN74116N	1.95	SN74191N	1.25
SN7430N	.20	SN74121N	.35	SN74192N	.79
SN7432N	.25	SN74122N	.39	SN74193N	.79
SN7437N	.25	SN74123N	.49	SN74194N	.89
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SN7439N	.25	SN74126N	.49	SN74196N	.89
SN7440N	.20	SN74132N	.75	SN74197N	.89
SN7441N	.89	SN74136N	.75	SN74198N	1.49
SN7442N	.49	SN74141N	.79	SN74199N	1.49
SN7443N	.75	SN74142N	2.95	SN74S200	4.95
SN7444N	.75	SN74143N	2.95	SN74251N	.99
SN7445N	.75	SN74144N	2.95	SN74279N	.79
SN7446N	.69	SN74145N	.79	SN74283N	2.25
SN7447N	.59	SN74147N	1.95	SN74284N	3.95
SN7448N	.79	SN74148N	1.29	SN74285N	3.95
SN7450N	.20	SN74150N	.89	SN74365N	.69
SN7451N	.20	SN74151N	.59	SN74366N	.69
SN7453N	.20	SN74152N	.59	SN74367N	.69
SN7454N	.20	SN74153N	.59	SN74368N	.69
SN7459A	.25	SN74154N	.99	SN74390N	1.95
SN7460N	.20	SN74155N	.79	SN74393N	1.95
		SN74156N	.79		
		SN74157N	.65		

C/MOS

CD4000	.23	CD4028	.89	CD4070	.55
CD4001	.23	CD4029	1.19	CD4071	.23
CD4002	.23	CD4030	.49	CD4072	.49
CD4006	1.19	CD4035	.99	CD4076	1.39
CD4007	.25	CD4040	1.19	CD4081	.23
CD4009	.49	CD4041	1.25	CD4082	.23
CD4010	.49	CD4042	.99	CD4093	.99
CD4011	.23	CD4043	.89	CD4098	2.49
CD4012	.25	CD4044	.89	MC14409	14.95
CD4013	.39	CD4046	1.79	MC14410	14.95
CD4014	1.39	CD4047	2.50	MC14411	14.95
CD4015	1.19	CD4048	1.35	MC14419	4.95
CD4016	.49	CD4049	.49	MC14433	19.95
CD4017	1.19	CD4050	.49	MC14506	.75
CD4018	.99	CD4051	1.19	MC14507	.99
CD4019	.49	CD4053	1.19	MC14562	14.50
CD4020	1.19	CD4056	2.95	MC14583	3.50
CD4021	1.39	CD4059	9.95	CD4508	3.95
CD4022	1.19	CD4060	1.49	CD4510	1.39
CD4023	.23	CD4066	.79	CD4511	1.29
CD4024	.79	CD4068	.39	CD4515	2.95
CD4025	.23	CD4069	.45	CD4518	1.29
CD4026	2.25			CD4520	1.29
CD4027	.69			CD4566	2.25

74C00

74C00	.39	74C85	2.49	74C163	2.49
74C02	.39	74C90	1.95	74C164	2.49
74C04	.39	74C93	1.95	74C173	2.60
74C08	.49	74C95	1.95	74C192	2.49
74C10	.39	74C107	1.25	74C193	2.49
74C14	1.95	74C151	2.90	74C195	2.49
74C20	.39	74C154	3.00	74C922	7.95
74C30	.39	74C157	2.15	74C923	6.25
74C42	1.95	74C160	2.49	74C925	8.95
74C48	2.49	74C161	2.49	74C926	8.95
74C73	.89			80C95	1.50
74C74	.89			80C97	1.50

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LM300H	.80	LM340T-5	1.25	LM723N/H	.55
LM301CN/H	.35	LM340T-6	1.25	LM733N	1.00
LM302H	.75	LM340T-8	1.25	LM739N	1.19
LM304H	1.00	LM340T-12	1.25	LM741CN/H	.35
LM305H	.60	LM340T-15	1.25	LM741-14N	.39
LM307CN/H	.35	LM340T-18	1.25	LM747N/H	.79
LM308CN/H	1.00	LM340T-24	1.25	LM748N/H	.39
LM309H	1.10	LM358N	1.00	LM1310N	1.95
LM309K	1.25	LM370N	1.95	LM1458CN/H	.59
LM310CN	1.15	LM373N	3.25	MC1488N	1.95
LM311N/H	.90	LM377N	4.00	MC1489N	1.95
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LM317K	6.50	LM380CN	.99	LM1556V	1.75
LM318CN/H	1.50	LM381N	1.79	MC1741SCP	3.00
LM319N	1.30	LM382N	1.79	LM2111N	1.95
LM320K-5	1.35	NE501N	8.00	LM2901N	2.95
LM320K-5.2	1.35	NE510A	6.00	LM3053N	1.50
LM320K-12	1.35	NE529A	4.95	LM3065N	1.49
LM320K-15	1.35	NE531H/V	3.95	LM3900N(3401)	.59
LM320K-18	1.35	NE536T	6.00	LM3905N	1.49
LM320K-24	1.35	NE540L	6.00	LM3909N	1.25
LM320T-5	1.25	NE544N	4.95	MC5558V	.59
LM320T-5.2	1.25	NE550N	1.30	8038B	4.95
LM320T-8	1.25	NE555V	.39	LM75450N	.49
LM320T-12	1.25	NE556N	.99	75451CN	.39
LM320T-15	1.25	NE560B	5.00	75452CN	.39
LM320T-18	1.25	NE562B	5.00	75453CN	.39
LM320T-24	1.25	NE565N/H	1.25	75454CN	.39
LM323K-5	5.95	NE566CN	1.75	75491CN	.79
LM324N	1.49	NE567V/H	.99	75492CN	.89
LM339N	.99	NE570N	4.95	75493N	.89
LM340K-5	1.35	LM703CN/H	.69	75494CN	.89
LM340K-6	1.35	LM709N/H	.29	RC4136	1.25
LM340K-8	1.35			RC4151	3.95
LM340K-12	1.35			RC4194	4.95
LM340K-15	1.35			RC4195	4.49

74LS00TTL

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74LS05	.35	74LS74	.45	74LS160	1.15
74LS08	.29	74LS75	.59	74LS161	1.15
74LS09	.35	74LS76	.45	74LS162	1.25
74LS10	.29	74LS78	.49	74LS163	1.15
74LS11	.75	74LS83	.89	74LS164	1.25
74LS13	.59	74LS85	1.25	74LS175	.99
74LS14	1.25	74LS86	.45	74LS181	2.49
74LS15	.35	74LS90	.59	74LS190	1.15
74LS20	.29	74LS92	.75	74LS191	1.15
74LS21	.35	74LS93	.75	74LS192	1.15
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74LS26	.35	74LS96	1.15	74LS194	1.15
74LS27	.35	74LS107	.45	74LS195	1.15
74LS28	.35	74LS109	.45	74LS253	.99
74LS30	.29	74LS112	.45	74LS257	.89
74LS32	.35	74LS123	1.25	74LS258	1.75
74LS37	.45	74LS125	.89	74LS260	.69
74LS40	.35	74LS132	.99	74LS279	.75
74LS42	.89	74LS136	.49	74LS367	.75
				74LS368	.75
				74LS670	2.49

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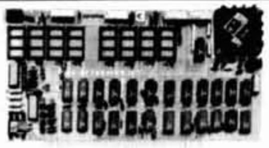
8K Bytesaver II



Cromemco's 8K BYTESAVER® card provides a built-in programmer for the popular 2708 PROM and has the capacity for a full 8K bytes of PROM memory storage. The BYTESAVER® II also offers a number of new features including convenient switch selection of board address and Cromemco's powerful memory bank selection. The BYTESAVER® II is assembled and tested (Model 8KBS-W) for $245.

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Memory Type: 2708 PROM or equivalent
Memory Access Time: 450 nanoseconds
Wait States at 2MHz: none required
Wait States at 4MHz: one per machine cycle
Bus: S-100
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Operating Environment: 0-55°C.

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XC556Y	yellow	4/$1	XC209Y	yellow	4/$1
XC556C	clear	4/$1			
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.170" dia.			XC526C	clear	4/$1
MV10B	red	4/$1	.190" dia.		
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MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	.300	.99
MAN 72	Common Anode-red	.300	.75	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.49	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.49	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	.630	1.49
MAN 4610	Common Anode-orange	.300	.99	DL750	Common Cathode-red	.600	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL338	Common Cathode-red	.110	.35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.99
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	.500	.99
MAN 4840	Common Cathode-yellow	.400	.99	FND507	Common Anode (FND510)	.500	.99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	.99
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.800	1.50
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode red	.800	1.50
MAN 6650	Common Cathode-orange ± 1	.560	.99	5082-7300	4 x 7 sgl. Digit-RHDP	.600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl. Digit-LHDP	.600	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character (±1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA2023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	.85	CA3401N	.59
CA3081N	2.00	CA3600N	3.50

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DM8865	1.00
DM8887	.75
DM8889	.75
9374 7 seg. C.A. LED driver	1.50

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MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	$.17	.16	.15	22 pin LP	$.37	.36	.35
14 pin LP	.20	.19	.18	24 pin LP	.38	.37	.36
16 pin LP	.22	.21	.20	28 pin LP	.45	.44	.43
18 pin LP	.29	.28	.27	36 pin LP	.60	.59	.58
20 pin LP	.34	.32	.30	40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

14 pin ST	$.27	.25	.24	28 pin ST	$.99	.90	.81
16 pin ST	.30	.27	.25	36 pin ST	1.39	1.26	1.15
18 pin ST	.35	.32	.30	40 pin ST	1.59	1.45	1.30
24 pin ST	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

8 pin SG	$.30	.27	.24	24 pin SG	$.70	.63	.57
14 pin SG	.35	.32	.29	28 pin SG	1.10	1.00	.90
16 pin SG	.38	.35	.32	36 pin SG	1.65	1.40	1.26
18 pin SG	.52	.47	.43	40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

8 pin WW	$.39	.38	.31	22 pin WW	$.95	.85	.75
10 pin WW	.45	.41	.37	24 pin WW	1.05	.95	.85
14 pin WW	.39	.38	.37	28 pin WW	1.40	1.25	1.10
16 pin WW	.43	.42	.41	36 pin WW	1.59	1.45	1.30
18 pin WW	.75	.68	.62	40 pin WW	1.75	1.55	1.40
20 pin WW	.85	.79	.72				

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XR567CT	1.25	XR2208	5.20	XR4202	3.60
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XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.95	XR2212	4.35	XR4739	1.15
XR1489	1.95	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400m	4/1.00	1N4002	100 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4003	200 PIV	1 AMP	12/1.00
1N752	5.6	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N753	6.2	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N757	9.0	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N759	12.0	400m	4/1.00	1N3600	50	200m	6/1.00
1N959	8.2	400m	4/1.00	1N4148	75	10m	15/1.00
1N965	15	400m	4/1.00	1N4154	35	10m	12/1.00
1N5232	5.6	500m	.28	1N4733	5.1	1w	.28
1N5234	6.2	500m	.28	1N4734	5.6	1w	.28
1N5235	6.8	500m	.28	1N4735	6.2	1w	.28
1N5236	7.5	500m	.28	1N4736	6.8	1w	.28
1N5242	12	500m	.28	1N4738	8.2	1w	.28
1N5245	15	500m	.28	1N4742	12	1w	.28
1N456	25	40m	6/1.00	1N4744	15	1w	.28
1N458	150	7m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N485A	180	10m	5/1.00	1N1184	100 PIV	35 AMP	1.70
1N4001	50 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.70
				1N1186	200 PIV	35 AMP	1.80
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MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
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TRANSISTORS

C106B1	.50			2N3904	4/1.00
MPSA05	.30	2N3055	.89	2N3905	4/1.00
MPSA06	5/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369A	4/1.00	MPS3705	5/1.00	2N5087	4/1.00
MPS2369	5/1.00	2N3706	5/1.00	2N5088	4/1.00
2N2484	4/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2906	4/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2907	5/1.00	2N3711	5/1.00	PN5134	5/1.00
PN2907 Plastic	7/1.00	2N3724A	.65	PN5138	5/1.00
2N2925	5/1.00	2N3725A	1.00	2N5139	5/1.00
MJE2955	1.25	2N3772	2.25	2N5210	5/1.00
2N3053	2/1.00	2N3823	1.00	2N5449	3/1.00
		2N3903	5/1.00	2N5951	3/1.00

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50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100+		1-9	10-99	100+
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

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.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

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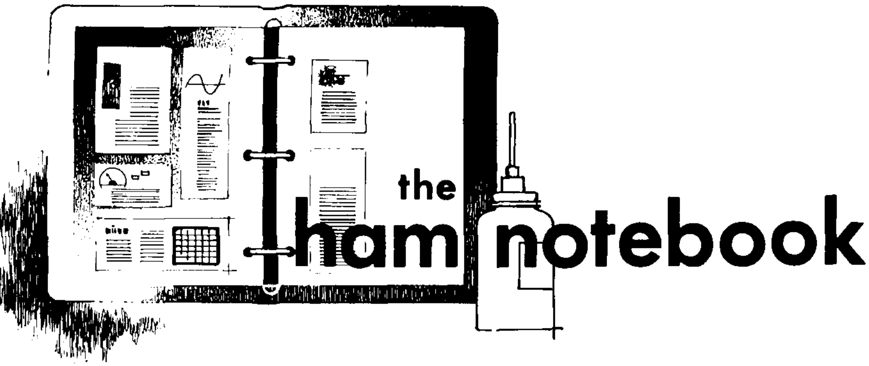
.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/35V	.35	.31	.27
.22/35V	.28	.23	.17	3.3/25V	.35	.31	.27
.33/35V	.28	.23	.17	4.7/25V	.33	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.49	.45	.35
.68/35V	.28	.23	.17	15/25V	.75	.68	.59
1.0/35V	.28	.23	.17	22/6V	.75	.60	.50

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26



improving the Drake R-4C product detector

The single-ended diode product detector used by Drake is typical of the type designed into many present-day receivers. Its simplicity and small number of parts make it a good performer in the Drake R-4C receiver.

However, the 1N270 diode used in this circuit creates large harmonic currents because of its nonlinear nature. This harmonic energy is generated by the BFO and appears as a constant hissing sound in the audio output. It's not noticeable on fairly strong signals but can become annoying if you're listening to a weak signal.

Some time ago I replaced the PN diodes in another receiver with hot-carrier diodes and noted an improvement in performance. Hot-carrier diodes differ from the usual PN diodes in that they switch very fast and don't suffer from the charge storage effect of the junction diode, which creates the high order of harmonics appearing in the audio output.

I replaced the 1N270 diodes in my R-4C with Hewlett-Packard HP5082/2800 hot-carrier diodes (**fig. 1**). The results were quite pleasing. Although the hiss was not completely eliminated, it was significantly reduced. The audio output level also increased.

A word of caution in replacing the 1N270 diodes: They're difficult to remove from the PC board because they are on the bottom of the board, which is mounted in a vertical position with other parts around it. A little extra care and a small pencil-type soldering iron should do it. Before replacing, note the polarity of the removed diodes.

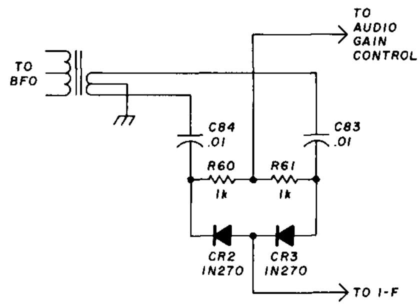


fig. 1. Diodes CR2, CR3 in the Drake R-4 receiver were replaced with H-P 5802/2800 hot-carrier diodes to reduce product-detector noise.

The HP5082/2800 diodes are very small and have a glass body. They crack easily if the leads are pulled too thightly through the holes in the PC board.

If the HP5082/2800 diodes are difficult to obtain, a suitable replacement is the Sylvania ECG519.

Bernard White, W3CVS

sealing coaxial connectors

Unfortunately, few Amateurs take the necessary precautions to safeguard coaxial cables from water contamination. This is especially true where connections are made to antennas. Often the braid and center conductors are simply fanned out, and no sealant is applied to impede water entry.

Dipole installations are often the worst. The old trick of looping the coax over the center insulator and taping it to provide a strain relief is a good one. However, unless the cable end is carefully sealed before connection to the dipole, water will enter the line, be drawn uphill around the loop by capillary action, and eventually contaminate the entire length of line.

Damage to the line by contamination is permanent. Even when the cable is dried out, the internal corrosion will impede effective shielding, change the characteristic impedance, and increase power losses. Because the braid can act like a metal sponge, putting a liberal application of electrical tape at the line end is about as effective as taping a rope but leaving the end exposed: Moisture will still enter the open end, and capillary action will do the rest.

Frequently, Amateurs attempt to seal line ends with silicone rubber sealants. Two problems exist here. The first is that nearly no adhesion exists between the vinyl or PVC jacket and the silicone rubber. The second problem is that, during curing, the silicone rubber compound releases highly corrosive acid vapors, which can devastate the conductive surfaces of connectors, leading to other problems. The following suggested methods are applicable to the majority of installations and can save you both coax cable and rf.

Before matching coaxial connectors for exterior use, apply a liberal amount of silicone grease, such as Dow Corning DC-4 or General Cement Z-5, to the interior of the connectors to reduce moisture contamination. Any silicone grease which oozes out of the connectors will prevent adhesion of tape or other sealant and should be washed away with a solvent. Aerosol spray solvents that leave no lubricating residue are appropriate for this purpose.

The female SO-239 connector is not waterproof. Care should be taken to seal the rear of the connector. Quick-setting epoxy provides a watertight seal.

Where the cable end attaches directly to an antenna, an effective means of sealing the end is to use epoxy. As shown in **fig. 1**, a plastic pipe cap or plastic chair-leg tip can be used as a form to hold the epoxy as it cures. It can then be left in place. The braid should be expanded so that it's loose enough for the epoxy to flow around all the conductors. After pouring in the epoxy, work the coax around in the pipe cap to promote complete saturation of the braid by the epoxy.

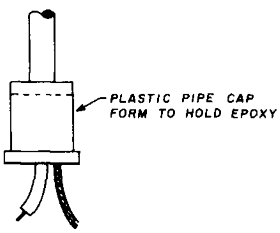


fig. 1. Recommended method for sealing a coaxial cable that connects directly to an antenna. The plastic form holds the epoxy until it cures.

Where a coaxial connector, such as the PL-259, is used to terminate the cable, it's common to attempt to seal it with plastic electrical tape. Depending on the method used, this can be quite effective. However, as often as not, in several days the tape will pull around on the connector as it adjusts its tension. Often this leaves the connector partially exposed to water, a fact not discovered until later when the cable is contaminated with water and some malfunction necessitates antenna service.

The problem can be easily avoided. Behind the connector, wrap enough plastic tape to build up the diameter of the cable gradually to the point where the connector is attached (**fig. 2**). Then, an overwrap of two or three layers of tape covering the entire area can be applied easily, with no wrinkles. This overwrap should be applied tightly, but without stretching the tape, especially during the last several turns. This prevents tension from tearing loose the tape end. Where the connection is to be suspended vertically, the last layer of overwrap should be started from the bottom. In this way water running over the surface will run over the tape laps, just as rain runs over shingles on a roof.

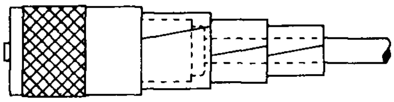


fig. 2. Sealing coax connectors using PVC tape. Proper tape application avoids water contamination (see text).

Robert Wheaton, W5XW

modifications for the K4JIU frequency counter

A number of people who have built the counter I described in the February, 1978, issue of *ham radio* have experienced problems on the 50- and 500-MHz ranges. The problem goes something like this: On the 5-MHz range the counter will usually count to around 7 MHz. Intersil guarantees only 5 MHz for the ICM7208, but typical performance is much better. However, on the 50-MHz and 500-MHz ranges, the counter is found to perform only to around 28 MHz and 280 MHz respectively.

The problem is not in the prescalers! Most of the counters I've seen and have had the opportunity to test don't have this problem; after some discussion with the Intersil applications and engineering people, there's a simple solution that I've tried, and it works well.

The problem is that the 74196 prescaler puts out a signal having a 20 per cent duty cycle. When inverted by half of the 75452 this becomes an 80 per cent duty cycle. The ICM7208 counter chip, unlike TTL devices, performs best when presented with a 50 per cent duty cycle.

Now for the solution. The Q_C output of the 74196 runs at the same frequency as the Q_D output but has a duty cycle much closer to 50 per cent. Therefore, the circuit trace going to pin 12 of the 74196 should be disconnected from pin 12 and reconnected to pin 2. This requires that the trace to the D data input be switched to the C data input; i.e., disconnect the trace from pin 11 and run it to pin 3. Concerning the last change, rather than disconnecting pin 11, simply jumper it to pin 3. The explanation for this is simple and obvious to anyone familiar with the operation of the 74196.

Much to my embarrassment I also learned that, of all the counters I've tested, the 50-MHz front end sensitivity is about 50 mV or less, flat to 65 MHz. Apparently my own unit has some marginal transistors.

I wish to thank the many hams who have written or called to tell me of their successes. I greatly appreciate the feedback, pro or con. The change described above has been incorporated into the artwork, and the next batch of boards, which I hope to have by the end of May, will have this change.

John H. Bordelon, K4JIU

Collins 32S PA disable jacks

The rear chassis lip of Collins 32S transmitters provides two phono jacks labeled P.A. DISABLE. These jacks disable the final amplifier screen supply and have +275 volts available on the inner conductors during transmit. To avoid equipment damage or operator injury by an incorrectly inserted cable, I inserted phono plugs filled with silicone sealant into each phono jack. Plastic-sleeve-covered plugs, such as Radio Shack 274-451, might be used instead.

With the jacks so covered, no accidental contact will occur. This idea may also be used for all other unused phono jacks for similar protection.

Paul Pagel, N1FB

More Details? CHECK—OFF Page 94

NEW products

microminiature encoder

Communications Specialists introduces the SS-32 Microminiature Tone Encoder, which produces either sub-audible or burst-tone frequencies.

This encoder measures 0.9 by 1.3 by 0.40 inches and adapts to all mobile units and most portables. It operates on any dc voltage from 6 to 30 volts and may be ordered in either the audible or sub-audible configuration.

The SS-32 is completely field programmable using a dip switch to produce any one of the thirty-two standard EIA sub-audible frequencies or any one of thirty-two audible frequencies which include touch-tones, burst tones, and test tones such as 600, 1000, 1500, 2175, and 2805 Hz. No counter or other test equipment is required to set frequencies.

The output is a low-impedance, low-distortion adjustable sine wave, 5 volts peak-to-peak. In the sub-audible version, the frequency accuracy is ±0.1 Hz maximum from −40° C to +85° C and the accuracy of the audible tone output is ±1 Hz.

A remote-mounted rotary switch may be purchased to allow selection of any of the tones within either group. Reverse polarity protection is built-in and all connections to the board are made with color-coded wires supplied with each unit.

A full one-year warranty is provided for factory repair. Price of the SS-32 is $29.95, wired, tested, and with complete instructions.

For more information, write Communications Specialists, 426 West Taft Avenue, Orange, California 92667.

model 299 talking counter

Ten-Tec's Model 299 Talking Counter is a self-contained frequency counter, speech synthesizer, and audio amplifier/speaker system which enhances operating convenience and pleasure for the blind ham operating on the high-frequency bands. It can be used with any high-frequency transceiver, analog or digital, or with any vhf transceiver with an appropriate prescaler. Also, it can be used with any signal generator below 22 MHz as a test instrument. When used with Ten-Tec transceivers employing 9 MHz i-f, special built-in presets allow proper readout of the operating frequency, even though the counter is reading VFO output.

Some operating features are:

1) Synthesized speech readout of any rf voltage applied to the input between 1 MHz and 22 MHz. This includes the 10-meter band on Ten-Tec transceivers since the VFO operates below 22 MHz.

2) Choice of MHz and kHz format, or only kHz portion for a quick-repeat cycle.

3) Choice of one-time or repeat cycling.

4) Counts to four places after decimal (100 Hz). When used with analog transceivers, Model 299 *increases* readout accuracy.

5) Self-contained audio amplifier and speaker. No need to tap into transceiver audio system.

6) Only connection required to the transceiver is for the VFO output signal.

7) Runs on 12 Vdc.

Model 299 Talking Counter user price is $290.00. For more information, write Ten-Tec, Inc., Sevierville, Tennessee 37862.

Plexiglas cabinets

Debco Electronics introduces a line of Plexiglas cabinets ideal for LED digital devices. All units feature a clear-red chassis which serves as a filter lens to improve readability. Two sizes are available: Cab-I, measuring 3 × 6¼ × 5½ inches, and Cab-II measuring 2½ by 5 by 4 inches.

Both types have a sloped front and friction feet, and are available with black, white, or clear covers. Cabinets are available factory direct. Cab-I costs $9.95, Cab-II $8.95.

For more information, contact Debco Electronics, P.O. Box 9169, Cincinnati, Ohio 45209.

AEA MorseMatic keyer

A computerized electronic keyer is now available that combines virtually all the features of all the other keyers in the marketplace, at a price that is affordable for any true CW enthusiast.

The AEA MorseMatic uses two custom, state-of-the-art micro-computer chips to perform functions that were previously only a CW operator's fantasy.

The MorseMatic can be tailored to the user's needs. Features considered to be great by some users (such as dot and dash memory) are disliked by others. For the first time, the MorseMatic makes a keyer available that will appeal to all users because it can be tailored exactly to each operator's desires with a sixteen-button keypad.

For serious contest enthusiasts, the MorseMatic offers the most flexible automatic serial-number generator on the market.

For serious vhf DXers, the MorseMatic offers the exclusive automatic-beacon mode for precise moonbounce, scatter, or tropospheric DX scheduling. To use the beacon mode, instruct the MorseMatic how long to transmit any selected message and how long to pause before the message is automatically transmitted again. The computers will automatically set the message code speed to fit the desired transmit window. The beacon mode can also be used for contest operating and for vhf beacon transmissions.

The MorseMatic keyer is the first to offer "soft-partitioning" of the memory, unlike the "hard partitioning" in all other keyers. Soft-partitioning means no wasted memory space. All of the memory can be allotted to one message location, or it can be divided up into as many as ten locations. The memory can be loaded in automatic mode for perfect message formatting, or it can be loaded in the real-time mode for individualizing a message. Memory can also be loaded in automatic-keyer mode (any dot and dash ratio) or in semi-auto (bug) mode. Any message can be played back with any selected dot and dash ratio. Hence, the user can send a sloppily loaded bug-mode message back with perfect 3 to 1 dash to dot ratio. Conversely, a perfectly loaded 3 to 1 dash to dot ratio message can be replayed later with as much as an 8 to 1 dash to dot ratio (sounding like a bug).

Automatic transmit-tune mode. The MorseMatic can be used to key the transmitter for tuning purposes. The operator need only hit any keypad button or the key paddle to defeat the tune mode.

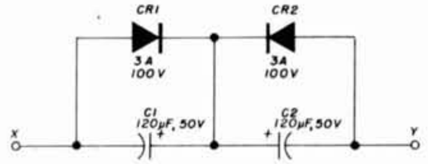
Editing a memory loading mistake is a snap with the MorseMatic. If you are near the end of loading a message into memory and a mistake is made, it only takes seconds to erase the mistake and then continue with an error-free message.

All this, plus the world's best Morse trainer, is included in the basic price of the MorseMatic. It is the only trainer that will automatically increase the speed of the practice characters so that your brain is "fooled" into thinking it is still copying the starting speed. No more need to keep buying practice tapes as you start memorizing old ones, or as you progress in speed. The MorseMatic will take you from 2 to 99 WPM. MorseMatic and Soft-Partitioning are trademarks of AEA.

Introductory Amateur net price is $199.95. Write Advanced Electronics Applications, P.O. Box 2160, Lynnwood, Washington 98036.

short circuits

rotator starting capacitors



In the September, 1979, issue of *ham radio* (page 92), K6WX describes a technique for guarding against failure in the electrolytic starting capacitor of the Ham-M rotator. His circuit, above, shows how to build a non-polarized rotator starting capacitor using electrolytics and steering diodes. This scheme protects the capacitors from being subjected to eventually destructive reverse polarities.

broadband baluns

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	LBL A	31 25 11	
	1	01	
	R/S	84	ENTER |Z|
	↑	41	
	5	05	
	0	00	
	÷	81	
	STO 1	33 01	
	2	02	
010	R/S	84	ENTER ANG°
	STO 2	33 02	
	RCL 1	34 01	
	g R→P	31 72	
	STO 1	33 01	Re Z
	h x↔y	35 52	
	STO 2	33 02	IMAG Z
	RCL 1	34 01	
	1	01	
	-	51	Re (Z_L/Z_0-1)
020	STO 3	33 03	
	RCL 1	34 01	
	1	01	
	+	61	Re (Z_L/Z_0+1)
	RCL 2	34 02	
	h x↔y	35 52	
	g R→P	35 72	
	STO 4	33 04	
	RCL 2	34 02	
	RCL 3	34 03	
030	g R→P	32 72	
	RCL 4	34 04	
	÷	81	$\|\Gamma\|$
	STO 1	35 01	
	1	01	
	+	61	$1 + \|\Gamma\|$
	RCL 1	34 01	
	1	01	
	-	51	$1 - \|\Gamma\|$
	CHS	42	
040	÷	81	VSWR
	R/S	84	DISPLAY
	1	01	
	To To A	22 11	

This HP-67 program for calculating VSWR for a given load impedance, Z_L, should have appeared in the appendix of W6TC's article on page 18, February, 1980, *ham radio*.

More Details? CHECK—OFF Page 94

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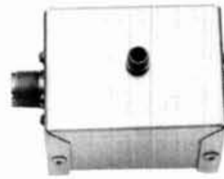

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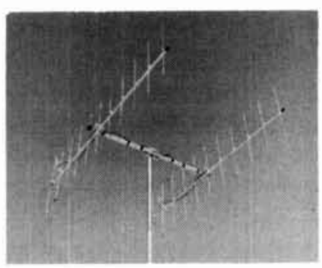

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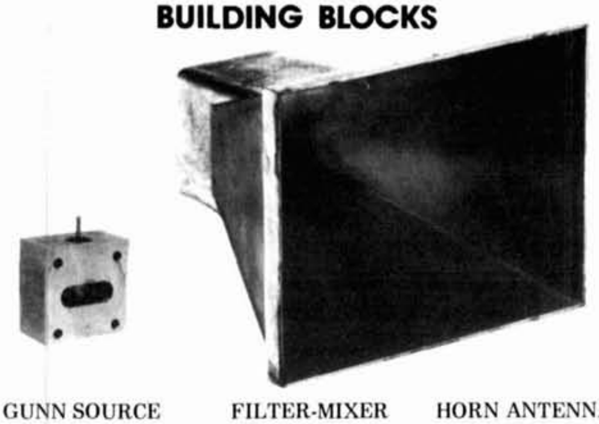

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TO: ALL AMATEURS
FROM: WILSON SYSTEMS, INC.

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With each product that we manufacture, we include a "Product Evaluation Sheet." This enables us to understand what you like and dislike about our products and services. We appreciate the ideas and comments that you have returned to us on these sheets and have instituted some of the changes suggested. So please continue to send them in.

I'm sure you've noticed the way prices have been creeping (and in some cases leaping) upward. We don't like to raise the prices any more than you like to see them go up, but have you seen the price of steel or aluminum lately?

Not all the price increases are directly related to increased materials costs. Sometimes it is the result of an upgrade to a better product. That is the case with the towers. I am very enthusiastic about the new "B" model towers. Did you take a look at the new specifications? Notice the features that have been changed: thickness of tubing, type of tubing used, and the wind loading. The wind load capability has increased dramatically. Oh yes, they've increased in price—but so has the quality! And did you notice the new tower? That's a 77', freestanding, rotatable tower that will safely handle 12 sq. ft. of antenna at 77' (or 18 sq. ft. at 72') in a 50 mph wind. All of this for less than $1,400, including the rotating base!

I would also like to mention that this month we are announcing a new antenna product. We are offering you an adapter kit for the SY-36 and SY-33 to add 40-meter operation. This kit, the 33-6 MK, will add 200kc of 40-meter operation to your tribander. It will work only with the SY-33 and SY-36.

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	33-6 MK	40 Mtr. Mod Kit for SY33 & SY36	UPS	49.95
	WV-1A	Trap Vertical for 10, 15, 20, 40 Mtrs.	UPS	49.95
	GR-1	Ground Radials for WV-1A	UPS	12.95
	M-520A	5 Elements on 20 Mtrs.	TRUCK	229.95
	M-420A	4 Elements on 20 Mtrs.	UPS	159.95
	M-515A	5 Elements on 15 Mtrs.	UPS	129.95
	M-415A	4 Elements on 15 Mtrs.	UPS	84.95
	M-510A	5 Elements on 10 Mtrs.	UPS	84.95
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	HD-73	Alliance Heavy Duty Rotor	UPS	109.95
	RC-8C	8/C Rotor Cable	UPS	.12/ft.
	RG-8U	RG-8U Foam-Ultra Flexible Coaxial Cable. 38 strand center conductor, 11 guage	UPS	.21/ft.

NOTE:
On Coaxial and Rotor Cable, minimum order is 100' and 50' multiples.
Prices and specifications subject to change without notice.
Ninety (90) Day Limited Warranty — All Products FOB Las Vegas, Nevada

WILSON SYSTEMS TOWERS

Qty.	Model	Description	Shipping	Price
	TT-45B	Freestanding 45' Tubular Tower	TRUCK	314.95
	RB-45B	Rotating Base for TT-45B w/tilt over feature	TRUCK	219.95
	FB-45B	Fixed Base for TT-45B w/tilt over feature	TRUCK	154.95
	MT-61B	Freestanding 61' Tubular Tower	TRUCK	549.95
	RB-61B	Rotating Base for MT-61B w/tilt over feature	TRUCK	299.95
	FB-61B	Fixed Base for MT-61B w/tilt over feature	TRUCK	214.95
	ST-77B	Freestanding 77' Tubular Tower	TRUCK	949.95
	RB-77B	Rotating Base for ST-77B w/tilt over feature	TRUCK	449.95
	FB-77B	Fixed Base for ST-77B w/tilt over feature	TRUCK	299.95
	GK-45B	Guying Kit for TT-45B	UPS	59.95
	GK-61B	Guying Kit for MT-61B	UPS	79.95
	GK-77B	Guying Kit for ST-77B	UPS	99.95
	WTB-1	Thrust Bearing for Top of Tower	UPS	49.95

Prices Effective March 1-31, 1980 — Nevada Residents add 3½ % Sales Tax

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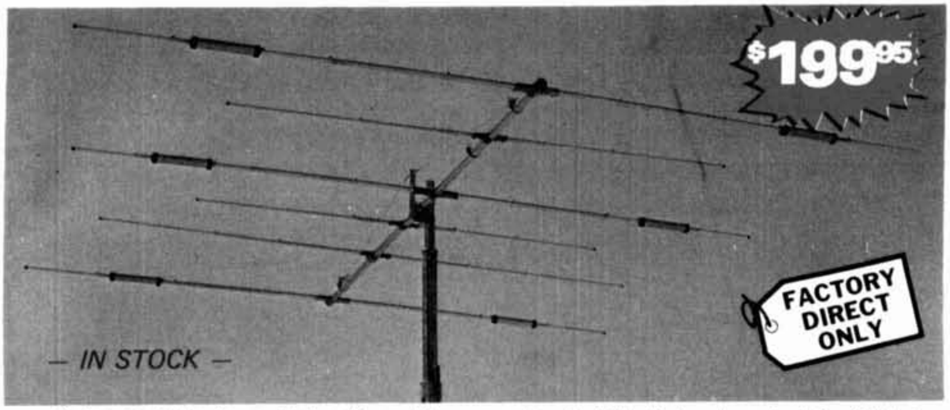
WILSON SYSTEMS INC. MULTI-BAND ANTENNAS



A trap loaded antenna that performs like a monobander! That's the characteristic of this six element three band beam. Through the use of wide spacing and interlacing of elements, the following is possible: three active elements on 20, three active elements on 15 and four active elements on 10 meters. No need to run separate coax feed lines for each band, as the bandswitching is automatically made via the High-Q Wilson traps. Designed to handle the maximum legal power, the traps are capped at each end to provide a weather-proof seal against rain and dust. The special High-Q traps are the strongest available in the industry today.

SPECIFICATIONS

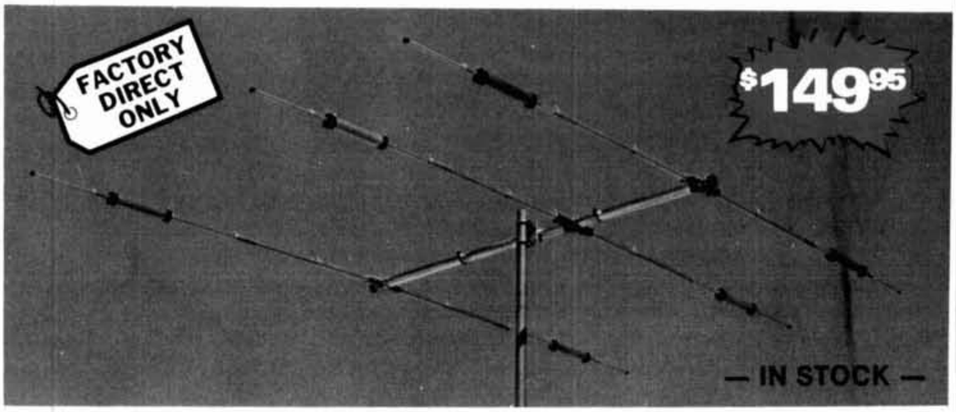
Band MHz	14-21-28	Boom (O.D. x Length)	2" x 24' 2½"	Wind Loading @ 80 mph	215 lbs.
Maximum power input	Legal Limit	No. of Elements	6	Maximum wind survival	100 mph
Gain (dBd)	Up to 9 dB	Longest Element	28' 2½"	Feed method	Coaxial Balun
VSWR @ resonance	1.3:1	Turning Radius	18'6"	Matching Method	Beta
Impedance	50 ohm	Maximum mast diameter	2"	Assembled weight (approx)	53 lbs.
F/B Ratio	20 dB or better	Surface area	8.6 sq. ft.	Shipping weight (approx)	62 lbs.

NEW! ADD 40 METERS TO YOUR TRI-BAND WITH THE NEW 33-6 MK

$49.95

— IN STOCK —

Now you can have the capabilities of 40-meter operation on the System 36 and System 33. Using the same type high quality traps, the 40-meter addition will offer 200HKZ of bondwidth at less than 2:1 SWR. The new 33-6 MK will fit your present SY36 or SY33, and using the same single feed line.



Capable of handling the Legal Limit, the "SYSTEM 33" is the finest compact tri-bander available to the amateur. Designed and produced by one of the world's largest antenna manufacturers, the traditional quality of workmanship and materials excells with the "SYSTEM 33". New boom-to-element mount consists of two 1/8" thick formed aluminum plates that will provide more clamping and holding strength to prevent element misalignment. Superior clamping power is obtained with the use of a rugged 1/4" thick aluminum plate for boom to mast mounting. The use of large diameter High-Q traps in the "SYSTEM 33" makes it a high performing tri-bander and at a very economical price. A complete step-by-step illustrated instruction manual guides you to easy assembly and the lightweight antenna makes installation of the "SYSTEM 33" quick and simple.

SPECIFICATIONS

Band MHz	14-21-28	Boom (O.D. x length)	2" x 14'4"	Wind loading at 80 mph	114 lbs.
Maximum power input	Legal Limit	No. of elements	3	Assembled weight (approx)	37 lbs.
Gain (dbd)	Up to 8 dB	Longest element	27'4"	Shipping weight (approx)	42 lbs.
VSWR at resonance	1.3:1	Turning radius	15'9"	Direct 52 ohm feed – no balun required	
Impedance	50 ohms	Maximum mast diameter	2" O.D.	Maximum wind survival	100 mph
F/B Ratio	20 dB or better	Surface area	5.7 sq. ft.		

WSI WILSON SYSTEMS, INC.

4286 S. Polaris Ave., Las Vegas, Nevada 89103

Prices and specifications subject to change without notice.

ORDER FACTORY DIRECT 1-800-634-6898

$49.95

WV-1A

4 BAND TRAP VERTICAL (10 - 40 METERS)

No bandswitching necessary with this vertical. An excellent low cost DX antenna with an electrical quarter wavelength on each band and low angle radiation. Advanced design provides low SWR and exceptionally flat response across the full width of each band.

Featured is the Wilson large diameter High-Q traps which will maintain resonant points with varying temperatures and humidity.

Easily assembled, the WV-1A is supplied with a base mount bracket to attach to vent pipe or to a mast driven in the ground.

Note:
Radials are required for peak operation.
(See GR-1 below)

SPECIFICATIONS

- 19' total height
- Self supporting — no guys required
- Weight — 14 lbs.
- Input impedance: 50 Ω
- Powerhandling capability: Legal Limit
- Two High-Q traps with large diameter coils
- Low angle radiation
- Omnidirectional performance
- Taper swaged aluminum tubing
- Automatic bandswitching
- Mast bracket furnished
- SWR: 1.1:1 or less on all bands

GR-1 $12.95

The GR-1 is the complete ground radial kit for the WV-1A. It consists of: 150' of 7/14 stranded copper wire and heavy duty egg insulators, instructions. The GR-1 will increase the efficiency of the GR-1 by providing the correct counterpoise.

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MOBILE HF ANTENNA 3.2-30 MHz inclusive, 750 watts PEP, center loaded, tuned from the base, eliminating coil changing or removing from mount. Less than 1.5 to 1 VSWR thru entire coverage. $129.95 ea. plus shipping. Contact your local dealer, if none in your area order direct. Anteck, Inc., Route One, Hansen, Idaho 83334. (208) 423-4100. Master Chg., and VISA accepted. Dealer and factory rep. inquiries invited.

WRITE OFF some of your amateur radio expenses! This proven HAM TAX SAVINGS booklet is itself tax-deductible and is guaranteed to save you many times its price. Applies to 1979 taxes, and the information can be used again every year you have ham-related expenses in the future. Perfectly legal, not a "gimmick". Only $3.95. R. Day, 27131 Indian Peak Rd., Rancho, Palos Verdes, CA 90274.

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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 98362.

WANTED: Hilltop property near Pollock Pines, California. WA6COA, 4 Ajax Place, Berkeley, CA 94708.

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

QSLs — $2.70 per hundred (minimum order, 1000) and up. 32 two-color designs. Send 30¢/stamps for catalog. Satisfaction guaranteed or money back. Since 1934. VP5QED Press, Box 1523, Boca Raton, FL 33432.

RTTY — Solid state CQer board with PROM programmed your call. Coming soon. Send name/address for future announcements. Nat Stinnette Electronics, Tavares, FL 32778.

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

THE MOR-GAIN HD DIPOLES are most advanced, highest performance multi-band HF dipole antennas available. Patented design provides length one-half of conventional dipoles. 50 ohm feed on all bands, no tuner or balun required. Can be installed as inverted VEE. Thousands in use world wide. 22 models available including two models engineered for optimum performance for the novice bands. The Mor-Gain HD dipoles N/T series are the only commercial antennas specifically designed to meet the operational requirements of the novice license. Our 1-year warranty is backed by nearly 20 years of HD dipole production experience. Write or call today for our 5-page brochure. (913) 682-3142. Mor-Gain, P.O. Box 329H, Leavenworth, KS 66048.

STAR-TRONICS monthly picture flyer is full of parts and pieces for the builder. U.S. only. Star-Tronics, Box 683, McMinnville, OR 97128.

WANTED: Magnetic Video Corp. Copycorder. Halliburton Briefcase. Larry Kleber, K9LKA, Belvidere, Illinois 61008.

WANTED: Motorola KXN 1024 and KXN 1052 Channel elements. WA6COA, 4 Ajax Place, Berkeley, CA 94708.

ONLY MY FRIEND'S recent physical disability makes this top-grade equipment available; purchased new, still in as-new condition, complete with manuals/cables. Bill had literally a store full of items, $10 to $100 range; too costly to advertise the list, so tell me what you need. I want to move them now. Anyone having a difficult time learning code and operating CW? These like-new visual decoders and electronic typewriter keyboard: Pickering 230-D Morse Decoder, $1500; Pickering KB-1 Electronic Keyboard keyer, $140; Atronics CR-101 Code Reader, $65; manuals/instructions. Collins: 51S1F, $2050; 55G1, $325; 30L1, $995; 32S3A/516F2, $1775; 312B4, $425; all Round Emblem, immaculate w/manuals. Two Hy-Gain HT-18, 10-80 meter vertical antennas, $195 each (phasing harness available); Two Murch Ultimate Transmatch UT-2000A, $125 each; DenTron 3000A antenna tuner, $230; KLM Multi-2700 144 MHz transceiver, $575; KLM PA 10-140BL linear amplifier, $175; Vista 120v.a.c./13.8v.d.c. power supply for above, $136; excellent condition w/manuals. Ralph E. Thomas, W2UK, 9 Emmons Avenue, Farmingdale, N.J. 07727; telephone (201) 938-5623.

WANTED: Heathkit SB-10 SSB Adapter for Apache Transmitter. Working Condition. Larry Eichhorn, 1449 Joseph St., Saginaw, Mich. 48603.

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

HARDLINE: Wanted in approximately 300 foot piece, ½" or 7/8" size. Contact: Mr. G. Holmes, c/o G.F.W., Box 501, Sault Ste. Marie, Michigan 49783.

ANTENNA FARM on six acres redwood forest, Santa Cruz mountains, 45 minutes to San Jose, CA. Quiet DX location, three-phase power, 125-ft Blaw Knox self-supporting tower with 40M and 20M rotary beams. Crank-up with TH6DXX. Many 150-ft redwoods for wires. 1925 square feet in house and garage, 960 in nearby shop and ham shack, all seven years old. Private well, 10,000 gallon storage. ½-mile paved private road. Top three acres fenced. Good DX location all directions, 7" horizon to SW. $300,000 by owner, W6MUR, terms. Write callbook QTH or call (408) 336-8800.

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PEAK READING WATT METER WM-2000A reads power in 200, 1000, 2000 watt ranges. 3.5-30 MHz. Reads average or PEP power output. Includes expanded VSWR scale.

IN-LINE WATT METER WM-2000 reads power in 200, 1000, 2000 watts. 3.5-30 MHz. Incl. expanded VSWR scale.

MOBILE WATT METER HFM-200 with remote directional coupler reading 20 or 200 watts. 3.5-30 MHz. Illuminated, with VSWR scale.

SWR BRIDGE SWR 1A with dual reading meters. 1000 watts RF. 3.5-150 MHz. Reads relative power output.

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KENWOOD TS-700S, Mint, $600. HEATH HR 1680 Ham Band Receiver, excellent, $175. SB640 Speaker, $25. F9FT, $40. Cushcraft A147-22, 2m beam, $40. 75ft 50 ohm hardline, $20. CO AR40, Rotor, $30. Offers Considered. Al Barnett, WO4SHO, P.O. Box 198, Indian Head, MD 20640. 301-743-3511 — Evenings.

SATELLITE TELEVISION — movies, sports, etc. Build or buy your own earth station. Send $3.00 for information. Satellite Television, Box 140, RD #3, Oxford, NY 13830.

FOR SALE: Reconditioned 33 ASR — Teletype. New York Teleprinter Service, 1 Burrow Road, East Northport, NY 11731. 516-499-3048. M-15 Parts.

HAM RADIO REPAIR, alignment. Prompt, expert, reasonable. "Grid" Gridley, W4GJO, Route 2, Box 138B, Rising Fawn, GA 30738.

WANTED: No. 19 Mark II or III Transceiver. State condition, price in letter. V. Grogan, WD8SEF, P.O. Box 382, West Salem, Ohio 44287.

RTTY AFSK *Modulator PC board. See Feb. 79 Ham Radio.* Drilled $5.00; with parts, $25. F. E. Hinkle, 12412 Mossy Bark, Austin, TX 78750.

SELL: Drake SW4-A $190.00, Moonbounce 160 element collinear $490.00, Details, List, write John Allen Bowling Green, MO 63334.

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

THE 11TH ANNUAL FM B*A*S*H will be held on the Friday night of the Dayton Hamvention, April 25, 1980 at the convention center, Main and Fifth Streets. Parking in adjacent City garage. Admission is free to all. Sandwiches, snacks and C.O.D. bar available. Live entertainment provided for a super social evening. Don't miss it . . . Awards include a new synthesized HT. For further information contact the Miami Valley FM Assn., P.O. Box 263, Dayton, Ohio 45401.

WANTED AFSAV-133D & AN/FRA-86 Demods TD-687 Demux, AFSAV-129A Selector & AFSAV-39C Rekeyer. C. T. Huth, 146 Schonhardt, Tiffin, OH 44883.

REPLACE RUSTED ANTENNA BOLTS with stainless *steel. Small quantities, free catalog. Elwick, Dept. 370,* 230 Woods Lane, Somerdale, N.J. 08083.

RTTY FOR SALE: 28ASR table-top compact (1); 28KSR single-speed (2), w/gearshift (1); M28 ROTR single-speed (2), w/gearshift (3); M28 LXD stand-alone TD (10); 28KSR compact w/gearshift (1); 28RO w/gearshift (2); 34ASR (1); M28 keyboard typing reperf single-speed (2); M28 triple LXD (2); M28-under-dome typing reperf single-speed (1), w/gearshift (2); friction-feed mod kits NEW (3); 2-shaft reperf for 28ASR (2); 60-75-100 wpm gearshifts for 28KSR, RO NEW (5); M28 motorized paper winders (10); self-contained answerbacks (3); 35KSR (1); 35ASR (1); 33ASR TWX (1); gears and parts available for all machines. Send SASE for full list and prices. Lawrence R. Pfleger, K9WJB, 2600 S. 14th Street, St. Cloud, MN 56301.

DX, YOU BET! THE DX BULLETIN — Best weekly DX info in the world. For FREE sample copy, send business-size SASE to: The DX Bulletin, 306 Vernon Avenue, Vernon, *Connecticut 06066.*

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CW FILTERS: Active audio 8-pole, install in any radio, selectable bandwidth, $15-$32. SASE info W8CBR, 80W. Mennonite, Aurora, OH 44202.

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MOTOROLA ALL SOLID STATE MOTRAN RADIOS. Model X43LSN-2170, four frequency, transmit 150 MC (30W), receive 450 MC. Will operate in Ham Bands. No modification required. Large stock available. $150.00 each. Omni Communications. Call (312) 852-0738.

KENWOOD INTERNATIONAL USER'S CLUB is now operational. SASE for details. N8RT, Pohorence, 9600 Kickapoo Pass, Streetsboro, OH 44240.

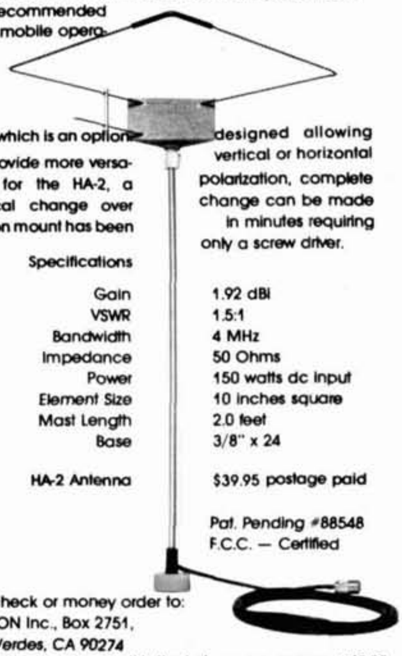
ATLAS OWNERS DD6-C and 350XL Digital Dial/Frequency Counters. $175.00 + Shipping (Calif. add tax). Mical Devices, Box 343, Vista, CA 92083.

HA-2 HORIZONTAL/VERTICAL 2 METER ANTENNA

The HA-2 is a low profile half wave, horizontally polarized omnidirectional 2 meter antenna. Although the HA-2 was designed for mobile operation, it will work well as a fixed or portable antenna and its small size provides the traveling ham with an antenna that can easily be packed in a briefcase.

The HA-2 comes complete with RG/58, which is fed through the center of the mast section, PL-259 RF connector and 3/8 24 stud base. A rain gutter mount is recommended for mobile operation, which is an option.

To provide more versatility for the HA-2, a vertical change over option mount has been designed allowing vertical or horizontal polarization, complete change can be made in minutes requiring only a screw driver.



Specifications

Gain	1.92 dBi
VSWR	1.5:1
Bandwidth	4 MHz
Impedance	50 Ohms
Power	150 watts dc input
Element Size	10 inches square
Mast Length	2.0 feet
Base	3/8" x 24
HA-2 Antenna	$39.95 postage paid

Pat. Pending #88548
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Send check or money order to:
SEM CON Inc., Box 2751,
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More Details? CHECK—OFF Page 94

Coming Events

IOWA: 3900 Club Sooland Repeater Association's 4th annual Hamboree, Saturday, March 29, The Oasis, Sioux City Airport. Entertainment, flea market, CW contest, Novice meeting, 3900 Club quarterly meeting, tech. programs. Flea market tables (reserved) $2.00. Contact Al Smith, WØPEX, 3529 Douglas, Sioux City, IA 51103. Advance registration including banquet $6.75. At door $7.75. Hamboree only (no dinner) $2.00. For advance tickets and motel reservations: Loren Barbee, WBØYOW, 1518 W. 30th, Sioux City, IA 51103. Talk in on .37/.97.

MISSOURI: The Missouri Valley Amateur Radio Club, Inc. proudly announces its second annual Pony Express Days from the original stables in St. Joseph, April 5 and 6. Operating time 1000 CST to 1900 CST both days. Anyone making contact with the club station will receive the Pony Express Award. Send legal-size SASE along with personal QSL card to: Missouri Valley ARC, 401 North 12th Street, St. Joseph, MO 64501. Certificate will be stamped with original seal of the Pony Express. Operating frequencies will be 28.575 and 10 kc's from the bottom of the General phone band on the other bands — 15 through 75. CW bands will be 28.150, 21.150 and 7.125. Listen for WØNH from the home of the Pony Express.

TEXAS: Midland Amateur Radio Club's annual swapfest, Saturday, March 15, noon to 7 p.m., Sunday, March 16 starting at 8 a.m. at the Midland County Exhibit Building, Midland. Door prizes. For pre-registration send $4.50 to: Midland Amateur Radio Club, Box 4401, Midland, TX 79701. $5.00 at door. Talk in on 146.16/146.76.

NEW YORK: Southern Tier Amateur Radio Club's 21st annual Hamfest, Saturday, May 3. NEW LOCATION: Owego Treadway Inn, Rte. 17, Exit 65, Owego. Flea market, tech. talks. Buffet dinner tickets and general admission $8.00. Reservations received after April 20 will be held at door. Admission only, $2.00. STARC has use of all public rooms of Treadway for that day, all on ground level. For hotel accommodations at the Treadway contact: Debbie Chambers, 607-687-4500. For information, ticket reservations contact: STARC, PO Box 11, Endicott, NY 13760.

OHIO: Toledo Mobile Radio Association's 25th annual Auction and Hamfest, March 23, 8 a.m. - 5 p.m., Lucan County Rec. Center, Key St., Maumee. For information, reservations, table space, write: T.M.R.A., Box 24, Temperance, MI 48182. Talk in on 146.52 simplex; information 147.87/27.

MICHIGAN: 19th annual "Michigan Crossroads" Hamfest, Saturday, March 15, Marshall High School, Marshall. Sponsored by Southern Michigan ARS, Calhoun County Repeater Assoc., and Amateurs of Marshall Schools. Doors open at 7 a.m. for exhibitors, 8 a.m. for general public. Door prizes and prizes for those checking in with Talk-in station. Forums, displays, and special programs for ladies. Free parking, unloading help, food service. Admission at door $2.00, advanced sale, $1.50. Table space, $.50/ft. reserved til 10 a.m. For information, table reservations contact: SMARS, Box 934, Battle Creek, MI 49016. Talk in on: 146.52, 146.07-67.

FLORIDA: Playground Amateur Radio Club's 10th Anniversary Swapfest, Saturday, March 22 & Sunday, March 23, 8 a.m. - 4 p.m. each day, Okaloosa County Shrine Fairgrounds, Fort Walton Beach.

ILLINOIS: Kishwaukee Radio Club & DeKalb County Amateur Repeater Club's 22nd annual indoor/outdoor hamfest, Sunday, May 4, 8 a.m. to 3 p.m., Notre Dame School (3 miles south of DeKalb between hwy. 23 and South 1st St. on Curler Rd.) Tickets, $1.50 advance, $2.00 at door. Indoor tables available. Own table, set-up free. For tickets & directions SASE to: Howard, WA9TXW, Box 349, Sycamore, IL 60178.

FLORIDA: Treasure Coast Hamfest, Vero Beach Community Center, Vero Beach. Talk in 146.13/73 — 146.04/64 — 222.34/223.94. For info: P.O. Box 3088, Vero Beach, FL 32960.

WISCONSIN: Tri County ARC Hamfest, March 16, Jefferson County Fair Grounds, Jefferson. (Formerly at Whitewater). Advance tickets $1.50, reserve tables, $2.00 advance, 6 ft. space $1.00. Send SASE to: Glenn Eisenbrandt, WA9VYL, 711 East St., Fort Atkinson, WI 53538.

MARYLAND: The Baltimore Amateur Radio Club's all new Greater Baltimore Hamboree and Computerfest, Sunday, March 30. New Location: Maryland State Fairgrounds, Timonium. Special events, lectures, demonstrations, food service. Door prizes plus grand drawing. Lots of space for tailgate sales, dealers, commerical exhibits. Admission $3.00, tables $5.00. For more info, tickets, space reservations, contact: Joseph Lochte Jr., 2136 Pine Valley Drive, Timonium, MD 21093. Talk in on BARC repeaters, 146.07/67, 146.34/94.

More Details? CHECK—OFF Page 94

NEW JERSEY: Chestnut Ridge Radio Club's Ham Radio and Computer Flea Market will be held March 29, 1980. Location: Education Building, Saddle River Reformed Church, East Saddle River Road at Weiss Road (new site) in Upper Saddle River, New Jersey. Tables $5.00. Tailgating $3.00. No admission fee. Hot dogs, soda. Contact: Jack Meagher, W2EHD, (201) 768-8360 or Neil Abitablio, WA2EZN, (201) 768-3575.

MICHIGAN: ARRL Great Lakes Division Convention & Hamfest, March 28 & 29, sponsored by the Muskegon Area Amateur Radio Council, Muskegon Community College, Muskegon. Free parking. Dining/cafeteria service. Special events, Wouff Hong initiation, ladies program. Saturday tickets, $2.50 — also purchase Swap & Shop space on 29th. For additional information write: MAARC, Box 691, Muskegon, MI 49443, or call Clarke Cooper, K8BP, Club President, at 616-865-6198.

TENNESSEE: Tennessee Council of ARC's 10th annual QSO party, Saturday, March 22, 2100Z to 0500Z March 23. Sunday, March 23 1400Z to 2200Z. Tennessee stations give RST and county. Out of state send RST and state, province, district or country. Same station may be worked on different bands, modes or counties. Frequencies: CW - 50 kcs approximately from bottom. Phone - 3980, 7280, 14280, 21380, 28580. Novices within their bands. Phone stations call CW TN QSO Party, CW call CQ TN only. Plaque to Tennessee top scorer, Tennessee mobile and portable and out-of-state score. Certificates with results to every station sending in log with at least 15 contacts. Mailing deadline: May 1. Send business size SASE with log to: Dave Goggio, 1419 Favell, Memphis, TN 38116.

YL Int'l SSBers, Inc. QSO Party 1980. CW 0001 GMT March 29 - 2359 GMT March 30. Frequencies: 3665, 7070, 14070, 21070, 28070. Phone 0001 GMT April 29 - 2359 GMT April 20. Frequencies: 3925, 7290, 14333, 21373, 28673. Exchange name, RST, SSBer number, country, state, partner's call. Awards: Extraordinary certificates issued to highest individual score, DX/WK teams, YL/OM teams and highest score in single operator category. Regular certificates to highest state and country winners. Logs: Date, GMT, RST, SSBer number, partner's call, mode, band and rest period. Members desiring to enter DX/WK team category send request to: Lyle F. Shaw, 52340 Tallyho Drive, South Bend, IN 46635. Please avoid nets on 14313 and 14336.5.

B.A.R.T.G. Spring RTTY Contest 1980. 0200 GMT Saturday, March 22 to 0200 GMT Monday, March 24. Bands - 3.5, 7.0, 14.0, 21.0 and 28.0 MHz. The same station may be contacted on different bands. Logs to contain date, time GMT, callsign of station worked, RST and message number sent. Send contest or check log to: Ted Double, G8CDW, 89, Linden Gardens, Enfield, Middlesex, England, EN1 4DX.

WISCONSIN QSO Party 2100Z March 29 to 0300Z March 31. Suggested frequencies: CW - 60 kHz up from band edge. Phone - 3990, 7290, 14290, 21390, 28590 and 20 kHz up from bottom of novice bands. Logs must show: date, band, mode, time (GMT), call, report and score. All entries postmarked before May 1, 1980. Send results to Wisconsin QSO Party, c/o West Allis RAC, PO Box 1072, Milwaukee, WI 53201.

MOSLEY TA 33, 56 ft. steel tower all hardware, prop-pitch motor — sell all or part. Tom Johnson, N6BP, 2212 Louise Ave., Ceres, CA 95307. (209) 537-0373.

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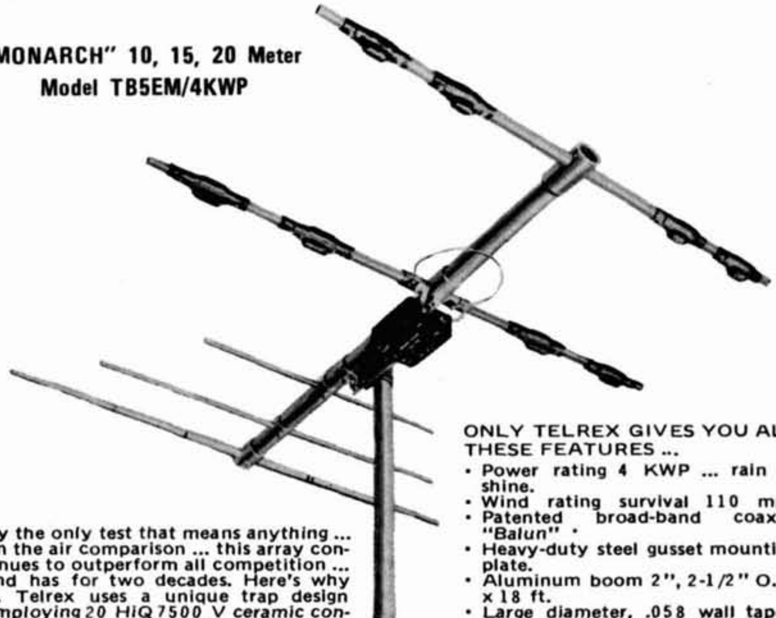

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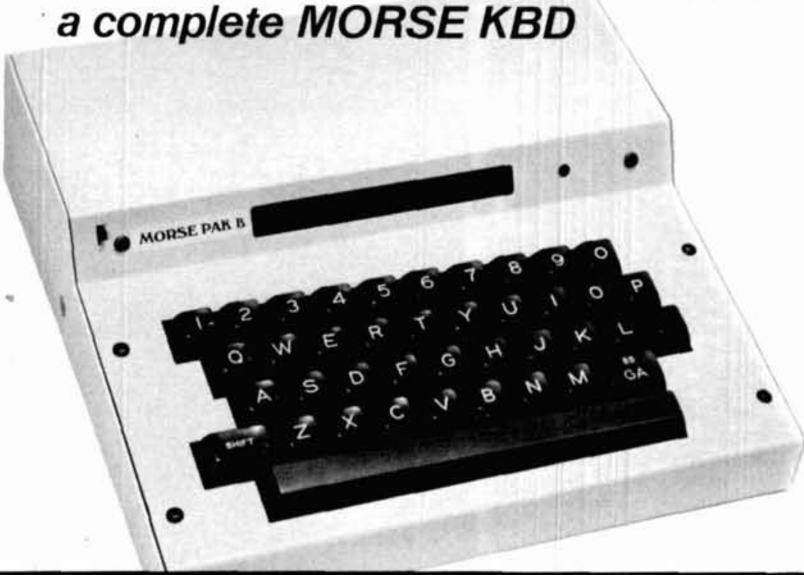

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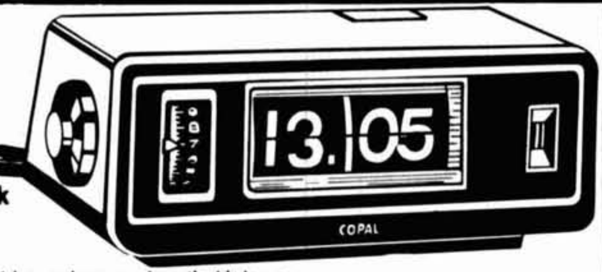

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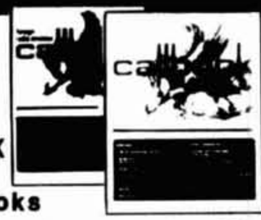

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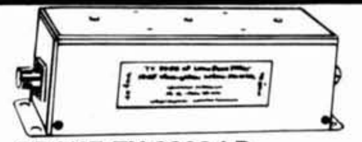

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FT-707 is shown with
optional FV-707DM VFO
& Scanning Microphone

THE FT-707 "WAYFARER"

The introduction of the "WAYFARER" by Yaesu is the beginning of a new era in compact solid state transceivers. The FT-707 "WAYFARER" offers you a full 100 watts output on 80-10 meters and operates SSB, CW, and AM modes. Don't let the small size fool you! *Though it is not much larger than a book*, this is a full-featured transceiver which is ideally suited for your home station or as a traveling companion for mobile or portable operation.

The receiver offers sensitivity of .25 uV/10 dB SN as well as a degree of selectivity previously unavailable in a package this small. The "WAYFARER" comes equipped with 16 poles of IF filtering, variable bandwidth and optional crystal filters for 600 Hz or 350 Hz. Just look at these additional features:

FT-707 with Standard Features

- Fast/slow AGC selection
- Advanced noise blanker
- Built-in calibrator
- WWV/JJY Band
- Bright Digital Readout
- Fixed crystal position
- 2 auxiliary bands for future expansion
- Unique multi-color bar metering—monitors signal strength, power output, and ALC voltage.

FT-707 with Optional FV-707DM & Scanning Microphone

- Choice of 2 rates of scan
- Remote scanning from microphone
- Scans in 10 cycle steps
- Synthesized VFO
- Selection of receiver/transmitter functions from either front panel or external VFO
- "DMS" (Digital Memory Shift)

Impressive as the "WAYFARER" is its versatility can be greatly increased by the addition of the FV-707DM (optional). The FV-707DM, though only one inch high, allows the storage of 13 discrete frequencies and with the use of "DMS" (Digital Memory Shift) each memory can be band-spread 500 KHz. These 500 KHz bands may be remotely scanned from the microphone at the very smooth rate of 10 Hz steps.

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