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ANNUAL 1984

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EDITORIAL

We dish it up...

Last weekend I took a motor trip through upper New York State. The leaves were that full green hue just prior to turning to the colors of fall. I saw old churches, quaint bridges, old red barns, dairy herds, and about a hundred backyard satellite-tracking antennas. I couldn't believe what I was seeing. What was so strange was that I saw what I had reported about in several magazine articles; and yet it is difficult to believe that common-folk consumers like you and me tie in our daily activities with a satellite 22,300 miles over the equator.

Since that "big step for mankind" much has happened to change communications in the world we live. So much so, that were you to check the contents pages of **Radio-Electronics** ten years ago—yea, five years ago—you would be hard pressed to find a definitive article on satellite communications for the consumer and do-it-yourselfer. This issue of **Radio-Electronics Annual** sports a satellite antenna on the cover, the lead article looks into the future of satellite communications, and several other video articles are tied into satellite communications. Yes, we're in step with the technology of today even though it amazes us!

Radio-Electronics Annual presents the pace-setting electronics stories of today with the selection of articles intended to fill the gaps in our knowledge of what is happening in the electronics state-of-the-art mainstream. Those gaps are caused by an over-emphasis of editorial content of electronics magazines on computers, and computer-related subjects in far too many publications. That is evidenced by the numerous (we counted about 80) computer magazines that appear (and some disappear) on newsstands, bookstores, and computer stores.

Our answer to that gap is in the pages of this annual publication. Here we have focused on the technologies that affect our lives today and those that will do so tomorrow. Video, here, and in space, is the story today. Audio and videodisc systems are entering our homes. New and expanded uses of communications are making our consumer society more mobile than ever before. But don't take my word. Start thumbing through the pages of this annual and see the wonderful world of electronics unfold.

Julian S. Martin

Julian S. Martin, KA2GUN
Managing Editor

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NEW PRODUCTS

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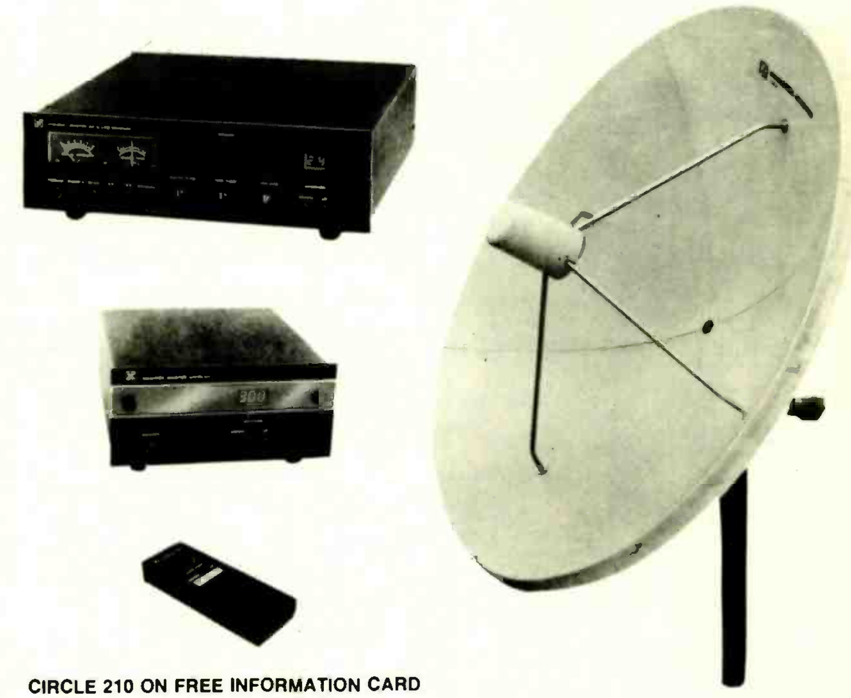


CIRCLE 210 ON FREE INFORMATION CARD

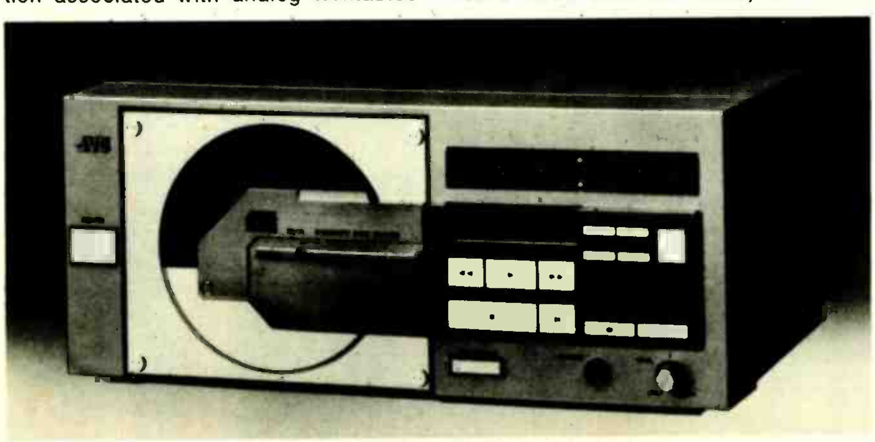
Channel Master has introduced a new high-performance, ten-foot, non-motorized satellite earth station. A low retail price is made possible by engineering and production advances that allow Channel Master to produce the new double-monopole mount more economically. The prime focus feed assembly (LNA, scaler feed and polarizer) and the down-converter are supported above the fiberglass dish by light-weight, high-strength aluminum struts, which provide extra stability during operation and easy alignment during assembly.

Once installed and aligned, the ultra-accurate polar mount provides full domestic satellite coverage through a single manual or remote control motorized adjustment. The all-weather system will successfully withstand hurricane force winds in excess of 100 mph. The motorized system features simple Up and Down buttons to aim the antenna and continuous three-digit LED readout which is accurate to ⅓ of a degree. It comes with a custom, easy-to-use satellite locator card and features 36-volt operation with heavy-duty actuator motor.

The electronics package offers an easily-operated 24-channel receiver. Push button tuning with automatic polarity switching and LED digital channel display are combined with a center/fine tuning meter and signal-strength meter for precise reception. Additional features include channel scan for rapid location of active transponders and a built-in modulator. An optional remote control unit makes channel selection and fine tuning even more convenient. The double monopole 120 degree LNA manual system, model 6174, is priced at $2995. Suggested retail for the SAT-SCAN version, model 6274, is $3695. Write to Channel Master, Ellenville, NY 12428.

JVC Compact Disc Player

JVC has introduced the Compact Disc Player—a front-loading player that features such advanced operations as soft-touch function controls, multi-purpose digital display, and random track selection. The Model XL-V1 Compact Disc Player virtually eliminates noise, distortion, and record deterioration associated with analog turntables through the use of a laser-beam pick-up system, rather than contact stylus. Specially encoded 4¾-inch digital discs are used to reproduce the sound exactly as recorded, doing away with sound degradation caused by scratches, dust, or repeated playing. The JVC player also incorporates a powerful error-correction code called CIRC (Cross Interleave Reed Solomon Code) to correct accurately for dropouts or reading errors by means of interpolation. The XL-V1 offers frequency response of 5 Hz to 20 kHz and can play up to 75 minutes per compact disc. The model features such advanced microprocessor-controlled functions as random track selection, allowing users to program up to 15 tracks for play in any order desired. A CLEAR button mkes it easy to change or cancel progammed tracks, while a CALL button lets you confirm the entered selections.



CIRCLE 211 ON FREE INFORMATION CARD

Other high-tech functions only possible on the Compact Disc include Quick Check Play, a scanning feature that plays the first two seconds of every 30-second portion for quick location of any particular track. Skip Play allows users to jump right to the next track or return to the beginning of the selection. A REPEAT button replays the complete disc or programmed tracks over and over. The multi-function digital fluorescent display provides three useful indications including Program Number (both total number of tracks available on the disc and number of tracks selected), Play Time of individual or total programmed tracks and Elapsed Time from th beginning of

continued on page 6

NEW PRODUCTS

For more details use the free information card inside the back cover

continued from page 4
the disc. Other operations include Pause, Memory Stop, Analog Location Indicator offering an LED display of approximate time elapsed since play began, headphone output with volume control and both fixed and variable line outputs. The unit measures 12¹¹⁄₁₆-inches wide by 5¹³⁄₁₆-inches high by 9¹¹⁄₁₆-inches deep. The player tips the scales at only 12.3 pounds. The XL-V1 represents a nationally advertised value of $1,000.00. Available at most quality hi-fi JVC outlets. Write to JVC, 41 Slater Drive, Elmwood Park, NJ 07407.

PAIA Keyboard Controllers

PAIA's new Series V Keyboard Controllers are loaded with features and available options. Standard features include pitch and modulation wheel controls, gate and re-trigger outputs, low-note-rule priority and Pratt-Read keybord actions. The controllers' trim sizes take up little space in the studio and their light weight allows them to be worn on stage for hours without fatigue. The long list of options available for the Series V includes 37 or 61 note actions, exponential or linear control voltage outputs, MIDI or parallel digital outputs and mono or poly configurations. The Controllers are available factory-assembled or in easily assembled kit form with prices starting at less than $180. Detailed descriptions, prices and ordering information are available from the manufacturer; **PAIA Electronics, Inc.**, 1020 W. Wilshire Blvd., Oklahoma City, OK 73116.

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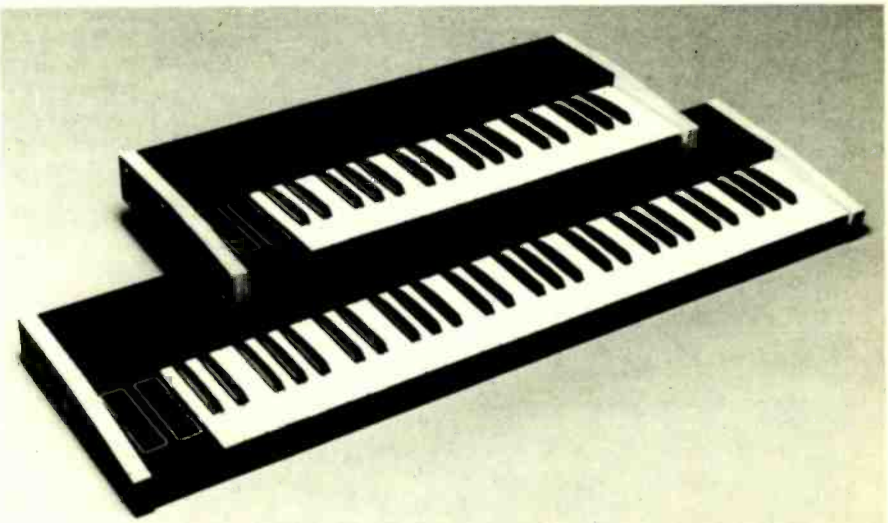
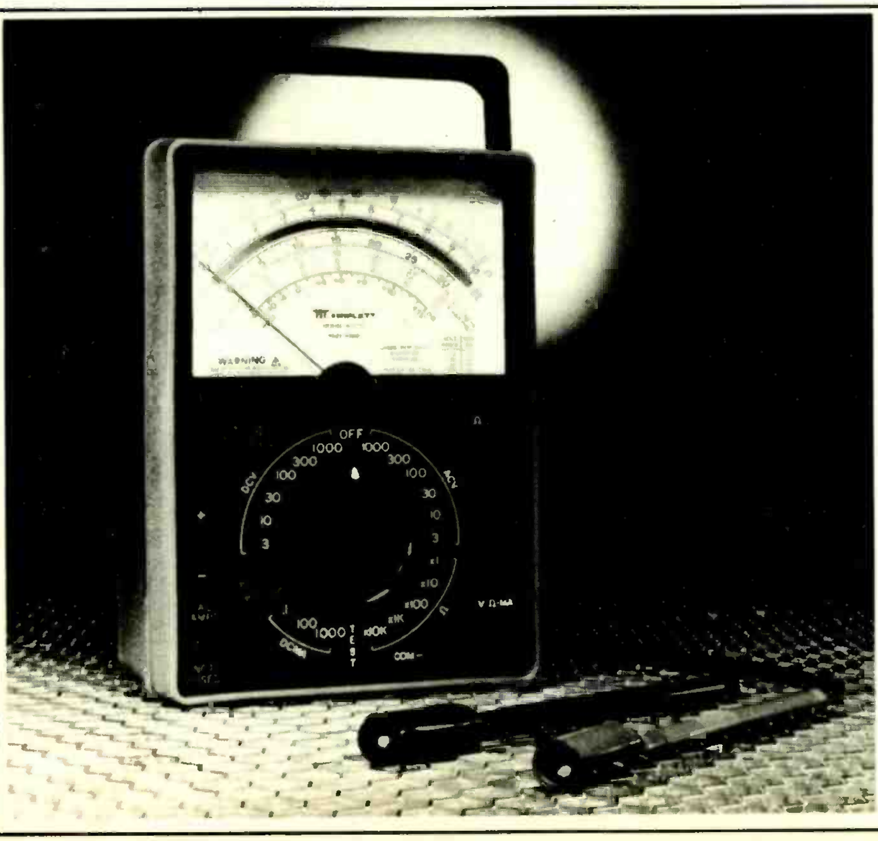




Triplett Multimeter

The Triplett 60-AC Multimeter features direct-reading AC current ranges and is ruggedly constructed to withstand an accidental drop from a height of five feet. Designed for lab or in-field electronic/electrical test measurements, the 60-AC has all-range fusing and newly designed safety-test leads. The mirror scale-for-accuracy, suspension-type meter is housed in a separate modular compartment for simple replacement. A built-in confidence check assures proper operation and the single-function switch and polarity-reversing switch simplify measurements. Ranges include: 0-1000-volt DC in 7 ranges, 0-1000-volt AC in 6 ranges, 0-1000-milliamperes DC in 3 ranges, 0-12-amperes AC (direct) in 2 ranges.

Furnished with the Multimeter are: batteries, 48-in. safety test leads, screw-on insulated alligator clips, spare fuses and a comprehensive instruction manual. The price is $155.00. Optional accessories include: Miniature test clips for high density circuit measurements, leather case, DC current shunts, high-voltage probes, clamp-on AC adapter and line separator. For a demonstration of the Model 60-AC Multimeter, contact your local Triplett distributor, Mod-Center, or representative. Literature is available from **Triplett Corporation,** One Triplett Drive, Bluffton, Ohio 45817.

CIRCLE 213 ON FREE INFORMATION CARD

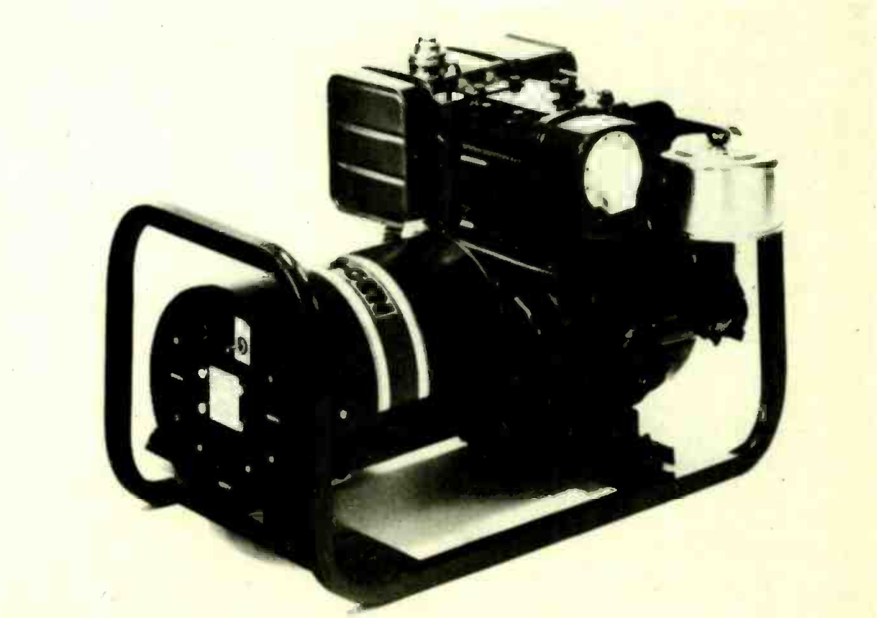
NEW PRODUCTS

For more details use the free information card inside the back cover

Auto-Gen Portable Generator

Auto-Gen, manufacturers of vehicle-mounted generators, now offers a family of portable generators called the Porta-Gens. The availability of a dependable and economical source of electricity in remote locations is often a necessity. People who live in rural areas, where loss of power is more likely to occur, can turn to Porta-Gen for a reliable back-up electrical system. Porta-Gen models are available to meet various electrical requirements. The smallest model has an output of 1750 watts of 120-volt AC and the largest unit provides 8500 watts of 120/240-volts AC. All Porta-Gens are powered by a gas-driven Briggs Stratton industrial class engine, long associated with durability.

The model shown in the photos, the P4000, has an output of 4000 watts (4 kW). At 120 volts output is rated at 33 amperes, while at 240 volts, output is 16.5 amperes. The 8-hp Briggs Stratton engine has a fuel capacity of 1 gallon, with consumption of .8 gallons-per-hour. the P4000 model weighs 140 pounds. Its suggested retail price is $1065.00. **Auto-Gen** is located at P.O. Box 895, Minden, LA 55432.



CIRCLE 214 ON FREE INFORMATION CARD

Polar Prototype Satellite Antenna

Polar Spherical Antenna Systems, new Metal Antenna is designed for the do-it-yourself addicts. It incorporates all the features of their current Wooden Model. The reflector is a ten-foot modified geodetic design which is completed by the Quad-Pod insomuch that a stress exerted on any member is cancelled out by its neighbor, making it a very rigid unit, both the reflector and the Chaparral Polarotor or similar unit are infinitely tuneable, all bearings and fixings are at maximum distance for stability, polar mount bearings nine feet apart, tracking anchorage five feet from axis, declination adjustment nine feet, and a six-by-seven foot base for the stand. All these factors, and its mesh reflector, make the antenna very stable in severe winds, its low profile has a distinct advantage. Material costs are less than $100, plans to built it are $40. Write **Prototype Engineers** P.O. Box 1812 Deming, NM 88030.

CIRCLE 215 ON FREE INFORMATION CARD

Matthews Auto Anti-Theft Device

Thanks to scientific advancements in digital electronics any car owner can have a highly effective anti-theft system at a reasonable price. The new Matthew's system is called "Theft-Aside". It locks out the ignition system unless a special 4-button code is pressed. Thus protected, the car cannot be hot-wired or jumped from inside of car. Each unit comes with complete step-by-step instuctions to guide the do-It-yourselfer through installation. No special tools, skills, or drilling is required and Theft-Aside works off any 12-volt auto system. Theft-Aside has been thoroughly

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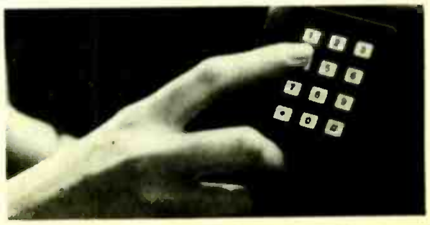
CIRCLE 216 ON FREE INFORMATION CARD ▶



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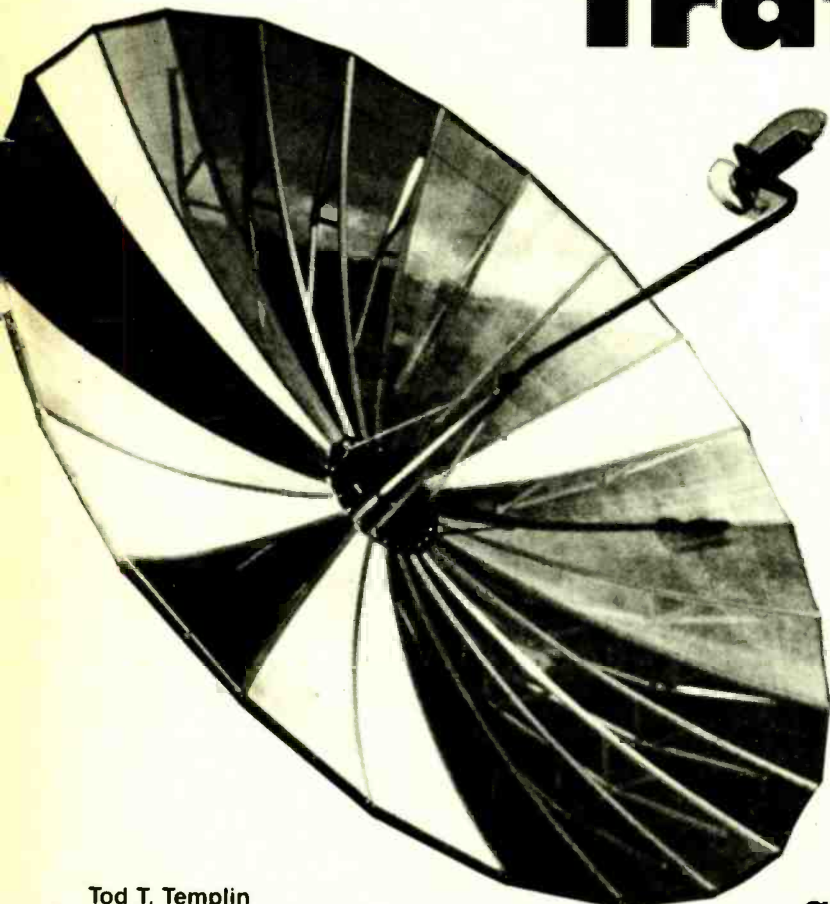


Satellites hover over our world every day crowding a narrow belt once considered limitless!

Tod T. Templin

THE NEWSPAPER I BOUGHT THIS MORNING was composed in New York City and printed in Chicago. A weekly news magazine arrives by mail every Tuesday in a timely fashion. It is also written in New York, but printed in a small Midwestern town near my home. I can pick up my phone and for a reasonable fee, instantly, and without any assistance, dial directly to almost anywhere in the world. I can choose from over 60 television channels on my cable-TV hookup. We all know that satellites make such everyday occurrences a commonplace reality. But how many of us can claim to understand the means by which satellites make those minor miricles happen?

You probably have a good general idea of what a TVRO system is (TVRO is the abbrevition for *T*ele*V*ision *R*eceive *O*nly.) Articles about TVRO's have been published everywhere from **Radio-Electronics** to *Time* magazine. Even non-technical magazines like *TV Guide* have deferred to the widespread interest created by the electronic revolution of satellites and TVRO's: They have published articles which have contributed to a high level of awareness in the general populace about satellites and their relation to television—especially cable TV. This article will explain the evolution of satellite technology and why that technology has made the backyard TVRO possible.

Satellite history

It was the noted science-fiction author Arthur C. Clarke, who is recognized as the first person to propose the use of geostationary satellites. Long before the first satellites were ever launched, he postulated that a satellite in orbit around the earth at the equator—at a distance from the surface such that the satellite's orbit duration was exactly 24 hours—would appear from the ground to hover in one spot. Clarke further suggested that three such satellites spaced equidistantly around the earth in that orbit could provide worldwide communications, because two of them would always be in view from any point on earth. The distance from the earth to that orbit is approximately 22,300 miles and is named the "Clarke Belt" in honor of Mr. Clarke. It is the fact that a satellite can be made to appear motionless relative to a point on earth; that makes inexpensive satellite communications possible. To earthbound antennas, a geosynchronous satellite looks like a stationary object in the sky, so the requirement for expensive motor-driven tracking-type antennas is eliminated.

It wasn't until 1963, when launch vehicles with enough power and payload capacity were developed, that the first geostationary satellite was placed into orbit above the Atlantic Ocean. This satellite was called SYNCOM. Built by Hughes Aircraft Corp., it had the capacity to relay only one television channel or about 50 individual telephone circuits between the United States and Europe. In spite of its limited capacity, SYNCOM was an unqualified success. It proved that geostationary satellite relays were both feasible and economical.

"UN" in space

In 1965 a consortium of 19 nations banded together to form a corporation

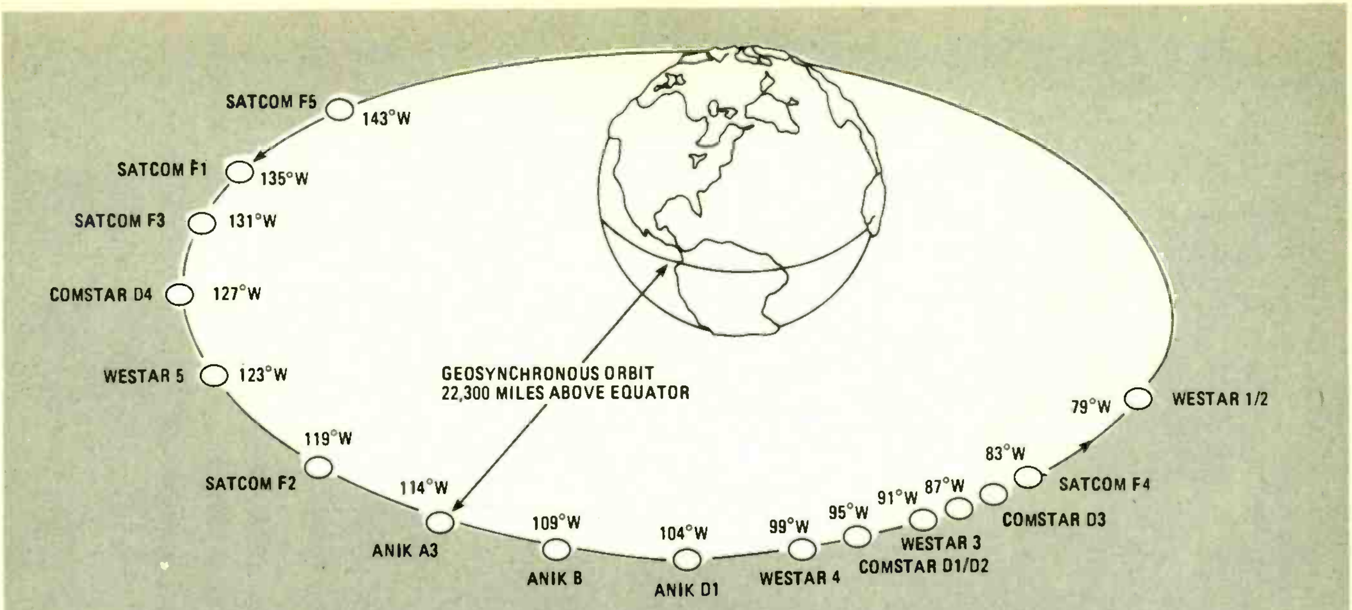


FIG. 1—HERE IS WHAT THE HEAVENS looked like at the time the author prepared this article. Sixteen satellites are currently in GEO orbit between 79 and 143 degrees West longitude. Each one is a multi-channel device aimed at selected regions.

called Intelsat. That international organization provided disipline and direction for the maturing satellite-communication industry. In the ensuing years, Intlsat grew to include over 100 nations worldwide. It is primarily responsible for building and launching a series of satellites which realized Arthur C. Clarke's prediction of a world linked together by three groups of geostationary satellites—positioned over the Atlantic, the Pacific and the Indian Oceans.

In the years which have passed since SYNCOM was launched, satellite technology has raced ahead at warp speed. Because of the financial success of Intelsat, many other large domestic-communication companies like RCA and Western Union soon got into the domestic-communication satellite business. In 1975, a small, regional cable-TV company named Home Box Office began leasing transponder time from RCA during evening hours to distribute sporting events and commercial-free entertainment to other small, independent cable companies across the country on a regular, network-like, basis. HBO was an instant hit, and proved that the public was ready and willing to pay for quality commercial-free programming. Thus, the pay cable-TV industry was born. Everyone immediately realized the potential for profit from supplying the cable-TV industry with satellite-delivered programming. Almost overnight companies formed to provide cable-TV operators with every imaginable type of TV programming. Soon everything from the so-called super TV stations, to sports-only channels, movie channels, religious channels, and all-news channels were being distributed by satellite. In almost no time, all the available satellite transponders were occupied and most future ones were spoken for. Why then, don't we just launch as many satellites as necessary to do the job? Read on.

Dividing up the Clarke Belt

In 1971 the nations which then comprised Intelsat (which of course included the United States) agreed upon a series of international technical standards for communication-satellite operation. They decided that the standard operating frequency for communication satellites would be a 500-megahertz band between 3.7 gigahertz and 4.2 gigahertz. That assignment was not an accident or a ploy to make it difficult for unauthorized reception. There is a natural drop in the background-noise level (static) from interstellar space in that frequency range. Thus, earthbound antennas pointed at satellites in space see a quieter backdrop from which to separate the very weak satellite signals. Intelsat also decided that initially, satellites would be placed into the Clarke belt at 5-degree intervals. That was a practical consideration, governed mainly by the physical properties of the antennas used to receive satellite transmissions. Because all satellites operate in the same frequency band, many engineers felt that placing satellites closer than 5 degrees could cause interference at receive sites; particularly with small-diameter antennas (less than 5 meters). It was felt that those antennas might not have narrow enough beam widths to prevent simultaneous reception from adjacently positioned satellites. Generally speaking, the smaller the diameter of a parabolic antenna, the wider its beam width, and the lower its gain. Because most satellite-receiving antennas in use, particularly those of cable-TV operators, are designed for 5-degree spacing; and because switching to larger antennas would be very expensive, there is strong resistance to closer satellite spacing. However, placing satellites 5 degrees apart means that there is room for only about 16 communication satellites between 70 degrees and 140 degrees West longitude—the prime real estate shared by the United States, Canada, and Mexico. (Figure 1 illustrates the 16 satellites that are currently in operation between 79 and 143 degrees West longitude. Table 1 gives the video satellite status of 1983-4.

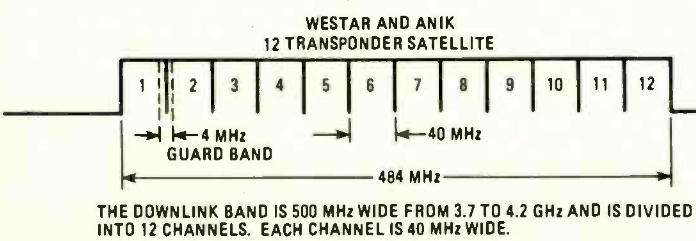


FIG. 2—IN THE BEGINNING downlink (transmitting to Earth) transmissions were divided into 12 channels, each 40-MHz wide. Output power per channel is usually 5 watts delivered by the solar cells.

And now!

Today, the demand for television, phone, and data circuits far outstrips the

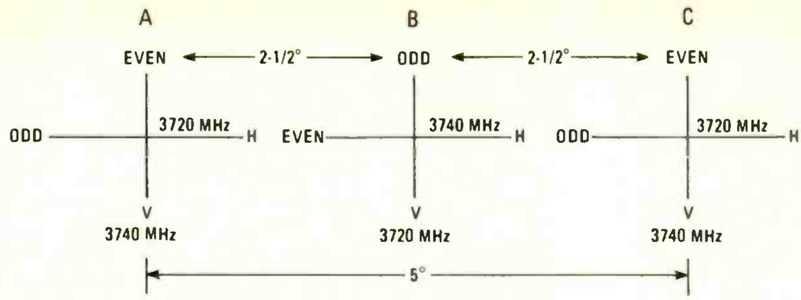


FIG. 3—CLOSER SPACING of satellites to 2½-degrees of arc requires that frequencies 20-MHz apart are polarized at right angles to each other. The diagram illustrates how three closely-spaced satellites would be polarized on a common pair of frequencies.

combined capacities of all the communication satellites currently in orbit. Transponders are at such a high premium that satellite operators have held lotteries to determine who would be allowed the privilege of paying millions of dollars per year to lease a transponder. Faced with that tremendous demand for greater capacity; it was proposed that in the 70- to 140-degree arc, satellites could be positioned closer than 5 degrees together if certain "tricks" were employed to make adjacent satellite signals less "visible" to receive antennas. To understand how that could be done, you need to know a little more about how satellites perform their signal-relaying functions.

The satellite

A communication satellite is really nothing more than a remote-controlled, solar-powered, microwave relay station in orbit. Communication satellites are equipped with two sets of antennas. One set is used to receive the signals being beamed up from earth—called "uplink" signals; a second set of antennas to re-transmit signals back to earth—called "downlink" signals. The uplink and downlink signals are *not* transmitted on the same set of frequencies. Uplink signals are transmitted in a 500-MHz band between 5.9 GHz and 6.4 GHz, and downlink signals are transmitted, as discussed earlier, between 3.7 GHz and 4.2 GHz. On the first satellite systems, this 500-MHz band was broken down into twelve 40-MHz wide channels, including guard bands. (See Fig. 2.) The remaining 16-MHz was used to monitor the satellites' onboard conditions, for command signals to switch onboard circuits, and for the beacon signals used to locate the exact position of the satellite.

Geostationary satellites, affected mainly by slight fluctuations in the earth's gravitational field, actually do tend to drift around slightly; that's why they are equipped with small rocket motors. Control signals are sent from the ground to fire those motors periodically to keep the satellite positioned exactly in its assigned

TABLE 1
Video Satellites

Position	Early-83	Mid-83	Mid-84
143°W	F5	F5	F5
139°W		F1R	F1R
135°W	F1	G1	G1
131°W	F3	F3	F3
127°W	D4	D4	D4
123°W	W5	W5	W5
119°W	F2	F2	S1
114°W	A3	A3	A3
109°W	AB	AB	AB
104°W	AD1	AD1	AD1
99°W	W4	W4	W4
95°W	D1/D2	D1/D2	D1/D2
91°W	W3	W3	W3
87°W	D3	D3	D3
83°W	F4	F4	F4
79°W	W1/2	W1/2	W1/2
74°W			G2
70°W			S2
66°W			F2R

F = SATCOM (RCA) **W = WESTAR** (W/U) **A = ANIK** (TeleSat)

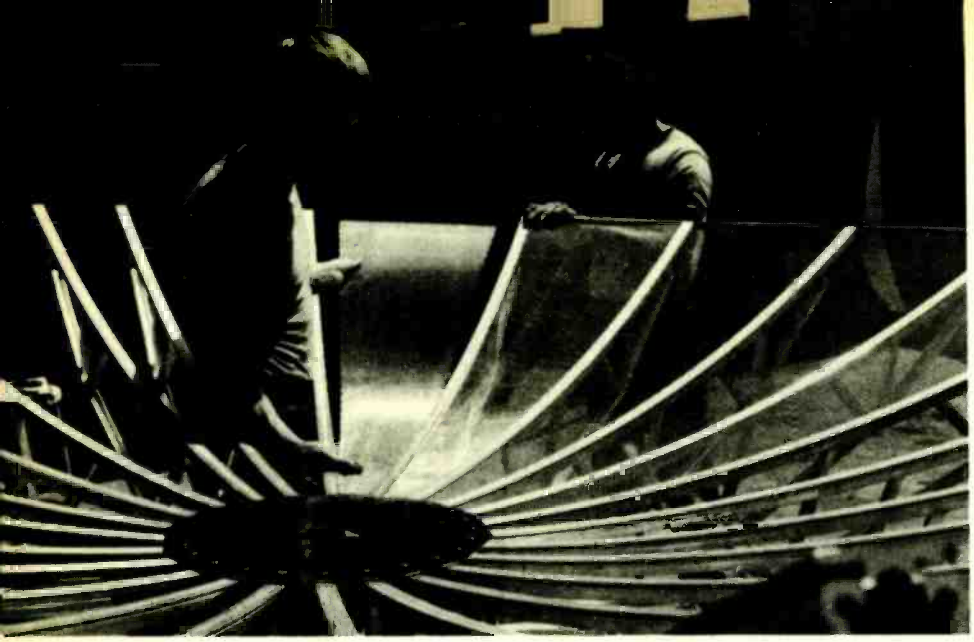
D = COMSTAR (AT&T) **G = GALAXY** (Hughes) **S = SPACENET** (Southern Pacific Communications)

Bird Launches & Operational Dates for 1983
F1R—139°W Launch 4-14-83, operational 5-83
AC—114°W Est. Launch 4-83, operational 6-83
G1—135°W Est. Launch 6-83, operational 8-83
G2—74°W Est. Launch 9-83, operational 11-83

TABLE 2
Satellite Frequency Assignments

Industry Standard No.	Frequency	SATCOM 1, 2, 3R & 4	COMSTAR 1, 2, 3 & 4	WESTAR 4 & 5 ANIK D1	WESTAR 1, 2 & 3 ANIK B
1	3720	1(V)	1V(V)	1D(H)	1(H)
2	3740	2(H)	1H(H)	1X(V)	
3	3760	3(V)	2V(V)	2D(H)	2(H)
4	3780	4(H)	2H(H)	2X(V)	
5	3800	5(V)	3V(V)	3D(H)	3(H)
6	3820	6(H)	3H(H)	3X(V)	
7	3840	7(V)	4V(V)	4D(H)	4(H)
8	3860	8(H)	4H(H)	4X(V)	
9	3880	9(V)	5V(V)	5D(H)	5(H)
10	3900	10(H)	5H(H)	5X(V)	
11	3920	11(V)	6V(V)	6D(H)	6(H)
12	3940	12(H)	6H(H)	6X(V)	
13	3960	13(V)	7V(V)	7D(H)	7(H)
14	3980	14(H)	7H(H)	7X(V)	
15	4000	15(V)	8V(V)	8D(H)	8(H)
16	4020	16(H)	8H(H)	8X(V)	
17	4040	17(V)	9V(V)	9D(H)	9(H)
18	4060	18(H)	9H(H)	9X(V)	
19	4080	19(V)	10V(V)	10D(H)	10(H)
20	4100	20(H)	10H(H)	10X(V)	
21	4120	21(V)	11V(V)	11D(H)	11(H)
22	4040	22(H)	11H(H)	11X(V)	
23	4160	23(V)	12V(V)	12D(H)	12(H)
24	4180	24(H)	12H(H)	12X(V)	

V = Vertical polarization H = Horizontal polarization



THE KLM ELECTRONICS X-11 all-aluminum satellite antenna assembles in just 2½ hours. It is 11 feet in diameter.

orbital parking space. That is referred to as station keeping.

Very simply stated, onboard the satellite, signals that are received from earth in the 5.9- to 6.4-GHz band are amplified and filtered, then directly converted by heterodyning with a local oscillator to the corresponding 40-MHz channel in the 3.7- to 4.2-GHz band, reamplified, and retransmitted back to earth. Each 40-MHz channel so processed by a satellite is called a transponder. Because satellites are solar powered, electrical energy to run the transponder transmitters is at a premium. Satellite output power is generally about 5-watts per transponder.

Although each 40-MHz transponder can handle hundreds of narrowband voice and data circuits, it requires the entire 40-MHz channel to relay just one television signal. Thus 12 transponder satellites are limited to carrying only 12 television signals at one time. Early satellites generally carried a mix of both television and narrowband circuits. But the growing cable-TV and common-carrier TV industries placed an ever increasing demand on satellite operators for more wideband-television circuits. Some means had to be found to increase individual satellite capacity for television circuits without going beyond the boundaries of the assigned 500-MHz band.

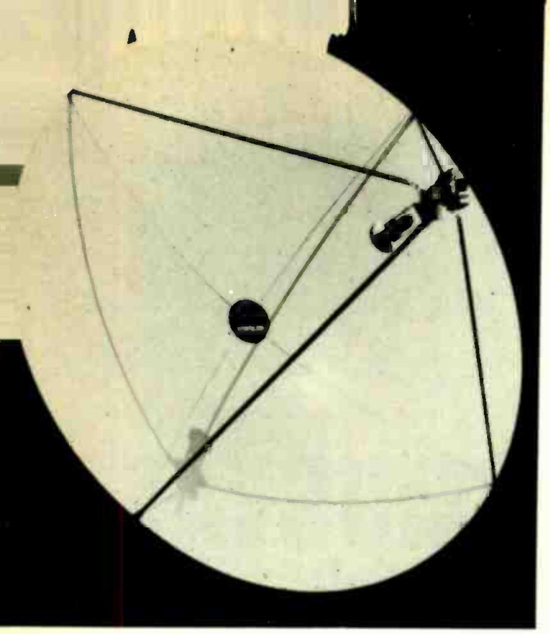
A better way

Fortunately, where there's a need, there's a way. Television signals relayed by satellite are frequency modulated and have a bandwidth of 36 MHz. FM was chosen as the means of transmission because it provides definite advantages in the ability to discriminate against noise. A television signal relayed by satellite is deviated plus and minus 18 MHz about the center frequency of the transponder.

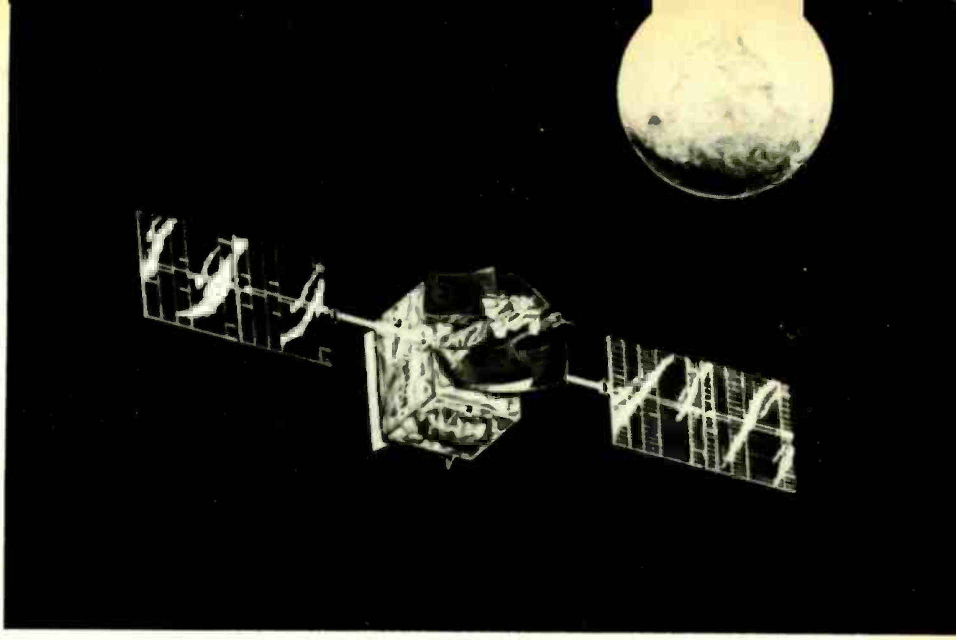
A characteristic of FM is that most of the signal-energy clusters very close to the center frequency, falling off rapidly as the band edge is approached. Because most of the signal appears at the center of the bandpass, the number of television transponders on a satellite can be doubled from 12 to 24 without an increase in the used spectrum. The 500-MHz band is divided into two sets of twelve 40-MHz transponders with the center frequency of one set offset from the other set by 20 MHz and the transponders of one set cross polarized from the other. (Refer to Table 2.) Cross polarization means that two sig-

TABLE 3—Orbit Assignments with New 2° Spacing

Position (degrees)	System	Frequency (GHz)	Position (degrees)	System	Frequency (GHz)
143°	Satcom V	6/4	99	SBS	14/12
141	Unassigned	6/4	98.5	Westar IV	6/4
139	Satcom IR	6/4	97	SBS	14/12
137	Unassigned	6/4	96	Telstar	6/4
134	Galaxy I	6/4	95	SBS	14/12
132	Rainbow	14/12	93.5	Galaxy III	6/4
131	Satcom IIIR	6/4	93	Unassigned	14/12
130	ABCI	14/12	91	Spacenet III	6/4 and 14/12
128	American Satellite	6/4 and 14/12	89	SBS	14/12
126	RCA	14/12	88.5	Telstar	6/4
125	Telstar/Comstar	6/4	87	RCA	14/12
124	SBS	14/12	86	Westar	6/4
122	Spacenet	6/4 and 14/12	85	USSSI	14/12
120	USSSI	14/12	83.5	Satcom IV	6/4
119.5	Westar V	6/4	83	ABCI	14/12
117.5	Canada	14/12	81	American Satellite	6/4 and 14/12
116.5	Mexico	6/4 and 14/12	79	Rainbow	14/12
113.5	Mexico	6/4 and 14/12	78.5	Westar	6/4
112.5	Canada	14/12	77	RCA	14/12
111.5	Canada	6/4	76	Telstar	6/4
110	Canada	14/12	75	Unassigned	14/12
108	Canada	6/4	74	Galaxy II	6/4
107.5	Canada	14/12	73	Unassigned	14/12
105	Gstar	14/12	72	Satcom	6/4
104.5	Canada	6/4	71	Unassigned	14/12
103	Gstar	14/12	69	Spacenet II	6/4 and 14/12
101	Unassigned	6/4 and 14/12	67	Satcom	6/4



DOWNLINK'S SKYVIEW IV parabolic antenna is made from lightweight, fiberglass sections that can be shipped anywhere.



SATELLITE SHAPES vary with succeeding designs. This RCA SATCOM III-R sports two large, solar, power-gathering panels.

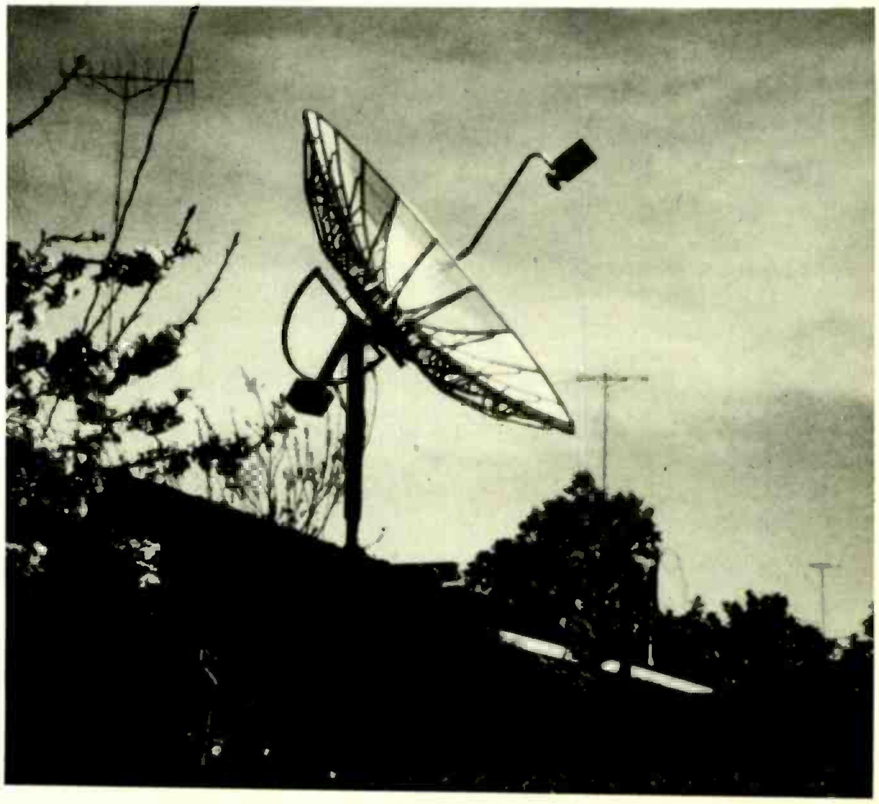
nals traveling in the same forward direction are transmitted at two different planes. Each plane is rotated 90 degrees from the other, like a plus (+) sign. For convenience of reference, the planes are described as having either horizontal or vertical polarization.

The receiver antenna is designed to accept signals only in the plane in which it is oriented and reject signals from the plane rotated 90 degrees. Although adjacent transponder pass bands now overlap by 16 MHz (because they are traveling displaced from each other by 90 degrees), and because most signal energy appears close to the transponder center frequency, sufficient difference exists in the signal levels delivered to the satellite receiver from adjacent numbered transponders. Satellite receivers are designed with very sharp bandpass filters, generally bout 30-MHz wide; that is, plus and minus 15 MHz of the transponder center frequency. Thus, most of the energy from adjacent transponders appears outside of the bandpass of the transponder the receiver is tuned to. That combintion of cross polarization and good bandpass control results in non-transponder interference.

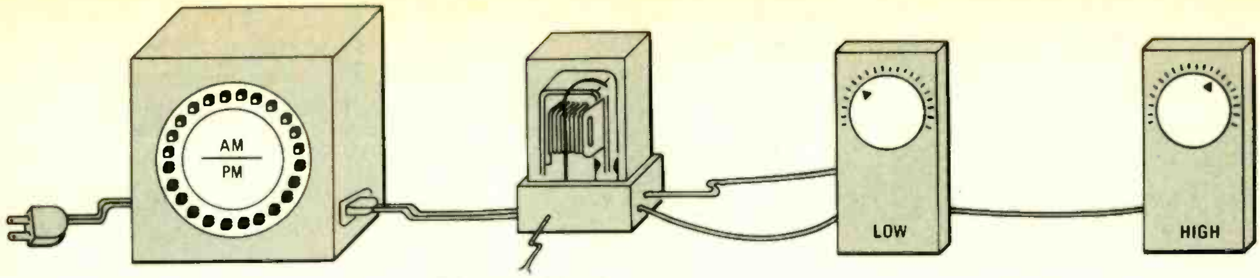
Polarization

Now, suppose we take the same idea and apply it to adjacently parked satellites. Theoretically, we could decrease the spacing between satellites by half if the center frequencies of all transponders operated in the same plane of polarization were alternated by 20 MHz. from one satellite to the next. To make it clearer, refer to Fig. 3, and consider only three satellites A, B, and C, located 2.5 degrees apart. Satellite B would operate all of its even-numbered transponders with horizontal polarization. Satellites A and C would operate their even number transponders with vertical polarization. An antenna aimed at satellite B adjusted for an even numbered, horizontally-polarized transponder might see some of the horizontally polarized, odd-frequency signals coming from satellites A and C. But, those unwanted signals would be displaced by 20-MHz on either side of the desired signal from satellite B and could be eliminated by good bandpass control in the satellite receiver. Signals of like polarity and frequency from satellites A and C are still separated by 5 degrees. Although 3-degree satellite spacing is not in effect at this time, and many engineers are skeptical of how well it will work, it has been proposed for future use. Table 3 shows a proposal of how the Clarke belt will be divided up under that closer-spacing plan.

Alas, tighter spacing of satellites will still not provide enough capacity for the anticipated needs of even the near future. Thus another communication-satellite band was created. That second band is located in the 12- to 14-GHz. region. Canada is the only North American country currently operating a satellite in the new band, but the United States and Mexico are readying their "birds" and they'll be flying soon. **R-E**



WITH NO OBSTRUCTION in its way, this satellite antenna installation pulls in a clear signal. Trees block signals, and falling limbs can totally destroy the dish.



PROGRAMMABLE THERMOSTAT

Two-level temperature regulator for your home saves thousands of BTUs a day, and 50 to 175 installation dollars if you do it our way!

NOEL BOUTIN

ONE EASY WAY TO SAVE ENERGY AND ALSO REDUCE heating bills is to lower the setting of the thermostat when nobody is at home, or when everybody is sleeping during the night. However, it is not very agreeable to put bare feet on a cool floor or to come back into an artic house. The solution to those problems is to use a thermostat that can be programmed to your own needs.

Here is a typical example. An hour before you get out of bed, your house temperature begins to rise to a comfortable one. You take your breakfast and leave the house for the day. Your house temperature begins to fall to your selected low temperature. A half or an hour before you come back home, the temperature begins to rise again to your selected comfortable one. When you go to bed, the same process occurs. You no more have to ask yourself if you really have lowered the temperature or not; it was done automatically.

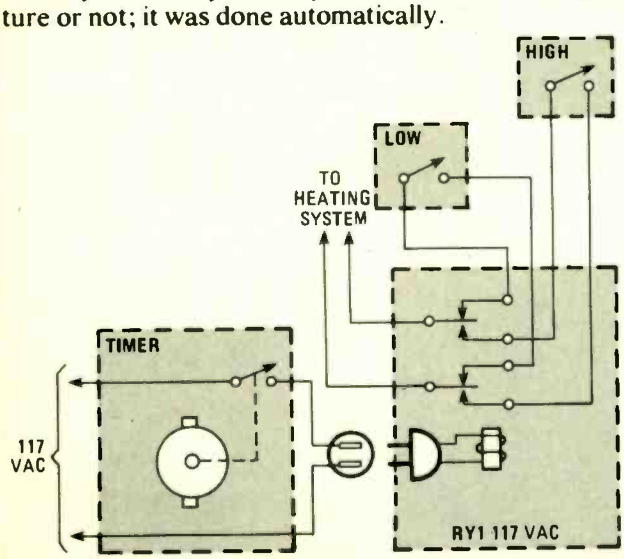


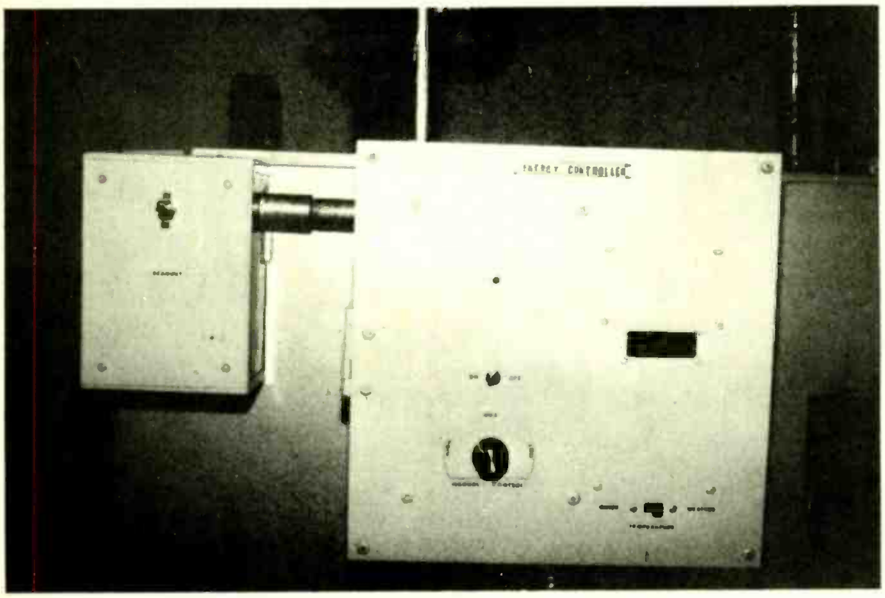
FIG. 1—HOW SIMPLE CAN IT BE? Old plus new thermostats, AC relay and 24-hour timer are all that you need to save bucks.

Of course, such programmable thermostats exist right now. However, they all have two points in common: They are expensive ($75 to $200) and they don't use your old thermostat.

The programmable thermostat proposed here can cost you less than $25 and uses your old thermostat. Furthermore, it is much more versatile than many commercial thermostats selling for three to five times that cost.

As illustrated in Fig. 1, the heart of this thermostat is a low-cost programmable timer normally used to turn appliances on and off. The more versatile the timer, the more versatile the end product will be. The Radio Shack 63-8061 is an example of a good one to use. That timer can switch a load on and off as often as 24 times a day. It can also be programmed for just one cycle or for a repetitive one. Here, the timer is used to turn on and off a DPDT relay. This relay must therefore have a 117V AC coil. A Radio Shack 275-217 is a good choice, but any surplus relay can do as well. The relay contacts select one of the two thermostats and connect it to the two-wire existing system. The required additional thermostat may be any general-purpose one having a SPST normally open contact, just like the one you are presently using. The contacts of the additional thermostat and those of the relay must have a current rating equal or greater than those of your present thermostat. A good choice for the additional thermostat would be the one used with an electrical baseboard-heating system. It is perhaps the lower cost one (about $5).

The programmable thermostat proposed here can replace any 24-volt two-wire thermostat controlling a central furnace system. By a proper choice of the relay and thermostats it can also be used for other systems. In summer, for example, it can be adapted for air-conditioning systems. R-E



ENERGY MISER FOR YOUR FURNACE

Cut fuel costs and increase the efficiency of your home heating system with this easy-to-build energy controller.

ROLAND GIBSON

EVEN IN THESE TIMES OF UNCERTAIN FUEL costs, there is one fact that you can be sure of—if less fuel is consumed, the cost of energy will be lowered. That is the purpose of this project—it is an energy "controller" designed to minimize the amount of oil used by a hot-water heating system.

Oil hot-water heating systems use an aquastat to control the system's water temperature. That aquastat has adjustable settings for hot-water temperature and circulator control. Before installing this controller, our fuel-oil supplier had recommended that the hot-water temperature be set at 180°F during the winter, and 160°F for the summer; the corresponding recommended circulator settings were 160°F and 140°F respectively. However, I did some tests and found that, except during periods of very cold weather, those settings were excessive and it should therefore be possible to reduce fuel-oil consumption if the circulator were set at 120°F and the water temperature were varied inversely with the outside temperature. From that idea grew the controller.

An energy controller

In the AUTOMATIC mode, the controller monitors the atmospheric temperature and compares that with the temperature of the water in the heating system's boiler. Based on that comparison, the circuit either turns on or turns off the boiler's burner, maintaining the water temperature at a level that is no higher than needed for heating.

In addition, in the MANUAL mode, provision has been made so that the water temperature can be set by hand and then maintained at any level between 100°F. That is intended for use during periods when heat is not required.

The circuit design is relatively simple, supplementing but not eliminating any of the oil-burner's control circuit. When the controller is switched OFF, oil-burner operation returns to normal.

The controller has a "fail-safe" design. But that we mean that if it fails during an "on" cycle, the oil burner will operate using the preset oil-burner controls. If a failure occurs during the "off" cycle, the burner will shut off and stay off until the controller switch is placed in the OFF position, returning the burner operation to the preset burner controls.

The components used in this project are readily available. Construction is straightforward and any technique can be used. A PC board can be used if desired, and will certainly make things a bit neater, but it is not *required*—none was used in building the prototype described here.

How it works

The controller's schematic is shown in Fig. 1. The power supply for the circuit is shown in Fig. 2-a; the power supply for the temperature readout is shown in Fig. 2-b. The two temperature sensors, IC5 and IC6, are AD590's from Analog Devices. They have an output of 1 microamp-per-degree Kelvin. Accuracy is 0.5°.

As most oil-burner controls in the U.S. are calibrated in degrees Fahrenheit, for convenience it would be desirable to scale the sensor output to those units; 10 millivolts-per-degree Fahrenheit was the output we chose. Let's see how that scaling is done. To keep things simple, we'll only discuss the scaling for the water-temperature sensor, IC6; the procedure, and values used, are identical for the air-temperature sensor, IC5. To convert from Kelvin to Fahrenheit, the following equation is used:

$$\text{Temp (in °F)} = \text{Temp (in °K)} - 459.67$$

Remembering that we are scaling the output to 10 millivolts-per-degree Fahrenheit, the total resistance of R1 and R2 becomes:

$$1.8 \times \frac{10^{-2}}{10^{-6}} = 18000 \text{ ohms}$$

To create that resistance, a 16K resistor and a 5K pot are connected in series; the pot is used to trim the total resistance until it is the precise value needed. When that is done, the voltage drop across R1 and R2 will be equal to 10-millivolts-per-degree-Fahrenheit, plus 4.5967 volts. To complete

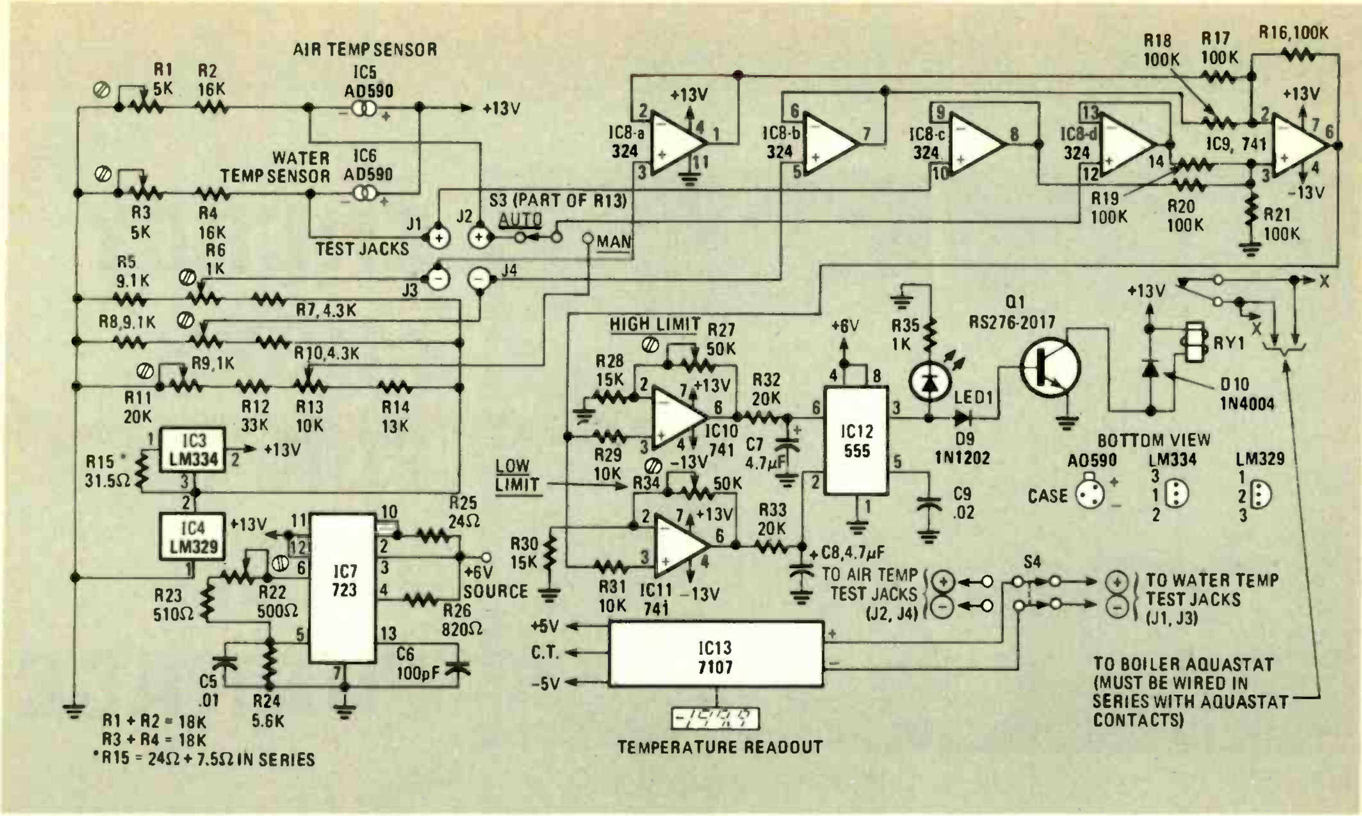


FIG. 1—SCHEMATIC DIAGRAM of the energy controller. Relay RY1's contacts must be wired in series with the oil burner aquastat's contacts.

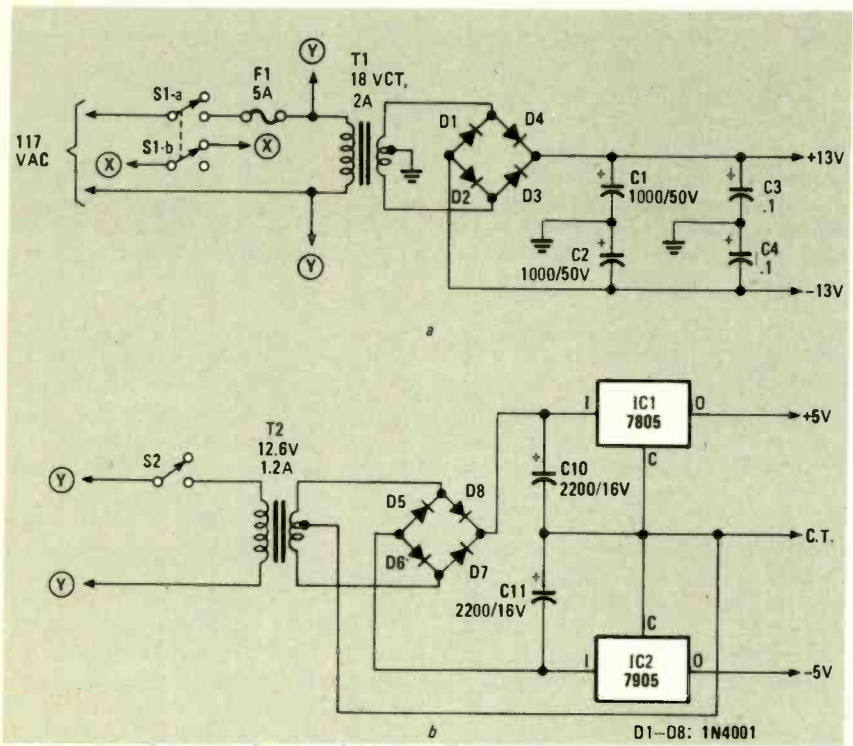


FIG. 2—POWER SUPPLY for the energy controller is shown in *a*; the power supply for the readout is shown in *b*.

that conversion, a 4.6-volt reference voltage is needed. That is done by generating a precise 6.9 volts using the combination of IC3, an LM334 constant-current source; IC4, an LM329 6.9-volt voltage reference, and R15. That voltage is then placed across a voltage divider network consisting of R8, R9, and R10. Trimpot R9 is used to balance the divider, and the 4.6 volts is taken from its wiper.

In the manual mode, a resistor network, R11-R14, is used in place of the air-temperature sensor. With the values shown, R11 is adjusted so that the voltage at the junction of R12 and R13 is 4.6 volts. The output, taken from the wiper of R13, can be adjusted so that is simulates an air-temperature of between 0°F and 100°F.

The outputs from the temperature sensors and reference voltages are buffered by IC8-a–IC8-d, a 324 quad op-amp. The op-amp outputs are connected to IC9, a 741 op-amp. That IC adds the two 4.60-volt reference voltages and subtracts them from the sum of the two temperature-sensor output voltages. The output of IC9 equals the sum of 10 millivolts-per-°F of outside temperature plus 10 millivolts-per-°F of water temp.

The controller's operation is a function of the sum of the air temperature and the water temperature. Take a look at Fig. 3. You'll note that irrespective of whether water-temperature scale A or B is used, the sum of the air and water temperatures is the same. That is, using scale A, at an air temperature of 0°F, the water temperature is 180°F, for a total of 180°F; at an air temperature of 30°F, the water temperature is 150°F, for a total of 180°F, and so on. That works the same way for scale B, and would for any other scale, as long as that relationship was maintained.

To conserve fuel, we want to turn off the boiler's oil burner when the combined sensor readings equal that critical value. When that is done, the higher the air temperature, the lower the water temperature maintained by the boiler. For the rest of this discussion, let's assume that we've chosen 180°F for that value. Remembering our scaling factor of 10 millivolts per degree Fahrenheit, we are going to want to open the relay when IC9's output reaches 1.8 volts. That output is connected to IC10 and IC11, two additional 741 op-amps; those IC's are used here

continued on page 129

CAR TELEPHONES
Cellular Technology Promises More Channels

DANNY GOODMAN

Long waiting lists for phones and a lack of channels have limited the usefulness of the mobile-telephone system. A sophisticated new system is about to change all of that.

AN EXECUTIVE HEADS FOR HIS CAR parked in a downtown Chicago office-building garage, hoping to make it home to suburban Lake Forest in time to entertain dinner guests. Weighing heavily on his mind are sensitive negotiations taking place in California with which he must be in constant touch during his drive up the expressway.

Still in the garage, he dials the number of his Los Angeles contact on the pushbutton mobile phone, just as he would from his office upstairs. In a couple of seconds the phone in L.A. is ringing, and our busy executive starts his drive. During his hour-long mobile conversation, neither he nor his associate will notice that their full-duplex communications channel will have shifted frequency three times, with the mobile call going through three separate base-station sites.

The entire process is channelled through one of the most sophisticated land-based communications systems available to the general public, cellular mobile telephone. A cellular mobile-telephone system divides a metropolitan area into a mosaic of small cells, each with its own low-power transceiver, so that the same channel can be used for different conversations in non-adjacent cells. The result is more available channels for mobile-phone customers. To accomplish that, cellular telephone uses a remarkable system of computer-controlled radios that "hand off" a mobile call from one cell to the next as a vehicle travels across town. The hand-off is done so smoothly that the caller will probably not even notice it.

In a conventional mobile-telephone setup, with a high-power base transmitter covering an entire metropolitan area, our executive would have just a 50% chance of getting an open channel at some time during his hour drive. If he did manage to get on the air, he would be occupying one of the 23 valuable channels in the Chicago area. (There are only 12 such channels in New York City!) But with the cellular system, there is a 99% chance that his call would go through on the first try. And, as he moves from one cell to another, our friend's telephone call shifts to a different channel on that other cell's transmitter/receiver, and the original channel opens up for another caller.

Additionally, the cellular system makes portable telephones feasible.

This is not a science fiction dream, but a real system proven in two trials in congested areas: Chicago, sponsored by an AT&T subsidiary called AMPS (*A*dvanced *M*obile *P*hone *S*ervice), and Washington, D.C./Baltimore, sponsored by Motorola and operated by American Radio-Telephone Service Incorporated. Because of the success of those tests last year, the FCC, in a preliminary action, allocated two 20-MHz segments of the 800-MHz band for cellular-telephone communications. If final approval is granted (a decision was expected just after this issue went to press early last December), within two years the first fully operational systems could be in place; the system should be available in 70 cities within 5 or 6 years. When that happens, a cellular network will allow so many more people to have mobile phones in their automobiles and trucks, that the usual waiting list for those phones will all but disappear.

FIG. 1—CELL-SITE BUILDING is dwarfed by the 150-foot antenna tower. The two antennas below the platform are used for reception; the antenna above the platform is used for transmission.

Basic cell systems

A cellular mobile phone system consists of a deceptively simple network of remote duplex transceivers. Cells are connected by landlines (telephone lines) to a central MTSO (*M*obile *T*elecommunications *S*witching *O*ffice). It is at the MTSO that mobile calls are automatically patched into the regular telephone network, without the need for mobile operators.

A typical cell site, like AMPS' Lyons, Illinois site, is little more than a small building (about 20 feet by 20 feet at Lyons) to house the equipment racks, and a 150-foot tower for the antenna system (see Fig. 1). In more urban areas, cell sites can be located on building roofs.

The base station's receiving antennas are two vertical monopoles set up in a diversity reception mode. Two antennas are used in diversity reception so that a moving vehicle can maintain contact with the base station at all times. In that mode, the base-station's receiver is able to choose between the stronger of the two signals coming from the antennas; if a car is temporarily shielded from one antenna, the receiver simply switches over to the other.

The base station's transmit antenna, which is also a vertical monopole, is capable of handling up to eight transmissions on different frequencies at once. Since line losses at 800 MHz can be incredibly high with conventional cables, all antennas are fed with Heliax gas-filled coaxial cables that are maintained at a constant pressure.

Equipment in the small building is completely automated. One typical site that we visited recently with an AMPS official had two racks of transceivers, each rack with eight channels in operation (see Fig. 2). Small fans on the 45-watt air-cooled amplifiers hummed quietly. Each cell site performs repeated self-testing of its equipment and reports irregularities to a central AMPS office. Only then is a service technician dispatched to a site. In addition, an outside transmitter tests the voice quality of each channel throughout the system by sending a 1-kHz tone and comparing the signal coming through the radios and phone lines to the original. That, too, is automatic, with a central printer logging the results of each test at approximately one-minute intervals.

In the event of power failures at the site, a wet-battery back-up power supply can operate the communications gear for about eight hours. Part of that back-up is also a power inverter to keep the automatic test gear in operation.

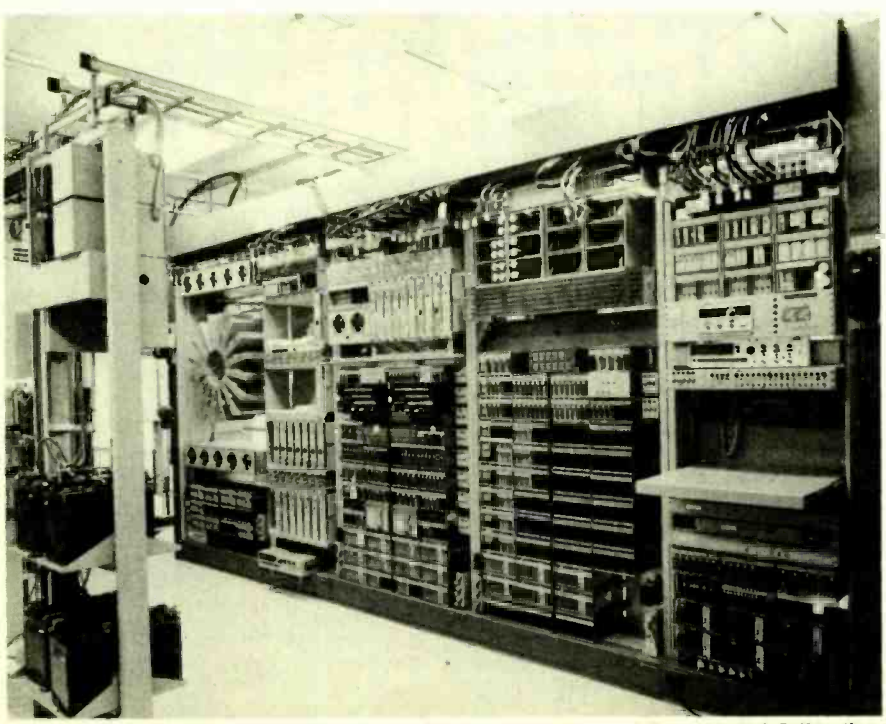


FIG. 2—RACK-MOUNTED TRANSCEIVERS and logic components are totally automated. Self-testing is done by the equipment on the right and the battery back-up system in the foreground is provided in case of a power failure.

Mobile installations

Vehicle installations are quite simple affairs. A one-piece trunk-mounted unit is a combination 800-MHz duplex FM-transceiver and sophisticated logic unit. Installation in most vehicles takes about 4½ to 5 hours, including complete testing. The vehicle's phone number is entered into the radio by way of a PROM chip that is programmed at the installation site. Because of the 45-MHz separation between the transmit and receive frequencies, cellular mobile phones use two 2.5-dB gain antennas at the car; one each for transmit and receive. The antennas are precisely tuned for the proper segment and can be either roof or trunk-lid mounted; roof-mounted antennas are ⅝ wavelength, while the longer trunk-lid antennas are ½ wavelength center-fed verticals.

Control heads vary somewhat with manufacturer. In the Chicago test, for example, mobile equipment was supplied by Motorola, Oki, and E.F. Johnson. Some heads have a *Touch-Tone* pad and resemble a standard desk phone (see Fig. 3). The deluxe model has a pushbutton pad and digital display built into the modern-looking angular handset.

Costs for cellular phone privileges have not been set, but the rates used in the Chicago test will give you an idea of how much is involved. Mobile equipment is leased for $45-60 per month, depending on control-head style and options. For air time, there is a basic charge of $25 per month, which includes 120 minutes of air time. Additional minutes are 25 cents each.

The Chicago test divided the 2100-square-mile metropolitan area into ten cells as shown in Fig. 4. While the downtown cell had the smallest geographical area, it also had the highest number of voice channels (26). Mobile units used 10-watt transmitters, but when the operational system is permanently set up, there will be more and smaller cells, allowing the mobile units to communicate comfortably using 3 watts. In the test, cells at opposite ends of the city used the same nine channels.

Growing cells

Cell sites are assigned a number of channels, based on the projected number of calls within that cell. More congested sites, such as the central business district of a major city, will have perhaps three or more times as many channels as an outlying cell. Because the base transmitters run at a low power-level of about 40 watts, the signal does not cover the entire metropolitan area—channels can be used by several cells as long as those cells are far enough apart. Motorola uses a four-cell cluster, while AT&T perfers a seven-cell cluster before reusing a channel.

Moreover, as the number of users increases within a cell, or throughout the system, cells can be subdivided into smaller cells with lower-power transmitters and directional antennas allowing channels to be used even more times within the system. Theoretically, a cell can be as small as one mile in diameter. With the number of channels currently allocated to cellular telephones, a large city with 500 one-mile cells could serve a quarter of a million users!

Typically, a cell will go through three stages to accommodate greater traffic. In the first stage, a transceiver and omnidirectional antenna are centrally located within a cell. The second, or transitional stage, establishes additional cell sites, with directional antennas for some of the channels. The new cell sites will service a more localized area with a lower-power transmitter. More channels are switched over to the new cells until the original cell becomes a final-stage cellular system, consisting of a complete network of directional, low-power cell sites. In practice, the growing system will always be in a transition stage because service needs in any area will always be changing. And since the mobile units are capable of switching to any channel, as instructed by the MTSO, the user will be unaware of any of the changes in cell locations and frequencies.

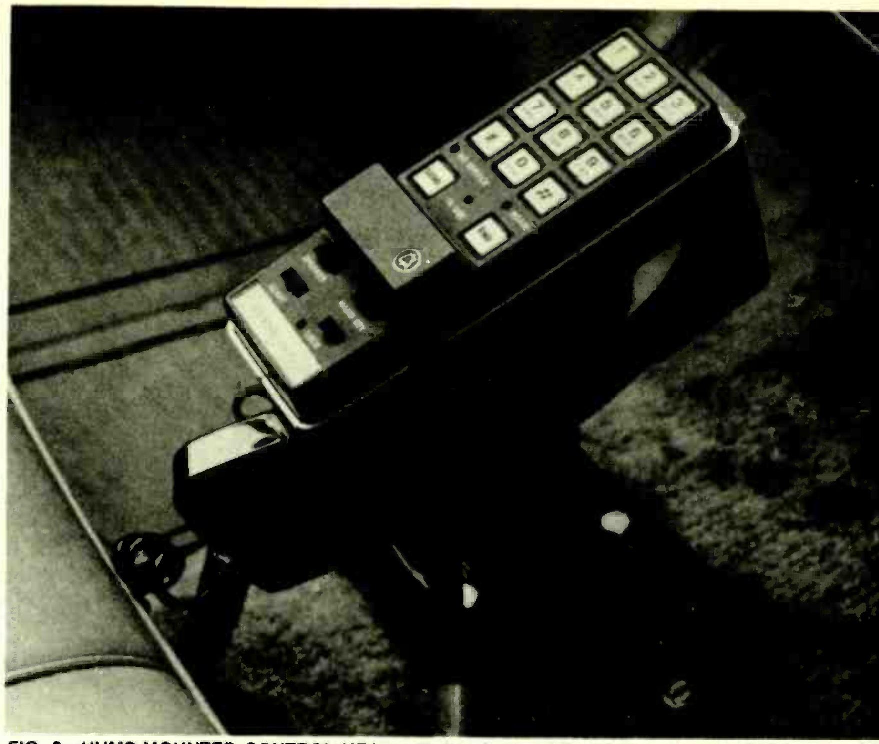


FIG. 3—HUMP-MOUNTED CONTROL HEAD with handset and *Touch-Tone* keypad. A deluxe model (not shown here) also has a readout of the last number dialed.

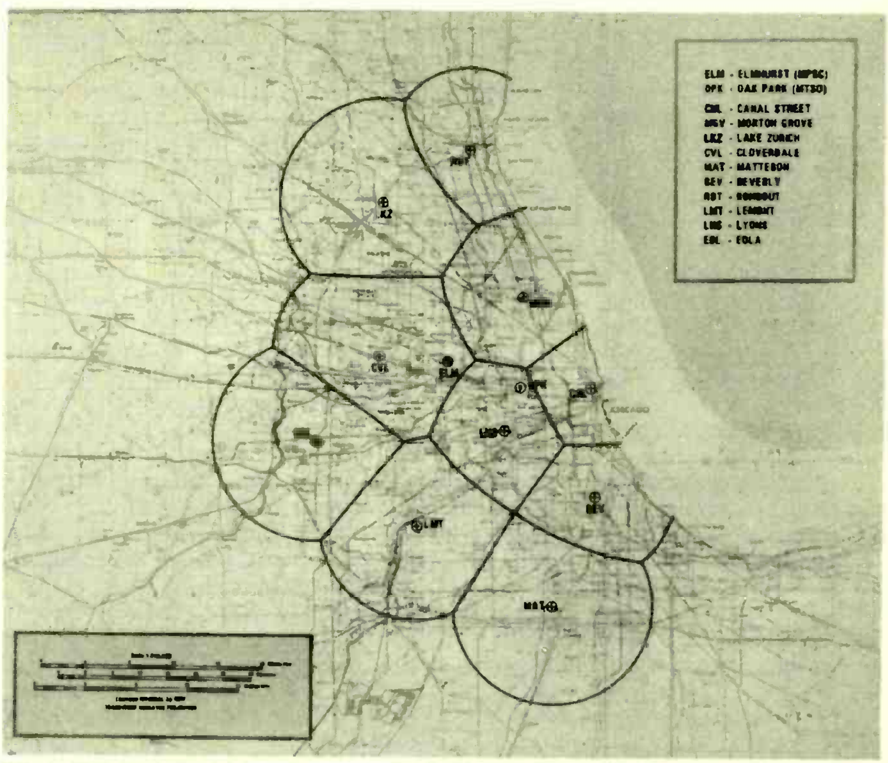


FIG. 4—THE CHICAGO TEST of the cellular mobile phone system divided the metropolitan area into 10 cells. Future networks will have smaller cells and use lower-power equipment.

How cellular phones work

The secret to the cellular system lies in two-way digital-data communications between car-and-cell, and cell-and-MTSO, plus one central computer at the MTSO keeping everything under control.

Perhaps the best way to describe all the intricacies of the system is to follow a couple of telephone conversations from start to finish, with a cell hand-off added for good measure. This example is based on calls through the Chicago developmental system, operated since 1978 by Bell Laboratories and Illinois Bell Telephone, and used by about 2000 willing customers from a cross-section of professions and businesses.

You get in your car and turn on the engine as you always do. Then you switch on your deluxe telephone-control head mounted on the transmission hump. Using the *Touch-Tone* buttons, you key in your own three-digit security code that makes sure you're the only one making calls from your mobile phone. Nothing is coming through the speaker, but the logic unit of the trunk-mounted transceiver scans through the control channels of all cell sites in your metro area and determines by Cell A's set-up channel's signal strength tht you are in Cell A. The set-up channel is a data-only frequency pair, and is a critical link in cellular telephone. Your radio is then kept on Cell A's set-up channel as long as the data signal there stays strong enough. At the cell site, there is a back-up setup channel transceiver if one should fail. The setup process takes less than a second.

As you drive along, you want to call your friend to see if he needs your help with a personal-computer problem he's been having. Without picking up the headset, you enter his telephone number on the *Touch-Tone* pad. An audible "beep" comes from the head's built-in speaker when each button is pushed, and the number appears in a display by the buttons. A quick glance at the display confirms you have properly entered the number, so you press the SEND button.

The following sequence takes place about as quickly as if you were calling your next door neighbor from your kitchen: The mobile logic unit sends out a data burst on the setup channel that identifies your radio, sends the number you're calling, and alerts Cell A that you have an outgoing call. Cell A's receiver passes the information over a landline to the central MTSO, where the Western Electric computer assigns an unused voice channel for the call. That frequency is passed back through Cell A to the mobile radio. The mobile transceiver obeys, and shifts frequency to the specified channel. When the MTSO senses the mobile unit's signal on that channel (the information is again relayed via Cell A's receivers), it places the call over the landline phone system.

The next sound you hear over the console speaker will be the ringing of your friend's phone. If the called number is busy, no problem. You will hear a busy signal, as you would expect. Simly press END. which alerts the MTSO to "hang up." Your channel opens immediately for other callers, as your radio shifts back to silently monitor the setup channel. Since that last number you dialed is still shown by the display, pressing SEND will automatically re-dial the call. The same instantaneous data exchange and frequency shift, though perhaps on a different channel, will take place.

Well, this time your friend answers the phone, and you become engaged in a long conversation. Unknown to you or him, your car is about to go from Cell A to Cell B. Here's what happens at a hand-off: The MTSO computer is busy monitoring the signal strength of every mobile signal coming through every cell site. It "sees" that your signal is starting to fall off from Cell A (though you don't realize it on your end) and it must find an open channel for you in Cell B. Since channels are not shared by adjacent cell sites, your hand-off involved a shift in both transmit and receive frequencies in addition to a change in cell sites.

The computer spots an open channel for you in Cell B. When your signal drops to a specified level, the MTSO sends a data burst (at a data rate of 10 megabytes-per-second) to your radio's logic unit via Cell A. In that one-quarter second, the audio is interrupted as the radio gets its instructions to shift channels—which it does without your even suspecting that brief "blank and burst" sequence.

When you hang up the handset, your radio goes back to the setup channel—but a different set-up channel, because you are now in Cell B. As you continue your drive, you decide that a quick call home may save you from having to go out later for milk. So you press a two-digit memory code to speed dial your home phone number, one of several frequently called numbers you previously stored. You find out that you are to pick up your children at a softball game on the way home.

At the field you find that the game is just about over, so you decide to park the car nearby and watch the last inning. Meanwhile, your wife finds that she does need milk, and wants to let you know before you get home. She dials your mobile phone number—a regular seven-digit number assigned to your telephone through an exchange located at a conventional (landline) telephone switching office.

The call is automatically sent to the central MTSO, whose job is to find you. It sends your identity code through every cell site in the service area on every set-up channel. Your radio, which you purposely left on, is constantly listening to the setup channel. When it hears your number, it tells Cell B via the setup channel that you are in Cell B. The MTSO then assigns a voice channel in Cell B for your wife's call. Your radio shifts to that channel, and your phone rings. Fortunately, you select the option that honks your horn when the phone rings.

As in that example, business users in the AMPS Chicago test found that the system saved them time and gas. A survey found that 84% of them were "very satisfied" with the service provided by the cellular telephone system.

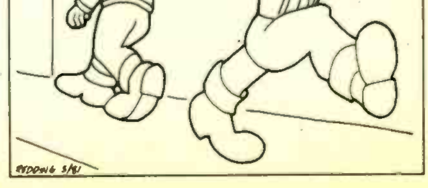
Our test

To test for ourselves the voice quality of the AMPS system, we took a ride in a car with a specially equipped mobile telephone. In addition to the telephone control head, that unit had a little box under the dash called a System Access Monitor, which gives a readout of the channel currently being used and has a signal-strength meter.

Local and long distance calls were as easy to make as if from a desk. Audio quality of the mobile phone was equal to any land-line, except when going through very low-elevation tunnels and extended viaducts. Even then, a couple of static crackles at the mobile end were at a very low level—perhaps inaudible to someone who did not know what he was listening for. None of those we called suspected we were talking on a mobile phone until we let them in on the secret. Communication was consistently flutter-free, even when the System Access Monitor meter showed that there were extreme changes in signal level.

The next test was to force a hand-off to an adjacent cell to detect the blank-and-burst used to shift frequencies. As the channel readout changed on the System Access Monitor, we heard a slight electronic "click," and that was all. Again, we were listening for it with a tuned ear; otherwise we would have missed it. And since normal installations don't have the Monitor readout or meter, you would never know when to expect a hand-off—or when one had occurred.

As the demand for mobile communications increases, especially with the growth of microwave digital telecommunications, a system is needed that will make every megahertz count. Cellular mobile telephone is such a system, and it will soon provide many of us with high-technology, reliable, two-way voice communications that will be just as convenient as dialing your home or office telephone. **R-E**



DIGITAL AUDIO DISC

So far, digital-audio recording technology has confined itself to tape. Now, digital discs are about to make their debut.

LEN FELDMAN
CONTRIBUTING EDITOR

THE SPRING OF 1982 WILL PROBABLY GO down in history as the time when a major revolution in the science of sound recording took place. During April and May of that year, Holland's Philips Company and Japan's Sony Corporation, in jointly held presentations in Europe and the United States, anounced their plans for the introduction of what has come to be known as the compact digital audio disc, or C-DAD.

If the companies meet their production target-dates, Japanese and European music lovers should be able to purchase a new kind of disc player in late 1982, while U.S. audio enthusiasts will have to wait a bit longer—until the beginning of 1983. From all indications, the long wait will be worthwhile, for the new digital C-DAD disc (sometimes acronyms become part of the language long before the item they represent is available) offers a level of performance that has been impossible to obtain with conventional analog records, no matter how carefully they were recorded and processed.

C-DAD format

The new Philips-Sony C-DAD disc is shown alongside a conventional LP record in Fig. 1. It is capable of playing one hour of stereophonic music *per side*, and can also hold up to four channels of audio on a side with reduced playing time.

Information on the C-DAD disc consists of approximately six *billion* digital "bits," which are linearly encoded along a helical track of pits and flats. The tiny pits are about 0.6 microns in width and 0.2 microns deep. The pits and flats represent the "ones" and "zeros" in the digital code used to store the signals. A solid-state laser beam is used to sense the sequence of pits and flats using a spot of light with a diameter several times smaller than that of a human hair. As shown in Fig. 2, the laser beam reads the presence or absence of the pits contained in the disc's surface beneath a protective plastic coating. The scanning rate is approximately 4.3 million bits per second. Variations in the reflected light rays are then converted into digital code and finally, through D/A conversion, back into a continuous audio waveform.

Since there is no physical contact between the pickup and the surface of the disc, the pickup must be guided by a dynamic-tracking servo system. The lack of physical contact also means that record wear is totally eliminated.

FIG. 1—THE 4.7-INCH DIAMETER C-DAD disc contains one hour of music on a side compared to a little over 20 minutes for a conventional 12-inch LP.

Unlike the turntables used to play today's analog records, the rotating platter that spins the C-DAD disc has a variable rotational speed—200 rpm when the laser is at the circumference of the disc and around 500 rpm when it is 50 millimeters from the center, the inner radial limit. Scanning takes place from *inside* to *outside* and rotation is *counterclockwise*. The total storage capacity of the C-DAD disc is over 8 billion bits per side—far more than is necessary for the 60 minutes of playing time that has been standardized for the disc. That provides a great many additional possibilities for designing C-DAD players. Both the Philips and Sony prototype players that were shown last spring (see Fig. 3) were able to "read out" such additional useful information as the number of the selection being heard, its length, the sequence of numbers programmed to be heard, etc. Owners of C-DAD disc players will be able to make use of sophisticated programming circuitry, enabling them to determine which songs they want to hear and in what sequence they want to hear them.

Audio quality and performance

The frequency response of the system is absolutely flat from 20 Hz to 20,000 Hz. The digital sampling-frequency is 44.1 kHz, which would theoretically give a response up to 22.05 kHz. Some margin, though, is left for high frequency cut-off

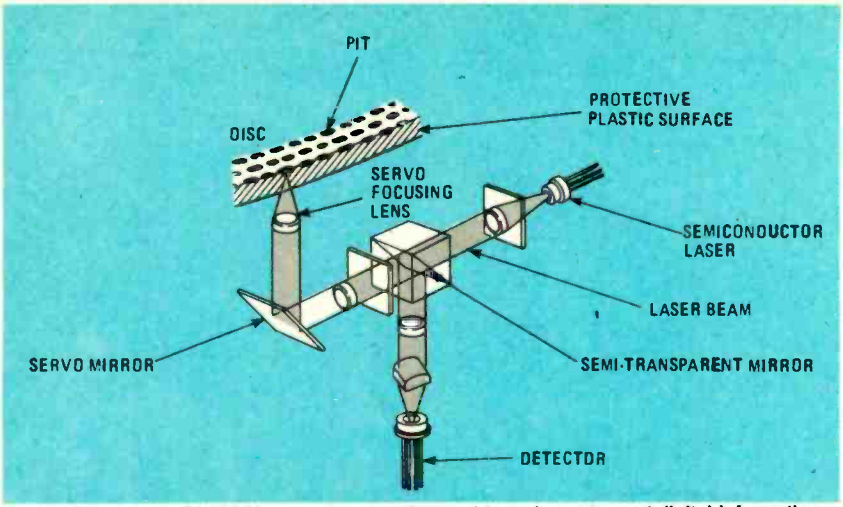


FIG. 2—THE C-DAD SYSTEM uses a tightly focused laser beam to read digital information represented by a series of pits on the disc.

TABLE 1

Specification	C-DAD disc	LP record
Frequency response	20-20,000 Hz	30-20,000 Hz
S/N ratio	More than 90 dB	More than 60 dB
Dynamic range	More than 90 dB	Max. 55 dB (1 kHz)
Channel separation	More than 90 dB	25-35 dB
High-frequency distortion rate	Less than 0.05%	0.2%
Wow & flutter	0%	0.03% (WRMS)
Playing time	60 Minutes	30 Minutes
Disc diameter	4.7 inches	12 inches

filtering.

The signal-to-noise ratio for the 16-bit digitizing format is better than 90 dB (theoretically, it could be as high as 97.5 dB); dynamic range—the difference in level between softest and loudest sounds that can be handled—is also better than 90 dB. Channel separation is 90 dB as well, while total harmonic distortion, referred to peak levels, is 0.05% or less (0.03%, theoretical).

As with any true digital-sound system there is no measurable rumble or wow-and-flutter. Tracking, decoding, and rotational speeds are synchronized by a central clock generator inside the player and the clock is itself governed by information encoded in the track on the disc. Since the digital data representing the music is stored briefly in semiconductor memory in the player before being clocked out at a steady rate to the digital-to-analog converter, there can be no wow or flutter in the conventional sense.

There is also no audible intermodulation-distortion of the type that plagues conventional analog recordings to such a large degree. To fully appreciate the significance of these performance levels, see Table 1, which compares the C-DAD system with conventional LP records.

Competing digital-disc systems

Of the many digital-audio disc systems that have surfaced over the last several years, two besides the C-DAD system have been successfully demonstrated and been under consideration by a 51-member Digital-Audio Disc Council. That group deliberated about standardization for about three years (and has only recently been disbanded) in Japan. The two other systems are:

1. A capacitance-pickup system, developed by JVC as an adjunct to its VHD videodisc system which is to be marketed in early 1982 and which has been given the name AHD (*Au*dio *H*igh *D*ensity).
2. A mechanical "groove-type" system developed by Telefunken.

Discs for the variable-capacitance system (AHD) are made of conductive materials. As shown in Fig. 4, digital signals in the form of tiny pits are engraved in these discs. As a miniature metal electrode follows the pits, signals, represented by changes in electrostatic capacitance, are detected. To maintain the necessary accuracy, the pits are engraved on the surface of the disc along with pilot signals impressed on either side of the audio signal pits. Since there are no physical grooves impressed into its surface, the pilot signals are used as part of a dynamic-tracking servo system to keep the electrode stylus properly positioned along the signal track of the AHD audio disc.

In the mechanical system developed by Telefunken, playback is accomplished in a manner similar to that used by ordinary analog players (see Fig. 5). That is, signals cut into the grooves of the disc are first converted into mechanical vibrations as the stylus traces them and the vibrations are then transmitted through a pick-up arm to a piezoelectric converter, where they are changed into electrical signals.

Table 2 offers a comparison of these two systems and the Sony-Philips C-DAD one. Of the three, only the Sony-Philips and the JVC systems seem likely to reach the marketplace in the near future. JVC's argument in favor of its system is based largely upon the fact that a single player would be able to handle both its videodiscs (the VHD discs that are to be marketed in 1982) and the AHD digital-audio discs, since both use a capacitance-pickup principle. Of course, a digital-to-analog converter/rpocessor would have to be added to the JVC system for decoding the digital-audio discs; the addition of such a D/A converter/processor would make the lower-cost argument somewhat questionable.

The JVC AHD disc, like its companion

FIG. 3—C-DAD PLAYER prototypes shown in 1981. Sony's is at left/ Philips' at right.

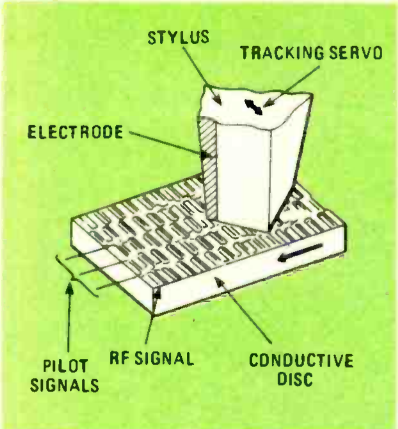


FIG. 4—**JVC's AHD digital-audio disc system works on the same principles as its VHD video-disc system.**

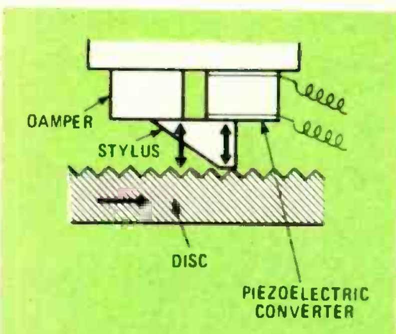


FIG. 5—THE MECHANICAL SYSTEM developed by Telefunken for digital discs is similar to that used for today's analog records.

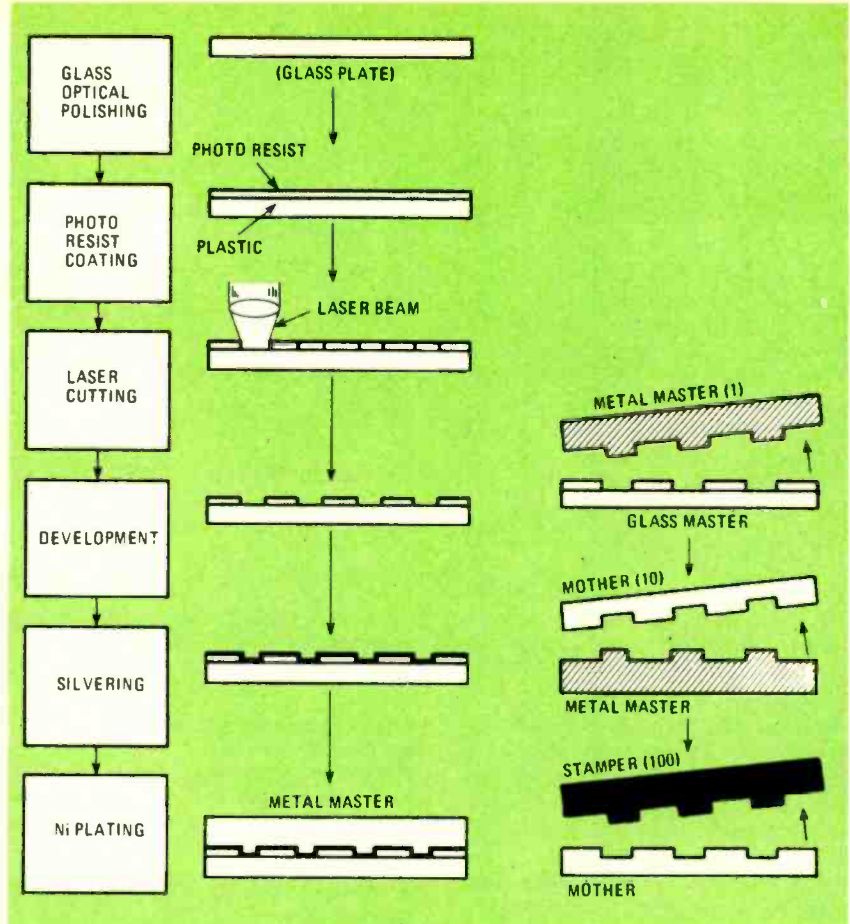


FIG. 6—STAGES INVOLVED in the manufacture of C-DAD discs. Numbers in parentheses at right indicate how many of each piece are produced.

TABLE 2

Characteristics	**Sony-Philips**	**JVC**	**Telefunken**
Signal-pickup method	Optical	Capacitance	Mechanical
Pickup	Non-contacting	Contacting	Contacting
Signal location	Beneath surface	On surface	On surface
Grooves	No	No	Yes
Surface material	Transparent plastic	Carbon-impregnated vinyl	Various
Disc caddy (holder)	Not required	Required	Required
Disc size	120 mm	260 mm	135 mm 70 mm
Playing time	60 mintues (2 channels)	60 minutes (4 channels)	60 minutes (2 channels) 30 minutes (2 channels)
Format	16-bit	16-bit	14-bit

VHD disc, is a little over 10 inches in diameter and comes supplied in a "caddy" or holder that protects the disc surface when it is not being played. The smaller, optically-tracked, C-DAD disc requires no such protective sleeve, of course, and is in no way affected by dirt or dust on its surface sine the focal point of the laser beam is beneath the transparent surface of the disc. An important point that has been emphasized many times by Sony and Philips is that the small C-DAD disc and its correspondingly smaller player can easily be adapted for use in cars and other moving vehicles, since the vibration of a vehicle should have little or no effect upon laser tracking.

The trend towards C-DAD

There seems to be a growing trend toward endorsement of the C-DAD system by equipment manufacturers and "software" (recorded material) producers around the world. Matsushita Electric Company (whose line of brands includes Panasonic, Quasar, Technics and National), although committed to the JVC VHD system for videodiscs, has nevertheless indicated that it will produce disc players for the Sony-Philips system. Recently, the worldwide Polygram Group, one of the leading international record manufacturers, and CBS/Sony, Inc., the largest record company in Japan, announced plans to produce music programs in the C-DAD format. In 1982, for example, CBS/Sony will release more than 100 C-DAD albums in Japan simultaneously with the introduction of the C-DAD players. On the hardware side, companies such as Marantz have already demonstrated their own versions of players which are compatible with the Sony-Philips optical-laser disc system. And, while the 51-member Digital Audio Coucil mentioned earlier did not specifically endorse the C-DAD system, its final report noted its compact size and its applicability to mobile use, which many interpreted as being just about as close to an endorsement as such a committee would ever be likely to come.

How C-DAD discs are made

Once you get past the hurdle of paying for a C-DAD optical-laser player (about the price of a high-end turntable), the software or discs themselves should be no more expensive, on a "per-minute-of-music" basis, then high-quality LP records. The process of making digital discs is quite different from the process currently used to make analog LP records, but once it has been mastered, it should be possible to turn out the new discs on a mass-production basis that will reduce disc prices drastically.

Mechanical cutting-techniques are impractical for digital-disc production because the pits to be carved are far too small. Instead, the process shown in Fig. 6 is used. First, a glass plate coated with photo-resist material is exposed to a digitally-modulated laser beam. The plate is then developed to form pits corresponding to the presence or absence of digital signals. After a silvering process, that glass plate becomes the "master."

It is next pressed against a nickle plate to make an inverse copy (the pits become small bumps and the flats become depressions) of the photo-etched depressions on that plate. A digital master is thus produced which, in turn, is used as the "mother" for making production "stampers." Each stage inverts the surface of the disc (pits-bumps-pits-bumps, etc.). The stampers have bumps.

The final production stages are shown in Fig. 7. Using the stamper, C-DAD discs are produced in large quantities in much the same manner as conventional analog records. The signal-bearing surface of each disc is then coated with a reflectivve material, followed by a coating of protective, transparent plastic. Aside from any labelling and packaging that may be required, that completes the manufacture of a single-sided disc.

For a two-sided disc, an additional process to combine two single-sided discs would be required, but it is entirely possible to produce such two-sided discs.

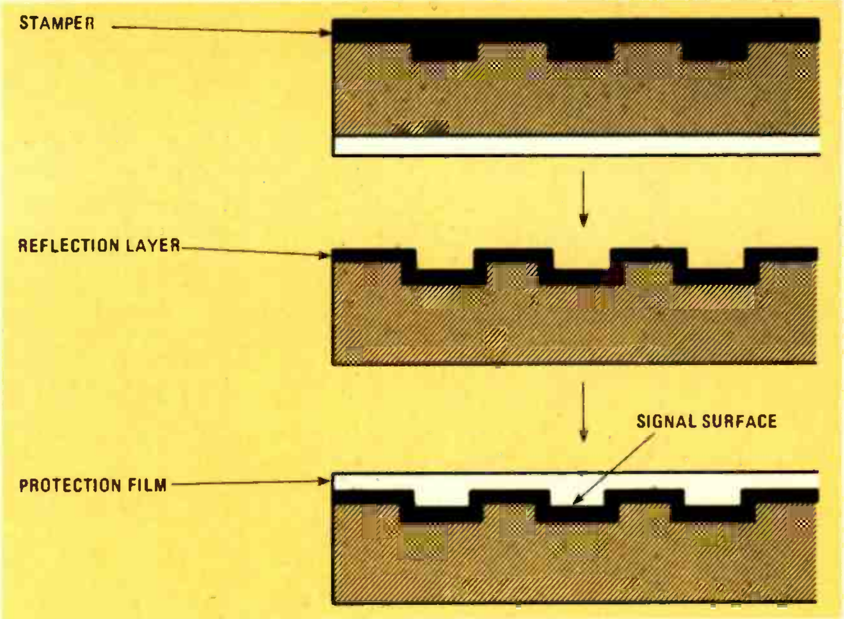
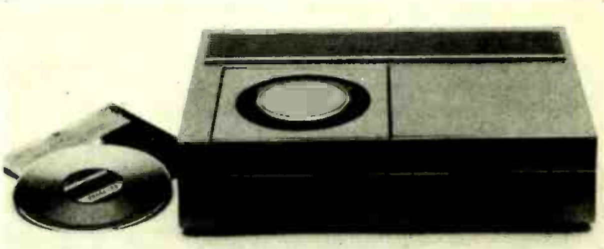


FIG. 7—FINAL STAGE in C-DAD disc production involves adding a reflective layer to the surface and protecting it with a clear plastic coating.



STYLING and compactness are the keynotes of this Marantz design. As a user component in a hi-fi system, the digital-disk player will see rapid acceptance because of its small size.

Digital source-material

Recognizing the advantages of digital recording almost as soon as it was made available on a commercial basis to recording studios several years ago, many recording companies around the world have been producing digital master-tapes for release as digitally-mastered, improved *analog* LP's (often erroneously referred to as "digital" records). Although many of those recordings have been praised as being clearly superior in sound quality to conventional LP's, they obviously cannot approach the performance levels that will be reached by C-DAD discs once they are made available. (See sidebar for more information.)

The fact that so many digital master tapes now exist in the archives of major recording studios bodes well for the future of true digital-discs. All those tapes can be used to make true digital-audio discs, with no degradation in quality from master tape to disc. The Sony-Philips system, in fact, uses the same 16-bit PCM (*P*ulse *C*ode *M*odulation) encoding currently being used for professional digital-audio purposes. Therefore, C-DAD recordings can be made in studios using existing PCM equipment. It is also possible to translate existing analog recordings, using PCM processors, to the C-DAD format. However, should that be done, the resulting product would not exhibit the increased dynamic range and other improvements made possible by digital-recording technology. **R-E**

"DIGITAL" vs. DIGITAL

FOR THE PAST SEVERAL YEARS 12-INCH "digital" discs have been available from companies such as Telarc, Teldec, London, and others.

It is a common misconception that those are *true* digital discs, but that is not the case. True digital discs carry the audio information as a series of binary-coded numbers—that is the method used by the C-DAD.

Digitally-mastered discs—the 12-inchers currently on the market—are so called because the master tapes from which they are produced are digitally-encoded. The discs themselves carry a conventional analog signal.

Those discs do have an advantage over ones recorded using analog processes all the way through—the quality of the master tapes is higher and some of that quality is carried over into the analog pressing. Dynamic range is greater, tape hiss is nonexistent, etc. The discs themselves, though, are still prone to the shortcomings of analog recordings—surface noise, restricted dynamic range, tracking problems, and so forth.

While "digital" (digitally-mastered) discs certainly represent a tremendous improvement over their all-analog predecessors, their quality is still far removed from that obtainable from all-digital recordings. **R-E**

TRAFFIC BROADCAST ZONES IN WEST GERMANY (ARI)

NEW USE FOR FM SCA AUTOMATIC ROAD INFORMATION SYSTEM

Most people think of SCA as a means of piping mood music into stores and restaurants. West Germany has found a much more valuable way to use that service.

Berlin-West
SFB 2 92.4 A
RIAS 2* 94.3 B

LEN FELDMAN
CONTRIBUTING HI-FI/VIDEO EDITOR

A FEW YEARS AFTER MAJOR ARMSTRONG FIRST DEMONSTRATED a workable system of wideband-FM radio broadcasting back in the 1930's, he demonstrated how a subcarrier could be used to modulate the main carrier of an FM station, and how that subcarrier could carry information that was totally different from what was being transmitted on the main carrier.

Many years later, in 1961, the basic techniques developed by Armstrong and modified by others resulted in the beginning of stereophonic broadcasting in the U.S., using subcarrier techniques which, though somewhat different from those first proposed by Armstrong, nevertheless fall into the general category for multiplexed FM.

SCA

In 1954—several years before stereo broadcasting began—the Federal Communications Commission, concerned over the increasing economic plight of struggling FM stations, authorized what came to be known as SCA transmissions. (SCA stands for *S*ubsidiary *C*ommunications *A*uthorization). In those pre-stereo days, FM stations were permitted to transmit one or more subcarriers at frequencies between 25 kHz and 75 kHz above the main carrier, and to modulate those subcarriers with virtually any sort of useful information for use on a point-to-point basis. In other words, the station could *lease* its subcarriers to companies. The companies leasing the subcarriers could then charge a rental fee for receivers provided to subcribers who wanted to hear whatever was being transmitted on the subcarriers.

The best know use of those subscriber-oriented services is for commercial-free background music. Such music, brought to us by such familiar names as Muzak, has been the butt of jokes and disparaging remarks almost from the day that SCA service began. Less familiar is the fact that SCA transmissions do not always consist of background music. In many parts of the country, SCA channels are used to provide a "talking book" service for the blind. And, with the shortage of regular radio-channel space becoming acute, some enterprising broadcasters are turning to SCA to provide foreign-language or ethnic programming for audiences whose numbers are too small to justify the assignment of a station-frequncy by the FCC.

With the advent of FM stereo in 1961, the space available for SCA channels was sharply reduced. Figure 1 shows the modulation spectrum of an FM-stereo transmitter. All of the frequencies given in the following discussion are referenced to the main carrier frequency. The sum (L + R) of the two audio channels occupies spectrum space from 30 Hz to 15 kHz (the highest audio frequency permitted on FM), the stereo pilot-signal is found at 19 kHz, and the sidebands of the suppressed-carrier 38-kHz AM subcarrier signal containing the difference (L-R stereo information) occupy the space from 23 kHz to 53 kHz. That leaves only the spectrum space from 53 kHz to 75 kHz for SCA or private subcarrier use. Some guard-band space must be provided for, so the first practical subcarrier will have a frequency of around 57 kHz. Stations transmitting in stereo and also providing an SCA service generally select 67 kHz as their subcarrier frequency.

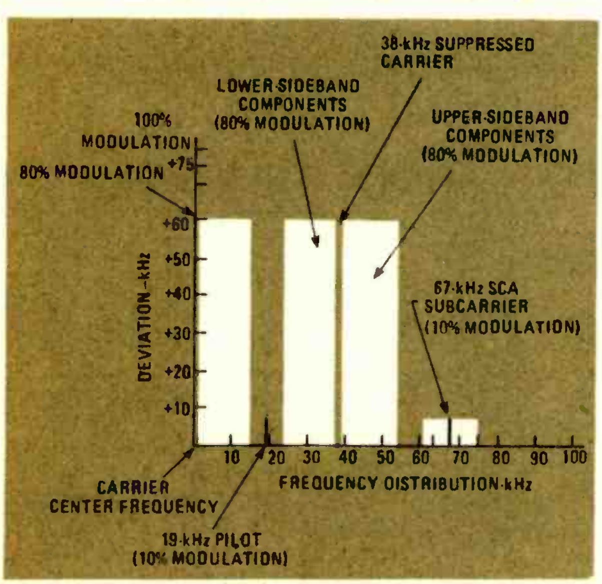


FIG. 1—AN FM-STEREO STATION that offers an SCA service does so at a frequency 67 kHz above the center frequency of its carrier.

Auto road information

We recently learned about a new use for SCA, which is currently in service in West Germany. The new service is helping to solve road problems in that country. As most drivers know, there are AM and FM radio stations in almost every part of this country that broacast traffic information as part of their regular programming. The same is true in West Germany and in other European countries. But the high density of traffic in Europe has caused problems that did not exist even a few years ago.

The traffic problems, of course, are worse during rush hours, weekend peaks, vacation periods, etc. When the capacity of a road is exceeded, traffic jams occur, leading to road accidents—rear-end collisions and the like. The authorities in West Germany reasoned that information supplied promptly to drivers would help keep traffic problems to a minimum. Indeed, way back in the 1960's the government-controlled Radio Broadcast Network began giving traffic information at the end of hourly news broadcasts. It was quickly realized, however, that even such an expanded information service would be of little use unless the information were of a local nature (so that drivers in the immediate area of a problem were informed of it), and unless drivers could be readily alerted to the problem.

As early as 1969, West Germany's well known Blaupunkt radio company began working on the problem and came up with a system that made it possible to distinguish a station that broadcast traffic news and information from the many other stations on the FM broadcast band. Some time later, that system was elaborated upon and became known as ARI (*A*utomatic *R*oad *I*nformation). After extensive testing, the system was adopted in West Germany in 1974, and is in use today. Since then, the system has been submitted to the European Broadcasting Union (EBU) for adaptation as a standard and, after practical tests in Switzerland, has been recommended to all European countries for the dissemination of traffic information. Austria introduced the system in 1976, and trials in other European countries have also been taking place to assess ARI's merits.

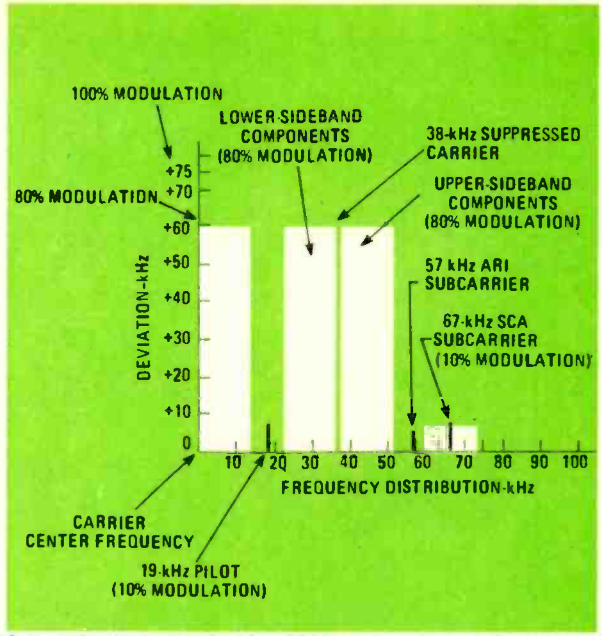


FIG. 2—THE ARI SYSTEM adds a 57-kHz subcarrier to indicate the presence of an ARI station.

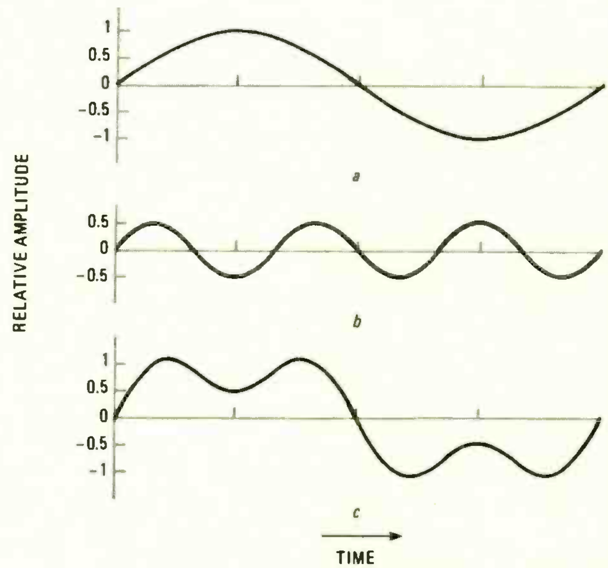


FIG. 3—THE PEAK AMPLITUDE of the 19-kHz stereo pilot-signal plus the 57-kHz ARI subcarrier does not exceed that of the pilot signal alone.

The ARI system

The ARI system is used to identify stations that broadcast information about traffic conditions, as opposed to those that do not. That is especially useful to a driver who comes from another geographical area and is not familiar with local stations. Uing a specially designed. ARI-equipped, radio, the driver can "tune out" stations that do not broadcast traffic information, leaving only the traffic-information stations audible.

One option in an ARI-equipped car radio automatically increases the volume to a predetermined level at the start of any traffic announcement, and returns to its previous level at the conclusion of the announcement. Another option available in ARI-equipped radios provides a visual indication (similar to the familiar stereo-indicator light) when the driver tunes to a "traffic information" station. It is also possible to have traffic announcements override a cassette-tape program that the driver may be listening to while driving, with automatic return to the cassette when the announcement has been completed.

Still another version of the ARI-equipped radio provides an advance warning that a traffic announcement is about to be made, using a brief "signature tune" to avoid starling a driver whose radio had been muted before the announcement. A suitably equipped ARI car radio can even warn a driver when a station's signal strength falls below usable levels as he leaves the station's area of coverage. That is useful as it will allow him to tune to another ARI-equipped station in his new region of travel.

How ARI works

An important characteristic of the ARI system is its ability to identify the station or stations in a given area that provide traffic information on a regular basis. Ordinarily, a driver would find it difficult and time consuming to single out a traffic-news station from all the others on the FM band in most metropolitan regions. With the ARI system, those stations that broadcast traffic information and are part of the ARI network transmit a continuous 57-kHz sub-carrier signal, known as the Station Identification signal (or "SK," from the German word "*S*ender*k*ennung"). That signal, nestled between a normally used 67-kHz SCA subcarrier, and the upper frequency of 53 kHz that is present during FM-stereo broadcasts, is derived by tripling the 19-kHz pilot signal associated with stereo transmissions. The 57-kHz signal is therefore locked to the stereo pilot-signal both in phase and frequency relationship.

The complete modulation spectrum of an FM transmitter operating in both stereo and ARI is shown in Fig. 2 Figure 3 illustrates an important aspect of the ARI system. The 57-kHz subcarrier modulates the ain carrier at half the level that the 19-kHz pilot signal modulates the main carrier, or between four and

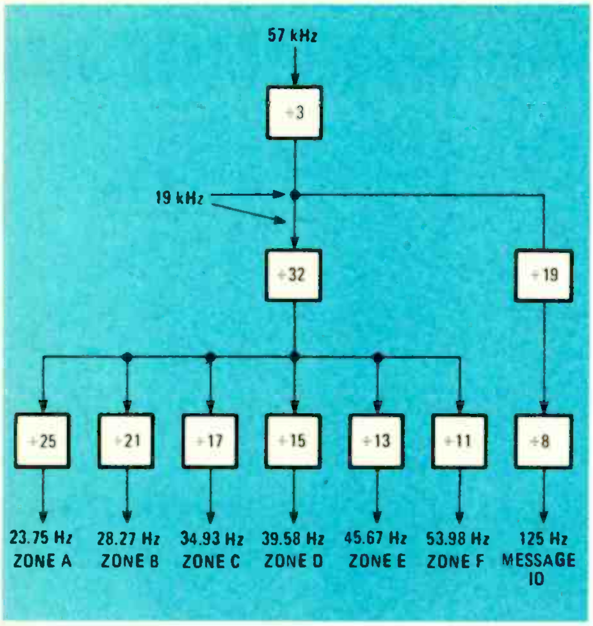


FIG. 4—ALL THE FREQUENCIES AND TONES used in the ARI signal are derived from the 19-kHz stereo pilot-tone.

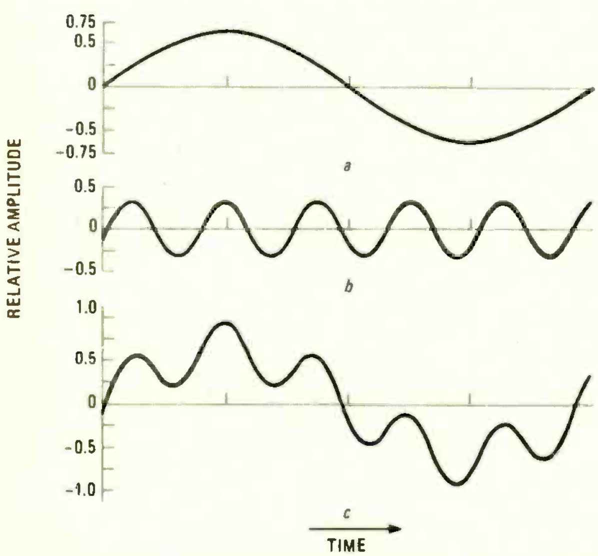


FIG. 5—ZONE-IDENTIFICATION TONE (a) is added to message-identification tone (b) to produce complex waveform (c).

five percent of total modulation. The waveform shown in Fig. 3-a represents the amplitude of the 19-kHz pilot signal, while the one in Fig. 3-b is a representation of the 57-kHz ARI station-identification signal (the third harmonic of 19 kHz). Figure 3-c shows the algebraic addition of the two signals and it is clear that the peak amplitude of the resulting waveform is never greater than that of th original pilot signal. Thus, the combination of the pilot signal and the station-identification signal does not increase the frequency deviation of the main carrier. That also means that signal-to-noise ratios and station coverage-areas are not affected by the addition of the station identiication signal.

Area identification

The limited range of FM transmissions presents both advantages and disadvantages in a traffic-information system such as that. On the one hand, drivers can be certain that the traffic information they receive applies to the region in which they are. But it is also possible that, in certain areas, they would be able to receive more than one traffic-news station. A driver would want to be sure that he had selected the right station.

To solve that problem, Blaupunkt developed a special zone-indicating system for ARI. The total area to be covered is divided into traffic areas that correspond closely to areas covered by local radio stations. As many as six different zone identifications can be used, designated by the letters "A" through "F."

Each zone is assigned a very low frequency tone, which is used to modulate the 57-kHz ARI subcarrier, as shown in Fig. 4. Extensive measurements and field observations have shown that no audible interference occurs as a result of that added modulations. Zone or area identification frequencies are derived by dividing down the 19-kHz pilot tone; the values used in performing the division are also shown in Fig. 4. Depth of modulation of the 57-kHz ARI subcarrier signal is limited to just 60%.

Traffic message signals

While many drivers want to stay tuned to traffic-news stations throughou their travels, there are others who would prefer to hear only the traffic announcements but not the rest of the program material. For example, they might wish to converse with fellow passengers, preferring to keep the radio's volume level low, or to listen to a cassette tape for part of their trip, even though their car radio remained tuned to an ARI station.

For that reason, it was decided to use a seventh low-frequency tone, at a frequency of 125 Hz, to modulate the 57-kHz subcarrier and serve as a message-identification signal. The modulation level of that extra signal is set at half the value used for zone-identification tones and the tone is transmitted for the entire duration of the traffic message. Figure 5 shows how the modulating frequency of a zone or area identification adds to the 125 Hz "message identification" modulating frequency, with the latter having 50% of the amplitude of the former.

An important advantage of the ARI system is that all of the tones it uses, as well as the basic 57-kHz subcarrier itself, are derived from the stereo pilot-frequency through division or multiplication of the 19-kHz stereo pilot signal. Because of that relationship to the 19-kHz stereo pilot-signal, the design of the ARI radio receiver is greatly simplified.

What's available

The simplest and least expensive type of ARI receiver is one in which only traffic-news station-identification is used. In that type of receiver, an indicator light comes on when the driver tunes to a traffic-information station. If he wishes, he can push a button to mute all other stations, allowing only the ARI-equipped one(s) to come through. A somewhat more sophisticated receiver is one that combines station identification and message indication. Still another type can interrupt the playing of a tape cassette when a traffic message begins, switching to FM reception for the duration of the message, and then switch back to the cassette.

The ultimate ARI system uses a car radio with signal-search capability combined with an ARI circuit. The signal-search feature is designed to stop only at traffic-information stations and, when leaving the area of the local transmitter, it automatically searches for another traffic-information station. If, having left one zone and entered another, no other station with the same identification letter can be received, a warning tone informs the driver that a new zone-letter should be selected.

Reports from West Germany indicate that the ARI system has proven to be of great benefit. With all industrialized countries looking for unused communications channels, SCA frequencies offer a convenient means for providing new and innovative forms of point-to-point communications. **R-E**

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2603-103

VIDEODISC SYSTEMS

What's the difference between the four systems? How do they work? Which system will best fit your needs? The answers to those and other questions can be found below.

BEBE F. McCLAIN*

VIDEODISC TECHNOLOGY IS FAR FROM NEW: MANY SYSTEMS have been developed over the years. Today, only four systems are being marketed—or are planned to be marketed—before 1983 comes to a close.

Over 50 years ago, John Baird recorded video signals on a wax disc. During the half century that has passed since then, videodisc systems have been developed independently by Hitachi, I/O Metrics, SEO, Syndor Barnt Scanner Corp., Digital Recording, Robert Bosch, and MDR. And those are the systems that never came to market!

In the 1960's, a good deal of work that was done by 3M and Westinghouse greatly advanced videodisc technology. But it wasn't until the 1970's that decisions were made that resulted in the four systems that exist today. During the past 10 years, an ever-increasing program of research and development devoted to videodisc systems has resulted in an explosion of technology, and a number of systems.

The first system to be marketed was developed by Teldec (Telefunken-Decca). It s no longer available. That system used a grooved 20-cm (approx. 8 inches) flexible disk that was read by a stylus.

Those systems that *did* survive, were developed by the following companies:

RCA	CED system has stylus riding on grooved disc with pits.
JVC	VHD system has stylus riding on non-grooved surface with pits.
Philips MCA	Reflective optical system uses a laser to read shiny disc with pits.
Thompson CSF	Transmissive (non-reflective) optical system uses a laser to read clear disc with pits.

While all four of those systems will have become available before the end of 1982, it is difficult to predict whether all four will survive. The first three systems are aimed at the consumer market. The fourth (Thompson-CSF) is definitely an industrial unit that is much higher priced; the discs it uses are not commercially available but must be custom-made for the users. Yet there are numerous applications for that system in business and industry.

Videodisc systems were developed because they are the most economical way to mass-produce programs containing both audio and video information. A single master disc is made, and from it (just as with audio-only recordings) thousands of discs are pressed quickly and inexpensively.

The stampng takes only seconds, and the raw materials are few and inexpensive compared to videotape uplication. Even more important: the picture quality delivered by a videodisc is better than that from a ½-inch VHS- or Beta-format videotape. And the sound is high fidelity, stereo and/or dual-language capable

The more industrial-oriented type of videodisc players are able to find and freeze-frame any one of the more than 50,000 frames crammed into each side of the disc. That means that 50,000 individual pictures could be stored on one side of a disc, then called up and displayed on the TV screen in seconds. As opposed to videotape machines, a videodisc machine can freeze frames for long periods of time.

Unlike the home videotape machines, the videodisc machines are used for playback only; they can not record. When a videodisc is played back, the video picture is displayed on the screen of a conventional TV (color or B&W) and the accompanying audio comes through the TV speaker. Some videodisc machines have stereo capability, but they must be hooked up to a home stereo system to make use of it. None of the four videodisc formats are interchangeable.

A typical videodisc is about the same size as an LP phonograph record, but contains both audio and video information. The information is contained in pits arranged in spiraling tracks or grooves on the disc.

Let's take a brief look at the relationship between the TV signal and the pits on the disc. The TV signal that represents the program that is eventually put on a disc is composed of three separate signals. Those elements are: a) luminance (brightness), b) color, and c) sound (see Fig. 1).

The peaks and troughs (tops and bottoms of the signal (d in Fig. 1) are "clipped" off. The distance between each wave (e) is representative of the length of the pit that is engraved into the surface of the disc. The length of the pits and the number of pits per second determine how the picture on the screen will look. When a disc is played, the pits are read and changed back into a TV signal.

Videodiscs that have grooves, have many more grooves than stereo phonoraph records. In fact, 50 to 75 grooves filled with video information fit into a space the width of a human hair.

*This article is an excerpt from Bebe McClain's forthcoming book on videodisc systems and manufacturing.

TV SIGNAL / PITS

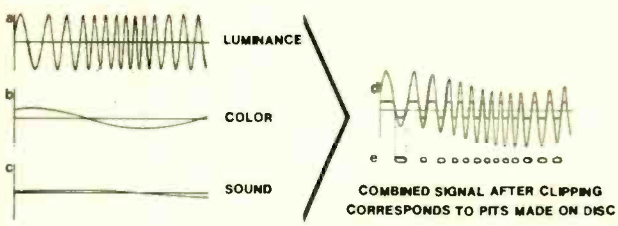

FIG. 1—THE TV SIGNAL placed on the disk is composed of three separate signals—luminance, color, and sound.

There are two basic types of videodisc players. One is the optical player that uses laser light to read the pits in the tracks of the disc. The other is the capacitance player; it sees a stylus that actually rides the surface of the disc. That stylus, in combination with the disc itself, forms a variable capacitor that converts the signal placed on the disc into an electronic representation of the TV signal originally recorded. There are two different kinds of capacitance-type disc players. One plays a disc that has grooves (the CED system); it uses a diamond stylus. The other (the VHD system) plays a disc that has a grooveless surface and uses a diamond or sapphire stylus. In both versions the stylus actually contacts the surface of the disc.

There are two optical-type disc players, too. One plays a reflective disc (Philips), while the other (Thompson CFS) plays a clear, transmissive disc that allows light to pass through it. Both use a laser beam whose light focuses on pits in the disc. Nothing physically contacts the disc's surface during playback in either of those optical systems.

The capacitance system with grooves was developed by RCA; the grooveless capacitance system came from JVC. The names listed in Table 1 and Table 2 are interchangeable.

TABLE 1—CAPACITANCE SYSTEM
Mechanical, Contact Stylus

CED (*C*apacitance *E*lectronic *D*isc)
Grooved
RCA System
Selectavision
VHD (*V*ideo *H*igh *D*ensity)
Grooveless
JVC System
Matsushita System

The optical systems, as a group, are often called VLP (*V*ideo *L*aser *P*layer) or Laservision. The optical system that uses a reflective disc is usually called transmissive optical. The two different formats are often identified by the name of the manufacturer that makes either the player or the disc.

TABLE 2—OPTICAL SYSTEM
Laservision, VLP, Non-contact/Laser

Reflective
Magnavision
Discovision
Sony System
Philips System
Universal Pioneer System
Optical/R
MCA System
IBM System
Laser Disc
Transmissive
Thompson System
Optical/T

All videodisc machines do not include the same special features. Some may offer fast and slow play in either forward or reverse; some have a single audio channel while others have two audio channels. In addition to including special play features, some players have microprocessors built in that make it possible to access any individual frame in the program immediately and either freeze-frame it on the TV or use that frame as a starting point for the program to follow.

The same programs are not available on the various systems. Many film companies, TV program distributors, record distributors, etc., have signed agreements with one or more manufacturers to supply programming. Program availability is one of the foremost concerns of potential purchasers.

RCA's CED system

The CED format uses a grooved disc and a contact stylus (see Fig. 2). It was designed by RCA as a simple, low-cost consumer machine that is very similar to a record player. It uses a diamond-tipped stylus that is easily replaced when it wears out. It plays a two-sided disc that has microscopic grooves in which the stylus travels. There are 10,000 of those grooves to the inch; they are so narrow that you could fit 38 of them inside one groove of a standard LP audio disc.

The stylus has an electrode tip that is actually half of a capacitor. (The disc itself acts as the other half.) As the stylus travels down the grooves on the disc, the resulting capacitance variations generate changes in the electrical signal that are converted into video and audio signals.

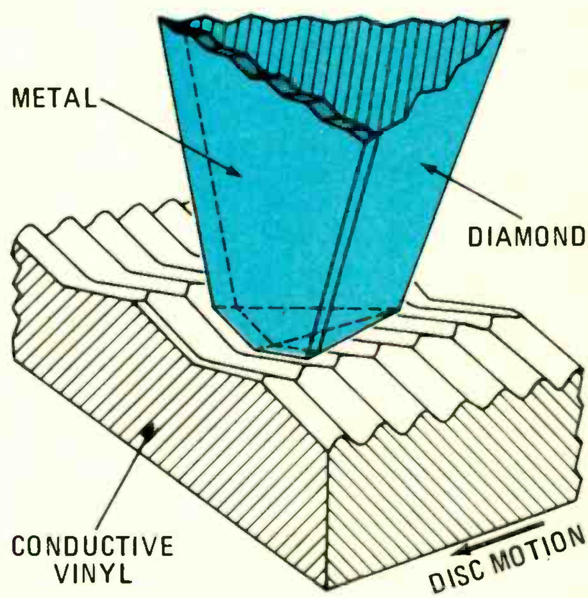

FIG. 2—MUCH LIKE A PHONOGRAPH, the CED system used a diamond-tipped stylus that rides in a groove on the disc. The stylus can be replaced easily.

The stylus rides in grooves that contain pits of different lengths. The stylus senses the electrical changes between where there is no pit and where there is one; the signal that results is transformed into a TV signal.

Because the stylus *does* contact the grooves, the disc must be kept totally clean. It is enclosed in a caddy for protection. The caddy unlocks when it is inserted into a player and the disc is left behind as the caddy is removed.

The caddy is marked side 1 and side 2. Each side plays for one hour, after which the disc must be removed from the player with the caddy, flipped over and re-inserted. On the player, there is an elapsed-time readout, calibrated in minutes, so the viewer can see where he is in the show or can access any particular minute. Other features include visual search that provides a fast-forward or fast-reverse function where the program can be viewed at 16 times normal.

Right now, players that will deliver stereo sound are not available but some discs are being recorded in stereo for use with future playback units offering stereo playback.

In the CED system, four frames of video are placed into each track (one track being one lap around the disc). That means that there are four still pictures read during each revolution of the disc. If one track were played over and over again, as must be done for freeze-framing, four frames would be repeated, and the resulting picture would be jumpy. For good freeze framing only one frame should be repeated. That is why freeze frame is not possible when playing conventional shows on the CED system.

The CED system is by far the simplest system. Because the stylus travels in a groove, there is no need for the additional tracking mechanism that all the other systems need to keep the stylus from wandering all over the disc. Also, since light isn't used as in the optical system, no light-focusing devices are needed.

The CED disc only has one coating applied after it is pressed; that is a lubricant that decreases wear and increases the life of the disc and the stylus.

To date, color-TV manufacturers representing over 50% of the U.S. color-TV market, have indicated their intention of introducing CED-type videodisc players (RCA, Zenith, J.C. Penney, Sears, Sanyo, Toshiba, Hitachi, Radio Shack). RCA has already sold some 40,000 to 50,000 players and hopes to have brought that number to well above 200,000 before the end of 1981. They are also looking for sales of more than 2 million discs made by both RCA and CBS before the end of 1982.

The VHD (*V*ideo *H*igh *D*ensity) system

This system has been seen only in prototype form, but its manufacturers promise that it will be available in the next few months. Originally, JVC and Matsushita developed different systems; but later, they decided that they would both manufacture units using the JVC technology. Matsushita, which owns a large part of JVC, abandoned its technology in favor of JVC's.

The VHD (*V*ideo *H*igh *D*ensity) system uses a grooveless disc that comes in contact with a sapphire (or diamond) stylus (see Fig. 3). The stylus has an electrode tip that reads electrical changes in the same way as the CED system. The main difference is that there are no grooves—only a series of pits in spiraling tracks situated on the disc's surface. Also, like the CED system, the VHD stylus generates different electrical changes as it comes into contact wth areas of pits versus areas of no pits.

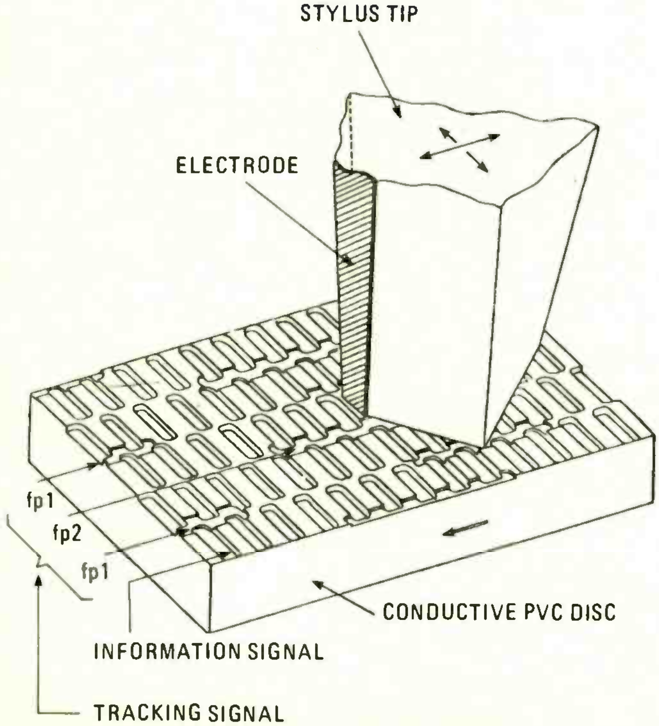

FIG. 3—INSTEAD OF GROOVES, the VHD system uses a series of pits. As in the CED system, the stylus comes in contact with the disc's surface.

OPTICAL REFLECTIVE PLAYER

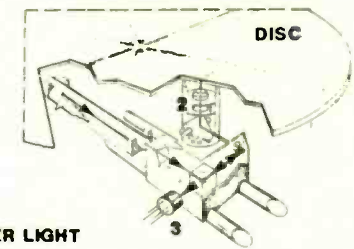

FIG. 4—THE VLP VIDEODISC PLAYER was the first consumer device to use a laser. The three main parts of the system are shown here.

To explain further, the VHD playback stylus has an electrode that, like the CED stylus, is actually half of a capacitor. The disc is the other half; the electrode detects capacitance variations between the disc and the stylus. Again, the electrical signal is directly related to the spacing and the size of the pits. The resulting signal is converted into a video signal that plays through the TV. The pits are similar to those in the CED system, but they are turned sideways.

There are no grooves to guide the pickup stylus and keep it on the right rack, so a tracking signal must be recorded on the disc. A corresponding tracking servo system is needed on the VHD stylus, to make the adjustments needed to keep the stylus on track.

As the VHD stylus travels over the disc, it comes into contact with 10 times more of the surface than the CED stylus does in the CED system. As in the CED system, the stylus must be changged when it wears out. The VHD disc is smaller than 12-inch CED disc; it's 10.2 inches, and it also must be enclosed in a caddy to protect it from dirt and scratches.

The VHD disc plays for 60 minutes on each side and must be removed from the player using the caddy, turned over, and then reinserted to play the flip side. There is variable slow and fast motion. The discs have two soundtracks, so stereo is possible if the system is hooked up to a home-stereo system.

Since the VHD system has two frames per revolution, it cannot have still frame. An optional unit is available to use with JVC's player that allows for still framing. Another optional unit makes the VHD player capable of playing digitally recorded super hi-fi audio (PCM) discs. By offering those options, the VHD system can be aimed at both the industrial and the consumer market.

Player and disc manufacturers are General Electric and the Matsushita affiliated companies, JVC, Panasonic, and Quasar.

Optical reflective system

The third system of the four present disc systems is the optical reflective format developed by MCA and Philips. This player (see Fig. 4) was the first consumer product to use a laser. The disc it plays is a record-type one, but with no grooves. It has a smooth, silvery, mirror-like surface as opposed to a grooved surface. It does not use a stylus. A safe, low-power gas laser light acts as a tracking guide and pick-up system as it scans across engraved pits on the disc.

A spiral series of pits around the disc form tracks. One track plays per each revolution of the disc. That represents one frame (one still picture) of the program. There are 54,000 tracks (with one frame each) on each side. It takes 1/30 of a second for the laser to scan one of those 54,000 tracks. Because one revolution plays only one frame, it is possible to "still frame" a picture on the screen by repeating the same frame. (The laser just goes around the same track over and over again.) That is important for industrial and educational programs, where viewers want to stop the show and/or catalogue thousands of still pictures.

One side plays for 30 minutes. This unit also has multiple speeds in addition to standard play. They include both fixed- and variable-speed slow motion, fast motion, and rapid scan, in both forward and reverse.

If the disc being played was recorded in stereo, the disc player can be hooked up to a home stereo system with an amplifier and two speakers for stereo sound. It would otherwise play through the TV speaker, which is monaural.

A long-playing disc called CLV (*C*onstant *L*inear *V*elocity), that has 60 minutes per side, can be used on the player—but the still frame and multiple speeds are sacrificed.

Looking at this in more detail, the standard play, referred to as CAV (*C*onstant *A*ngular *V*elocity), has 30 minutes per side. Those discs have one frame per revolution. Since, in the standard play, the disc is always turning at the same speed it takes longer to go around an outside track than an inside track. The pits are more spread out on the outside rim and closer together on the inside rim. To extend the playing time, the CLV disc (*C*onstant *L*inear *V*elocity) was developed. By putting the pits closer together, four frames of picture could be put on the outside tracks instead of one. That number gradually decreases to one frame as you proceed to the innermost tracks. Since there is more than one frame of picture in some tracks, it would be impossible to repeat one revolution of the disc over and over for a still-frame effect. The long play is for movies and entertainment programs, where 60-minutes-per-side is desirable.

Let us now take a look at the technology behind this optical system. The reflective discs are covered with a metallic coating that enables the laser beam to reflect off the surface, through a lens, and onto photodetectors in the player.

As Fig. 5 shows, the laser (1) travels through the lens (2) and is reflected off the disc back through the lens (2) and out into the photodetectors (3). The actual system has a more complicated path than shown; the beam is reflected by a series of mirrors before it strikes the disc.

The end result is that the laser light, reflected by the disc, is concentrated onto a photodiode inside the player. When a light hits a pit in the surface, much of the light is diffracted about and is not reflected back into the lens. In essence, less light is received when a pit passes in front of the lens than when a smooth sectio of the disc does. In that way the pits modulate a current.

Because the optical reflective system uses a disc that has a protective coating, no caddy is needed. The pits are actually imbedded in the disc underneath the protective coating. Since no stylus contacts with the disc, dirt or scratches on the surface do not affect the playback. The disc is removed from the jacket and placed on the disc player's turntable as is done with a phonograph record.

An optical system is more complicatd than a capacitance system because it has more mechanisms. Two additional systems are needed—one to keep the beam focused on the pits and one to keep the beam on the right track.

LASER BEAM BOUNCES OFF PIT

REFLECTIVE DISC

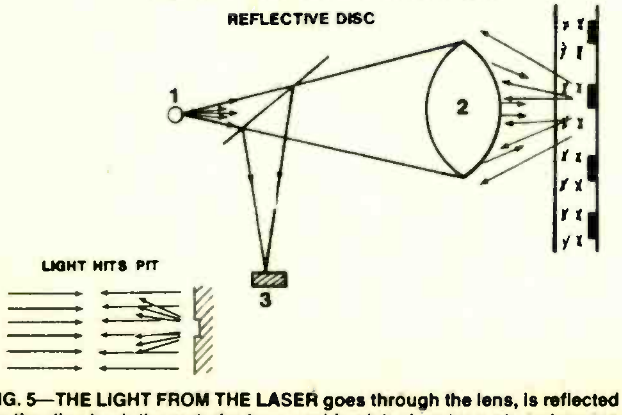

FIG. 5—THE LIGHT FROM THE LASER goes through the lens, is reflected by the disc back through the lens, and is picked up by a photodetector.

LASER BEAM PASSES THROUGH PIT

TRANSMISSIVE DISC

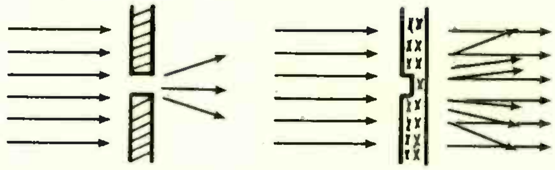

FIG. 6—IN THE TRANSMISSIV OPTICAL SYSTEM, light from the laser passes through the clear videodisc.

The light beam needs a servo system to stay correctly focused on the pits within the track as the disc rotates. If the disc moves (vertically) up or down the light beam will not be focused on the track. To compensate for any such movement, there are two photodiodes, one on each side of the slit through which the light beam passes. After the beam passes through the objective lens, it hits the disc and reflects back equally onto the photodiodes. But if the disc changes position (moves vertically) the light beam is reflected more onto one photodiode than onto the other. Sensing that, the lens refocuses so that the light is evenly reflected.

In addition to that focusing system, a tracking system is needed to insure that the beam stays on the track and does not wander radially across the surface of the disc. As the main laser beam strikes the disc, two other light beams also strike it—one on each side of the main beam. Those two additional beams send information back to separate photodetectors that are part of the tracking system. The system adjusts the main beam radially to keep it on track.

It is interesting to note that in the optical system the picutres in the outer tracks are better than those in the denser inner tracks, and yet the manufacturers have seen fit to have the optical discs play from the inside to the outside. (The CED and VHD systems play like records—from the outside in.) That means that the first pictures seen are of the poorest quality found on the disc.

Transmissive optical system

The fourth and final system to be outlined is the optical transmissive format developed by Thomson CSF. It is designed for the industrial ad educational market, and is priced at more than $3000 for the player. It can be interfaced with a computer for retrieval of information.

Thomson and 3M ae mastering discs in this format. The price for having a program mastered is over $1500 for one side (30 minutes). Replication of discs from the master costs on the order of $18 each.

The system works on a method similar to the reflective optical system in that it uses a laser beam that reads pits that have been developed on the disc in spiral tracks. There are two sides to the disc, with pits on each side.

The disc is transmissive to light and the difference in the path of the laser light where there are pits, as opposed to where there are no pits, causes the modulation as the beam travels along the track (see Fig. 6). The laser light shines through the disc to photocells underneath the disc. Unlike all the other systems, it is not necessary to turn this clear disc over, since the laser can refocus on the bottom side. Since a protective surface is not applied, the disc uses a caddy that inserts with the disc into the player and is then removed (as with the CED and VHD system).

Like the reflective disc, one revolution represents one frame. Therefore, still framing is possible by merely repeating the same frame; variable fast and slow motion both forward and reverse are possible, too. There are two audio channels, but stereo play is not available now since only one channel can be layed a a ime.

As you can tell, that unit is intended to be interactive with the viewer and is not for the mass market, where viewers usually watch a program uninterrupted and do not need special features and retrieval capability. **R-E**

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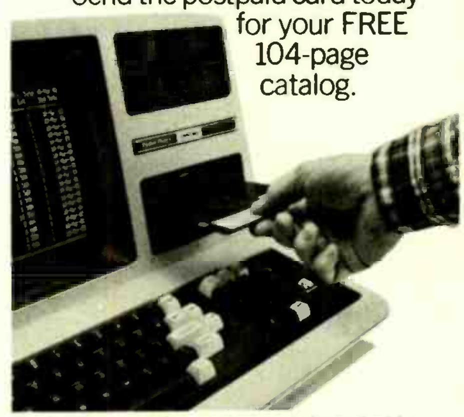

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Buyer's Guide

CORDLESS TELEPHONES

With all the cordless phones on the market, making a choice can be quite difficult. To make things easier, here's a rundown of what's currently available.

IF ALEXANDER GRAHAM BELL SAW THE modern versions of his invention, the telephone, he most likely would not recognize them. Not because they would look that much different from his original 1876 model, but because the new breed of telephones can do so much more. One particularly exciting and useful telephone innovation is the wireless or cordless phone.

What's so special about a cordless telephone? It means no more tangled wires, expensive extension wiring, or missed calls. With a cordless phone, you can be up to 700 feet from your phone, and still be able to answer it. With many models, you can even originate a call from anywhere within the unit's range. You can use a cordless phone both indoors and out—you can be working in the shop, washing the car, or over at the neighbor's house, and still catch every call.

Cordless phones have indeed become a popular household tool—so much in fact, that there are literally dozens of models now on the market. With so many models to choose from, there's bound to be something for everyone, but finding a perfect match between your needs and an available unit can be no easy task. So we've put together this survey of the major cordless phones now on the market, including what they can't do, what they can do, and how to make them work even better.

The basics

A typical cordless phone consists of two primary parts—a base unit (or transponder) and a handset (or remote). The base unit plugs into a 117-volt AC line and uses your home wiring as a carrier current antenna to transmit a 1.7-MHz FM signal to the handset; the base uses a separate telescopic-antenna to receive the incoming 49-MHz signal from the handset.

Often, the base also includes a battery-recharging circuit for the handset's nickle-cadmium batteries. To recharge the batteries, the handset is usually placed into a cradle on the base when the device is not otherwise in use.

The base connects easily to your phone line using a standard RJ11W modular jack. All units (unless specially ordered otherwise) use pulse dialing, even though the handset invariably is equipped with a *Touch-Tone*-type pushbutton keypad. The reason behind that is simple: All phone lines, whether they be designed for rotary pulse or *Touch-Tone*, will accept pulse dialing. However, the reverse is not true; few pulse-only lines can use *Touch-Tone*. (There is an exception to that rule—some specialized phone systems, especially those used within a large building, may only be able to accept *Touch-Tone* dialing. When in doubt, consult your phone company.) A few cordless phones are also capable of either pulse or tone dialing.

Several models allow a user at the base to "call" the remote handset, or vice versa. To use that feature, a call switch is pressed, which transmits a loud "beep" to the handset. Of course, the handset must be turned on to receive any signal, although its telescopic antenna need not be extended since it is used for transmitting only; an internal loopstick antenna is used for reception.

A few of the phones also include an intercom capability, allowing direct communications between a phone connected to the base, and the remote. In addition, quite a few of the systems can be used as a "limited" intercom by simply lifting the receiver of the telephone connected to the base and dialing a single digit. That cancels the dial tone and allows communications between the base unit and the remote. Most phone systems incorporate a time-out feature, however, limiting that type of intercom operation to only a minute or so.

The handset is composed of a speaker and mouthpiece, as in a regular telephone, but often includes other features such as a loudness control or switch, an on/off/standby switch, etc. More complicated models include other features such as an "intercom call" and "security". The security feature is used to prevent unauthorized use of your phone line. Manufacturers routinely offer their phones in a variety of operating frequencies, but it is possible that an individual near you could use another cordless phone or other type of communications equipment, and "tap" into your line. If your cordless phone does not have a security feature, it is recommended that you disconnect the unit from your phone line whenever you will be away from home for any length of time.

As mentioned earlier, a pushbutton keypad is provided for dialing on those units that offer dial-out capability. Quite often, the # or * key is used for an automatic redial function; pressing the appropriate key will cause the phone to redial that last number called—handy whenever the line is busy.

Nearly all of the cordless phones on the market use standard duplex transmission, allowing either party to speak at any time; a few less expensive models operate in the simplex mode, like a walkie-talkie or CB radio, and only one person can talk at a time. Also, with very few exceptions, today's cordless phones use FM. That allows the unit to operate with much less static and interference, although a completely static-free cordless phone, at this time at least, does not exist.

Because the base transponder usually uses the AC wiring in your home to transmit its signal, the structure of your house, as well as how it's wired, can have a significant effect on your reception. If your AC lines are enclosed in metal conduit, you'll have quite a bit of trouble getting a worthwhile signal to the handset. Aluminum-backed insulation in walls and attics will also impede the signal somewhat, as will concrete and brick structures. Many phone manufacturers recommend using a 25 foot AC extension-cord on the base if you have trouble with reception caused by those factors. Lay out the extension cord along a wall or, better yet, along two walls that are at right angles to each other.

Locating the base as high up as possible will help improve reception. According to many manufacturers, the higher the base unit, the better the reception. Avoid placing the base unit in basements or other parts of your house that are below ground level.

Obviously, since cordless phones use RF signals for communication, some interference problems may result when two or more units are used in close proximity to one another. Several manufacturers offer as many as five different channel selections to help avoid that problem. The frequency set is not user adjustable, however, and, at least so far, avoiding such interference is mostly a hit and miss affair. If, when you bring the unit home, you notice your neighbor's cordless phone is also operating at or near your frequency, the only recourse you have is to bring the unit back to the store and try another one. As cordless phones become more popular, the seriousness of that problem will increase rapidly. Already, some manufacturers are petitioning the FCC to open more frequencies for cordless-phone use.

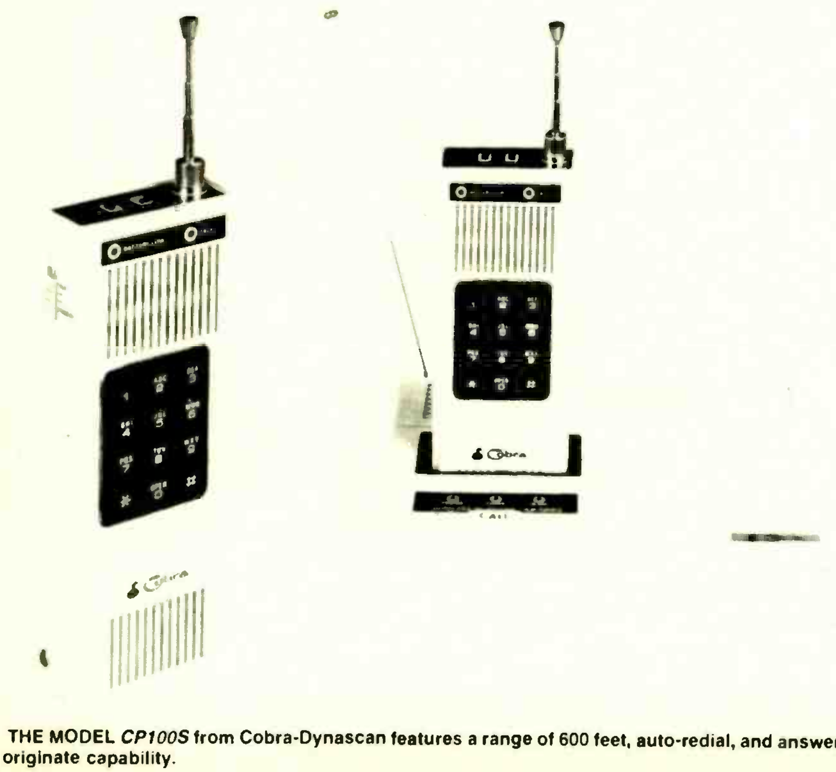
It's difficult to request specific frequency sets from the manufacturer, and even more difficult to order the base unit and handset separately. There may be an occasion when you may wish to have more than one base unit or handset on any one line. Keep in mind, however, that you cannot operate more than one handset with the base station at any one time. As the majority of models use FM, the handset with the stronger signal would simply capture the base station, effectively cutting out the other remote completely.

What does the phone company have to say about cordless phones? After all, by using a cordless, you are bypassing the need for installing and wiring extension phones, which is one of their primary sources of income. Simply stated, the telephone company cannot do a thing.

Over the past few years, Congress and the FCC have passed new laws and regulations governing the use of privately made equipment on common-carrier local and long distance phone-lines. Since 1977, it has been legal to own and connect your own commercially manufactured and FCC-approved phone or phone accessory. As of this writing, the FCC has ruled that all phone companies must "unbundle" their rates, that is, they must itemize your phone bill into service, rental, wiring, and other important catagories. Thus, you may be able to reduce your monthly charge for phone rental by as much as 50% by using your own phone—cordless or not—meaning a yearly savings of about $25 to $100.

The phone company does require (legally) that you notify them whenever you place a new phone or phone accessory onto their line. All you need to do is call up the customer service office (or other number so designated in your phone book), tell them you have installed a cordless phone per the instructions packed with the unit, and read off the make, model, FCC registration number, and Ringer equivalent number. All of that information should be stamped on the base unit, or clearly marked on the box or instruction booklet.

Keep in mind that no additional charge or fee is required when you own a cordless phone, and, since there is little or no extra wiring involved, you save yourself a service call and any monthly extension-wiring fee as well.



THE MODEL *CP100S* from Cobra-Dynascan features a range of 600 feet, auto-redial, and answer and originate capability.

What's available

The following is a rundown of all the major cordless-phone manufacturers, and their models that are currently on the market. Remember that models come and go, so consult with your local dealer to see what's currently available. The price given for each model is the manufacturer's list price; the price you pay may vary from dealer to dealer.

TABLE 1—CORDLESS-PHONE FEATURES

Manufacturer	Model	Price	Frequencies (MHz)	Range (Feet)	Auto Redial	Security	Dial Type	Simplex Duplex	Modulation Type	Operating Modes	Intercom
Cobra/ Dynascan	CP15S	$ 89.95	1.7/49	600	—	No	—	Duplex	FM	Answer Only	No
Cobra/ Dynascan	CP100S	$189.95	1.7/49	600	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Cobra/ Dynascan	CP200S	$189.95	1.7/49	600	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Cobra/ Dynascan	CP210S	$219.95	1.7/49	600	Yes	No	Pulse	Duplex	FM	Answer/ Orig	Yes
Electra	FF-200	$149.95	1.7/49	300	—	Yes	—	Duplex	FM	Answer Only	No
Electra	FF-550	$219.95	1.7/49	600	Yes	Yes	Pulse	Duplex	FM	Answer/ Orig	No
Electra	FF-1550	$279.95	1.7/49	600	Yes	Yes	Pulse	Duplex	FM	Answer/ Orig	Yes
Electra	FF-3050	$239.95	1.7/49	600	Yes	Yes	Pulse	Duplex	FM	Answer/ Orig	No
Electra	FF-3500	$329.95	1.7/49	600	Yes	Yes	Pulse	Duplex	FM	Answer/ Orig	No
Electra	FF-4000	$349.95	49/49	600	Yes	Yes	Pulse and Tone	Duplex	FM	Answer/ Orig	No
Fracom/ Rovaphone	Rovette	$250	1.7/49	300	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Fracom/ Rovaphone	Rovette 2	$189.95	1.7/49	600	Yes	No	Pulse	Duplex	FM	Answer/ Orig	Yes
Midland	80-200	$119.95	1.7/49	60	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Midland	80-250	$169.96	1.7/49	600	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Midland	80-300	$219.95	1.7/49	600	Yes (Nine-Number-Memory)	Yes	Pulse	Duplex	FM	Answer/ Orig	Yes
Mura	MP600/ 601	$200	1.7/49	600	Yes	Yes	Pulse	Duplex	FM	Answer/ Orig	No
Mura	MP510 511	$150	1.7/49	150	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Pathcom	Pacer 7800	$219.95	1.7/49	1000	Yes	Yes	Pulse	Duplex	FM	Answer/ Orig	No
Pathcom	Pacer 7800T	$229.95	1.7/49	1000	Yes	Yes	Tone	Duplex	FM	Answer/ Orig	No
Pathcom	Pacer 7800D	$239.95	1.7/49	1000	Yes (Nine-Number-Memory)	Yes	Pulse	Duplex	FM	Answer/ Orig	No
Pathcom	Pacer 9800	$299.95	1.7/49	1000	Yes	Yes	Pulse and Tone	Duplex	FM	Answer/ Orig	Yes
Pathcom	Pacer 9800D	$329.95	1.7/49	1000	Yes (Nine-Number-Memory)	Yes	Pulse and Tone	Duplex	FM	Answer/ Orig	Yes
Radio Shack	ET-300	$199.95	1.7/49	500	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Radio Shack	ET-310	$119.95	1.7/49	600	—	No	—	Duplex	FM	Answer Only	No
Radio Shack	ET-350	$ 99.95	1.7/49	50	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Universal	Tote & Talk (TEL-3000)	$249.95	1.7/49	700	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Universal	Talk-A Bout	$129.95	1.7/49	100	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Webcor	575	$239.95	1.7/49	700	Yes	Yes	Pulse	Duplex	FM	Answer/ Orig	Yes
Webcor	555	$229.95	1.7/49	400	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No
Webcor	525	$129.95	1.7/49	500	—	No	—	Duplex	FM	Answer Only	No
Webcor	777	$129.95	1.7/49	100	Yes	No	Pulse	Duplex	FM	Answer/ Orig	No

Cobra-Dynascan

Cobra, well known for its citizens' band radios, has come out with four cordless-phone models. The least expensive is their *CP15S*, an answer-only phone. That model has neither security nor intercom features.

The other models, the *CP100S*, *CP200S*, and *CP210S*, are all essentially identical. They all feature auto-redial circuitry, are capable of receiving as well as making calls from the handset, and use pulse dialing. All of them have claimed maximum ranges of up to 600 feet, although the manufacturer stresses that reception in enclosed areas, such as a warehouse, is usually limited to about 300 feet.

The only difference between the *CP100S* and the *CP200S* is cosmetic—the *CP100S* has a two-way-radio-styled handset. The *CP210S* has all the features of those two models, but also includes an intercom feature. That feature allows the user to disconnect the base unit phone from the line and use the handset and base unit as a wireless intercom system.

Electra-Bearcat

Electra has six "Freedom Phone" models to choose from, perhaps the most extensive line on the market. Available are units that range all the way from the pocket-sized *FF-3500* to the fully multiplexed, multi-featured model *FF-4000*.

Electra's most basic model is its *FF-200*, an answer only unit. The estimated reception range of that phone is about 300 feet. It includes several features that are found in all of this company's units. Those are a call button mounted on the base unit, a volume switch, and a security feature that automatically engages when the handset is placed in the base's recharging cradle.

Up the ladder we find two nearly identical models, the *FF-550* and the *FF-1550*; both use *Princess-Phone*-type styling. The biggest difference is that the *FF-1550* comes with a separate handset recharger in addition to the charger built into the base. Both models have a range of up to 600 feet and feature auto-redial circuitry. The *FF-1550* also includes a fully automatic two-way intercom that allows you to carry on a conversation between the handset and base without using the phone lines. Similar to those models is the *FF-3050*, which uses "military" styling and does not have an intercom.

The *FF-3500* is a refreshingly different cordless phone—both the base and the handset have been down-sized considerably. The handset has a few extra goodies built into it as well, including a three-position volume switch, a pulsing light for dialing confirmation, and pushbutton dialing with tone confirmation. The *FF-3500* is claimed to have a maximum range of about 600 feet.

Electra's best is their new *FF-4000*, a fully multiplexed 49-MHz/49-MHz unit that has a claimed range of 600 feet. In addition, that model boasts a three-phone-number-capacity automatic redial system and a three-position switch for 10 pulse-per-second (normal), 20 pulse-per-second, or *Touch-Tone* dialing. A coded security system helps ensure that only your handset will be able to access your base.

TABLE 2—
CORDLESS PHONE MANUFACTURERS

Cobra Communications
A Division of Dynascan Corp.
6460 W. Cortland
Chicago, IL 60635

Electra Co.
300 E. County Line Road
Cumberland, IN 46229

Fracom/Rovafone International
2130 W. Clybourn St.
Milwaukee, WI 53233

Midland International Corp.
1690 N. Topping
Kansas City, MO 64120

Mura Corporation
177 Cantiague Rock Rd
Westbury, NY 11590

Pathcom Inc. (Pace)
24105 S. Frampton Ave.
Harbor City, CA 90710

Radio Shack
One Tandy Center
Ft. Worth, Tx 76102

Universal Security Instruments, Inc.
10324 S. Dolfield Rd.
Owings Mills, MD 21117

Webcor Electronics
28 S. Terminal Drive
Plainview, NY 11803

Fracom/Rovaphone

This company's *Rovette* features *Trim-Line*-like styling and allows you to either store the base unit and handset on any flat surface like most other cordless models, or hang it up on a wall.

The unit uses pulse dialing and has an estimated maximum range of 300 feet. In addition, the unit includes auto-redial circuitry and pager-call buttons on both the base unit and remote. An intercom switch allows a phone connected to the base to communicate freely with the remote, bypassing the phone lines.

A unique feature of that cordless is that its base has no visible reception antenna. Instead, the antenna is encased in the coiled cord that attaches the base unit to the modular phone jack on the wall.

The company also offers the *Rovette 2*, which is similar to the *Rovette* but offers a 600-foot range.

Midland

Midland offers three cordless-phone models. All feature pushbutton pulse dialing, auto-redialing, a call button to page handset users, and slim styling. In addition, all are answer/originate models.

The model *80-200* has a range of up to 60 feet. The model *80-250* has a range of up to 600 feet. The top-of-the-line model *80-300* also has the 600-foot range of the *80-250* but adds intercom capability and a security feature; it can also store up to nine pre-programmed numbers for automatic dialing.

Mura

Mura Corporation has trimmed down its cordless-phone line and offers two moderately priced full-duplex versions—the *MP600/601* and the *MP510/511*. Previously, Mura had been offering several AM simplex-type units, but those have recently been discontinued.

The *MP510/511* has a maximum effective range of about 150 feet. It offers auto-redial and pulse dialing, but has no intercom or security feature. The *MP600/601* has a maximum range of 600 feet, auto-redial, and a security feature. Unlike most other cordless units, that one does not have a recharging unit built into the base. Instead, a coiled-cord battery charger plugs into the handset; that recharger will recharge the handset even when it is in use. The base unit can then be hidden away in a closet, behind a bookself, or even in an attic.

Pathcom (Pace)

Pathcom offers two of the more advanced lines of cordless phones currently on the market. Their *7800* series consists of three models. The base model *Pacer 7800* offers pulse dialing, paging from base to handset, automatic redial, and a security feature. The *Pacer 7800T* adds true *Touch-Tone* dialing. Their *Pacer 7800D* offers pulse dialing, but features a nine-phone-number memory for automatic dialing.

Unlike most other manufacturers, Pathcom allows you to order base units and handsets separately, allowing you to have more than one remote for each base, or vice versa. (Remember, you cannot operate more than one handset with a base at a time.)

Pathcom's top-of-the-line model, the *Pacer 9800*, has everything the *Pacer 7800* has, as well as a personal wireless intercom, call forwarding (where available from the phone company), and has switch-selectable pulse or *Touch-Tone* operation. The wireless intercom feature allows one user to screen calls at the base, call the other user with the handset, and speak to him or her over the intercom system before passing the incoming call to the handset. Also, while most cordless phones have a provision that allows the base to call the handset, the *Pacer 9800* allows the handset to call the base as well. A *Pacer 9800D*, which adds a nine-phone-number memory is also available. All *Pacer* phones have a maximum range of 1000 feet.

Radio Shack

Radio Shack currently offers three different cordless phone models: the *ET-300*, their top-of-the-line extended range answer/originate model; the *ET-310*, an answer-only model that is similar to the *ET-300*, and the *ET-350*, a short range answer/originate unit.

Radio Shack claims that their model *ET-300* has a 500-foot operating range. The handset is equipped with a telescopic antenna (an interesting feature of that antenna is that it is connected to an internal switch that will allow the remote to turn on only when the antenna is fully extended), a volume switch, and a pushbutton keypad. That model also has an auto-redial feature—but, as with all other Radio Shack cordless phones, no security feature. The model *ET-310* is similar to the *ET-300*, but it is an answer-only model. Also, the claimed range for this unit is slightly larger—up to 600 feet.

The model *ET-350* is an answer/originate unit with a range of 50 feet. As this unit is intended primarily for indoor use, giving the user more freedom than a cord telephone, the keypad here is *base* mounted. Like the *ET-300*, this model features auto-redial and pulse dialing.

Universal

Universal Security Instruments offers two cordless phones, the *Tote and Talk* (also known as the *TEL-3000*), and the *Talkabout*. The *Talkabout* is an answer/originate model and has a range of about 100 feet. The handset has a spring-loaded switch that automatically switches the phone from "talk" to "standby" mode whenever the handset is placed face down on a flat surface. The pushbutton keypad in that model is housed in the base rather than the handset.

The *TEL-3000* has a handset-mounted keypad and a claimed maximum range of 700 feet. Both Universal models have a built in recharger in the base unit and feature auto-redial.

Webcor

Webcor has four models in its "Zip" cordless-phone line. Their answer-only model, the *525*, has a claimed range of 500 feet. The model *777* is a low range (100 foot) answer/originate unit that features FM duplex-operation and auto-redial. Climbing up the ladder we find the model *555*, with a range of 400 feet. Featurewise, it's identical to the *777*. That model features the popular walkie-talkie-type styling.

Webcor's top-of-the-line model *575* has a claimed range of 700 feet. Like their other answer/originate models, it too has auto-redial. In addition, it has a security switch that prevents someone else in your area from using your base, or your phone line. The phone not only features a call button on both the handset and base unit, but comes with true intercom capability, allowing communications between the base and handset, even when the base is disconnected from the phone line. All Webcor phones use pulse dialing.

Finding the right phone

Today, cordless phones are available with a wide range of features, and at a wide range of prices. To help you find the right one for you, we've provided a summary of the models we've discussed in this article in Table 1; Table 2 gives the names and addresses of the manufacturers. When picking a unit, be sure that you don't overlook such things as styling, simplicity of operation, and durability. The best way to find which model is right for you is to see and try as many of them as you can. **R-E**

I LIKE BIRDS, BUT...

EARL "DOC" SAVAGE, K4SDS

I AM NOT FASCINATED BY BIRDS, BUT I DO enjoy watching them as they cavort about my yard in the morning and evening. I could identify only a dozen or so species if the need ever arose, so it's apparent that I do not study them beyond casual observation. (But that's enough to have discovered some of their quirks, and to understand that old epithet "bird-brain.")

The reason I'm saying this up front is just to keep you from assuming that I am an enemy of our feathered friends. I do like the little things as long as they stay away from where they don't belong. One of the places they don't belong is in the gutter on my patio roof. When they start carrying nest material in there, they're asking for trouble!

Not wanting to electrocute them or shoot them (and put holes in the patio roof), I despaired of finding a solution other than waving them off from behind the sliding doors. That action, by the way, is effective for about two minutes. Lately, however, they don't care for my gutter. They've learned to steer clear of it because I used my head instead of my arms. In case you have a similar problem, here's how you can solve it.

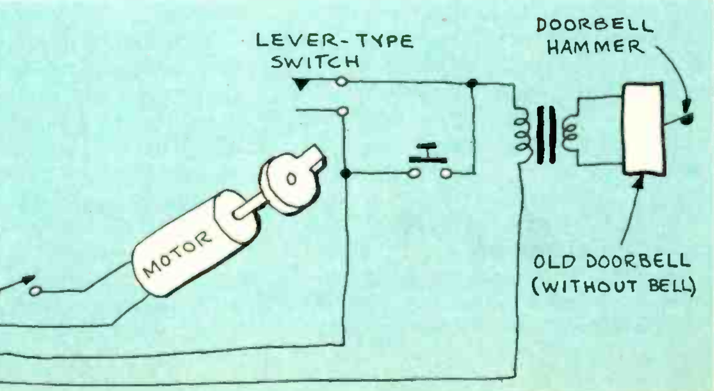
It's all done with an old doorbell and a timer. The doorbell—minus the bell part—is mounted so that the hammer strikes the gutter (instead of a bell) when it is activated. It both vibrates the gutter and makes a bit of noise—enough of one or the other to send the birds scooting out of there.

At first, I rang the "bell" by pressing a momentary switch when the need arose. Later, my smarts grew, and I put a small clock-type motor in the control box. On the shaft of the motor is a cam that completes the circuit to the bell for a few seconds every five minutes. The setup is shown in Fig. 1. Now, the "scare 'em away" action takes place automatically. After a while, even birds learn that my gutter is not a pleasant place to build a nest.

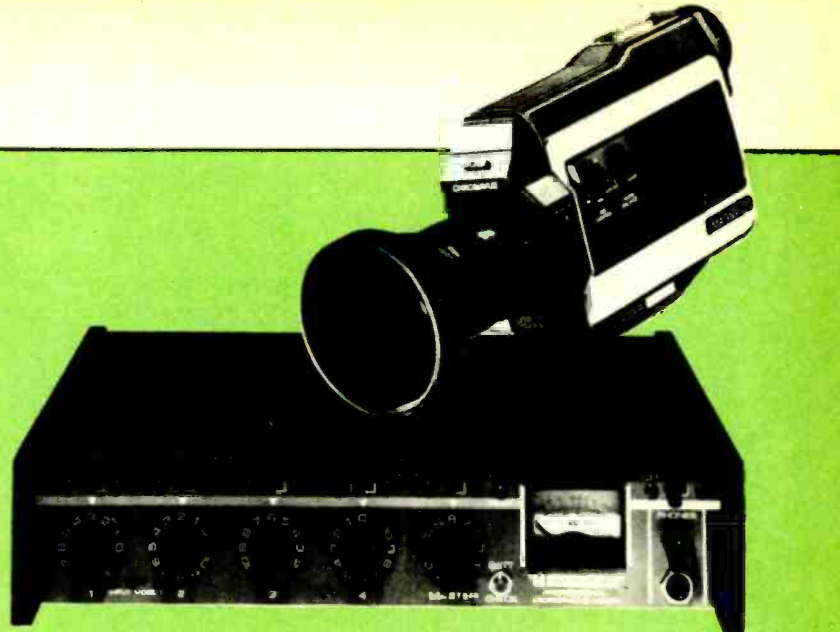
Of course, the motor can be switched in and out of the circuit. It is not necessary to let the thing sound off every five minutes forever. In fact, the mechanism isn't put in its automatic mode except early in the spring, and a little bit later whenever a new crop of youngsters starts the nest-building ritual.

The wiring diagram in Fig. 1 can also be used in case you need to keep away other animals (cats or whatever) without harming them. **R-E**

FIG. 1



IMPROVE VIDEO SOUND



LEN FELDMAN
CONTRIBUTING HI-FI/VIDEO EDITOR

Dissatisfied with the sound quality of the videotapes you make? Here are several ways to improve it.

HOME VIDEOCASSETTE RECORDERS, LIKE TV receivers, tend to place more emphasis on the quality of the picture than on that of the sound. While the color pictures reproduced from videotape are often indistinguishable from those obtained from good, off-the-air TV reception. The sound portion of those recordings, however, seem almost to have been tailored for reproduction by the small speakers and minimal-power amplifiers found in most table-top TV receivers.

If, however, you have ever connected the audio-output jack from your home or portable VCR directly to your component stereo-system, you know that the frequency response of the sound-track on a videotape is not all that bad. When VCR's are operated at their fastest speeds (0.79 ips for Beta-format machines or 1.31 ips for VHS machines) the audio response often extends to beyond 10 kHz, while the signal-to-noise ratio may be as high as 45 dB or more if high-grade tape is used. While those specifications are not outstanding in high-fidelity terms, they would be more than adequate for general use were it not for some steps that makers of VCR's take to "simplify" the audio sections of their products.

Live-taping situations

Most VCR's are equipped with a single microphone-input and, in some cases, another high-level input. Home-video cameras usually have built-in omnidirectional microphones that are connected to a VCR by the multi-pin camera cable that has become fairly standard on this type of equipment. In any case, there is no means of controlling audio gain at the camera, nor is there a master level-control at the VCR. The VCR is equipped with an ALC (*A*utomatic *L*evel *C*ontrol) circuit that restricts the dynamic range of the audio severely.

The ALC can cause problems when the built-in camera microphone is used as the sole sound-pickup device in a home-videotaping setup. The reason is that, more often than not, the camera and microphone are several feet away from the subject being taped, and the resulting soundtrack has an echo-laden, reverberant quality that is incongruous when heard together with close-up views of the subject (taken with the aid of a zoom lens).

Background noise also increases, because the ALC circuit is doing what it was intended to do (maintaining a constant audio level—even if the only audio is irrelevant background-noise), and the effect is anything but natural-sounding. In addition, if the camera is hand-held or shoulder-supported (rather than being mounted on a tripod), one can often hear the sound of "heavy breathing" from the camera operator because of his proximity to the camera-mounted microphone and the "wide open" gain that is provided by the ALC circuitry.

The solution to the problem, obviously, is to use an off-the-camera microphone (or microphones), preferably of the directional or cardioid type. It can be kept just out of camera range, but still be positioned close enough to the subject or subjects being taped to give good solid audio.

Whether you choose a dynamic microphone or a condenser type, the plugs found on the higher quality, low-impedance microphones are not likely to fit directly into the miniature jacks found on most portable and home VCR's. However, adaptors that convert from one type of plug to another are readily available from electronics-parts stores.

Audio mixing

It's just one step from using a single external microphone to using several microphones and even some line-level program-sources (like music from records or tapes). Using multiple sources instead of the single-microphone approach is also preferable when dubbing a new audio-track onto your existing videotapes.

FIG. 1—A MIXER, such as the Shure *M267*, allows you to use several microphones or other audio sources.

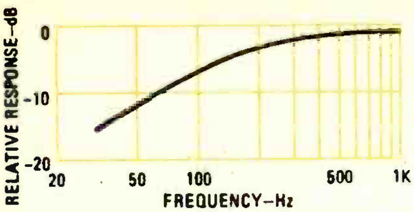


FIG. 2—LOW-CUT FILTERS can reduce the annoying effects of wind noise, turntable rumble, and other low-frequency sounds by decreasing low-frequency response.

Shure Bros. (222 Hartrey Ave., Evanston, IL 60204), a well known manufacturer of phono pickups, microphones, and professional audio equipment and accessories, has introduced recently a small, 4-input audio mixer, the *model M267*. While it is intended for use primarily in audio-recording applications, the versatile, relatively inexpensive ($395.00) mixer can also solve a lot of problems for serious videophiles who want better-quality soundtracks on their tapes. (Shure also manufactures a *model M268* mixer that includes many of the features of the *model M267*, but sells for $250.00.)

The *model M267*, shown in Fig. 1, has wide frequency-response (30 Hz to 20 kHz, ±2 db) and low distortion up to +18-dBm output (less than 0.35% at +15 dBm at any frequency within its passband), extremely low noise, and very low susceptibility to RF interference—a problem that can often crop up in an untested "field" environment.

Four switchable microphone or line-level balanced inputs with individual gain controls and low-frequency rolloff switches are provided, and the output is switchable for either line or microphone levels. Thus, if your video camera is equipped with only an external-microphone input (and there is no line-level input on your VCR), you can still get the benefit of good signal-to-noise ratios.

There's a built-in peak limiter—together with an LED peak-indicator—that can cut distortion due to overload; it can be switched in or out. The sensitivity of a small VU meter can be set for +4 or +8 dBm with a VU RANGE switch (normally, 0 dB on the meter is equal to +4 dBm; the +8-dBm setting is used to reduce sensitivity). The meter is illuminated for easy reading when the mixer is AC-operated.

However, the *model M267* will operate either from AC or from an external battery pack. In case of an AC-line failure or power interruption, noiseless automatic switchover to the batteries takes place. Battery-charge condition can be checked at any time. A front-panel monitoring-jack will drive just about any mono or stereo headphones, and a separate level control is provided for the phones. Finally, a built-in 1000-Hz tone oscillator is incorporated for line tests and level checks.

The low-cut filters associated with each of the four LINE/MIC inputs provide a low frequency roll-off that follows the response curve shown in Fig. 2. The filters can be used individually with each input control to reduce wind noise or undesirable low-frequency signals, such as turntable rumble, or overly bassy voices caused by speakers or singers holding microphones too close to their mouths.

Better audio dubbing

Most of the owner's manuals supplied with VCR's suggest that the proper way to do audio dubbing (the process whereby a new soundtrack is substituted for the original one) on a videotape is simply to plug a microphone (or a mixer such as the one we have been describing) into the external-microphone jack of the VCR, hit the AUDIO DUB button, and substitute new audio for the old.

There are several disadvantages to that procedure. For one thing, it erases the original soundtrack, which you may want to include in the new sound mix. Secondly, working in "real time" and getting all the musical and voice portions to fit together, on cue, during the very first "take" is a rarity—if you've ever tried it, you know that the task can be extremely frustrating.

A much better technique involves transcribing the existing audio soundtrack from the videotape onto audio tape and, with the aid of a mixer, adding the additional microphone or line-level contributions, as shown in Fig. 3. If you don't get the "perfect" mix the first time, you have not destroyed the original videotape soundtrack and can try again—as many times as you need to get it right.

Figure 4 shows the hookup for the final audio-dubbing process. In that step, of course, it is necessary to synchronize the newly mixed audio master-tape with the VCR program using the audio-dubbing feature on your VCR. The synchronization process is not as difficult as you may think, at least for scenes of relatively short duration. After all, the final mixed tape contains the original "live" soundtrack, which is already perfectly synchronized with the video. Since the same audio-tape deck is used both to record and play back the final mix, tape speed—even if not perfectly accurate—will be consistent for the brief periods needed to transcribe the new audio mix back onto the videotape via the audio-input jack on the VCR.

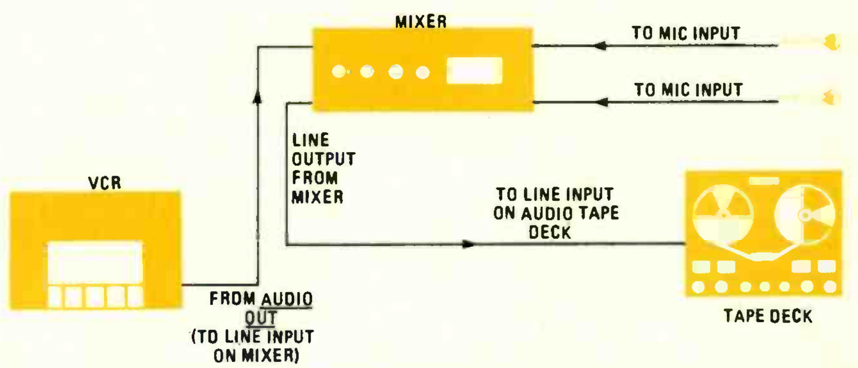


FIG. 4—THE ORIGINAL SOUNDTRACK is replaced by the new one by transcribing the master audio tape to videotape using the VCR's "dub" function.

With practice, the PAUSE control on the VCR (which, in most cases, produces a still-frame picture on the screen), used in conjunction with the PAUSE button on your audio tape-deck, should permit a close-to-perfect audio-dubbing operation. (As for the VCR's speed stability, you don't have to worry because its tape-transport system is synchronized to the standard NTSC 30-frames-per-second picture rate.)

Imaginative use of a microphone/line mixer, together with playback through your sound system rather than through your TV set, can give your home-video productions near-professional audio quality. R-E

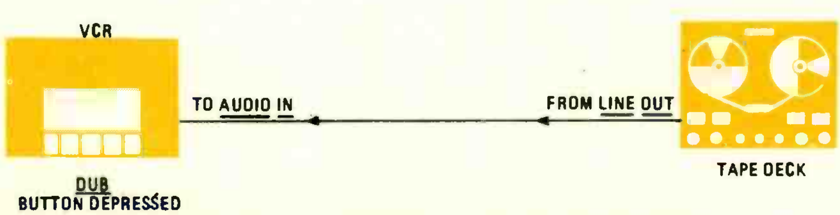
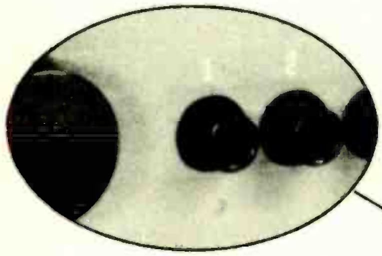
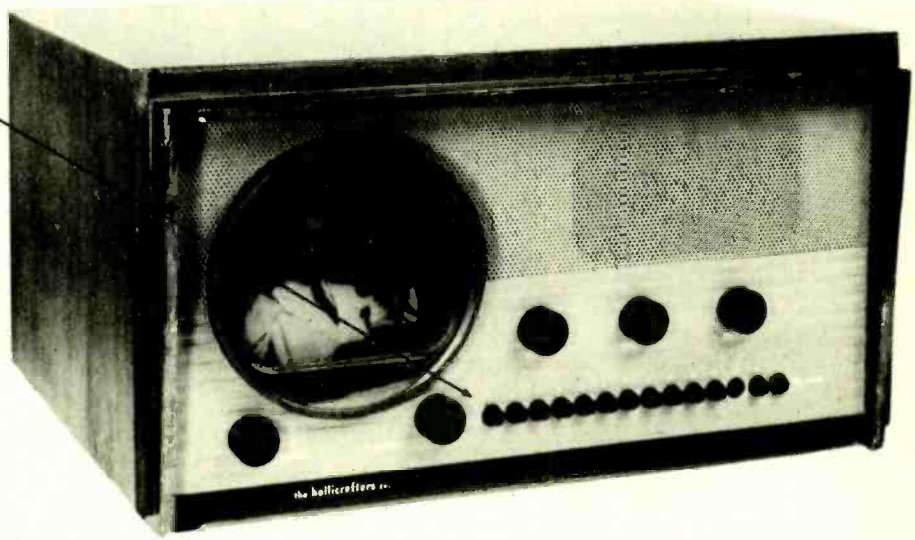


FIG. 3—A MASTER AUDIO TAPE is prepared by using a mixer to combine the orginal video soundtrack with new material.

WHAT EVER HAPPENED TO CHANNEL 1?





Ever wonder why your VHF-television dial starts with Channel 2? Find out why in this brief look at the early days of television and how it all began.

DAVID A. FERRE

WHEN A TELEVISION RECEIVER IS PURchased in the United States, you can take it anywhere in the country, plug it in, pull up the "rabbit ears," and tune in a station. That is possible because we have national broadcasting standards that are common throughout the country. Yet, at one time commercial television was going to be introduced to the American public without standards; fortunately, that "experiment" ended before it even started. But let's not get ahead of our story!

Up to 1934

During the first few months of 1933, RCA demonstrated the first successful all-electronic television system. Broadcasts were made from the RCA experimental television transmitter, W2XBS, located at the top of the Empire State Building in New York City. The characteristics of that early all-electronic television system were modest:

Lines:	240
Frames:	24 per second
Scanning:	sequential (no interlacing)
Bandwidth:	2 MHz
Video carrier:	AM modulated, full sideband
Audio carrier:	AM modulated, full sideband

Yet, the results were far better than any mechanical television system had ever accomplished. For those experiments, the video carrier was at approximately 45 MHz.

It may be hard for us to appreciate fully what RCA had accomplished in 1933. But to give you an idea: Many of the experimental television broadcasters were still using frequencies in the 2- to 3-MHz range, and bandwidths of 100 kHz. In addition, the earlier systems were mechanical using gears, motors, mirrors, etc. As television advanced, each step pointed towards non-mechanical systems, and higher bandwidths and carrier frequencies.

The Federal Communications Commission was established by an act of Congress on June 22, 1934. It was about that time that a portion of the VHF radio spectrum was allocated to television for the first time (see Fig. 1). Previously, any frequency above 30 MHz was available to experimenters. Those experimenters included a number of pioneering amateur-radio operators; there were also experimental stations that included television. In 1934, the experimenters were moved to the frequencies above 110 MHz, while television was allocated two bands, 42-56 and 60-86 MHz. There were no channels associated with the allocations, but it was a beginning; television was making its first move.

1934 to 1938

Progress was slow for television during those years. The depression was at its worst, and even mighty RCA lost

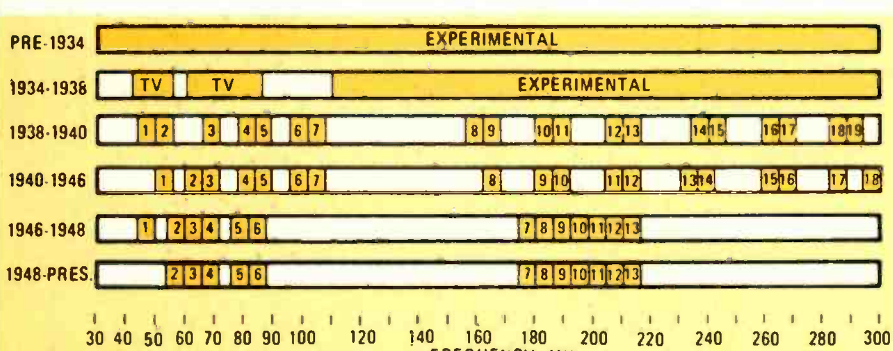


FIG. 1—HOW THE TELEVISION ALLOCATIONS have changed over the years. This chart shows the approximate frequencies of the channels; the exact frequencies are given in Table 1.

money. But advances were made in RCA's all-electronic system. In June, 1936, RCA announced the start of a massive field test. A total of 100 experimental-television receivers were distributed to RCA employees for placement in their homes and offices (see Fig. 2). RCA then began regular television broadcasts from W2XBS, using their new Radio City television studios. Those studios were linked to the Empire State Building transmitter by an experimental 177-MHz radio link and a coaxial cable. The composition of the television signal used for that test was as follows:

Lines:	343
Frames:	30 per second
Scanning:	interlaced (2:1)
Bandwidth:	5.75 MHz
Video carrier:	AM modulated, full sideband
Audio carrier:	AM modulated, full sideband

On June 15, 1936, the FCC began informal hearings concerning the radio spectrum above 30 MHz. There was an increasing demand for those frequencies and a new word began to be heard at the FCC: that word was standards. The Radio Manufacturers Association (RMA), the trade association for the radio and television equipment manufacturers, had formed a sub-committee on television. They attended the June, 1936 hearings because of their interest in the possible future commercialization of television. In addition to urging definite channel allocations, the RMA had a set of television channel standards to present (see Fig. 3-a). Although those standards were incomplete in some respects, one important recommendation that the RMA made to the Commission was that the bandwidth of a television channel should be 6 MHz—the same bandwidth that is used today. The RMA television standards were:

Lines:	441
Frames:	30 per second
Scanning:	interlaced (2:1)
Bandwidth:	6 MHz
Video carrier:	AM modulated, full sideband
Audio carrier:	AM modulated, full sideband

It is interesting to note that the proposed 441-line standard was beyond the capabilities of any system that had been demonstrated up to that point. It wasn't until eight months later, on February 11, 1937, that a manufacturer (Philco) gave a convincing demonstration of a television system that completely met the RMA standards.

The FCC hearings that had started on June 15, 1936, resulted in the allocation of 19 television channels, each with a bandwidth of 6 MHz. The new allocations, which are shown in Fig. 1 and Table 1, became effective October 13, 1938. The RMA revised and completed their set of television standards, which were essentially the same as the 1936 standards except for one important difference: The video carrier would now be transmitted with a full upper sideband and only a partial lower sideband, as shown in Fig. 3-b. That vestigial sideband system was eventually adopted by the FCC and is used today.

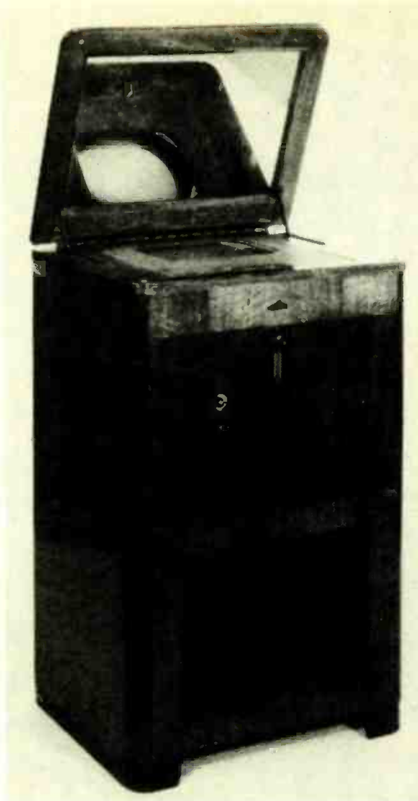


FIG. 2—ONE OF THE LAST in existence, this receiver was one of the ones used in RCA's test of the first all-electronic television system. The vertically-mounted picture tube was viewed through a mirror in the cabinet top.

Television now had allocations and channel numbers. Our mysterious Channel 1 was assigned to the 44- to 50-MHz band as shown in Table 1. RCA's experimental station quickly received a permit for one of those new television allocations and selected Channel 1!

1938 to 1940

The television industry was generally pleased with the FCC allocation of 19 TV channels. They were hoping for a continuous band of frequencies to simplify tuner design, and were somewhat disappointed that 12 of the 19 channels were above 150 MHz; those frequencies were virtually unused, and thought to be useful only for television-relay networks. But the seven channels between 44 and 108 MHz were enough to begin plans for commercial television operation. By then it was believed that the RMA standards would be adopted by the FCC and commercialization could begin. But not everybody agreed with the RMA standards, and the FCC wasn't about to approve any standard unless the television industry was in almost total agreement.

On October 20, 1938, just one week

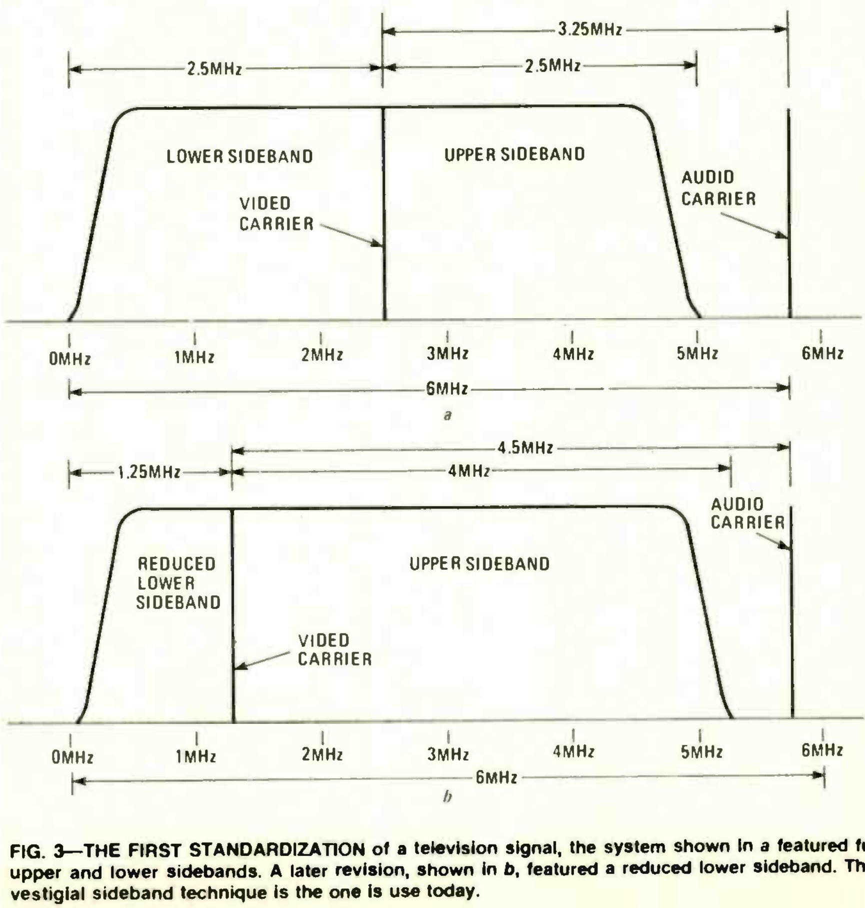


FIG. 3—THE FIRST STANDARDIZATION of a television signal, the system shown in a featured full upper and lower sidebands. A later revision, shown in b, featured a reduced lower sideband. That vestigial sideband technique is the one is use today.

TABLE 1

Channel	Year			
	1938-1940	1940-1946	1946-1948	1948-PRESENT
1	44-50	50-56	44-50	–
2	50-56	60-66	54-60	54-60
3	66-72	66-72	60-66	60-66
4	78-84	78-84	66-72	66-72
5	84-90	84-90	76-82	76-82
6	96-102	96-102	82-88	82-88
7	102-108	102-108	174-180	174-180
8	156-162	162-168	180-186	180-186
9	162-168	180-186	186-192	186-192
10	180-186	186-192	192-198	192-198
11	186-192	204-210	198-204	198-204
12	204-210	210-216	204-210	204-210
13	210-216	230-236	210-216	210-216
14	234-240	236-242	–	–
15	240-246	258-264	–	–
16	258-264	264-270	–	–
17	264-270	282-288	–	–
18	282-288	288-294	–	–
19	288-294			

after the allocations became effective, RCA announced that regular television programming would begin as a "public service" on April 30, 1939. That date coincided with the opening of the 1939 New York World's Fair. A number of manufacturers began producing television receivers, and by the opening of the fair they were in the stores and ready for sale. The opening ceremonies of the fair were broadcast on Channel 1 by RCA's W2XBS, and featured the President of the United States. After that event, broadcasts were scheduled on a regular basis.

By the end of May 1939, large department stores, such as Macy's in New York, offered as many as nine different models for sale; those were supplied by three manufacturers (Andrea, DuMont, and RCA). Screen sizes for those telvision sets ranged from 5 to 14 inches, and prices ranged from $189.50 to $600.00. Most of the early sets were complete receivers, but one, the *model TT-5* from RCA (shown in Fig. 4), had no audio section; if audio was desired, it had to be connected to a compatible RCA receiver. Unfortunately, sales of those early television sets were not very good, and by the end of 1939 fewer than 400 of them had been sold in the New York area.

All of the major television broadcasters (incidently, the stations were still considered experimental) had adopted the RMA standards by the end of 1939. That included the stations in New York City, Chicago, Los Angeles, and Schenectady. The FCC was urged to adopt the RMA standards so that commercialization could begin. The FCC responded to the pressure from the TV industry by publishing rules for limited commercialization on December 22, 1939. It was a kind of Christmas present for the television industry.

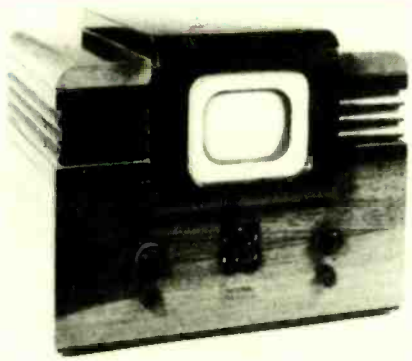


FIG. 4—THIS EARLY TELEVISION SET, the RCA *model TT-5*, was one of the first offered for sale to the general public. It featured a five-inch screen, five-channel coverage, but no audio section; it sold for $199.50 in 1939.

At the time those rules were published, the FCC also announced that hearings would be held in January, before establishing a date for limited commercialization. At those hearings, it was made clear to the FCC that many of the broadcasters did not agree that the RMA standards were the best. Philco urged the FCC to adopt their system of television with 605 lines and 24 frames-per-second. DuMont wanted standards that included 625 lines and 15 frames-per-second. In addition, there was some vague talk about something called color television. Nevertheless, in an order issued on February 29, 1940, the FCC ruled that limited commercialization could begin on September 1, but warned that nothing should be done to encourage a large public investment in television receivers. They refused to adopt any standards, with the implication that each of the broadcasters could use whatever standards they liked best, with the public deciding who had the best system.

RCA responded to the authorization for limited commercialization with full-page newspaper ads in early March announcing the "arrival of television," and ordered the immediate production of 25,000 television receivers. The FCC realized that limited commercialization wasn't going to work, as the sale of thousands of television sets would, in effect, "freeze" the standards, making a change to other standards almost impossible. Within a few days of the RCA newspaper ads, the FCC's permission for limited commercialization was withdrawn.

Television was also about to undergo some more changes. *F*requency *M*odulation (FM) had been introduced by its developer, Major Edwin H. Armstrong, in 1935. Shortly after its introduction, FM was granted five experimental frequencies between 42.6 and 43.4 MHz. By 1940, the FCC had 150 applications for experimental FM stations on file that could not be processed because of lack of frequencies. As a result of hearings held on March 18, 1940, the FCC assigned FM a continuous band of frequencies (that was done to simplify tuner design), and expanded the FM allocation to include the frequencies from 42 to 50 MHz. The new allocation included the 44- to 50-MHz band that had previously been assigned to Channel 1.

But that is not what happened to Channel 1! The TV channels were renumbered with Channel 1 now assigned to 50-56 MHz band and the remaining channels were shifted around the spectrum. But when the smoke cleared, the television industry had lost one channel, leaving them with 18 allocations.

The new FM channels and the changes in the television allocations became effective on June 20, 1940; commercial FM broadcasting was authorized to begin on January 1, 1941.

1940 to 1946

When the revised 18-channel TV allocations went into effect, the television industry was unhappy, to say the least. The limited commercialization plan was suspended; the FCC continued its refusal to set television standards; a television channel was lost to FM, and, because of the changes in the allocations, many of the experimental TV broadcasters had to go off the air to complete extensive transmitter changes. For example, the RCA experimental transmitter, W2XBS, had been operating on the old Channel 1 (44-50 MHz); because of the changes, they were forced to switch to the new Channel 1 (50-60 MHz).

However, soon after that things began to look up. A member of the RMA had met with the FCC to ask just what the television industry could do to win approval of a set of standards. The FCC replied that if the industry could agree on *one* set of standards, they would be approved without delay. Quickly, the RMA organized the National Television Standards Committee (NTSC). The NTSC was open to all major interests in the television field whether they were associated with the RMA or not. Eventually, over 160 individuals became associated with the NTSC. On July 31, 1940, under the RMA's sponsorship and with the FCC's blessing, the NTSC held its first meeting.

With the opportunity to propose a set of standards to the FCC, you might have expected that the NTSC would simply have endorsed the existing RMA standards, but that is not what happened. Every aspect of the television-standards question was re-examined and discussed at length. On January 27, 1941, the NTSC met with the FCC and presented a progress report. The preliminary NTSC standard presented to the FCC at that meeting closely paralleled the RMA standards. That seemed to indicate that the RMA standards were essentially correct. There was one important difference, however: The audio carrier was to be FM. The FCC had one reservation about the proposed standard—they felt that the 441-line standard recommended by the NTSC was too low. That standard went way back to the first RMA standards of 1936, when both video sidebands were transmitted. It was common knowledge that the vestigial sideband system in use since 1938 allowed a much higher line count and, accordingly, a better television picture. The NTSC agreed to re-examine that question and said that it would present more information at hearings that were to be held in March, 1941.

Those hearings were held on March 20, 1941. The NTSC standard that was presented at the hearing was almost identical to the one proposed earlier, except that the number of lines was increased to 525 lines. (Although the number of lines seemed to be random, it was not. The line count had to be an odd number and to be related to few multiples of odd numbers, such as $3\times3\times7\times7=441$ or $3\times5\times5\times7=525$, for example. That was necessary for generation of the synchronizing pulse.) The new standard was as follows:

Lines:	525
Frames:	30-per-second
Scanning:	interlaced (2:1)
Bandwidth:	6 MHz
Video carrier:	AM modulated, vestigial sideband
Audio carrier:	FM modulated, ±75 kHz deviation (later ±25 kHz deviation)

Virtually all of the participants in the hearings (they went on for four days) agreed that the NTSC Standards were correct and should be adopted quickly. The FCC was convinced that the industry had finally agreed and the NTSC Standards were adopted as the national standard in April 1941. The effective date was July 1, 1941; commercial television could finally begin!

When that "Opening Day" for commercial television finally arrived, only two television stations were licensed and ready for operation; WNBT (NBC, old W2XBS) transmitting on Channel 1, and WCBW (CBS, old W2XAX) transmitting on Channel 2. Both of those stations were in New York City. Soon after (on September 1, 1941) WPTZ in Philadelphia, transmitting on Channel 3, came on the air. By the spring of 1942, a total of four commercial stations were in full operation and 10,000 television receivers had been sold.

Television's growth was halted by World War II, with the Defense Communications Board ordering the construction of new radio and television stations to end. Television programming was reduced to just four hours per week for the broadcasters already in operation (all devoted to war-related activities).

As the end of the war approached, the FCC was faced with a monumental task. The war effort had brought about an extraordinary leap in communications technology. Frequencies that had been thought to be useless were now in tremendous demand. The entire spectrum had to be re-examined, with new allocations made and old ones revised. The FCC began by holding hearings on September 28, 1944. They were promptly overwhelmed. The 18-channel television allocations in effect since 1940 were attacked by one group as being wasteful of the valuable VHF spectrum, yet another group urged an increase to 26 channels. Others urged the FCC to move all of the television allocations to UHF frequencies immediately. But the television industry aruged that television had waited long enough and should develop now, using the existing allocations.

After hearings that were held on February 14, 1945, it became clear that no group was going to get everything it wanted. In the FCC's final decision, released on June 27, 1945, television's allocation was reduced to 13 channels, and FM was moved from the 42-50 MHz slot to 88-106 MHz (the band was later increased to 88-108 MHz). The television interests were very unhappy that they were left with only 13 channels, but the FM interests suffered a major blow because all of the existing stations had to go off the air and switch to new frequencies. In addition, 500,000 home-FM receivers were now obsolete.

The reduction to 13 television channels was accompanied by new and reorganized frequency allocations (see Table 1). Again the broadcasters had to go off the air to switch frequencies.

Our Channel 1 was still around, but it was moved back to the 44- to 50-MHz band that it had occupied from 1938 to 1940. In addition, there was a restriction for Channel 1: It could only be assigned as a community channel, and was limited to a maximum power of 1000 watts. Other TV channels were for metropolitan stations, with a maximum power of 50,000 watts permitted. All channels, except Channel 6, were shared with fixed and mobile services—a fact that left the television interests concerned about interference. The changes became effective March 1, 1946.

1946 to 1948

Even with the reduced number of channels, the boom was on! Manufacturers quickly began producing television receivers, transmitters, antennas, etc. New television stations were being built all over the United States. The FCC had identified the top 140 metropolitan cities and assigned each at least one channel; a total of 400 were to be allotted. The FCC received many more applications than it had available channels. In an effort to provide the public with as many channels as possible, the FCC routinely threw away the "safety factor" of mileage between licensed transmitters. Television-receiver sales were doing very well, with 175,000 sold by the end of 1947. Manufacturers were selling television sets as fast as they could be made, even though the sets were rather expensive. (A typical set with a 10-inch screen sold for $375.)

But problems began to appear. Propagation theories at that time predicted that television signals would not be received over the horizon—but they were, quite readily. So, even with just 50 stations on the air, interference problems were beginning to appear. Meanwhile, the FCC had reduced the minimum distance between stations using the same channel to just 80 miles. An engineering study released by the FCC warned of interference problems if immediate action wasn't taken. That led to an FCC report, issued on May 5, 1948, that ruled that television could no longer share its frequencies with fixed and mobile services, and that the 72- to 76-MHz band could be used for fixed radio services only.

But where could the mobile services be located if they could no longer share the television allocations, and could no longer use the 72- to 76-MHz band? There was only one place to go—the television industry would have to give up another TV channel. But which channel would that be? The American Radio Relay League (an association of amateur radio operators) urged that Channel 2 be deleted so that the second harmonics of the 28- 29.7-MHz amateur-radio band would not interfere with

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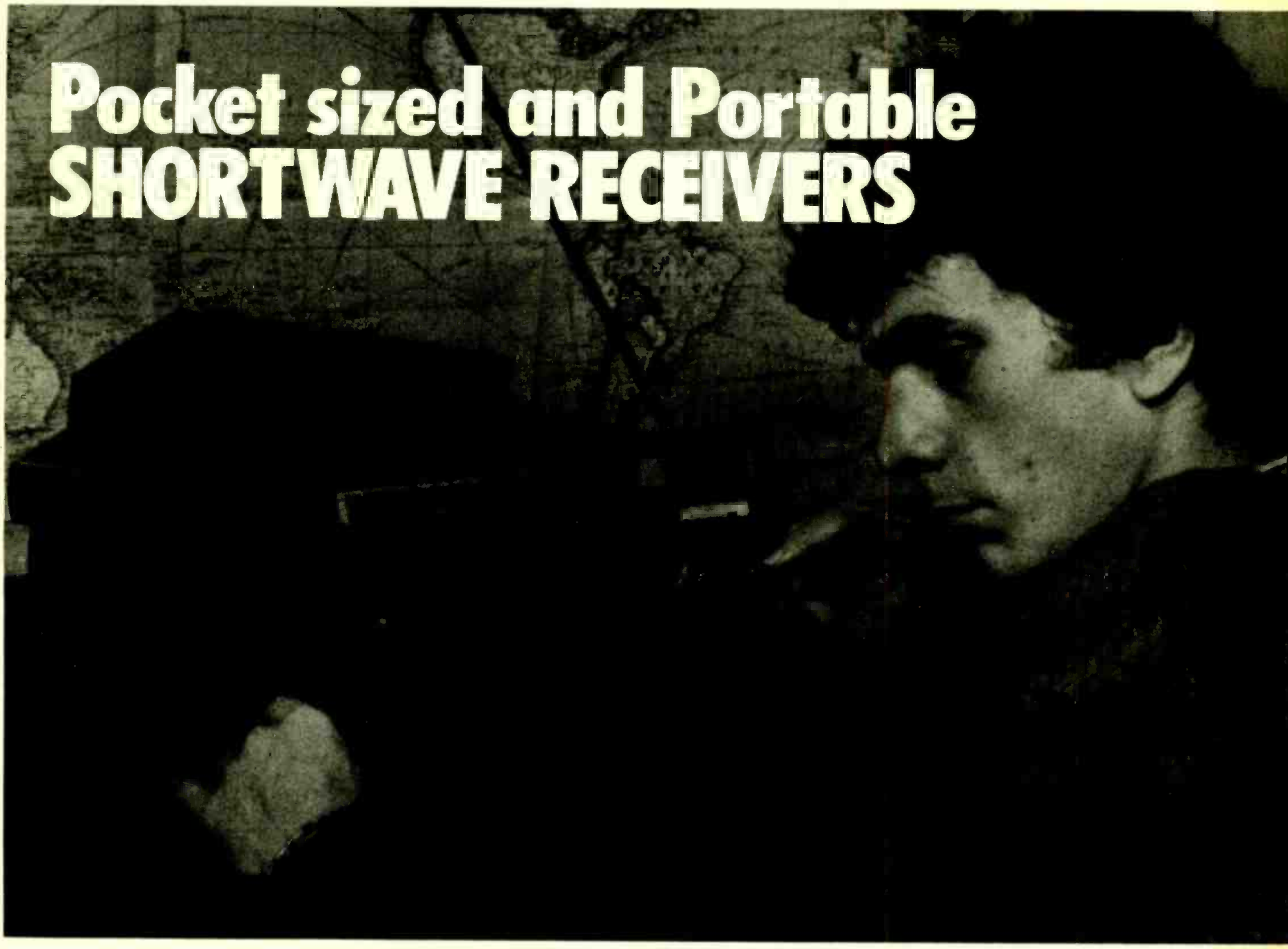
Pocket sized and Portable SHORTWAVE RECEIVERS



The newest generation of portable shortwave receivers offers features and performance previously found only on top-of-the-line table models. Here's a look at what's available, and what these small powerhouses can do.

DANNY GOODMAN

IT WASN'T MANY YEARS AGO THAT shortwave listening was a hobby enjoyed only by technically capable individuals who had tabletops full of complicated receiving equipment. But that has changed dramatically over the past year or two as advanced semiconductor technology has found many applications in portable communications receivers, making them as easy to use as your TV set.

Today, affordable portable shortwave radios offer features previously available only on professional-quality equipment costing many thousands of dollars more. And some of the newest portables use integrated circuits and miniature components, allowing the sensitive electronics to be housed in cases that are small enough to fit in your pocket.

The shortwave spectrum

By international agreement, users of the high-frequency (shortwave) spectrum (3.0-30.0 MHz) confine broadcasts intended for general listeners to several segments of the spectrum, called bands. Each band is identified by both its frequency and its wavelength (in meters) as shown in Table 1. Thus, the shortwave broadcast band that begins at 9.5 MHz is also called the 31-meter band, while the band of frequencies that begin at 17.8 MHz is called the 16-meter band (see Table 1). You'll note, of course, that as the frequency increases, the wavelength decreases.

The thing that makes shortwave listening so fascinating, however, is that under certain conditions a transmitted signal can be heard halfway around the world. That's because signals with frequencies below 30 MHz are reflected by the ionosphere. That phenomenon makes long-distance shortwave listening possible.

Because the ionosphere is strongly affected by the sun, the nature of that reflection—and hence, how far away the signal can be received—depends mainly upon the time of day and time of year. What that means is that not all frequencies are useful for broadcasting at all times. What's more, various factors can make conditions unstable even on a day-to-day basis. Radiation from the sun (more accurately, from sunspots) changes daily (and, on a larger scale, over an approximately 11-year cycle), adding uncertainty as to how well a signal will be received in a particular area. Signals may be strong on one frequency today, suffer from periodic fading tomorrow, and occasionally be almost inaudible. The last occurs especially during sudden ionospheric disturbances.

Broadcasters study radio-wave propagation carefully to help plan the times and frequencies for their broadcasts.

Equipped with predictions from propagation scientists, station planners may choose several frequencies in more than one band to make sure that a target area is adequately served during the season, no matter what the daily propagation variances may be. Then, even if they have correctly predicted the proper bands, they must hope that other broadcasters choose frequencies in those bands so that neither one interferes with the other. That is a far cry from the fixed-frequency allocations of our own AM and FM broadcast bands, which are strictly regulated by the Federal Communications Commission.

Tuning in

To help SWL's keep track of broadcaster's schedules, the *World Radio TV Handbook* (WRTH) is like an annual *TV Guide* updated three times a year by a subscription newsletter. The WRTH is the most comprehensive listing of radio and television stations from practically every country in the world. Included with each listing is the mailing address for each of the stations, many of whom have detailed schedules available on request.

Once you know the time and frequency of a program you'd like to hear, you'll need to tune your receiver precisely to that frequency. However, on many multiband radios with shortwave capability, the shortwave spectrum may be divided into only two or three sections. The tuning rates—how big a chunk of the spectrum is covered with a single revolution of the tuning dial—of those receivers are inadequate for the number of stations you can tune in one revolution of the dial.

Consider, for example, that the entire AM broadcast band (0.550-1.600 MHz) is slightly more than one megahertz wide, and takes up the entire width of the tuning dial. That makes for comfortable tuning, given the local station spacing of 30 kHz or more. But a tuning range marked SW1 on a portable radio may use the same tuning dial space to cram nine megahertz: 3-12 MHz is a common range and it includes four complete shortwave broadcast bands, where crowded nighttime conditions will often find stations within 5 kHz of each other. Just tuning from station to station requires surgeon-steady hands for turning the dial just a small fraction of a degree. And trying to find 11.750 MHz accurately with a tuning dial on which the pointer covers a third of the band is practically impossible.

Another drawback to those types of receivers is that they are not necessarily optimized for shortwave reception and are, therefore, not particularly sensitive to stations other than the powerhouses. Nor are their circuits selective enough to eliminate interference from strong stations on frequencies close to that of the desired station. Many of them also are unable to tune above 16 MHz, cutting listeners off from two daytime shortwave bands, 16 and 13 meters.

Today, however, You can buy portable shortwave radios that overcome most of those deficiencies, making shortwave listening more enjoyable for the casual listener. Less time is spent twiddling with the radio, and more time is spent listening to the program.

Today's receivers fall roughly into

TABLE 2—PORTABLE SHORTWAVE RECEIVERS

Type	Brand/Model No.	Price	LW	AM	FM	SW Coverage (MHz)
Pocket-sized	Panasonic *RF-085*	$ 89.95	N	Y	Y	2.3 - 18
	Sony *ICR-4800*	89.95	N	Y	N	5.95 - 6.2
			N	N	N	9.45 - 9.85
			N	N	N	11.70 - 12.00
			N	N	N	15.10 - 15.50
			N	N	N	17.60 - 18.00
	Sony *ICF-7600A*	159.95	N	Y	Y	5.95 - 6.20
			N	N	N	7.10 - 7.30
			N	N	N	9.50 - 9.80
			N	N	N	11.70 - 12.00
			N	N	N	15.10 - 15.45
			N	N	N	17.70 - 17.90
			N	N	N	21.45 - 21.75
Digital readout	General Electric *7-2990*	235.00	N	Y	Y	2.3 - 31
	Magnavox *AL999*	299.95	Y	Y	Y	1.6 - 26.2
	Panasonic *RF-2600*	239.95	N	Y	Y	3.9 - 28
	RF-2900	299.95	N	Y	Y	3.2 - 30
	RF-3100	319.95	N	Y	Y	1.6 - 30
	Sony *ICF-6500W*	199.95	N	Y	Y	3.9 - 28
	ICF-6800W	699.95	N	Y	Y	1.6 - 30
	CRF-1	1,795.00	Y	Y	N	1.6 - 30
	CRF-330K	2,495.00	Y	Y	Y	1.6 - 30
Microprocessor-controlled	Magnavox *D2924*	179.95	Y	Y	Y	5.95 - 15.45
	Panasonic *RF-799*	249.95	Y	Y	Y	2.3 - 26.135
	RF-6300	749.95	Y	Y	Y	1.6 - 30
	RF-9000	3,800.00	Y	Y	Y	1.6 - 30
	Sony *ICF-2001*	349.95	Y	Y	Y	1.6 - 30

TABLE 1—BROADCASTING BANDS

Meter Band	Megahertz
120	2.30 — 2.50
90	3.20 — 3.40
60	4.75 — 5.06
49	5.95 — 6.20
41	7.10 — 7.30
31	9.50 — 9.78*
25	11.70 — 11.98*
19	15.10 — 15.45*
16	17.70 — 17.90*
13	21.45 — 21.75*
11	25.60 — 26.10**

*This band will be expanded in the late 1980's or early 1990's.

**This band will be decreased in the late 1980's or early 1990's.

The Magnavox model *AL999*.

G-E model *7-2990* six-band portable.

Size (inches)	Wght.	BFO	Wide/Narrow Filters	Dual Conversion	Tuned RF Amplifier
4 7/16 × 6 15/16 × 1 1/4	17 oz	N	N	N	N
2 15/16 × 5 1/4 × 7/8	8 oz	N	N	N	Y
4 5/8 × 7 1/8 × 1 1/4	22 oz	N	N	Y	Y
14 5/8 × 10 3/4 × 6	8 lbs	Y	Y	Y	Y
13 × 9 × 4 1/4	8 lbs	Y	Y	Y	Y
9 3/8 × 13 1/2 × 4 9/16	7lbs, 4oz	Y	Y	Y	Y
9 11/16 × 15 × 4 3/4	8lbs, 10oz	Y	Y	Y	Y
4 3/4 × 14 9/16 × 9 1/2	7lbs, 1oz	Y	Y	Y	Y
6 1/2 × 11 3/8 × 4	4lbs, 1oz	Y	N	Y	N
7 1/4 × 17 7/8 × 9	13 lbs	Y	Y	Y	Y
10 1/4 × 4 × 13 1/8	14lbs, 9oz	Y	Y	Y	Y
13 1/2 × 17 3/4 × 8 1/8	33lbs, 15oz	Y	N	Y	Y
9 1/4 × 6 × 2 1/4	5 lbs	N	N	N	
6 9/16 × 10 15/16 × 2 5/16	3lbs, 7oz	N	N	S	Y
11 7/16 × 17 1/8 × 5 3/16	11lbs, 7oz	N	N	Y*	Y
20 9/16 × 14 5/32 × 8 1/32	50lbs, 11oz	Y	Y	Y*	Y
6 3/16 × 12 13/16 × 2 3/16	4lbs	Y	N	Y	Y

*For most shortwave bands, single conversion for others.

three categories: sensitive pocket portables with analog (slide-rule) tuning; those with simple digital frequency readouts, and those with microprocessor-controlled phase-locked-loop (PLL) tuners. Table 2 lists some of the units currently available.

Shirtpocket shortwave

Among the small shortwave portables, Sony's *ICF-7600A* is a good example of an easy-to-use receiver even though it features an analog, rather than digital, tuning-system.

The receiver covers the local AM and FM bands, plus seven shortwave bands from 49 to 13 meters in a most useful way: Each shortwave-broadcast band has its own tuning range. That spreads out the stations within a given band so that tuning is not so critical. Moreover, you are better able to tune to a specific frequency with the help of dial markings spaced every 50 kHz.

The receiver covers the 49- through 11-meter bands. That coverage, plus a bit of tuning above and below those ranges, includes most of the English-language stations you'll want to hear. Some broadcasts, however, like Radio Peking's clear frequency of 15.52 MHz (one of several frequencies) and a growing number of stations above 12.0 MHz, are outside the internationally agreed bands, and the tuning range of the unit.

Miniaturization plays a big role in the circuit design of that small receiver. Each shortwave band has its own crystal oscillator for tuning stability. It uses dual-conversion (two intermediate frequencies) superheterodyne circuitry on shortwave for good sensitivity and to help reduce unwanted images from interfering with the station you want to hear—a common problem in small portables. It also features a tuned RF amplifier to help insure that the best possible signal-to-noise ratio is obtained. There is even a ceramic filter to help limit interference from stations on adjacent frequencies, thus improving selectivity. While the performance of a radio its size—even with all its "big radio" features—won't measure up to table-model standards, that receiver holds its own rather well against many of the receivers listed in Table 2.

The *7600A's* little brother, the Sony *ICR-4800* is one of the smallest portable shortwave receivers available, measuring 5 1/4 × 2 15/16 × 7/8 inches. It features Am broadcast and five shortwave bands: 49, 31, 25, 19, and 16 meters, the ones most popular with broadcasters. The tuning range of some bands is a little wider than that offered by the *ICF-7600A*, making it possible to pick up more of those broadcasters who are slightly "out of band."

What neither of those receivers can tune, however, is the standard time signal station, WWV, a service of the National Bureau of Standards in Ft. Collins, CO. Usually audible on 5, 10, 15, and 20 MHz, a voice announces the time (with atomic clock accuracy) on the minute, plus severe ocean-storm warnings and radio-propagation forecasts at appointed times during the hour. The paperback-book-sized *RF-085* from Panasonic does allow you to receive WWV as it provides continuous tuning from 2.3 to 18 MHz (120 to 16 meters) over three bands. But, although it is remarkably sensitive for its small size, a beginning SWL may find the cramped and inexact shortwave band tuning a bit frustrating at times.

With those small radios—all of them wonderful travel companions—you'll have adequate signal quality under most conditions with the built-in telescoping antennas. Reception can often be improved by placing the radio as close to a window as possible, or by adding an external antenna, as discussed later.

Digital readout

Another recent advance in portable-receiver technology is the addition of digital frequency-readouts to assist in tuning. The units offering that feature are anything but pocket sized, yet once you've experienced the convenience of such a readout, you won't want to return to the analog style unless you need to travel very light. With the digital display, there is no guessing whether you have the correct frequency. If you know that Swiss Radio International begins transmitting in English on 9.725 MHz at 0145 Greenwich Mean Time (8:45 pm EST), then

Panasonic's model *RF-085* five-band receiver.

The Sony nine-band *ICF-7600A*.

simply dial up 9.725 on the readout a few minutes before, and you'll be ready for the start of their broadcast. Digital-readout receivers are available with vacuum fluorescent displays (which consume a lot of battery power but can usually be turned off when not needed for tuning), or liquid crystal displays (LCD's). The latter require a backlight for viewing under low-light conditions.

General Electric's *7-2990* is a new receiver in this category. The GE receiver offers AM, FM, and four bands of shortwave tuning giving you continuous coverage from 2.3 to 31 MHz. That means you can hear all shortwave broadcast bands as well as amateur radio and commercial bands. Frequency can be read on either an analog- (slide-rule type) or vacuum-fluorescent digital-display. In that receiver, as in others in its class, the digital readout is provided by adding a frequency counter (with some modifications) to a standard analog shortwave receiver. An SW CALIBRATOR control on the front panel helps you align the receiver and the counter by tuning to a frequency standard like WWV.

The unit features dual conversion as well as a tuned RF amplifier. Another control you'll notice on that type of receiver is a WIDE/NARROW bandwidth switch. The intent of a narrow bandwidth is to reduce the amount of interfering signals on either side of the desired signal from reaching the speaker or headphones. Ideally, a narrow setting should keep out extraneous signals. But in practice, portable-receiver bandwidth filters are generally not as effective as those used in more expensive table radios. The wide setting may be fine for local AM stations with their healthy frequency spacing between stations, but is impractical for tightly spaced shortwave stations. Among today's portables, the *Sony CRF-1* has the most effective narrow bandwidth, according to specifications, but its price is out of reach for many.

The Panasonic *RF-3100* is one of a new generation of portable receivers. Adapting a technique used in expensive table-model communications receivers, the unit features PLL frequency synthesis—a sign of a very stable tuning section. Even solid-state receivers can be unstable and drift off their original frequency, particularly during the first 10 minutes of operation. They may also suffer from mechanical instability—just lightly tapping the receiver case with a finger will make the unit change frequency. But a PLL synthesized tuner "locks" onto the desired frequency. Nowhere is that more appreciated than when tuning single sideband (SSB) amateur radio or commercial stations. Successfully tuning those stations requires that the receiver's beat frequency oscillator (BFO) be engaged and tuned to the signal's natural voice pitch. The slightest drifting will raise or lower the voice's pitch beyond intelligibility.

To tune, say, 15.260 MHz on the *RF-3100*, you first turn the rotary BAND switch to the 15-MHz band, and then tune the large tuning knob until the last three digits on the display read 260. The tuning range is divided into 29 one-megahertz bands, plus AM and FM. Sometimes, as when you're just tuning through the spectrum to see what you can pick up, that one-MHz stepping can be just a little inconvenient because, if you want to tune continuously, you must whirl the tuning knob back to the beginning of the band every time you increment from one range to the next.

The *RF-3100*, like many other portables its size, comes with a soft shoulder strap for the SWL on the go; it can be removed if the receiver stays mostly at home.

Computerized shortwave

The third type of portable receivers we will discuss takes the concept of PLL tuning a step farther. In those, microprocessors control the PLL circuit. The tuning knob, as we've known it, doesn't even exist. Instead, pushbutton keyboards let us "punch in" the frequency we want to hear. If we want to casually tune up or down the band looking for stations, we just push an appropriately marked button and the synthesizer will step up or down in frequency under microprocessor control until the button is released. The microprocessor can also store favorite frequencies in memories; those can be instantly recalled by just pressing a button.

The first affordable pushbutton shortwave was Sony's *ICF-2001*. More recently, Panasonic and Magnavox have added "smart" portables to their shortwave lines.

The Magnavox *D2924*, though offering only limited shortwave band coverage (49 through 19 meters), has a number of features useful for the shortwave neophyte and veteran as well. The radio has essentially four broad bands: longwave, AM, shortwave, and FM, each selected by pushbutton. In the shortwave mode, each press of the SW SELECTOR button puts the receiver at the lowest frequency in one of the five international broadcast bands. An indicator on the LCD display shows which band you're tuned to. From the bottom of each band, you can either tune up or down in steps with the corresponding manual tuning buttons, or have the receiver search the band for a strong signal. Pressing SEARCH silences the receiver's audio as the radio's frequency display shows where it's tuning. If a strong signal is detected, scanning stops on that frequency, and the audio is restored. If the station is not what you want to hear, press SEARCH again, and the tuner will quietly continue up the band. When it reaches the top band edge, it re-starts the search from the bottom. If no signals are found, the receiver searches twice more, just in case a station had briefly faded out when the tuner first raced by. If no signals are heard after three passes, the receiver then goes back to the lower band edge, awaiting further instructions.

Just because no strong stations were found in the SEARCH mode, doesn't necessarily mean there aren't weaker stations on the band that could be tuned manually. But for inexperienced listeners, using the SEARCH mode is one way to hear a variety of signals without a lot of extraneous signals to distract you along the way.

If, on the other hand, you know what frequency you want to tune, simply press KEYBOARD (which tells the microprocessor that you're about to enter a frequency on the keyboard) and key in the frequency. With the *D2924*, you can also store up to six frequencies from any band in the radio's memories using a simple two-button sequence. When you're tuned to one of the stored frequencies, the memory number appears on the LCD display along with the frequency. With receiver memories, you can switch instantly back and forth among broadcasters transmitting on different bands at the same time. Of if you have a set sequence of programs

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SOURCE LIST

General Electric Company
Audio Electronics Products
Syracuse, New York 13221

Magnavox
N.A.P Consumer Electronics Corp.
I-40 & Straw Plains Pike
Knoxville, Tennessee 37914

World Radio TV Handbook
c/o Watson Guptill
1515 Broadway
New York, New York 10036

Gilfer Shortwave
Box 239
Park Ridge, New Jersey 07656

MFJ Enterprises, Inc.
921 Louisville Road
Starkville, Mississippi 39759

Sony Corporation of America
Sony Drive
Park Ridge, NJ 07656

Panasonic
One Panasonic Way
Secaucus, New Jersey 07094

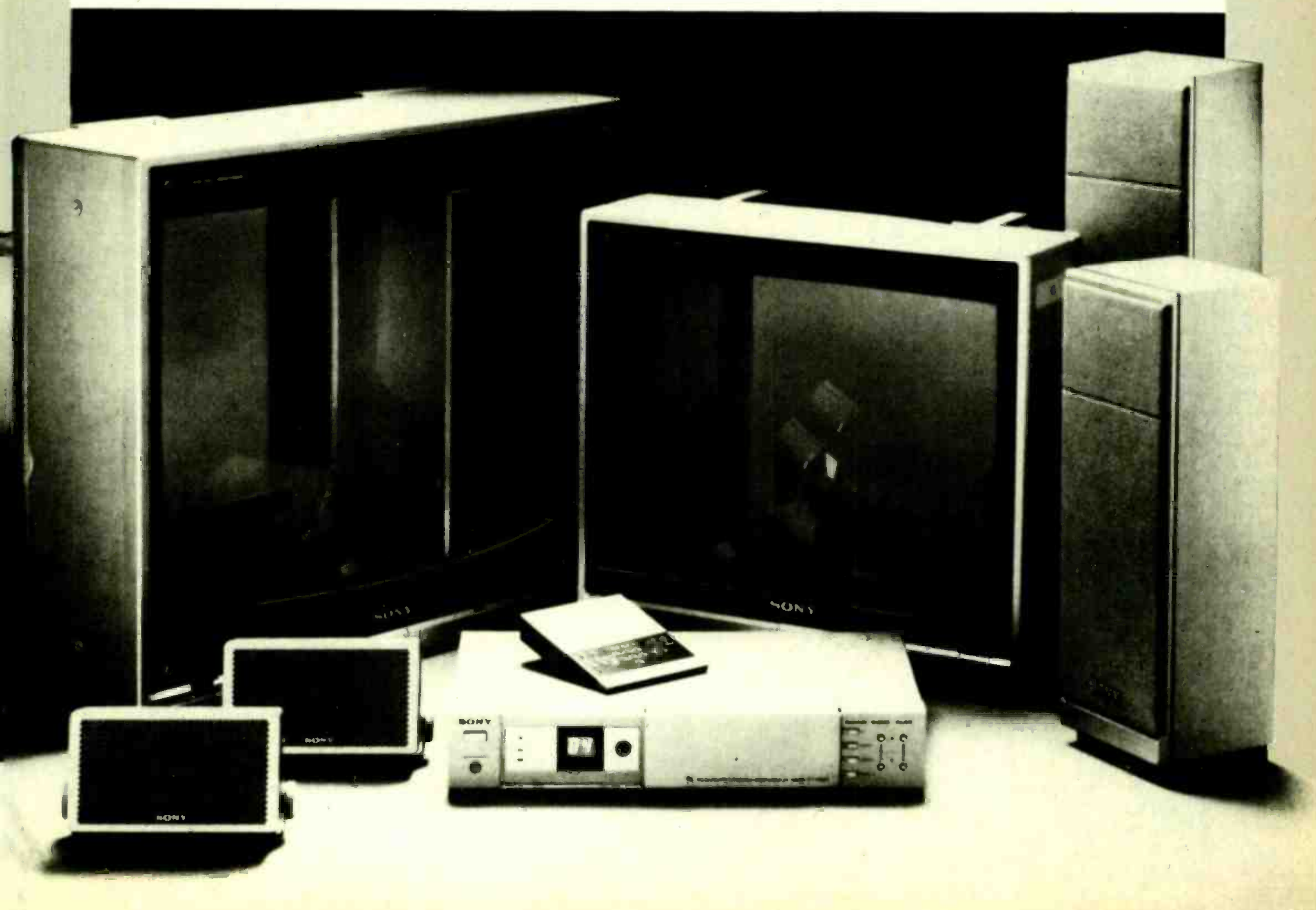
VIDEO ENTERTAINMENT

VIDEO ENTERTAINMENT IN THE HOME—the consumer electronics revolution has changed the way we look at and use television!

NEW VIDEO COMPONENTS—from sizes like gigantic to tiny, new video packages are emerging for your indoor and outdoor viewing pleasure wherever you are!

VIDEO ACCESSORIES—no longer do you have to settle for snow and picture jitter—bring out the best in videotapes you play!

HOW TO CONNECT VIDEO COMPONENTS—with a small amount of technical knowhow and inside information on video gadgets—TV can still be fun!



VIDEO ENTERTAINMENT

The video revolution has changed the way we look at and use television. But has your set kept up, and will it keep up in the future? The following will help answer that question.

A. LEVIS

IT WAS ALL SO SIMPLE BACK IN THOSE EARLY DAYS OF VIDEO, BEFORE SONY'S *Betamax* and Atari's *Pong* began to change the way we viewed the lowly TV set. In that ancient era, which began drawing to a close in the early 1970's, video simply meant television. The only choice one faced when shopping for video equipment was whether or not to blow the entire budget on that huge 25-inch console.

Unless you've been asleep these past few years, you know that those days are most certainly gone for good. Walk into any video store or department and you are likely to see VCR's (*V*ideo*C*assette *R*ecorders), videodisc players, projection televisions, television-component systems, VCR and cable-TV accessories, and perhaps even a complete satellite-TV earth station. You're also likely to find a great many computers and video games; we'll not say much about those products in this section, but you can be certain that the next year will feature the kind of new products and exciting advancements we've all now come to expect. What we will be looking at is video—the latest developements in the field, as well as what the near future holds. But first, let's look at what our old family TV-set has grown into, and why.

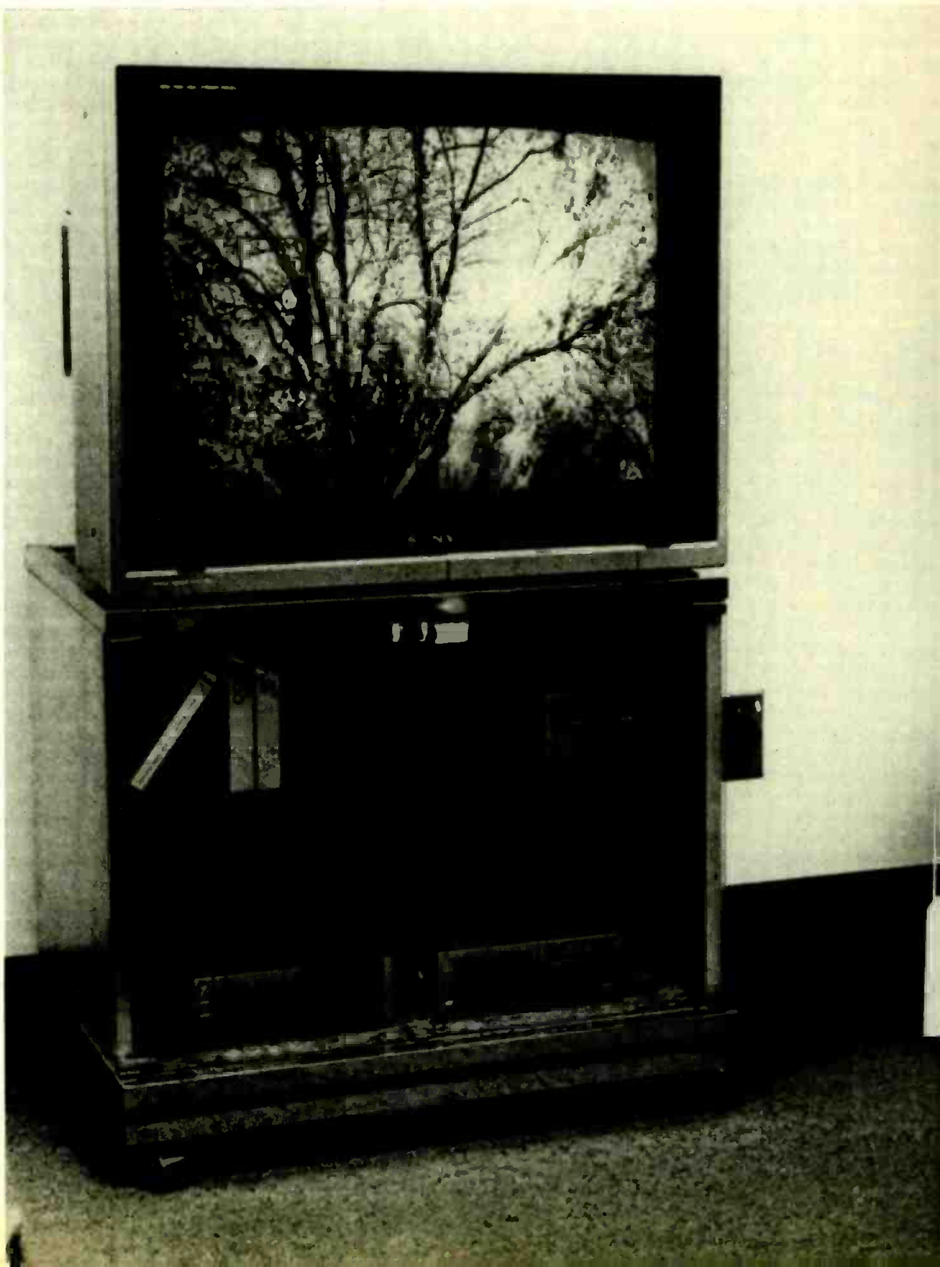
Alternative programming

In the old days, television "quality" generally referred to a set's reliability rather than to the kind of image it reproduced. After all, few consumers would have been willing to lay out the extra dollars for such things as high resolution—even if the manufacturers had been capable of producing sets with such features—just to watch the generally low-quality fare offered by the networks.

That began to change with the advent of cable-TV services such as Home Box Office. That service, and others like it, offered viewers a real alternative in the form of recent movies, live sports events, and specials.

The real beginning of the so-called video revolution, however, began with the introduction of the VCR. That device gave the viewer almost complete programming control. Today, programming can be drawn from a vast array of pre-recorded videotapes, including the very latest movies (sometimes the videotape is released simultaneously with the movie's premiere); from both free (broadcast) and pay-TV services, or can be original—the video camera allows your video programming to be limited only by your imagination. For those who demand the very best, there are now video accessories that help clear up many picture, color, and stability problems; we'll take a closer look at those elsewhere in this section.

A relatively new program source is the videodisc. Although those devices lack the recording capabilities of the VCR, and have not proven as successful in the marketplace as was predicted, there is still considerable hope that it will succeed as an alternative program source. Among its advantages are its lower initial outlay, as compared with a VCR, and its potential for use with a computer.



IN THE HOME

Currently, satellite-TV reception is out of reach to all but a few. That too is about to change as an exciting new service, direct broadcast satellites, will be in place by the end of this decade. Aside from being yet another source of alternative programming, it may also offer such attractive features as high-definition TV and stereo sound.

A new kind of TV

Although TV set manufacturers were slow in responding to the explosive growth of alternative programming and video-related products, they soon realized that their product was destined to become the centerpiece of a sophisticated, highly complex, and demanding electronic home information and entertainment system. They also realized that the conventional TV-receiver was inadequate for that purpose. There were many reasons for that, but among the most important was the way a signal is fed into the receiver. Up to recently, the only signal that the TV was required to handle was a combined over-the-air audio/video RF signal; that signal was simply fed into the set through the antenna terminals. Once inside, the RF signal was demodulated, with the video information extracted and displayed on the screen. The result of that process was degradation of the signal that showed up as poor resolution, video noise, and the like.

With some recent exceptions, that's exactly how it's still done. But now, as we pointed out before, the TV set is being called upon to handle the audio and video information from a variety of sources. Those signals are still fed in through the set's antenna terminals, and on an RF carrier. As a result, that same modulation, demodulation, and extraction process still causes significant signal degredation. And what may have been acceptable for watching your favorite soap opera certainly is not when dealing with computer-generated graphics, videotapes, videodiscs, etc.

The standard television set also fails in another important area. The audio quality of most sets is poor. And while high-quality audio may not be particularly important for getting the most out of your video game or computer, some things that should happen in the near future will make TV audio more important than it has ever been before. One of those is multichannel, or stereo, TV-audio. Such audio has been available in Japan for many years now, and last year was introduced in West Germany. In both cases, the set manufacturers were prepared and had sets on the market by the time the service was approved. In this country, three TV-stereo systems have been proposed; as this is written, though, no commitment has been made to any of them, so neither we, nor the set manufacturers can be certain of which standard(s) will eventually receive acceptance. In the meantime, however, VCR's and videodisc players with stereo-audio capability are already on the market.

But help is on the way, thanks to a new generation of TV equipment designed to meet the high requirements of new and future video technology, and to be the centerpiece of that home-entertainment/information center of the future. The age of component television is here.

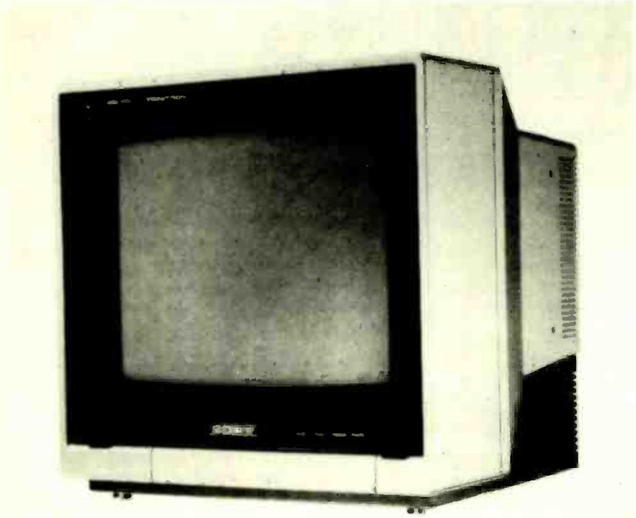
The term component television is currently used to refer to a wide range of products. In the past year, many of the leading set manufacturers, and some manufacturers that previously had dealt with audio products only, have introduced at least a few models designed to solve some of the video and audio problems we've mentioned. In some cases, they've simply taken an existing TV chassis and added separate audio and video input jacks. Doing that allows direct access to both video and audio circuits, getting rid of many of the problems associated with feeding an RF signal to the set. That helps, but you're still stuck with a receiver with limited flexibility, and limited growth potential.

A better alternative is the true component approach. Systems of that type were first available last year from Sony (1 Sony Plaza, Park Ridge, NJ 07656) and Teknika (1633 Broadway, New York, NY 10019); now they are available from a variety of manufacturers. Those systems are by no means identical, and each manufacturer has its own idea as to how a component system should be configured. For instance, some offer a seperate amplifier and monitor while others offer a combined package. Also, in some the tuner doubles as a switcher while in others those functions are handled by separate components. Since you now have a bit to choose from when picking your component system, it's important to match your needs to what's available.

THIS NEW VIDEO-COMPONENT SYSTEM from Jensen offers a choice of tuners either with (shown) or without AM and FM-stereo.

What's available

The *Profeel* system from Sony remains unchanged from last year except for the addition of a new 12-inch monitor to the series. Like the larger 19- and 25-inch *Profeel* monitors, this one boasts good video resolution and offers an RGB (*R*ed, *G*reen, *B*lue) input. While currently that input will only be of interest to some computer hobbyists, it is hoped that will change with the eventual availability of RGB outputs on consumer video equipment. The main advantage of an RGB input is that it allows you to bypass all of the signal processing stages in the receiver. The RGB signals are fed directly to CRT grid amplifiers. For the time being, however, such outputs are available only on professional equipment.



THE NEWEST ADDITION to the *Profeel* line, is the model *KX-121HG* showh here. Like all *Profeel* monitors, it boasts RGB inputs.

Sanyo (1200 W. Artesia Blvd., Compton, CA 90220) enters the field with their *Pro-Ponent* system. It features a 19-inch monitor with a built-in 5-watts-per-channel stereo amplifier, a separate TV-tuner with remote control, a companion stereo-audio sound system, and a pair of accessory speakers. The tuner has multiple inputs designed to accept a wide variety of sources (VCR, videodisc, etc.).

Zenith (1000 Milwaukee Ave., Glenview, IL 60025) was the first U.S. manufacturer to offer a component TV system. It includes a 19-Inch monitor, TV tuner, a separate source-selector, a separate stereo-amplifer, and speakers. The monitor also has its own built-in audio amplifier and speaker and features both composite-video/audio and RGB inputs. The source selector allows the connection of up to six sources to the system. The tuner features an infra-red remote control and has 112-channel capability, including 42 for cable TV.

Several high-fidelity audio-component manufacturers have also come out with systems. Pioneer (200 West Grand Ave., Montvale, NJ 07645) is offering two screen sizes, 19- and 25-inches, with the larger monitor offering 400-line resolution, which is the highest claimed by any manufacturer. The tuner is housed separately and features 127-channel capability and an infra-red remote control; the tuner also serves as the system's source selector, handling all of the switching functions.

Jensen (4136 N. United Parkway, Schiller Park, IL 60176) has a new entry that offers the consumer an additional choice. While many manufacturers are marketing systems with more than one monitor size, Jensen is marketing two tuners—one for AM and FM-stereo as well as TV, and one with TV capability only.

Even some smaller companies are getting into the act. NAD (675 Canton St., Norwood, MA 02062) and Proton (1431 Ocean Ave., Suite B, Santa Monica, CA 90401) are marketing systems built around the same 19-inch monitor, but will sell them through different outlets.

Component-TV systems are also available from Mitsubishi (7045 N. Ridgeway Ave., Lincolnwood, IL 60645), JVC (41 Slater Drive, Elmwood Park, NJ 07407), and others. And you can be sure that the list will grow considerably in the near future.

The future of video

Will your new video-entertainment/information system soon become obsolete? The answer to that is yes and no. No, because the U.S. is almost certainly tied to the 525-line NTSC broadcast standard for many years to come, although just about everyone involved with the technical end of the television industry—from broadcasters to set-makers—agrees that it is less than perfect. (For one thing, the resolution of current sets is not limited by technology, but by that standard.) Yes, because there are several developments that may soon result in higher definition television, with signals compatible with the NTSC standard.

Work is continuing on high-definition TV (HDTV), with much of it concentrating on developing a system that is NTSC compatible. RCA, for one, is involved in an intensive NTSC-compatible HDTV project, and believes such a system can be operational within this decade.

Another thing to look forward to is the arrival of digital TV. ITT in Europe is scheduled to begin offering set makers digital-circuit kits sometime next year, and such international companies as RCA, Sanyo, Philips of Holland, Sharp, Blaupunkt and Thomson CSF are involved in intensive research and development projects in that area.

But one of the chief advantages of a component system is its adaptibility. It's relatively easy to modify your system to keep in step with the latest changes in technology, or your needs. So, don't let what's coming tommorrow spoil your fun today. R-E

NEW VIDEO COMPONENTS

From the looks of things, the video revolution is nowhere near over. Here's what's new in home-entertainment equipment, and what to expect in the next couple of years.

DANNY GOODMAN

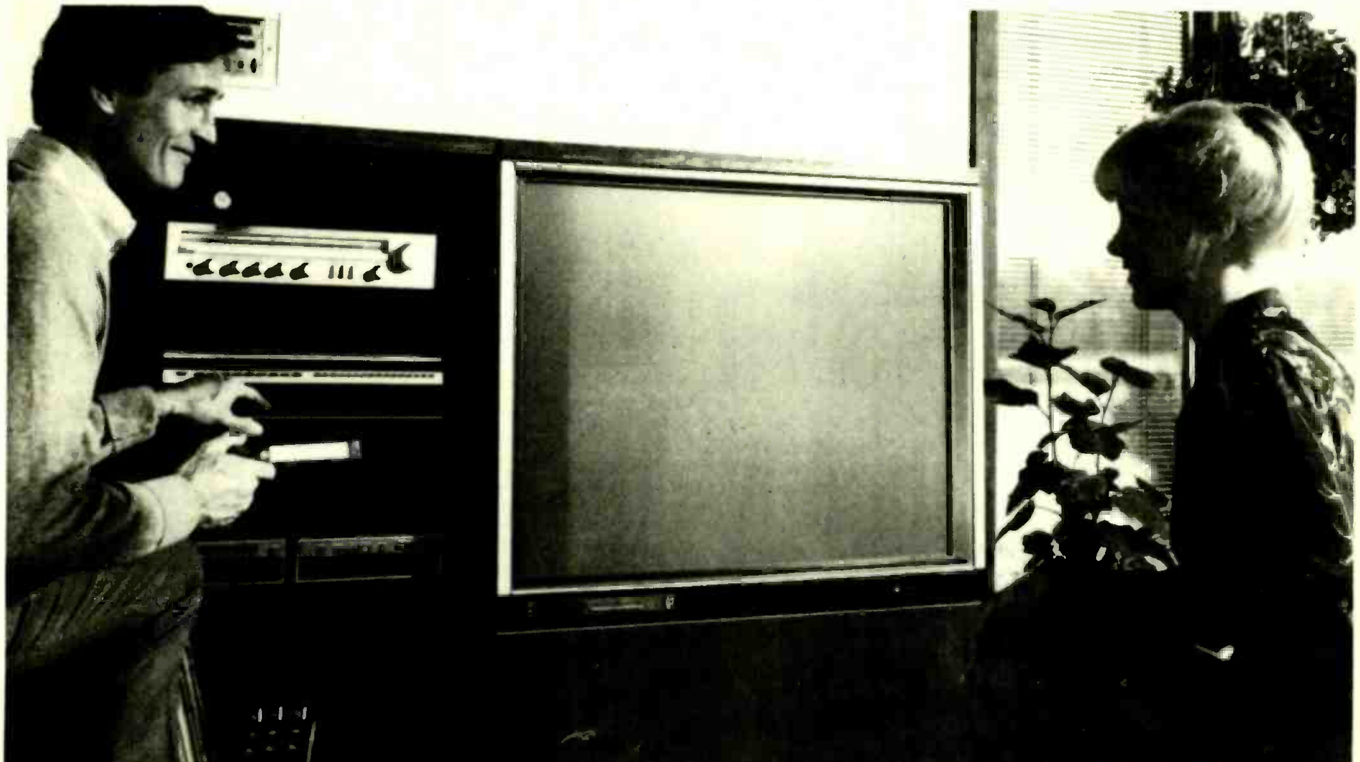
IN THE LAST FEW YEARS, WE'VE SEEN THE INTEREST AND activity in video grow at an almost explosive rate, and there is no sign of that letting up. Consider, for instance, that VCR's continue to sell briskly; pre-recorded videotape rentals are way up; and, according to an RCA estimate, those who own videodisc players also own, on the average, a library of about 30 discs. It's also expected that video camera sales in 1982 may double those of the previous year.

Manufacturers of home video equipment are very much aware of the consumer's love affair with video. They continue to produce better performing, more advanced equipment in new shapes, sizes, and concepts—all designed to lure more of us into the video picture. And, from the looks of the trend-setting video innovations already here and expected soon, they're likely to succeed.

Hi-Fi VCR

Stereo-audio for broadcast TV is still only in the planning stage in the U.S., but the absence of a broadcast standard isn't preventing stereo from being included in several home videocassette-recorders. For now, stereo is limited to the upper end of the VCR price scale. In the VHS format, for example, top-of-the-line models from Panasonic (*PV-1780*), JVC (*HR-7650*), Quasar (*VH5623UW*), and General Electric (*1VCR3018W*) all feature stereo-audio inputs and outputs, including Dolby noise reduction. As high-end models, costing roughly $1500 to $1600, those units also have the deluxe special effects features and remote control offered on last season's expensive recorders. In the Beta format, Marantz has a home deck, the model *VR200*, with stereo and *Dolby C* noise reduction. That deck lists for $1295.

Although there are few pre-recorded stereo-videocassettes currently available, there are other possible sources for two-channel audio, including FM simulcasts of TV concerts, stereo videodisc players, and your own dubbing. But, as stereo VCR's become more popular, you can be sure that much more pre-recorded material will become available. The quality of the audio, howev-



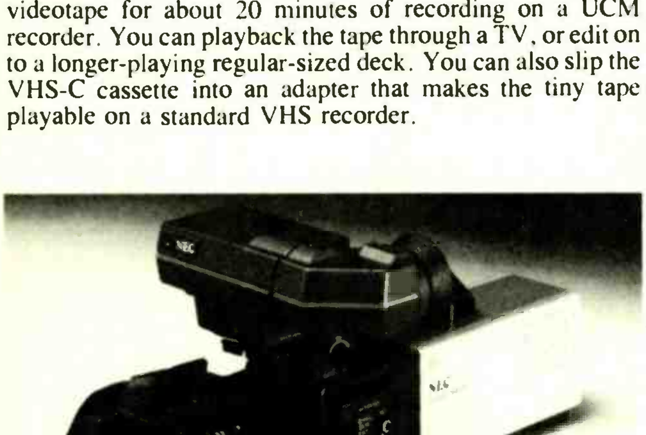
er, may not measure up to what you might expect from a hi-fi tape recording. The audio tracks on videotape are narrow, and the tape speed relative to the fixed audio tape-heads (ranging from 1.31- to 0.44-inches-per-second depending on format and selected speed) is slower than an audio cassette's 1⅞-inches-per-second. But if the stereo is played through a hi-fi amplifier and speakers, it will provide a spatial feeling and left-right separation that you can't get from any of the TV stereo-audio adapters currently on the market. And stereo isn't just limited to the home—a new portable VHS-format VCR, the JVC *HR-2650*, lets you record your own stereo material in the field. That unit sells for about $1150.

Finding stereo in such compact recorders is not surprising considering that the trend in new portables is to equip them with as many features as the stay-at-home models. Today, the full-featured portable essentially breaks the home VCR's tape playing and tuning/timing elements into separate, mobile components. That arrangement offers the most in flexibility, since the VCR system can be a compact portable-recorder for remote taping with the addition of a camera, but can also act as a sophisticated home deck with such features as infrared remote control, multi-day/event time-shift programming, and special effects.

The lightweights

The race is on in the industry to see who can develop the smallest and the lightest VCR. Sony's *SL-2000* ($1150) and the Zenith *VR-9800*, which is sold with its companion tuner for $1425, are the lightest Beta portables, weighing just 9.5 pounds. But several lighter (8.5 pounds) VHS-portables were recently introduced; those are built on the same Matsushita chassis and carry brand names like Magnavox, Panasonic, Quasar, General Electric, and Canon. Those units range in price from about $750 to $1500. The high-end models are full-featured VCR's that include, among other things, 14-day, 4-event programmable tuner/timers.

An intriguing new portable VCR was announced this year; it was developed by JVC and is called the *U*ltra *C*ompact *M*achine, or UCM for short. It is just what the name implies. Though not yet available, Sharp has demonstrated a model of that machine, the *VC220*, which weighs just 5.8 pounds, including battery, and measures approximately 7 × 2¾ × 9¼ inches. The key to the UCM is the *VHS-C* ("C" for compact) format cassette. About the size of a pack of cigarettes, a *VHS-C* cassette contains enough ½-inch videotape for about 20 minutes of recording on a UCM recorder. You can playback the tape through a TV, or edit on to a longer-playing regular-sized deck. You can also slip the VHS-C cassette into an adapter that makes the tiny tape playable on a standard VHS recorder.



SOLID-STATE IMAGE SENSORS, such as the one used in this NEC *TC-100* color camera may eventually replace the cumbersome and power-hungry image tubes of today.

Many more home video-recordists are eagerly awaiting the all in-one camera-recorders currently under development by several Japanese companies. Those companies are working toward a uniform ¼-inch videotape standard to help avoid another battle such as the one over the Beta/VHS format. But the way things are going, even if a standards agreement is reached in 1983, it may be 1985 or later before finished products reach the store shelves.

Still looking to the future, most of you are probably familiar with the ¼-inch VCR format—CVC—from Japan's Funai Electric. In the U.S., their small, five-pound portable recorder is sold by Technicolor. But an even smaller recorder, using the same CVC format, will be marketed in the U.S. in 1983 by Grundig. Grundig, a popular brand in Germany, has been selling their five-pound *VP-100* successfully in Europe. It measures only 4¼ × 2¾ × ½ inches and can be easily mistaken for a portable audio-cassette player; among its features are variable speed and freeze frame.

Lights, camera...

The producer and director in us all will appreciate the features found on advanced color cameras. General Electric's two newest cameras, for example, both feature automatic focusing, relieving the cameraman of that chore. The more expensive of the two, the model *1CVC3035E*, which sells for $1350, uses a *Newvicon*-style pick-up tube that is designed to reduce "picture lag"—the tendency of an image to persist, thus streaking when the camera pans away from it. In addition, a control panel on the camera gives the operator fingertip command of fade-in/fade-out between scenes, and a built-in character generator capable of adding titles of up to 60 characters.

An exciting bit of news is the development of advanced solid-state imaging devices. Those, it is hoped, will eventually replace the power-hungry and cumbersome image tubes found in most of today's cameras. The heart of Hitachi's *VK-C2000* color camera, for instance, is a one-IC MOS image-sensor. That sensor, which is about the size of a postage stamp, consists of wafers of color filters over an intricate grid of semiconductor material. The material appears to be impervious to the burn-in that many cameras suffer when the lens is directed at a bright light. With its electronic viewfinder, the compact camera weighs only 3¾ pounds, but carries a heavy price tag—about $2,000.

Another type of solid-state image sensor is a CCD (*C*harge *C*oupled *D*evice). NEC, for one, is currently developing a CCD color camera. The CCD in that camera will consist of a mosaic of 384 × 490 picture-elements and is expected to produce 250 horizontal lines of resolution. And, while the cost of cameras with solid-state image sensors will initially be very high, as manufacturers find ways to produce those sensors more efficiently, that cost should drop significantly.

For the do-it-yourself recordists, several new accessories can be very helpful for producing more varied programming. Although converters that let you videotape 35-mm slides for home-spun travelogues have been available for some time now, Sony has introduced a more advanced version, the *HVT-3000* ($179.95), that gives you the option of doing the same with print film negatives when used with their *model HVC-2400* ($1250) color camera. That camera converts the negative images to positives before they're recorded using a standard color video-camera.

More dramatic and professional productions can be done using Sony's new *HVS120K* special-effects kit, which consists of a model *HVS-2020* black-and-white camera, model *HVS-2000* special-effects generator, graphics aids, etc. If the kit is used with a color VCR-camera, you can superimpose either titles and graphics (from a six-color palette), or any image from the black-and-white camera, over the color-camera image. A slide-control fades titles in and out for quite a professional look. The generator also lets you alter color keying (up to six different colors), which can make for some interesting "sci-fi" footage—as does electronic black-and-white reversal. The kit, which should be available by the time you read this, is expected to sell for around $550.

Anyone with real creative talent will want to be first on the block with the *Video Scribe* electronic color-video titler ($795), from Comprehensive Video Supply Corporation. You can be a real artist, using the device's 80 letters, numbers, and graphic elements, all addressable by a flat-membrane keyboard, to draw colorful titles and animation sequences in 8 colors—red, green, yellow, blue, buff, powder blue, orange, and magenta. Graphic output goes directly to the video input of your VCR.

Videodiscs

Videodiscs aren't generating all of the excitement they did about a year ago, but the two current formats, RCA's CED and Philips' LaserVision optical format, have been making some news as more consumers are selecting videodiscs as an alternate program source.

New on the scene are stereo CED players from RCA, Toshiba, and Hitachi. RCA now offers two stereo models, both of which contain CX noise-reduction decoders (stereo CED discs are CX encoded). The top-of-the line *SGT250* sells for about $449. That model features infrared remote control and an automatic start function, which replaces the front-panel control lever. Toshiba offers a $90 accessory that allows owners of their monaural CED-players to get the full benefit of CX-encoded stereo discs.

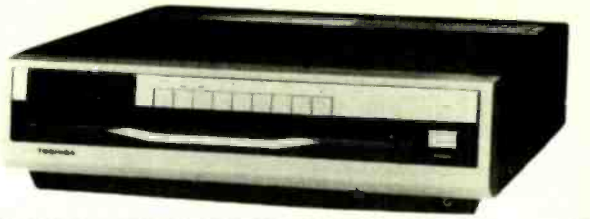
The LaserVision group also has chosen CX noise-reduction. Two North American Philips companies (Magnavox and Sylvania) have newly styled stereo LaserVision players, featuring remote controlled random frame-access and special effects. Those players sell for about $750 and are made for N.A.P. by Pioneer.

LaserVision backers are still looking toward the future with the knowledge that their optical videodisc-players can be more than simple playback devices. North American Philips (Magnavox and Sylvania) has been demonstrating how their players can be used interactively with home computers. Interfaces exist now that allow computers like the *Apple II* and Texas Instruments *TI-99/4A* to control a videodisc player's search and frame-access functions. Soon, we're likely to see very realistic video-game-type interactive video based on such a setup. The use of a videodisc will allow for realism unmatched by any other home or arcade game.

Video separates

With all of the new video sources available, you need something to use for display. That display device is, of course, your home television set—but even it is undergoing some major changes. For one thing, more and more sets are including separate video and audio input jacks in addition to the antenna-input terminals. Previously, the video and audio signals from a VCR or other video source had to be fed into an RF modulator, with the modulator's RF-output fed to the set's antenna terminals. The set would then demodulate the RF signal to extract the audio and video information. The addition of the separate audio and video inputs skips all of those steps and eliminates the losses caused by them.

Even more significant, however, is the trend toward video separates or components. In a component TV-system, the TV set is broken up into separate units; just how it is broken up varies from manufacturer to manufacturer, but often the the system is made up of a separate video monitor, tuner, controller/switcher, and speakers. The monitors used in component TV-systems are capable of high-quality displays, but there is a premium to pay for that quality, and for the flexibility that those units can offer. For instance, Pioneer's *Foresight* 19-inch monitor lists for about $850, while their 25-inch monitor lists for $1500; the companion tuner for those lists for about $500. Also, you should bear in mind that



AMONG THE FEATURES of this *VP-500* CED videodisc player are stereo audio and CX noise reduction.

the displayed video can only be as good as what is input.

But, on the positive side, with a component approach to video you have the flexibility to build your system one piece at a time. With Sanyo's *Pro-Ponent* series, for instance, you can start with their model *AVM195* 19-inch monitor ($600) and their model *AVT95* tuner/controller ($400). The audio outputs can be fed to a separate stereo audio-amplifer and played through stereo speakers; the monitor also has its own built-in five-watt-per-channel stereo amplifier.

Zenith takes the component approach a bit farther. In its *Hi-Tech* system, all of the components feed into a central source selector, the model *CV-540*. That is one system in which the tuner and selector are separate units. The tuner here, the model *CV-510* lists for $279.95, and features an infrared remote control. Getting back to the source selector, that $169.95 component can accept up to six video and audio inputs. The video inputs and mono audio-inputs are routed by the selector to the system's model *CV-1950* 19-inch monitor, which lists for $469.95; stereo audio-inputs are routed to a 20-watt-per-channel stereo amplifer that lists for $149.95. That amplifier, the model *CV-520*, is designed specifically for the component TV-system; some manufacturers simply use one from their standard audio line. The amplifier also has phono and auxiliary inputs for adding hi-fi audio sources to your system.

Like many of the other new component-TV monitors, the Zenith monitor has an RGB (*R*ed-*G*reen-*B*lue) input. While such outputs are currently available on only a few consumer products, such as the IBM *Personal Computer*, they offer a great advantage. Unlike video-modulated RF (such as broadcast TV) or composite video signals, an RGB signal is fed directly to the video amplifiers, bypassing many stages of lossy signal conversion. With an RGB input, most component-TV monitors are capable of high-resolution displays.

A component-TV system, with its stereo amplifiers, speakers, and controller functions sounds much like a stereo-audio setup. In fact, it's getting harder and harder to classify entertainment as either all video or all audio; instead, it's simpler to consider the two as part of a broader home-entertainment catagory. Consider, for instance, Jensen's model *AVS 1500* audio/video receiver; it's an AM/FM- and TV-receiver, as well as a stereo amplifier, all in one package. The AM/FM receiver section features a synthesized AM/FM-tuner and a digital frequency-readout. On the TV side, there's a 133-channel (including cable channels) TV tuner and National Semiconductor's DNR (*D*ynamic *N*oise *R*eduction) circuit. The amplifier has an output of 50-watts-per-channel. The unit lists for $990. Two companion monitors are available—the 19-inch model *AVS-3190*, which lists for $800, and the 25-inch model *AVS-3250*, which lists for $1030.

Teknika is another company that blends audio and video into the same components. Their $1200 *ATV-19* system consists of a 19-inch monitor, AM/FM/TV tuner, and 2 speakers. A 25-inch monitor is also available.

Tiny TV's

There's been a great deal of interest in small-sized TV and this year the first commercial flat screen (or pocket) TV's may become available. Sony's 2-inch diagonal screen

POCKET-SIZED TELEVISION, such as the Sony *Watchman* shown here, may finally become available this year.

Watchman uses a new picture tube design which places the electron gun below and parallel to the screen surface. The scanning electron beam is magnetically "bent" to hit the screen at a perpendicular; the result is a TV only 1¼ inches thick. The estimated retail for that set is around $300.

Sinclair, developers of another bent electron-beam flat TV-tube, may get their 3-inch TV on the U.S. market soon; its price is expected to be in the $100 range. Both the Sony and Sinclair tubes are black-and-white only.

The LCD flat-screen display is still under development, but may be still a year or two away. Seiko has been demonstrating a prototype of a wristwatch TV. Only the LCD screen is worn on the wrist. The bulk of the receiver, including an FM-stereo receiver, is housed in a vest-pocket sized unit.

Turning to small-sized color TV, Panasonic is offering what may be the world's smallest color TV/monitor; its *CT-3311* sells for $499.95 and features a screen size of just 2.6 inches. It even has separate audio and video input jacks.

Projection TV

From the very small, we turn to the "giants" of home video—projection TV. More companies are heading toward one-piece, rear-screen projection systems. They are typically more expensive than front-projection units, but recent scaling down of chassis size, as RCA has done for example, allows 40- to 45-inch screens to be placed in a cabinet that takes up no more floor space than a console TV. New for this year are many cabinet styles and sizes from General Electric, Mitsubishi, NEC, Panasonic, Quasar, Sharp, and Sony, to name a few; prices for those are in the $3,000-$4,000 range. Many like GE's new *Widescreen 40* feature built-in stereo amplifiers and twin, two-way speakers.

It may sound odd to put the words projection and portable together, but Kloss Video Corp has developed a portable (i.e. movable) projection-TV called the *Novabeam Model Two*. The unit is about the size of a 19-inch portable TV (though only 12-inches deep), and opens to project a 5-foot diagonal image on any wall. Room lighting needs to be controlled for best viewing, yet the ability to use a plain wall as a screen allows the unit to be played anywhere in the house and makes the viewing angle much less critical. Assuming that most projection-TV buyers have VCR's with TV tuners, Kloss eliminated the tuner completely from that model, which helped keep the price to about $2200.

It appears, then, that there's more available in video this year than ever before. The so-called video revolution is continuing, and it's getting easier all the time to become a part of it. **R-E**

LIST OF MANUFACTURERS

Canon U.S.A., Inc.
One Canon Plaza
Lake Success, NY 11042

Comprehensive Video Supply Corp.
148 Veterans Dr.
Northvale, NJ 07647

General Electric
Portsmouth, VA 23705

Grundig AG
Kurgartenstrabe 37
Furth, W. Germany 8510

Hitachi
401 W. Artesia Blvd.
Compton, CA 90220

Jensen Sound Laboratories
4136 N. United Parkway
Schiller Park, IL 60176

JVC
41 Slater Drive
Elmwood Park, NJ 07407

Kloss Video Corporation
145 Sidney Street
Cambridge, MA 02139

N.A.P Consumer Electronics Corporation
I-40 and Straw Plains Pike
Knoxville, TN 37914

Marantz
20525 Nordhoff St.
Chatsworth, CA 91311

Mitsubishi
7045 N. Ridgeway Ave.
Lincolnwood, IL 60645

NEC Home Electronics
1401 W. Estes Ave.
Elk Grove Village, IL 60007

Panasonic
One Panasonic Way
Secaucus, NJ 07094

Pioneer Electronics
1925 E. Dominguez St.
Long Beach, CA 90810

Quasar Co.
9401 W. Grand Ave.
Franklin Park, IL 60131

RCA
600 N. Sherman Dr.
Indianapolis, IN 46201

Sanyo Electric Inc.
1200 W. Artesia Blvd.
Compton, CA 90220

Sharp Electronics Corp.
10 Sharp Plaza
Paramus, NJ 07652

Sinclair Research, Ltd.
50 Stanlford St.
Boston, MA 02114

Sony
1 Sony Dr.
Park Ridge, NJ 07656

Technicolor
299 Kalmus Dr.
Costa Mesa, CA 92626

Teknika
1633 Broadway
New York, NY 10019

Toshiba
82 Totowa Rd.
Wayne, NJ 07470

Zenith Radio Corporation
1000 Milwaukee Ave.
Glenview, IL 60025

VIDEO ACCESSORIES

With the three devices described below, there's no need to put up with poor-quality videotapes any longer. While they can't work miracles, they can make an amazing difference in the recorded image.

GORDON McCOMB

THERE WAS A TIME NOT TOO LONG AGO WHEN THE AMAteur video enthusiast endured videotapes with poor or shifted colors, fuzzy details, and picture instabilities. But as the home-video industry has grown to include millions of owners of videocassette recorders (VCR's), add-on components have been introduced to help clear up the annoying color, detail, and picture problems that have plagued videophiles for years.

There are three video componenets that no top-quality video system should be without (at least not for long): a color processor, an image enhancer, and a sync stabilizer. Color processors can shift, exaggerate, even delete the color information on signals from a tape, disc, camera, or any other standard NTSC format video source. Image enhancers improve the high-frequency response and help restore clarity and sharpness to old tapes, dubs, and less than perfect video equipment. The vertical sync pulses on many pre-recorded videotapes have been altered in an attempt to prevent unauthorized VCR-to-VCR duplication. Unfortunately, the circuitry in some TV's can't handle those altered sync pulses. That results in vertical hold instability and horizontal 'tearing' of the picture. To eliminate the problem, sync stabilizers are used to restore the altered sync pulses to their original shape.

Let's examine each of those components further, and discuss the ways they can be used to improve your video pictures.

Color processors

Color processors enable full manipulation of the color and brightness components of any standard NTSC video signal. Colors can be shifted so that reds become green, greens become blue, and blues become red. The intensity of the image and colors can also be modified. A videotape with washed out colors can be rejuvenated by increasing the CHROMA or COLOR controls on a color processor. Special effects such as fading from a black-and-white to a full color scene can also be created.

The main function of the color processor is to correct for errors in the brightness, color, and tint of video signals, particularly with equipment lacking color and tint controls, as when dubbing between one VCR to another.

Three important fundamentals must be considered when reviewing the operation of television signals and color processors. Those fundamentals are luminance, hue, and saturation. The luminance signal occupies a bandwidth of 0 to 4.2 MHz, and includes all the brightness information seen in a black-and-white or color-TV picture.

Hue (adjusted by the TINT control on most color-TV sets) is the actual colors (red, blue, green, etc.) seen in a picture. Saturation (adjusted by the COLOR control on most color-TV sets) is the degree to which a hue is diluted by white light, enabling differentiation between vivid and weak shades of the same color. For example, a vivid blue is a saturated hue; a pastel blue is an unsaturated hue.

A color-TV picture consists of hue and saturation information, in addition to the black-and-white luminance information. The combination of hue and saturation is called chroma. The chroma signal is transmitted as a 3.58 MHz subcarrier of the luminance signal and consists of two color-difference signals, designated I and Q. The I signal determines the saturation, and the Q signal determines the hue. The I signal is transmitted as an amplitude modulation of the 3.58 MHz subcarrier signal, and has a bandwidth of 0 to 1.5 MHz. The Q signal frequency modulates the 3.58 subcarrier, and has a bandwidth of 0 to .5 MHz. A 3.58 MHz color-burst signal is inserted after every horizontal sync pulse in the composite video signal. The color-burst signal is used to synchronize the phase of the 3.58 MHz oscillator in the TV receiver, enabling proper color demodulation.

The instantaneous phase angle of the modulated chroma signal, with respect to reference color burst, controls the hue. The variations in the amplitude of the modulated chroma signal, in relation to the corresponding brightness

THIS COLOR PROCESSOR from Showtime Video Ventures features independent chroma and burst amp controls.

or luminance level of the scene, determines the saturation of the color.

Color processors can manipulate the amplitude and phase of the chroma signal, and thus can vary the tint and saturation of any scene. Old movies, either recorded or broadcast with weak color, can be rejuvenated by boosting the amplitude (saturation) of the chroma signal. Poorly taped home movies with incorrect colors can be corrected by altering the phase angle of the modulated chroma signal. Of course, there is no way to selectively boost, retard, or shift only certain colors with this type of color processor. If skin tones are excessively yellow, shifting the scene to normalize the skin color may also change the color of blue swimsuits to green. But those side effects, usually slight, are more than compensated for by the overall improvement of the video image.

A TRUE PROCESSING AMPLIFIER, this unit from Vidicraft allows full control over both the color and sync of the video image.

Operating a color processor, like the one manufactured by Showtime Video Ventures (2715 Fifth Street, Tillamook, OR 97141), is relatively easy. Showtime's color processor, model *VV-777P* , sells for $377 and uses a MODE switch along with four front-panel controls for manipulation of the brightness, color saturation, and tint of a TV picture.

The LUMA control determines the relative amplitude of the luminance signal being processed. Decreasing the LUMA control darkens the scene; increasing the control brightens the scene. Color saturation is determined by the CHROMA and BURST AMP controls. The CHROMA control adjusts the amplitude of the color subcarrier with respect to luminance (hence the LUMA and CHROMA controls are interactive), and so alters the degree of color intensity. A BURST AMP control, unique to the *VV-777P*, adjusts the color-burst amplitude without actually affecting the subcarrier level itself, and is used as a fine adjustment for resolution and proper skin tone. Rotating the BURST PHASE control counter-clockwise a quarter-turn shifts reds toward blue, blues toward green, and green toward red. Rotating the BURST PHASE a quarter-turn clockwise will have the reverse effect. Secondary and complementary colors undergo a similar change. Switching the MODE switch to MONOCHROME squelches the color-burst signal, rendering a black-and-white picture.

Showtime's *VV-777P* color processor, like nearly all video components made by Showtime and others, operates with a demodulated composite video signal. To use the color processor with an RF signal (from the RF output of a VCR or from an antenna downlead, for example) the signal must first be demodulated by use of an RF demodulator. An RF modulator or converter is then used to remodulate the processed video to a suitable RF channel (usually Channel 3 or 4) for reception on a standard TV set. Most VCR's have separate RF IN/OUT and VIDEO IN/OUT connections, and in some instances, an RF demodulator and RF modulator may not be required.

AN RF CONVERTER or modulator is used to modulate separate audio and video signals for viewing on a standard TV.

SYNC STABILIZERS, such as this one from Vidicraft, are used to eliminate side effects caused by tape-duplication prevention schemes.

Image enhancers

Image enhancers are used to improve the detail and sharpness of programs viewed off-the-air, while recording or playing videotapes, and during tape-to-tape duplication. Image enhancement involves boosting or accentuating high-frequency video signals, thus increasing overall detail.

The picture displayed on a TV screen is produced by varying the intensity of an electron beam (or three beams in the case of a color TV) as the beam sweeps across from left to right, and from top to bottom on the face of the picture tube. Extremely fine detail and outlines require the beam to vary its intensity more often—up to several million times per second. The smaller the detail in the image, the higher the frequency required to produce it. Likewise, the sharper the outline of an object, the faster the beam must cycle from light to dark or vice versa. Again, high frequencies are involved.

The bandwidth of the TV luminance (brightness) channel is from 0 to 4.32 MHz. However, high frequencies are often distorted and rolled off by the less than perfect circuitry used in most home VCR's and TV sets. That combined with the maximum bandwidth of most VCR's of about 2.0 MHz, leaves only a 0 to 2 MHz bandwidth for all the picture detail and information displayed in any given video frame. Reduplication of a videotape—three of four generations from the original—will yield a muddy, hardly discernable image

THE SHARPNESS AND DETAIL of both recorded and broadcast video can be improved by using an image enhancer.

where only the largest objects can be recognized.

The easiest way to think of an image enhancer is to look at it as a video version of an audio-frequency equalizer. But instead of dealing with audio frequencies, video image enhancers handle frequencies of 1.0 MHz and beyond. By boosting high-frequency signals, much in the same way as an equalizer or treble control boosts audio high frequencies, sharpness and detail can be improved. Low-freqency signals (0 to .5 MHz) are ignored by the image enhancer as they do not contain any detail or sharpness information.

Most image enhancers split the high-frequency signals into separate bands by using a comb filter, then selectively amplify the signals giving them an extra boost. Preshoots and aftershoots are added to the signal, driving the signal transitions (dark-to-light and light-to-dark) at a steeper amplitude than normal. That helps eliminate the soft edges in light-to-dark and dark-to-light transitions in the picture.

Of course, an image enhancer cannot produce something that isn't there in the first place. If the delineation of each blade of grass no longer exists in the image recorded on a videotape, no enhancer—no matter how well designed or made—will restore the lost detail.

Boosting the high-frequency content of a video signal also brings out noise, seen as snow. Most enhancers incorporate noise-reduction circuitry in addition to the main enhancement circuitry. The noise-reduction circuit reduces the level of enhancement to compensate for the introduction of snow, and usually works in direct opposition to the enhancement circuit. Noise, usually of high-frequency content, has a lower amplitude than most desired signals. Noise reduction circuitry is designed primarily to suppress low-amplitude, high-frequency signals.

For example, Vidicraft's (Box 13374, Portland, OR 97213) *Detailer I* (selling for approx. $149) and *Detailer II* (selling for approx. $295) incorporate a VNX control that suppresses noise. It performs the opposite function of the DETAIL control, but uses a different set of amplitude thresholds, thus removing a majority of the increased noise and a smaller portion of the enhanced signal. There are trade-offs to be considered when using an image enhancer, as excessive noise cancellation can totally counteract all efforts to enhance detail. The proper enhancement level for any given program, with relation to detail and snow, is performed by interactive adjustment of both the enhancement and noise-reduction controls.

Connecting an image enhancer to a video system is similar to the hook-up procedures for the color processor, in that all units on the market can accept demodulated video signals only. Depending on the installation, RF modulators and/or RF demodulators may be required.

The operation of an image enhancer, such as the *Detailer II* from Vidicraft, uses several knobs for enhancement control. The DETAIL control is used to compensate for detail loss encountered in VCR recording and playback. It can be used to exaggerate detail before the signal is recorded (and so precompensating for high frequency roll-off inherent in home VCR's) or to help restore a VCR signal on playback. The SHARPNESS control increases the overall sharpness of the picture whether the signal be from a tape, camera, videodisc, or off-the-air. The SHARPNESS control is adjusted for maximum edge detail without creating false, black outlines. The VNX control (also called CORE, NOISE SUPPRESS, or NOISE CANCEL on some other models and brands) helps reduce snow and other low-amplitude, high-frequency interference—however, at the expense of detail. It's function is very much opposite that of the DETAIL control and is most helpful when sharpness-only enhancement is used. Normally, fine adjustments of all three controls must be made to obtain the best results, and the settings must be optimized for each program.

It should be noted that image enhancers improve the horizontal resolution of a video image—that is, fine details that occur from left to right in a TV picture. Image enhancers, unfortunately, aren't tested for any given horizontal resolution standard or minimum, since the quality of the original program will determine the results achieved by the enhancer.

Sync stabilizers

Many pre-recorded videotape program distributors, to protect against unauthorized duplication of their product, have altered the vertical sync pulses recorded on their videotapes. That technique, most often called *Copyguard*, (although similar systems with different tradenames are available) disables the sync circuits in a VCR. However, several side effects of sync alteration can appear on the screen of a standard television receiver. *Copyguarded* tapes have a tendency to make the picture on a TV screen roll and shake, as well as "tear" at the uppermost portion of the picture. Adjusting the vertical-hold control on the TV can correct for most of the problems, but many of the newer sets often have the vertical-hold control mounted inconveniently on the back of the chassis, or may even lack a vertical-hold control altogether.

Sync stabilizers restore the vertical sync pulses and provide sync stability to TV's and VCR's. In the NTSC broadcast standard used throughout the United States (as well as Canada, Mexico, and Japan), an electron beam scans 525 horizontal lines 30 times each second. Every picture then consists of 30 frames composed of 525 vertically stacked lines. The scanning process is actually done in a 2:1 interlace pattern, so 262.5 lines are scanned in one pass over the tube, and the second 262.5 lines in a second pass. The scan lines of the first pass or field is comprised of all the odd-numbered lines; the second field is comprised of all the even-numbered lines.

When the beam reaches the bottom of the screen after each field, it is then directed to retrace back to the top of the screen, and repeat the scanning process again. The synchronization pulses required for the circuit to direct the beam to the top of the screen are contained in the vertical blanking interval.

Within that vertical blanking interval, six vertical sync pulses, bracketed on both sides by equalization pulses, are used to trigger the vertical sync circuits in the receiver (those pulses are at one-half the normal horizontal line rate). Vertical sync pulses have extremely long duty cycles of 87% (the longest duty cycle involved in TV sync timing). In most TV's, only one vertical sync pulse is required to trigger the vertical-sweep circuits. In VCR's, however, nearly all of the vertical-timing pulses are required to ensure full sync stability while recording.

Sync-alteration techniques, (again, there are numerous types currently in use), normally pass just one pulse—the remaining five pulses are changed or distorted.

Nearly all sync stabilizers currently on the market, such as MFJ Enterprise's (921 Louisville Rd., Starkville, MS 39759) model *1400* (selling for approx. $80), reshape the vertical sync interval to the point where a stubborn TV or VCR will trigger properly. A timing circuit is normally used that triggers when the circuitry in the stabilizer detects the first vertical sync pulse. The stabilizer circuit then generates a single long pulse equal to the normal vertical sync interval (three horizontal lines long), overriding the altered signal produced by the tape. The sync stabilizer has a frequency adjustment to allow the unit to match its frequency with that of the incoming vertical sync pulses.

The actual half-line equalizing pulses of the vertical blanking interval are lost by use of most sync stabilizers, meaning that the horizontal sync circuits in the TV lack a timing reference for three lines in each field, which can cause horizontal sync loss during the vertical blanking interval. This can create some picture instabilities as well as horizontal tearing at the top of the screen. Only one sync stabilizer, the Showtime Video Ventures' model *VV-170P*, recreates the pulses contained in the vertical interval. Usually, however, simply adding one long pulse to the vertical interval compensates for most of the serious side effects caused by *Copyguard* or similar encoding, and produces a relatively stable, jitterless picture.

Sync stabilizers work only with demodulated video signals, although some units are now available with built-in RF modulators. To use a video-only stabilizer, the VIDEO OUT jack on the VCR is connected to the VIDEO IN on the stabilizer. An RF modulator is then used at the output of the stabilizer. It should also be noted that video processor components can be combined in one installation along with a sync stabilizer. Normally, there are no restrictions as to the order in which the components should be placed in the signal path. Be certain, however, that a sufficient video level (1 volt peak-to-peak) is supplied to the input of each component. Many video accessories incorporate distribution amplifiers (some with adjustable gain) that can be used to overcome excessive signal loss when passing the signal through several components. Video distribution amplifiers are available separately as well.

Quite a few video components have provisions whereby more than one input source can be connected to the unit at one time. A front-panel switch is used to select the desired input. Additionally, many units have several outputs allowing for multi-point signal distribution.

Operating a stabilizer requires the user to adjust one knob, the STABILIZE control. The control is usually readjusted for each tape viewed. **R-E**

NEARLY ALL of the sync stabilizers on the market, including the one from MFJ enterprises shown above, reshape the vertical sync interval.

HOW TO CONNECT VIDEO COMPONENTS

Watching TV is no longer a matter of simply turning on the set and sitting back. Here's a look at some devices and ways to take the nuisance out of what should be a pleasure.

GARY McCLELLAN

THANKS TO CABLE AND SUBSCRIPTION TV, TV GAMES, AND personal computers, television is becoming more interesting and useful than ever before—not to mention a lot more fun. Furthermore, VCR's (*V*ideo *C*assette *R*ecorders) and videodisc players are making available to us an even wider range of entertainment. And, on the horizon, there is the promise of interactive videotex, which can allow us to shop and be informed from the comfort of our living rooms.

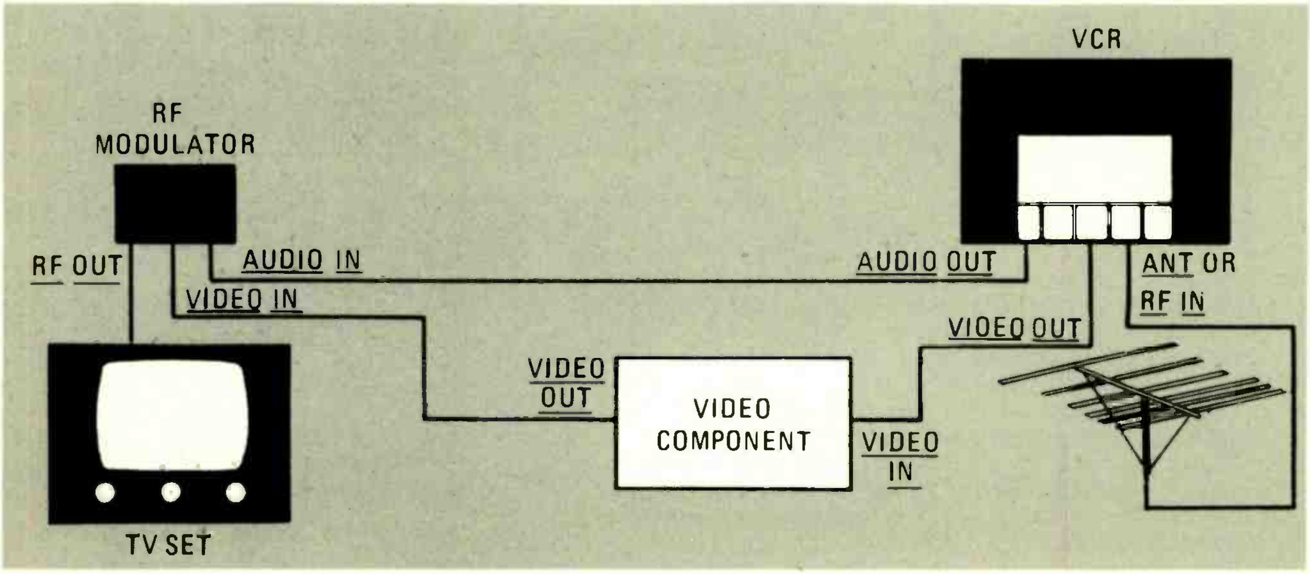
Hooking up all the equipment needed to an existing TV set can become a bit confusing, especially if several devices are involved; this situation is becoming more and more common these days. Most people start out with a VCR, and over a period of time add other equipment, turning a TV set into a video system. Perhaps there's a cable box with a decoder for sports and movies; then a programmable TV-game for the kids, a personal computer for Dad, and so on.

The result is often a rat's nest of wiring centered around a complicated switching arrangement. And, while *you* may understand it, it can make life very difficult for other people who use the system, especially if they have to change cables! Also of concern is the fact that every connection in that maze of cables causes signal losses that can degrade picture quality. What's needed is an easy and simple way to mate all that new equipment with the TV set, creating a true integrated video-system that's easy to use and provides the highest quality possible.

In this article we'll discuss how to connect additional equipment to your TV set. We'll start with the simple addition of a VCR and build up to a "full house" video system featuring almost every device you are likely to want. We'll finish up by adding useful accessories such as cameras, enhancer/stabilizers, commercial editors, and others.

The hookups described will bring many benefits. For example, your video system will be easier for the family to use (no cable swapping), and there will be fewer connections and less signal loss. All you have to do is to read through the article to find the descriptions that best match your equipment, and then follow the diagrams to hook it up. It's as easy as that!

Of course, it isn't possible to cover every possible combination in this short space; there are just too many variations. Instead, we'll concentrate on the ones that most people are likely to use. With a little thought you should be able to adapt those ideas to your particular situation.



Basics

Before you do anything, there are few simple rules to remember when making these hookups, and they boil down to one thing—*go first class, inside and out*. Lots of people will spend a thousand dollars or more for a VCR, $15 and up per month for subscription-TV service...and then use a 15-year-old antenna and rotten cables. Naturally, they get angry when their expensive equipment performs poorly. The moral is to save a little extra cash for a new antenna and lead-in. If you don't, you'll wind up paying for your "economy" with poor reception. Read the following basics, and apply them to your own situation. Make any improvements required.

Start outside with the TV antenna and lead-in, if you use them. They are often overlooked because rooftop mounting makes antenna inspection an unpleasant chore. Yet, if your antenna and lead-in have been up 4–5 years or longer, you may not be getting the best picture possible. Why? To begin with, the sun's heat and ultraviolet radiation degrade the insulators and lead-in, which means increased signal-losses. Also, soot deposits and humidity will cause breakdown of the cable insulation, and wreak havoc with connections. The result is predictable; more losses and noisy pictures! And, in extreme cases, corroded connections, combined with a near-by CB or ham transmitter, will invite interference. So if your antenna and lead-in are four years old or more, check them out carefully, and replace them if necessary. The same goes for lightning arrestors and guy wires.

If you are going to replace your lead-in, you should use coaxial cable, rather than twin lead. For one thing, it tends to reduce noise pickup, and for another, it is more compatable with the newer equipment. In my own case, using coaxial cable cut ignition-noise pickup noticeably and reduced ghosting; the extra cost was worthwhile.

Once the antenna and lead-in have been taken care of, the antenna should be carefully oriented for the best picture-quality on all channels. Often that requires a compromise, but with patience, things can be worked out. Of course if you have a rotator, antenna positioning will be no problem!

Go first-class inside the house, too. The lead-in cable should be routed to the area where the video equipment is located, and F-type connectors used. If necessary, use a VHF/UHF signal-splitter between the cable and TV set.

Now turn your attention to the TV set you will be using. It should be in good condition and provide a good color picture. Adjust the fine-tuning control for the best sound and picture quality. If you don't get a good picture and sound, repairs or adjustments may be required; have them made. You should then be getting first-rate results, and will be ready to add other equipment.

You are going to need baluns (impedance-matching transformers), short lengths of cable with F-type connectors on each end, and other parts. Refer to Table 1 for a list of parts of this sort that you will probably require.

Adding a VCR

Video cassette recorders (VCR's) are very popular, and thanks to decreasing prices, are becoming quite widespread. Figure 1 shows a simple VCR/TV hookup. The antenna cable connects to a VHF/UHF splitter that goes to the VHF and UHF inputs of the VCR. From the VCR, separate cables are connected to the antenna inputs on the TV set.

Several remarks concerning that arrangement are in order. First, many older TV sets have balanced 300-ohm antenna inputs. To use the cable hookup shown, a 75–300-ohm matching transformer (balun) will be needed between the 75-ohm RG-59 cable and the TV set's VHF terminals. Don't try to do without the transformer or you may get a noisy picture. Second, some early VCR's don't have UHF output-terminals. If that's so in your case, run a short length of 300-ohm twin-lead from the VCR's UHF input-terminals to the UHF antenna-input on the TV set.

Adding CATV/MATV

In some parts of the country, cable TV (CATV) or master-antenna TV (MATV) takes the place of an outside antenna. Figure 2 shows a hookup for such systems. Note that the switch box is not required if just one of those services is available.

Your setup may differ somewhat from the one shown, but can probably be handled in a similar fashion. For example, your area may have CATV and still permit outside antennas. If that's the case, just substitute the antenna cable for the MATV connection to the switch box.

Subscription-TV service has become popular, thanks to its uncut, no-commercials, format of movies and sporting events and the fact that the programming is sent over the air and no cable-service is required. Figure 3 shows two simple ways to connect a subscription-TV decoder to your VCR and TV set.

The hookup shown in Fig. 3-a will work well except for one thing: when the decoder is turned on, the VCR or TV will receive *only* the decoder! That can be a problem if there are two good programs broadcast at the same time on subscription- and free TV.

The solution is shown in Fig. 3-b. By adding the a device like the *Channelizer* (made by Energy Video Corporation, 20371 Prairie St., Chatsworth, Ca. 91311), it is possible to receive all channels without any switching. You can tape one program for viewing later, and watch the other program right now. Special circuitry inside the unit makes that possible without interference, and the decoder output appears on a channel unused in your area (channel 3 in mine).

There may be an unused input on the subscription-TV decoder that can be used to connect the output from any other video equipment (game, computer, videodisc player, etc.) to it, and you can then use those devices without throwing any

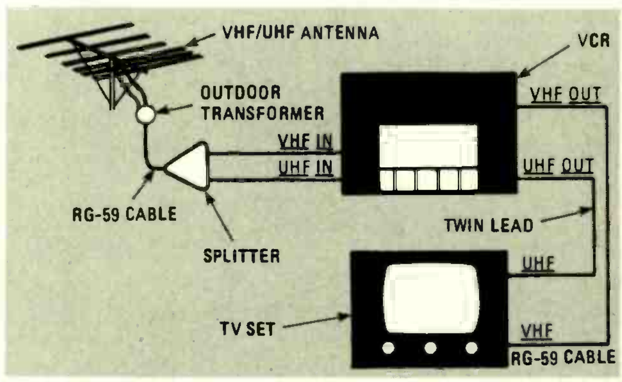


FIG. 1—CONNECT THE TV ANTENNA to your VCR, and then connect the recorder to your TV set. Keep the VHF and UHF signals separate.

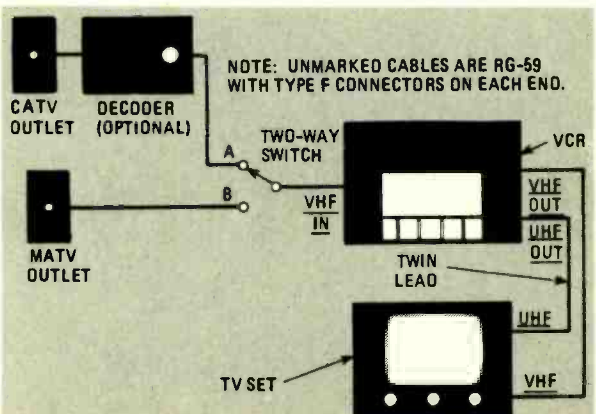


FIG. 2—A SIMPLE 2-WAY SWITCH will allow you to select between two TV-signal sources like CATV and MATV.

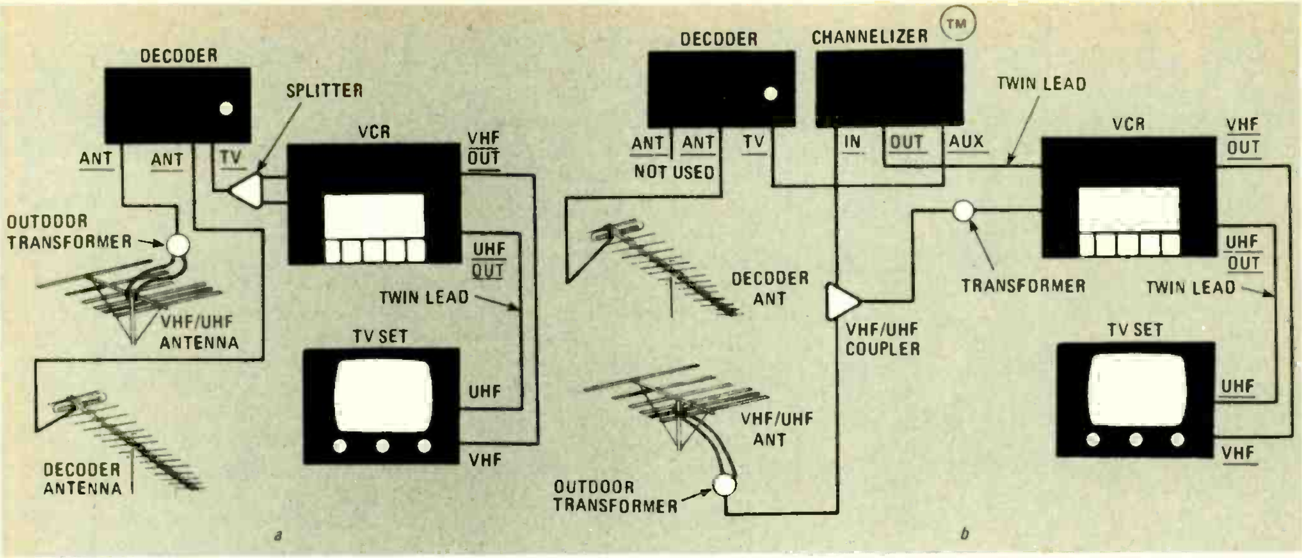


FIG. 3—A SUBSCRIPTION-TV DECODER in the line usually restricts you to receiving only one channel at a time (*a*). A device like the Channelizer (*b*) removes that restriction.

switches. Just set the TV set to your local "vacant channel," turn on the equipment, and go. That's great for the non-technical members of the family who hate to figure out switches!

Adding other equipment

Add-on devices like video games, personal computers, and videodisc players are rapidly increasing in popularity, and making one part of your video system is easy—just use a two-position switch as shown in Fig. 4.

That arrangement does have a drawback; it allows you to connect only one device at a time. If you're lucky enough, however, to have a device with a VHF antenna-input (perhaps a videodisc player), you can "daisy chain" it with another device. Figure 5 shows how that kind of hookup can be made. You might be able to connect the output of your video game to the antenna input of the videodisc player, and the output of the player to the switch. Often that method will work well, and will eliminate a second switch. However, since not all video equipment has an antenna input, that hookup may not be practical for you! The solution, then, may be a video switch, our next topic.

Getting sophisticated

All the hookups described so far have assumed that you would be adding just one device to your video system but the chances are that, with time, you will be adding several pieces of equipment. That can complicate things greatly if you are not careful, and you can end up with a rat's nest of cables. But take heart; there's a way around that problem.

This solution is simple enough: Use a multi-position video switch to select the output of a particular device for viewing on the TV set or for recording.

Actually, the term "video switch" is a misnomer. Those devices actually switch VHF/UHF RF signals, *not* low-frequency video, as their name would imply. However, since most manufacturers refer to their products as "video" switches, we'll do so, too.

The switches are sold under various names: *Bambi Electronic Video Switch* from Simple Simon Electronics (3871 S. Valley View No. 12, Las Vegas, NV 89103), *Video Organizer* from Zenith (1000 Milwaukee Ave., Glenview, IL 60025), and many others. All those products have one purpose: to switch in or out a number of program sources with a minimum of loss and crosstalk. They neatly replace the array of 2-position switches that are often used, and eliminate cable swapping. So, once your video system reaches the point where a 2-position switch won't be enough, or where cable swapping is required, a video switch would be a wise investment.

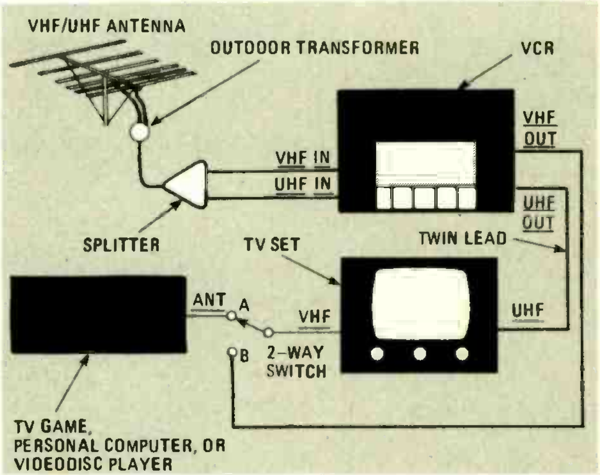


FIG. 4—USE A 2-POSITION switch to select between off-the-air TV reception and using an add-on video device.

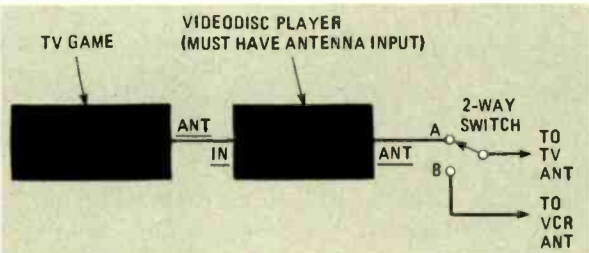


FIG. 5—"DAISY CHAINING," when you can do it, can reduce or eliminate the need for switches.

To really appreciate how neatly a video switch simplifies cabling, suppose you add a video game, personal computer, and a videodisc player to your system. You could make the whole thing work by using the scheme shown in Fig. 4 and using three 2-position switches. Or, you could daisy-chain the devices as shown in Fig. 5. A better way, though, is shown in Fig. 6. There, a single video-switch takes care of everything and fewer cables and connections are required. That means less fuss in hooking the devices up, and less signal loss. But, best of all, using the switch is easy—all that you need to do is press the appropriate button to get what you want.

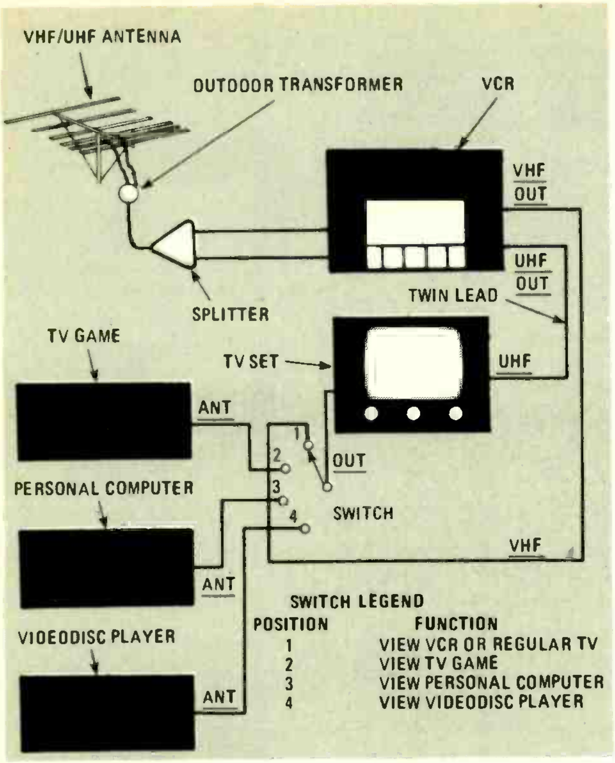


FIG. 6—A MULTI-POSITION switch will allow you to hook up several pieces of equipment to a single receiver easily.

A full-house system

There are many people who take video very seriously, and, as a new item is introduced, they will add it to their systems. With each addition, the switching becomes more complicated, until most video switches become inadequate. The solution to that problem is to select a more versatile video switch.

A setup for those who have "everything" is shown in Fig. 7. That particular arrangement is based upon the *Bambi Electronic Video Switch*. It can handle up to six inputs, and can route the signals from any of those inputs to any of three outputs.

The manufacturer quotes an especially high isolation-figure (65 dB) for the unit, which is important because that reduces interference among sources. Interference can occur because most inputs to a video switch are on the same channel (typically channel 3), and that can cause multiple pictures and interference lines to appear on your TV set(s). The solution is to use a switch with a high isolation-figure, indicated in dB. Watch for that specification when you buy.

As shown in Fig. 7, an outdoor antenna, subscription-TV decoder, VCR, videogame, personal computer and a video-disc player provide inputs to the video switch. Those devices can be switched independently, and the VCR can tape a program while the kids use the TV game and you watch another program off the air. A video switch makes it easy; in the case of Bambi, just press two buttons and go!

Selecting a "full-house" video-switch is easy. First, figure out how many devices you will be hooking up to your system. You will need a video switch with *at least* that many inputs, and—I would recommend—a spare or two. If you buy a switch without allowing for future expansion, you'll soon regret it.

There are plenty of video switches on the market, with a wide number of inputs and outputs, so scan the ads when you get ready to buy a switch. When you have narrowed your choice down to a few units, select the one with the greatest isolation figure, if those numbers are available to you. Once you have a video switch, just hook it into your system as shown in Fig. 7.

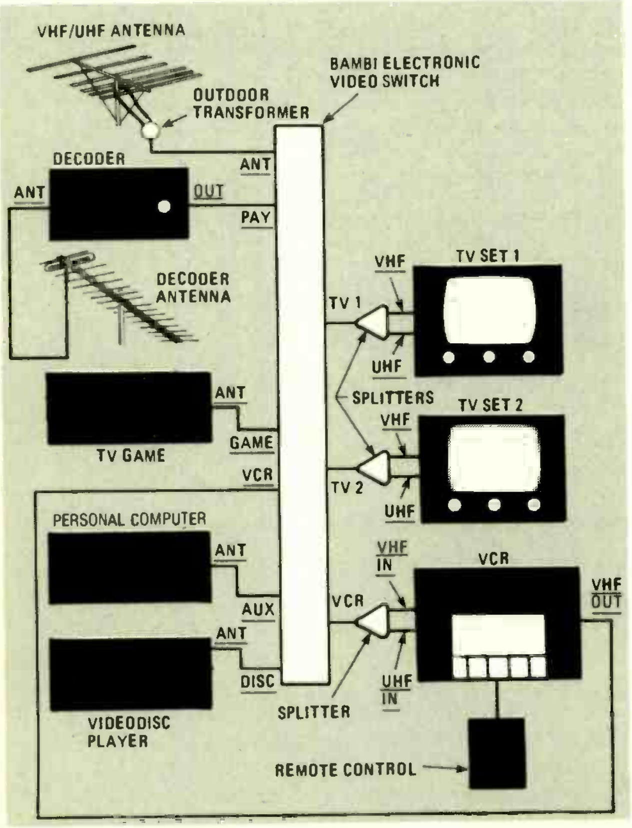


FIG. 7—"FULL HOUSE" VIDEO SYSTEM is easy with an electronic video switch. Any input can feed any output.

Copying

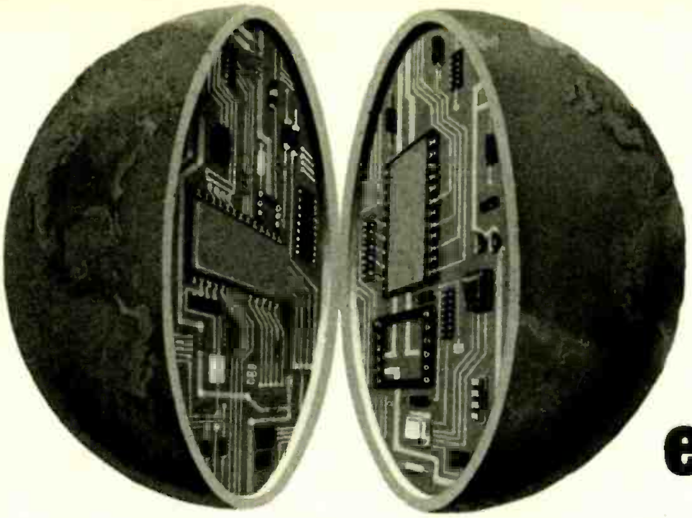
There are times when it becomes necessary to copy material recorded on one VCR onto another. For example, I recently replaced my Beta-I machine with a newer VHS model and had to re-record my old lectures and family outings onto VHS-format tapes as the new machine couldn't handle Beta-format tapes.

There are two methods that can be used for dubbing videotapes. You could use an RF hookup to the antenna terminals of the second recorder, but that would put a lot of signal-processing circuitry between the two machines and cause a reduction in picture quality. A direct-video/audio hookup using separate audio and video cables is preferred.

You may have to make the cables if you can't buy them locally. The audio cable can be standard audio or microphone cable with RCA phono plugs, or miniature phone plugs on the ends. The video cable should be RG-174 coax with RCA phono plugs on each end. The reason for for using coaxial cable is to reduce losses. While a very short length of microphone cable could be used, it is very lossy and will reduce picture definition.

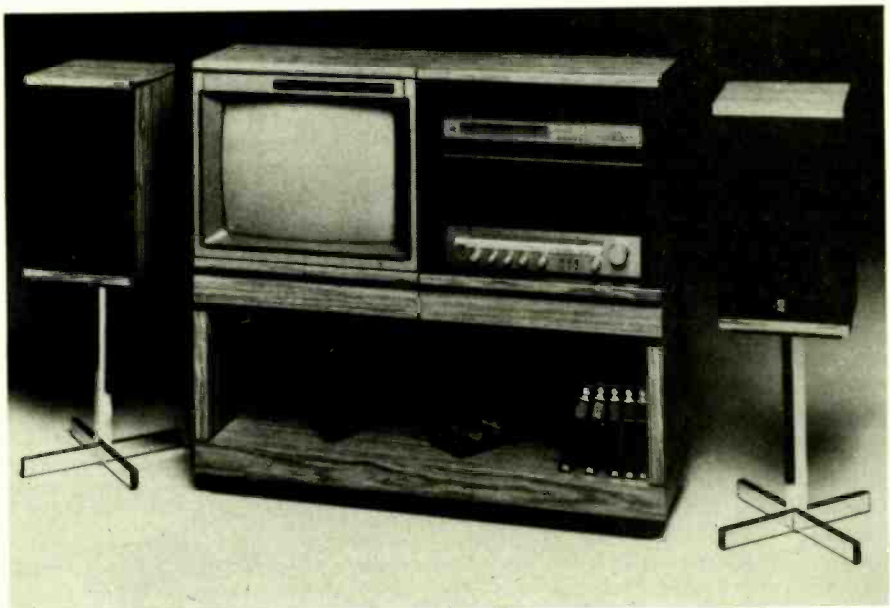
In some cases you may want to make a copy of an old tape that is of poor quality. Sometimes a video enhancer/stabilizer can make improvements in the quality, if the tape isn't too bad.

Enhancer/stabilizers are available from a wide range of suppliers (many of whom advertise in **Radio-Electronics**), and are very useful. The enhancer section of the device boosts—or peaks—the high-frequency portion of the video, which makes the picture look better. The stabilizer portion is used to stop vertical roll when some commercially available tapes are viewed on certain TV sets—especially some of the newer ones. Thus, the enhancer/stabilizer can be is a valuable tool when it becomes necessary to copy tapes. R-E



STEREO AUDIO FOR TV

Stereo and multichannel TV programming is already a reality in several countries. Here's the latest on what's happening here.



LEN FELDMAN
CONTRIBUTING EDITOR

BY THE TIME YOU READ THIS, ALL THE tests should have been completed. Even the report prepared by the Electronic Industries Association's Broadcast Transmission Standards (BTS) Committee may already be in the hands of the FCC, and we will be a step closer to having stereo audio for television broadcasts in the U.S. And, with two (or more) audio channels available, not only will stereo be able to be broadcast, but the second channel can also be used for the transmission of a second monophonic program—perhaps a soundtrack or commentary in a second language, for viewers whose native tongue is not English.

No matter how soon a multichannel audio system is adopted for U.S. TV, and no matter which system is chosen, the U.S. will still be a late starter in adopting stereo for TV. In Japan, that type of service has been available since 1978. In fact, of the three basic systems being proposed for use in the United States, one is the Japanese system that was developed and tested over a period of four years by the Technical Research Laboratories of NHK, the Japanese Broadcasting Corporation.

The two other systems currently being considered for use in this country are by Telesonics Systems, Inc. and by the Zenith Radio Corporation. The Japanese system under consideration is officialy known in this country as the EIAJ system, since it is being sponsored in the U.S. by the Electronic Industries Association of Japan. Finally, a fourth system, developed—and just being introduced—in Germany, may have some influence on what method is finally adopted. (That system will be discussed in detail soon in a future issue of **Radio-Electronics**).

Further complicating the decision-making process is the fact that, in addition to the three basic transmission-systems just referred to, there are also three noise-reduction systems being proposed for use with them, making a total of nine possible combinations. The incorporation of more audio channels in the bandwidth now assigned to a single TV audio channel will degrade the audio signal-to-noise ratio, regardless of which of the three stereo systems is selected. That is what has prompted Dolby, dbx, and most recently, CBS, to propose noise-reduction encoding/decoding systems. Those, coupled with any of the proposed multi-channel TV-audio systems, would reduce background noise to acceptable levels and allow broadcasters to maintain the quality of fringe-area signals.

Since multichannel TV-audio will eventually be with us, it would be a good idea to understand how the three basic transmission:systems that have been proposed work. The principles involved in audio companding are familiar to most readers of **Radio-Electronics** so we will not include a description of the three noise-reduction schemes in this discussion.

The EIAJ system

The components of the signal used by the Japanese system are shown in Fig. 1. Note that the "x" axis (horizontal) serves two purposes—it shows both the audio-frequency response of each channel and the frequency of the subcarrier and pilot tone *relative* to that of the main audio carrier. The "y" axis (vertical) shows the frequency deviations of the main and sub-

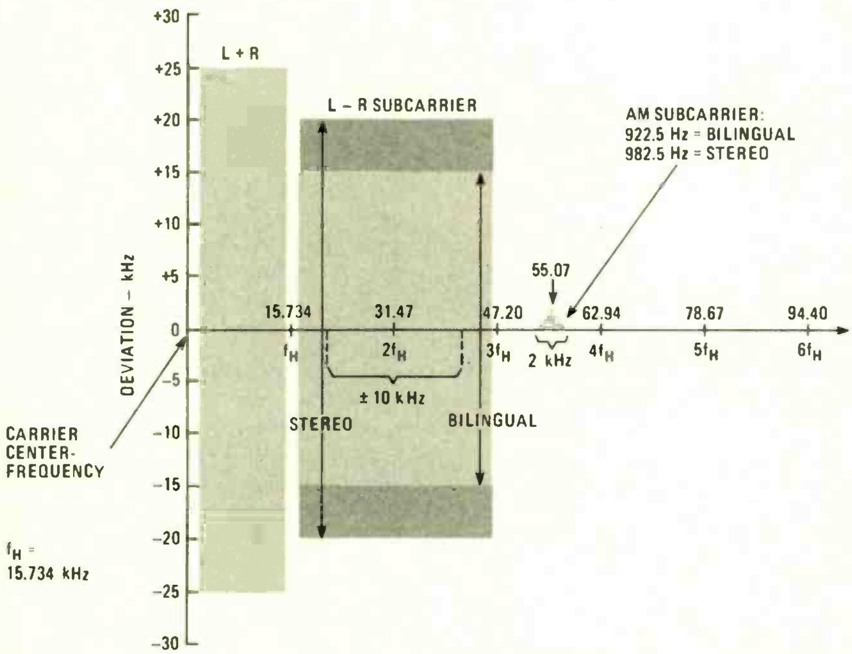


FIG. 1—ORIGINAL EIAJ SYSTEM uses a subcarrier with a deviation of ± 10 kHz to transmit the L-R or second-channel audio information. Maximum frequency-response is 12 kHz.

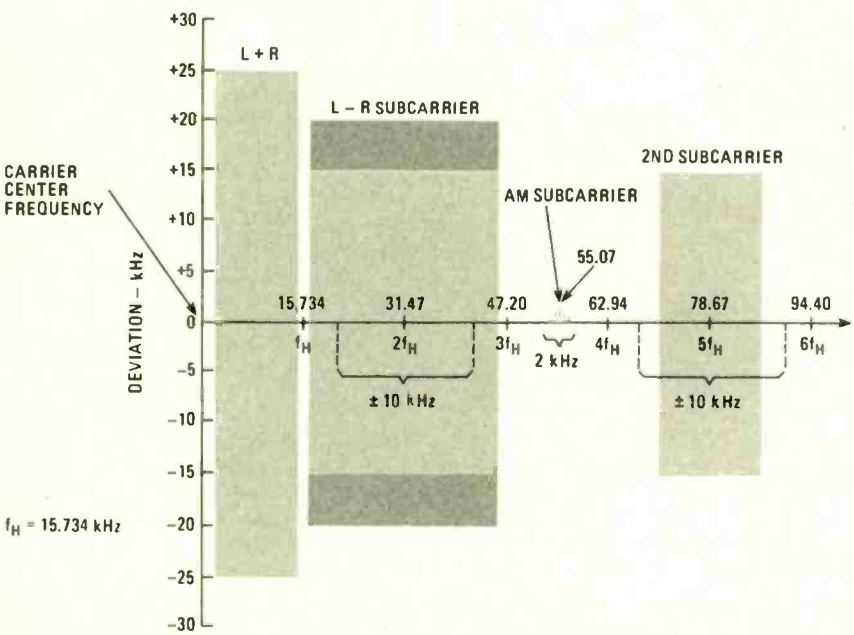


FIG. 2—U.S. VERSION of the EIAJ system extends frequency-response of the subcarrier to 15 kHz. In addition, a second subcarrier, with an 8-kHz bandwidth, is provided for.

carriers.

The main audio carrier—used for monophonic transmissions, for one channel of multichannel transmissions, or for the L + R component of a stereo transmission—has a maximum deviation of ± 25 kHz (just like the NTSC system used in the U.S.) and a frequency response from 50 Hz to 15 kHz.

The subcarrier, located at a frequency of 31.47 kHz (twice the TV horizontal line-frequency) above the main carrier, is used for the second channel of a multichannel transmission, or for the L-R component of a stereo transmission. That frequency was chosen because it minimizes interference between the video signal and the subcarrier in intercarrier-type receivers. When frequency-modulated, the subcarrier has a maximum deviation of 10 kHz on either side of the center frequency. In Japan, the frequency response of that channel is from 50 to about 12 kHz, but the system has been modified for use in the U.S. to extend the response to 15 kHz.

The subcarrier is used to modulate the main carrier—a technique known as *injection*. When stereo is being transmitted, the amount of injection is ± 20 kHz, giving the main carrier a total deviation of ± 45 kHz; in the multichannel mode, the amount of injection is ± 15 kHz, producing a total deviation of ± 40 kHz.

An amplitude-modulated control signal having a bandwidth of 2 kHz is transmitted at a frequency 55.07 kHz (3½ times the horizontal line-frequency) above the main carrier. Its purpose is to inform the decoding equipment at the receiver which mode is being used. A 982.5-Hz tone indicates that a stereo program is being transmitted; a 922.5-Hz tone indicates that a multichannel program is being broadcast. The absence of a tone means that the program material is monophonic. The control signal can also be used to activate a visual indicator to inform viewers/listeners which audio mode was being used with the video they were watching.

Tests made by the developers of the Japanese TV multiplex-system have shown that a *second* subcarrier can be added without making it necessary to change the parameters of the first subcarrier. In tests conducted by the EIA last summer in Chicago, such a system—as shown in Fig. 2—was used. The characteristics of the second subcarrier were the same as those of the first, with the exception that the audio-frequency response was restricted to an upper limit of 8 kHz. It is expected that that subcarrier would be used for services where limited frequency-response would not pose a problem.

The Telesonics system

The Telesonics system, whose arrangement is shown in Fig. 3, uses a double-sideband, suppressed-carrier, AM subcarrier similar to that used in stereo-FM broadcasting in the United States and many other countries. (The EIAJ system, with the exception of the control signal, is all-FM.) Such an arrangement requires a pilot signal, which is used at the receiving end to restore the suppressed carrier. In the Telesonics system, the pilot signal has

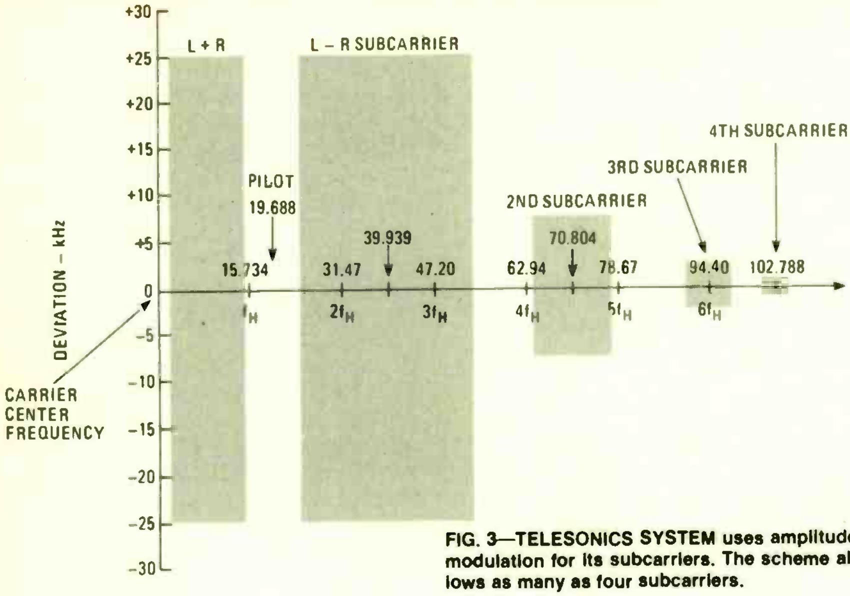


FIG. 3—TELESONICS SYSTEM uses amplitude modulation for its subcarriers. The scheme allows as many as four subcarriers.

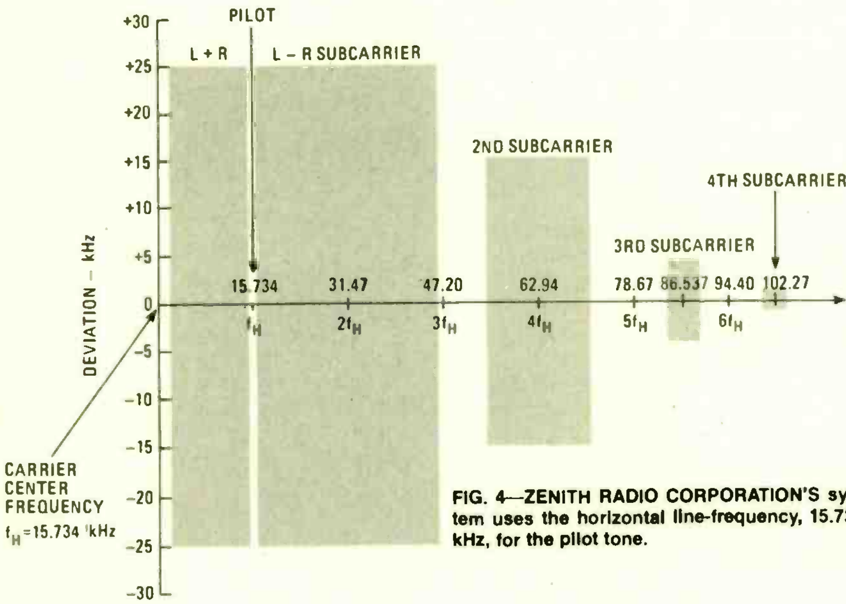


FIG. 4—ZENITH RADIO CORPORATION'S system uses the horizontal line-frequency, 15.734 kHz, for the pilot tone.

a frequency of 19.668 kHz, or 1.25 times the TV horizontal line-frequency. The double-sideband suppressed-carrier used for transmission of L-R information is 39.939 kHz, or 2.5 times the horizontal line-frequency, away from the audio carrier center-frequency. Tests of the system have been proposed using three different levels of deviation of the main carrier by the subcarrier: 11.25 kHz, 25 kHz, and 33.75 kHz. Tests using additional FM subcarriers at other frequencies, in order to provide a second subchannel for sound transmisison; a third carrier for ENG (*E*lectronic *N*ews *G*athering), telemetry, or another service, and a fourth subcarrier for telemetry alone have also been suggested. The additional FM subcarriers are impressed upon the main carrier at very low levels and with highly restricted audio-frequency ranges, as shown in Fig. 3.

The Zenith Radio system

Frequency allocations and subcarrier arrangements used in the Zenith Radio Corporation system are shown in Fig. 4. Like the Telesonics system, the Zenith system also uses a double-sideband, suppressed-carrier AM subcarrier. Instead of using a separate pilot signal, the Zenith system uses the horizontal line-frequency itself for that purpose, with the center frequency of the suppressed subcarrier falling at twice the horizontal line-frequency, or 31.47 kHz. Provision for a separate audio program (such as a second-language summary of the news) is made using an FM subcarrier having its center frequency at four times the video horizontal-line rate, or 62.94 kHz, while other FM subcarriers at 5.5 and 6.5 times the horizontal frequency can also be included for telemetry or other telecommunications purposes.

Signal-to-noise ratios

As we noted earlier, all the stereo/multichannel TV-audio systems involve some degradation of the signal-to-noise ratio. In Japan, where the system employed uses a frequency-modulated subcarrier for transmission of the L-R information (or the second-channel information), results at station JOAX (the anchor station of the national network, based in Tokyo), using an 85 kW audio carrier, show that the signal-to-noise ratio is about 60 dB on both the main and sub-channels at receiving points within the city, fairly close to the transmitter site. In fringe areas, of course, that figure would be worse.

Experiments have already shown that the systems using AM subcarriers (Telesonics and Zenith, so far) for their difference (L-R) information or second-channel transmissions suffer a greater reduction in signal-to-noise ratio than do all-FM subcarrier systems. That's especially true in fringe areas, where the main audio-carrier is of insufficient strength to send the receiving circuitry into full FM-limiting.

Several critical listeners, none of whom knew which companding systems were being used (or, for that matter, that they were being asked to judge the merits of three companding systems), were asked to listen to a variety of recorded material and to judge which "sounded best." Having monitored some of the tests myself on behalf of the EIA, I can report that, while each companding system was judged effective for certain kinds of music, the difference in background noise between *all* the uncompanded transmissions and those using noise reduction was obvious, regardless of which system was used for the test. That was particularly true when "fringe area" reception conditions were simulated.

Audio enthusiasts have complained for many years about the poor quality of TV sound. In fact, the NTSC system has always been capable of providing "high fidelity" FM sound, with response up to 15 kHz. Small-speaker TV sets, together with TV-station-owner apathy, has resulted in a vicious circle that has kept us from enjoying the kind of sound we get from FM radio and other high-fidelity program sources.

The coming of stereo-TV sound may change all that, if only for the reason that the TV tuners and adaptors needed to supply the two channels of audio will permit us to connect our stereo component-systems directly to the line outputs of those new products. In that way, we will finally be able to bypass the sound systems contained in our TV sets.

I am indebted to my friend William S. Halstead, who provided me with much of the background material used for this article. **R-E**

BUILD THIS

VIDEO SYNC STABILIZER

Some VCR's and TV sets have difficulty in playing back certain videotapes. This sync corrector will eliminate that problem.

GENE ROSETH

THE LAST FEW YEARS HAVE SEEN A REVOlution in home-TV entertainment as video cassette recorders (VCR's) and the program material available for them have proliferated.

A problem that has plagued many VCR users has been picture instability, in the form of vertical roll. It afflicts many of the older VCR's and *newer* TV receivers—the ones without external vertical or horizontal-hold controls. This can also occur when viewing prerecorded videocassettes that have been recorded using a system to prevent tape duplication. The instability is generally caused by a distortion of the vertical-sync pulse, and, to say the least, is an annoyance.

The device described here will reconstitute distorted vertical-sync pulses and eliminate the vertical-roll problem. It can be built in two different versions: The first is a baseband-video unit that performs the sync-correction and outputs a video signal. It can be used only in video-to-video applications—it does not provide an RF signal.

The second version incorporates an RF modulator and outputs the corrected video (and the audio, as well) on VHF Channel 3 or 4. Feed the RF signal to your TV and glitch-free viewing is yours. Furthermore, this version can be used with a TV camera or computer to turn your TV set into a monitor.

Construction of the stabilizer is simple, and alignment can be done with only a voltmeter (although an oscilloscope is helpful).

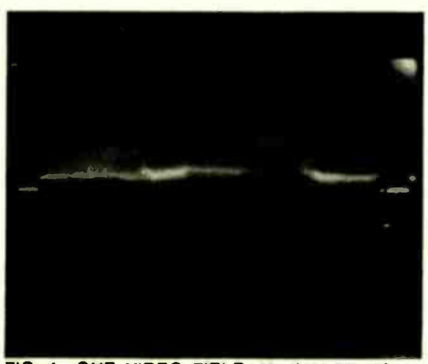


FIG. 1—ONE VIDEO FIELD. Vertical blanking-intervals are visible to right and left of video "fuzz."

A little background

Let's begin with a look at a video signal. Figure 1 shows one field of video (our system uses 60 fields per second). Most of what can be seen (the "fuzz") is picture information and will be different for each field. At 60 fields per second, the individual fields blend into a continuous, smoothly changing display on the screen. There is one element of the field, though, that does not change—the sync pulses.

At the left and right ends of the scope trace there is a short, flat area that contains no picture information, but just a short negative-going pulse. That portion of the signal is termed the vertical blanking-interval. We'll talk more about it momentarily. There are also other sync pulses (called horizontal sync pulses, and occurring 15,734 times per second) in addition to the vertical blanking-intervals. Since they are of very short duration, they do not show up well in Fig. 1. The purpose of the sync pulses is to match the timing of a TV receiver to that of a video source (VCR, camera, of-the-air signal, etc.).

The vertical blanking-interval can be seen more clearly in Fig. 2. It is at the center of the screen, with picture information to its right and left. The horizontal sync pulses can now be seen as well—their tips appear as two rows of dots below the picture information and the vertical blanking-interval. The negative-going pulse within the blanking interval is the vertical-sync pulse, and it is this that can cause picture instability if it is not recorded properly.

Circuit description

A circuit to correct distorted vertical-sync pulses is shown in Fig. 3. It contains two isolated video buffer/amplifier stages, Q1 and Q2, and a vertical-sync detection and regeneration subsection that adds a stable vertical-sync pulse to the composite-video signal through diode D6.

In operation, the clamped video (with the sync tips at +5 volts) is passed through buffer/amplifier Q1-Q2 and is simultaneously applied to pin 5 of IC1-a (one-fourth of a CA339 quad comparator). Pin 4 of that comparator is biased a few tenths of volt above the clamp level; that causes a positive-going pulse to appear at pin 2 every time a sync pulse occurs.

Resistor R5, R6, and capacitor C2 form an integrator circuit that allows the horizontal and vertical sync pulses to be distinguished from one another. The bias at pin 7 of IC1-b sets the level at which that will take place and a negative-going pulse occurs at pin 1 of that IC only when a vertical-sync pulse is present.

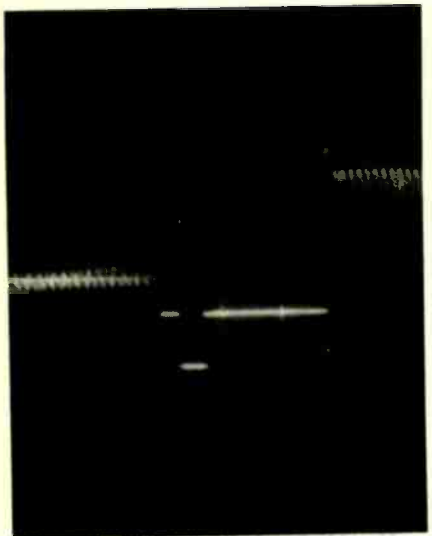


FIG 2—EXPANDED VIEW of vertical blanking-interval showing vertical-sync pulse. Blips indicate tips of horizontal-sync pulses.

Another section of the quad comparator, ICI-c, is configured as a one-shot with a time constant of about 180 microseconds (the same as the vertical-sync pulse interval). The pulse generated is inverted by IC1-d and its amplitude adjusted by R14, after which it is mixed with the original video signal through D6. The result is a signal with a vertical-sync pulse of the proper strength and duration that "fills in" any gaps in the original signal.

RF modulator

The modulator shown in Fig. 4 will allow you to combine the audio and corrected video from the VCR and display them on your TV set using channel 3 or channel 4.

Most of the work is done by IC3. All that has to be added is an RF tank-circuit to determine the RF-carrier frequency, an audio tank-circuit for the FM audio-subcarrier, and a bias circuit. The RF tank-circuit is made up of L1 and C10; adjusting L1 allows the carrier to be tuned to either Channel 3 or Channel 4.

The audio tank-circuit uses L2 and C7 to generate a subcarrier 4.5 MHz above the video carrier. This circuit is shunted by the base-collector capacitance of Q3. The audio input is buffered and amplified by IC2, and then applied to Q3 which acts

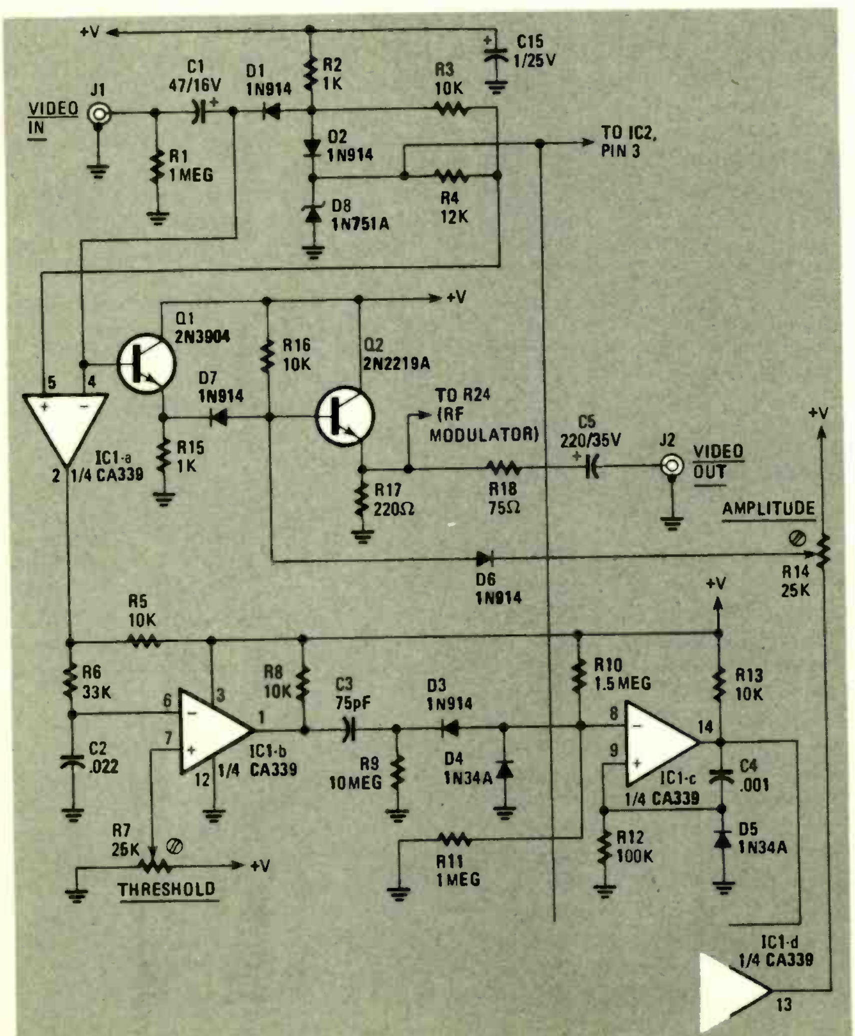


FIG. 3—DETECTION ND REGENERATION of vertical-sync pulse are performed by IC1.

PARTS LIST

All resistors 5%, ¼-watt
R1, R11—1 megohm
R2, R15, R30—1000 ohms
R3, R5, R8, R13, R16, R20, R32—10,000 ohms
R4—12,000 ohms
R6, R21—33,000 ohms
R7, R14—25,000 ohms, trimmer potentiometer
R9—10 megohms
R10—1.5 megohms
R12, R19—100,000 ohms
R17, R27, R28—220 ohms
R18, R29, R31—75 ohms
R22, R23—15,000 ohms
R24—2200 ohms
R25—1000 ohms, trimmer potentiometer
R26—100 ohms
Capacitors
C1—47 µF, 16 volts, electrolytic
C2—.022 µF, Mylar
C3, C10—75 pF, dipped silver mica
C4, C11—.001 µF ceramic disc
C5—220 µF, 35 volts, electrolytic
C6, C15—1 µF, 25 volts, tantalum
C7—100 pF ceramic disc
C8—.01 µF, Mylar
C9—22 pF ceramic disc
C12, C13, C16—0.1 µF, Mylar
C14—470 µF, 25 volts, electrolytic
Semiconductors
IC1—CA339 quad comparator
IC2—741 op amp
IC3—LM1889 video modulator
IC4—7812 twelve-volt regulator
Q1—2N3904
Q2—2N2219A
Q3—MPSA05
D1-D3, D6, D7—1N914
D4, D5—1N34A
D8—1N751A 5.1-volt Zener
BR1—full-wave bridge rectifier, 1 amp, 50 volts
T1—12.6 volts, 300 mA, PC-mount (Radio Shack 273-1385 or equivalent)
L1—071-.082 µH (J.W. Miller 48A778MPC or equivalent)
L2—7-12 µH (J.W. Miller 23A105RPC or equivalent)
F1—¼ amp, 3AG pigtail fuse
Miscellaneous: PC board, enclosure, hardware, connectors, optional vestigial-sideband filter (Plessy SW300), etc.

The following are available from JENGCO, 3232 San Mateo NE, Suite 75, Albuquerque, NM 87110: KRF-1—kit including etched, drilled, and plated PC board and all board-mounted components, $65.00; KRF-2—PC-board only, $15.00; KBBV-1—same as KRF-1 but without RF modulator (for video-to-video applications only), $42.00; KBBV-2—PC board only, $13.00. Kits do not include cables, hardware or connectors. Please add 5% for postage and handling; NM residents add 4% sales tax. Please allow six weeks for delivery.

as a varactor diode in parallel with C7-L2. (You can use a regular varactor diode in place of Q3, but may have to change the value of R21.)

The audio subcarrier and the corrected video are applied in the proper ratio to pin 12 of IC3. Resistor R25 supplies bias for the IC, and affects both the degree of modulation and the level of the RF carrier.

The output of IC3, from pin 10, is attenuated by R30 and R31, and then coupled to the RF-output connector by C13.

Capacitor C13, at the output jack, can be either a capacitor *or* a vestigial sideband SAW (*S*urface *A*coustic *W*ave) filter. The filter eliminates the lower sideband of the TV signal and helps prevent adjacent-channel interference. Normally it is not needed, but should you experience interference problems, you may want to include it (see the "Construction" section).

Finally, as designed, the RF output is intended to match 75-ohm coaxial cable (RG-59). If you prefer to use 300-ohm twin-lead, change the value of R31 to 300 ohms.

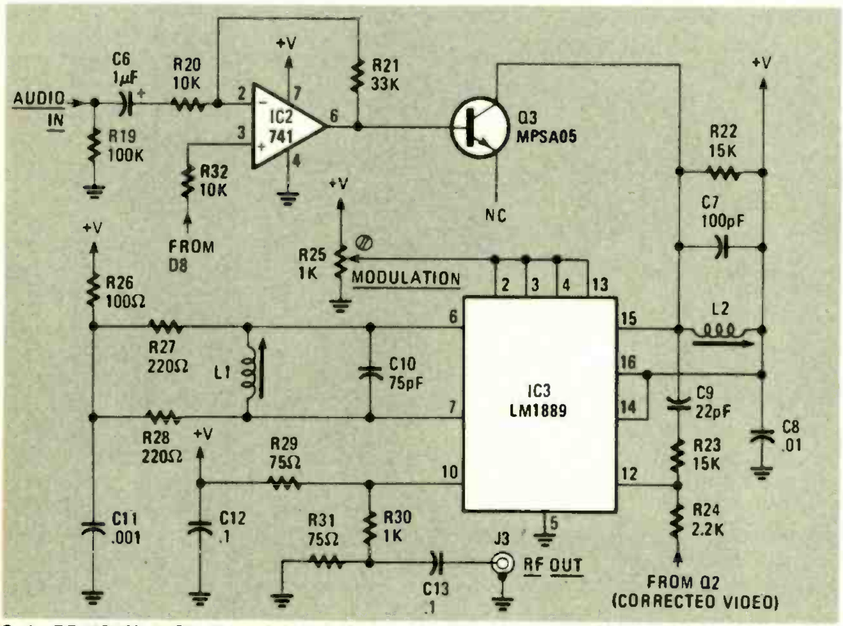


FIG. 4—RF MODULATOR. Capacitor C13 at RF OUT jack may be replaced by vestigial-sideband filter if desired (see text).

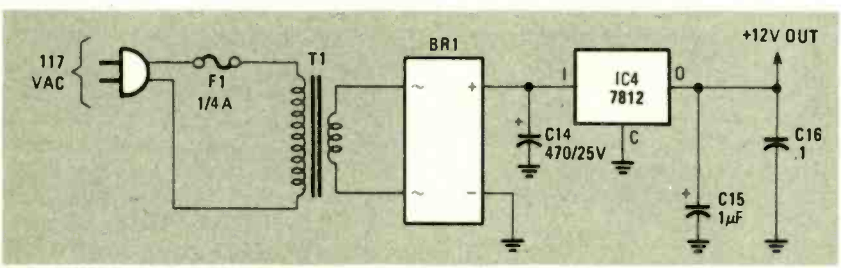


FIG. 5—SIMPLE 12-VOLT POWER SUPPLY is constructed on same PC board as rest of circuit.

Power supply

The power supply (Fig. 5) is of conventional design and is wholly contained on the same PC board as the rest of the circuit, making construction easier. A 7812 positive 12-volt regulator, IC4, supplies power for both the sync-corrector and RF modulator sections of the circuit.

Construction

Because lead length and layout are critical, wire-wrapping or point-to-point wiring techniques are not recommended for this circuit. A foil pattern is provided in Fig. 6 and a board is available from the source shown in the Parts List. A parts-placement diagram is shown in Fig. 7. Note that the section of the board to the right of the dashed line is used only for the RF modulator and may be omitted if a baseband video unit is required; the board could be reduced in size by about 25%.

When installing the polarized components (diodes, IC's, electroytic capacitors, etc.) make sure they are oriented properly. That is especially true for the power transformer. It's also a good idea to put a piece of heat-shrink tubing over the pigtail fuse to reduce the possibility of getting a shock during the alignment procedure.

Mount Q2 a little more than ⅛-inch above the PC board to allow its heat sink to clear nearby parts. The heat sink is not a necessity, but serves to add some operating margin to the design.

The heat-sink the voltage regulator, IC4, mount it on the *bottom* of the board and then bend it over so its mounting hole

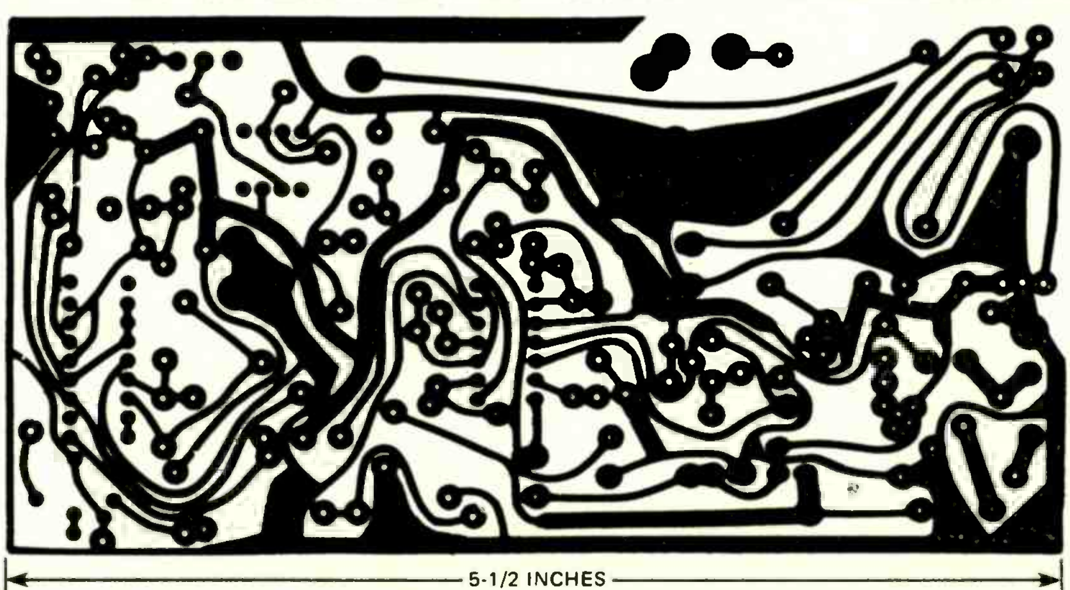


FIG. 6—SINGLE SIDED PC BOARD contains sync corrector, RF modulator, and power supply.

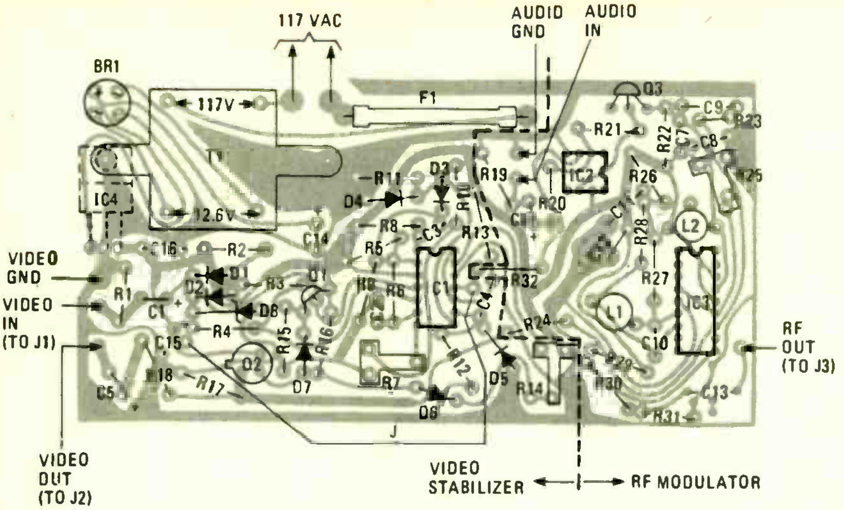


FIG. 7—REGULATOR IC4 mounts on *bottom* of board with tab away from it (see text). Area to right of dashed line contains RF-modulator circuit.

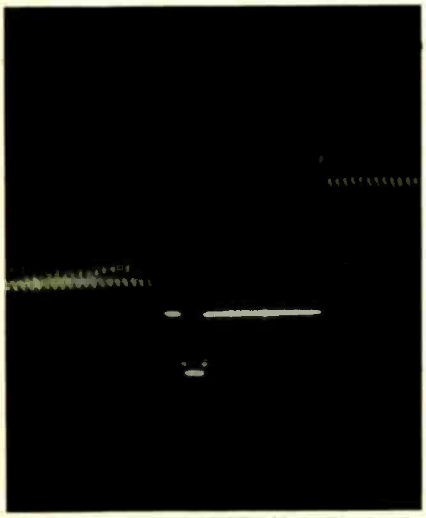


FIG. 8—CORRECTED VERTICAL-SYNC signal. Note extra amplitude added to tip of sync pulse.

aligns with one of the transformer's. Place a short spacer—about ¼ inch—between the tab of the IC and the board and pass the mounting bolt through the aligned holes so that the IC lies flat on the floor of the enclosure. The enclosure will then serve as the regulator's heat sink.

The 75-ohm RG-59 video-input line can be connected directly to the board, if desired, eliminating the need for J1. For best results keep it short—less than 1½ feet. The output line can be of any reasonable length. Mount the PC board on spacers in a metal cabinet; add the appropriate input and output connectors, and the power cord.

If you intend to use the vestigial sideband filter, proceed as follows: Remove R31 and R30, and replace R30 with a jumper. Remove C13 and insert the filter in its place. The Plessy SW300 filter has about 20 dB of attenuation at midband, so the RF-output signal level will remain approximately the same as before (2 mV).

Checkout and alignment

This procedure assumes that you have included the RF modulator on your board. If not, disregard the portions that do not apply.

Apply power to the unit and insure that the 12-volt supply voltage is present at the output of the regulator. Use a meter or scope to verify that this voltage is present at several spots throughout the circuit, such as the IC supply-voltage pins. Also check for 5-volts DC at the cathode of Zener diode D8. (If the voltages are incorrect, D8 is probably installed backwards.)

Not turn R7 (THRESHOLD) fully clockwise and R14 (AMPLITUDE) fully counterclockwise. Adjust R25 until you read about seven volts at pin 2 of IC3. When you're satisfied that al the voltages are correct, you're ready to start the alignment procedure.

Your'll need a video source to perform the alignment. That can be your VCR, a video camera, or any other video-generating device. If you use a VCR, make sure that it is supplying a clean, noise-free signal. Connect the video source to the video input of the sync connector.

If you're using a scope, connect it to pin 1 of IC1 and adjust R7 until the display resembles the top trace of Fig. 9. The negative-going pulses should be about two milliseconds in duration.

If you are using a meter, connect it to pin 1 of IC1—it should read close to zero volts. *Slowly* turn R7 counterclockwise. At some point, the voltage should jump up to about 10 volts. As soon as that happens, stop turning R7—it's now correctly adjusted.

The AMPLITUDE pot, R14, can be adjusted by trial-and-error using a videotape with distorted sync (such as a rental movie) as a video source. If you don't have a scope, turn R14 about ⅔-turn clockwise (approximately its correct setting). Jump ahead to the RF-modulator alignment. Return to this step last.

You can set R14 most accurately by connecting a scope to the video output (emitter of Q2) and observing the vertical-sync pulse. Most general-purpose scopes will not lock on to the composite-video signal due to its complex shape. These tips may help: Try using the scope LINE SYNC position—the frequency of the vertical blanking-interval will either be locked to, or very close to, the 60-Hz power line frequency. If the scope has a trace expander (i.e. 5× or 10×), do the following: Trigger the scope's sync with the signal present at pin 1 of IC1; set the sweep rate at about 2 ms/division; expand the trace, and then adjust the trace's horizontal position until a vertical blanking-interval comes into view. (That is how the display shown in Fig. 2 was obtained.)

Once you have a good display, ajdust R14 until the track looks like the one shown in Fig. 9. Notice that it is exactly like the "ideal" trace in Fig. 2 except for the small addition to the peak of the sync pulse. Be sure you have that extra amplitude, because it will insure proper switching of diodes D6 and D7 when portions of the vertical-sync pulse are missing.

You are now ready to align the RF modulator. Leave the video signal connected to the input of the sync connector and connect the RF output to the antenna terminals of your TV set. Use an impedance-matching transformer (balun) if necessary. Tune the set to Channel 3 or 4—whichever's not used in your area—and disable the set's AFT (*A*utomatic *F*ine *T*uning) if possible.

Use a none-conductive tuning wand to adjust L1 until you observe some sort of picture on the TV screen. Adjust R25 (MODULATION) and L1 alternatly until you get the best picture quality you can. Now you can bring in the sound by adjusting L2. The two coils and R25 are interactive, so readjust several times to get the best results.

If you have been working without a scope, now is the time to return to R14 and carefully adjust it for the best and steadiest picture from the distorted tape you've been running (this stage had to wait until the RF modulator was adjusted so you could refer to the picture on the TV screen). As you turn the pot, the picture should suddenly "lock in." Stop at that point—if you go farther, the regenerated sync pulse may be too strong and interfere with the rest of the signal.

Should you run into any problems in performing the alignment, go back and check your work—specially for poor solder joints, solder bridges and for correct component-orientation. Also try readjusting R7 and R14 slightly. If the circuit seems to be working properly but you are still having problems with vertical roll, try increasing the value of R12 to 150K or 220K. That will widen the vertical-sync pulse farther, and lock-in even most stubborn TV set. **R-E**

Make Your Own COMPUTER CABLES

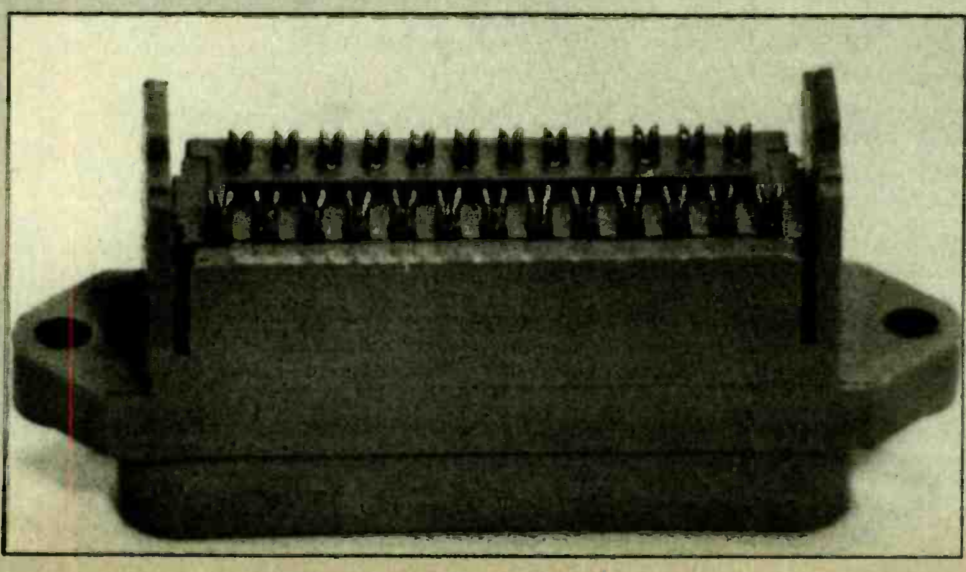
JOHN SMITH-RICHARDSON

Computer cables either stock items or custom design are very expensive. Make them yourself and experience a retail savings from 50 to 75 percent!

IT IS SAID, NOT COMPLETELY IN JEST, THAT POLAROID COULD afford to give their cameras away, because once you own one you're married to Polaroid forever. Only they make the film; they can charge what the traffic will bear, and that's economics!

The same can be said of computer-peripheral manufacturers. There are many places to get a discount on hardware such as modems, printers, and the other gizmos that make personal computing a pleasure, but in almost all instances the gear comes without cables. When you ask for the cables, you then find out why they can sell the peripherals at such fabulous discounts—most of the profit is in the cables. For example, an ordinary Centronics-type printer cable that you can assemble yourself for about $18 costs between $40 and $60 at your local computer emporium. And ordinary RS-232 extension cables for a modem, printer, or a terminal are a literal gold mine: a 5-foot length with something like $13 worth of parts sells for $40 and up, while a simple gender-reverser you can throw together from some junk connectors starts at $30.

The best way to overcome the greed of the computer shops, and save a bundle at the same time, is to simply make your own cables. Sometimes it's a snap, 10-minute job to assemble the equivalent of a $60 printer cable, other times it takes a little more effort because some of the manufacturers throw a "hook" into their connections to force you to buy their cables. For example, the non-standard Apple parallel printer connections are legendary. The quixotic numbering



THE CONNECTORS specifically made for ribbon cable have razor-sharp "insulation displacement" terminals. When the ribbon is pushed against the terminals the "knives" slice through the insulation and the wire makes contact with the terminal(s). No soldering of any kind is required.

RIBBON connections are simultaneously secured by squeezing the connector—with the ribbon wire in position—between the jaws of a vise. Use only as much pressure as necessary to seat the ribbon completely against the connector—there must be no "daylight" between the ribbon and the connector.

of Radio Shack's original printer-port connections led to many repairs during the warranty period—and many users believe it was innumerable *freebie* repairs that convinced Radio Shack to use standard terminal numbering. Then there was Heathkit with an RS-232 terminal #20 connection known only to Heathkit.

But does anyone every learn? Never! The latest version of the Osborne computer instruction manual has a completely erronious set of parallel-printer connections; after you blow your mind and a few days work, most users wind up spending $40 to $60 for an "approved" cable. And let us not forget that if you use a standard "reversed" modem cable between an Osborne and a professional RS-232 modem the computer will lock-up. Or how about Radio Shack's Color Computer? The rest of the world uses a D-connector for a serial interface; the CoCo uses a 4-terminal DIN connector.

When you come right down to it, in many instances there is no such things as a standard cable. If one end is standard the other probably isn't; but that's no reason why you still can't save *big bucks* by making your own cables.

Most computer cables can be easily assembled from a small assortment of parts: some ribbon cable, press-fit ribbon connectors, multi-wire (round) cable with solder connectors, or some combination of ribbon and solder connectors. At most, it's simply a question of using the easiest cable and connector for a given job.

Ribbon cable is usually preferred because the connectors clamp on; they are not soldered. Ribbon cable consists of may individual plastic-insulated wires moulded side-by-side. It's usually available in specific wire widths, such as 20, 26, 30, 36, or 40 wires. If you need something like 38 wires you simply strip away 2 wires from a 40-wire ribbon cable. Ribbon cable can be either all one color with one single wire on either side a different color, or every fifth wire might be a different color to help you count from either end, or every group of wires might have individual colors, say all colors of the rainbow repeated in sequence.

Regardless how it's done, the two outside wires are never the same color unless someone has deliberately gone out of their way to be stupid by stripping multi-color wire in such a manner the two outside wires are the same color. The outside wires are polarized tracers and *must* be a different color. If you use conventional ribbon cable one side wire will be red, or black, or blue, while the other wires are one other color. If every fifth wire is color-coded, only one outside wire will be color marked.

To save yourself the heartache of an inadvertently "blown" periperal, standardize and use the color-coded wire as the #1 lead connected to the #1 terminal. Regardless of what the manufacturers of your computer and peripherals do, your cables will be OK if you use one, and only one, cable wiring standard.

Ribbon cable comes in several different gauges. The stuff from Radio Shack, however, is the easiest to locate and is among the least expensive; it works just fine because its insulation appears to be the exact thickness required for most ribbon-type connectors. If the wire is too heavy, you can easily damage a connector during assembly.

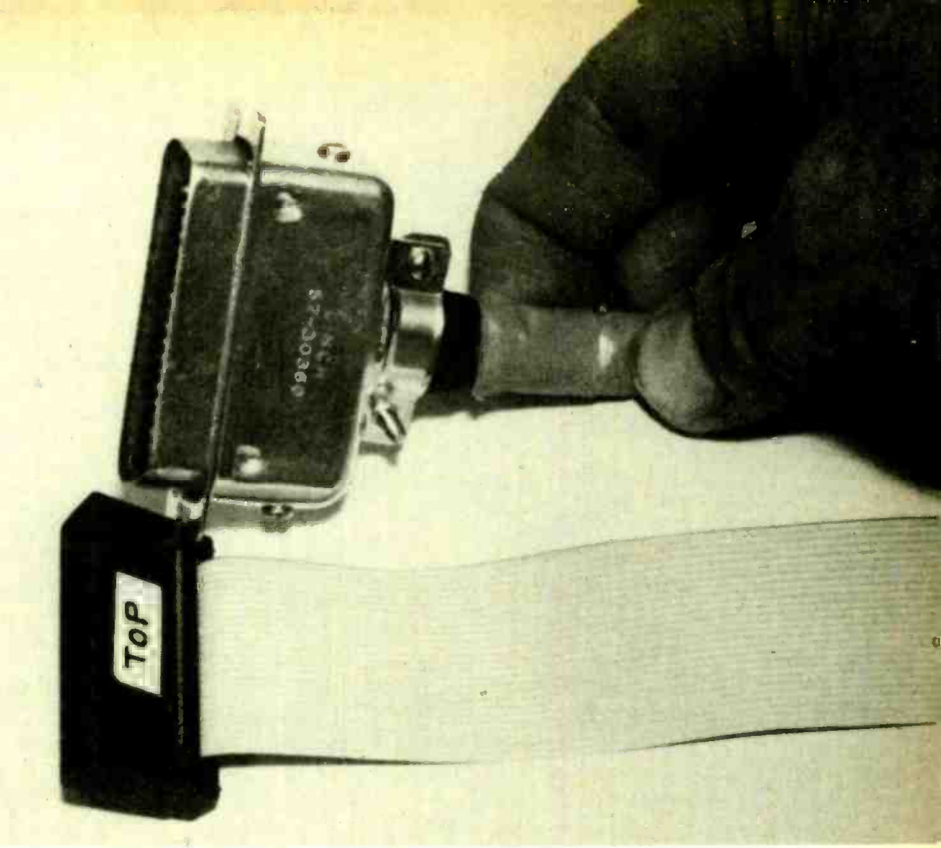
Unfortunately, while I have always been able to purchase the wire in a Radio Shack store I have never been able to find it in the catalog, though it must be there somewhere.

At times, you'll have had no choice but to use solder connections and you'll create the least problems if you: A) use a "light" iron (about 22 watts) with an ultra-thin (1/6-inch) soldering tip; B) use the so-called "wire type" solder of #22 or #24 gauge; and C) you twist the wire ends very, very tightly and tin them solid from the insulation to the tip before you try to install them on the connector's terminals.

Is it really standard?

The first step in making your own computer cables is to determine if the things you want to connect together are "standard"—whatever *standard* is supposed to mean. If you're connecting to a Centronics-type printer, the connections at the printer itself are standard, or at the very least the eight signal lines, the ground, the strobe, the busy, and the *ACK* connections will be standard.

If you're making up an ordinary RS-232 extension cable, HERE'S HOW you handle a cable that can use a ribbon connector on one end (bottom connector) but needs a solder-type connector (top connector) on the other. At the solder-type connector, fold the sides of the ribbon inward to form what is best described as "a flat tube;" then wrap the tube with several turns of plastic tape where it enters the connector's cable clamp. If the cable clamp doesn't bite down hard into the tape, add a few more turns; the wire(s) must be secured by the clamp, not by their soldered terminal connections. Note how the top of the ribbon connector has been labled to prevent it from being installed the wrong way.



which usually sells for between $40 and $60 depending on its length, both ends are usually "standard" unless its a *modem cable* which reverses pins 2 and 3 on one end. If there are any peculiar connections, they won't be in the cable, but rather in the equipment. For example, if you're connecting serial I/O (input/output) equipment the ground, TX (transmit), and RX (receive) connections are standard, or TX and RX will be reversed for a modem, but after that anything goes—and usually does. On some RS-232 modem cables the RTS and CTS connections must be reversed for a modem, or completely disabled, or the #20 terminal polarity must be reversed through an outboard integrated circuit serving as an "inverter". All those things are your problems. But once they're resolved it's on to assembling the cables.

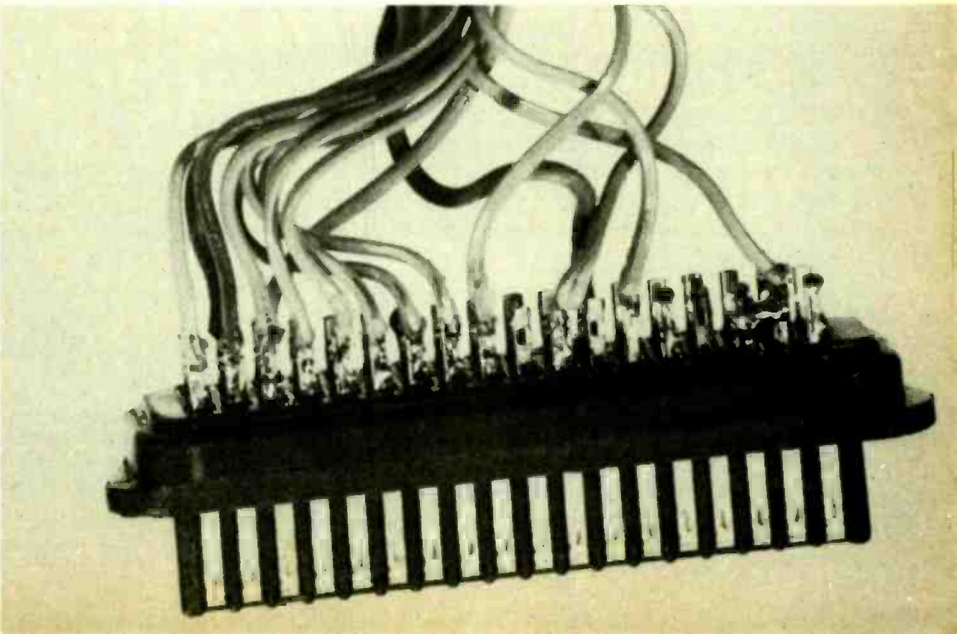
Ribbons are easiest

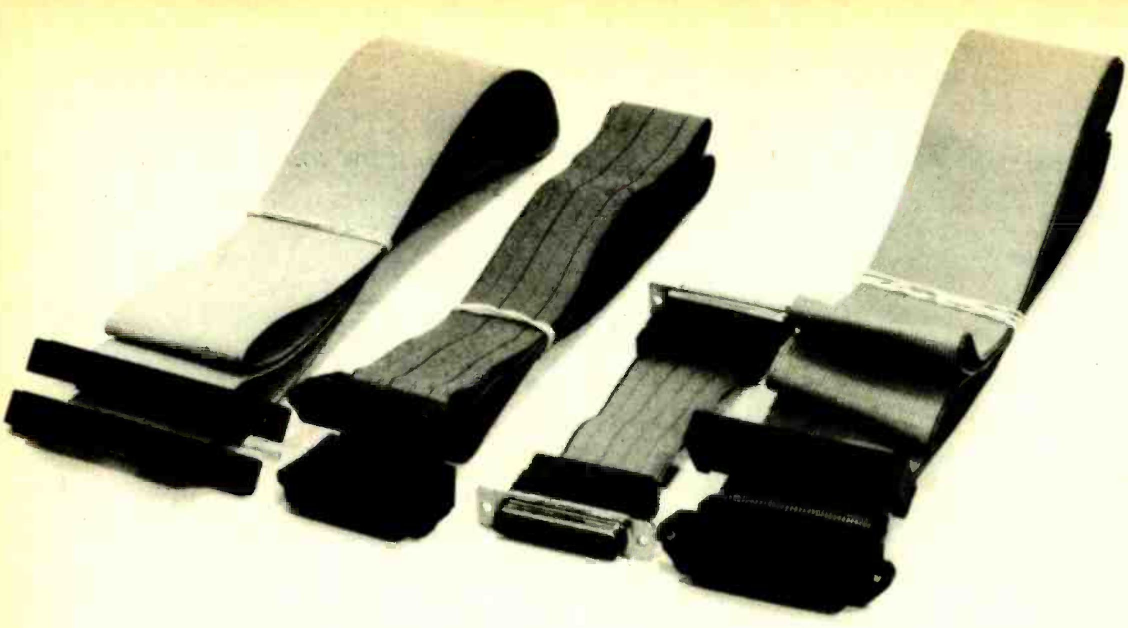
Quite possibly, the cables for the most of the Radio Shack computers and printers, Heath/Zenith equipment, the Centronics-type printers, and RS-232 extensions are the easiest to make because the terminal connections were intended for flat ribbon cable; hence, they match on both ends even if the connectors are different. By "match" I mean that the order of the wires is the same even if the connectors and their numbering aren't. For example, if wire #1 on one end is ground, it's ground on the opposite end. If wire #11 is the printer *busy* on one end, it's in the same order on the other end even if the connector terminal isn't #11. Except for the CoCo, Radio Shack computers are a good example of wire standardization; while a Radio Shack computer's parallel-printer output connector isn't necessarily the same as the connector used on the printer, the wires are in order, and to make your own cable—at a savings of at least $23—you simply crimp connectors conventionally to both ends of a length of ribbon cable and the whole thing works.

In most instances—cables for modems being the exception—ordinary ribbon cable is the best thing to use.

Though connectors for ribbon cable are the easiest to install, they are also the easiest to damage or completely foul

IF YOU MUST use a solder-type connector, make the connections short-circuit proof. The wires' insulation should extend right up to the terminal, and a little bit into the terminal if you can manage it. It takes practice. The trick is to have only about 1/8-inch of tinned wire protruding beyond the insulation. Here is where "practice makes perfect," and patience is a virtue!





IF YOU FOLLOWED instructions very carefully, used all your basic skills and proceeded with care, your computer cables assembled from the instructions in this article should have a pro-type look.

up, and you usually don't get two chances with ribbon connectors. Unlike solder-type connectors with some form of channeled terminals, ribbon connectors have nasty little razor-sharp knives euphemistically called "insulation displacement terminals." The connector itself has at least two components, possibly three: the main body, a pressure bar that secures the wires, and possibly an orientation bar that guides the wire out of the connector straight up, straight down, or out the back.

The main body, which is usually a plastic material, has V-shaped, razor-sharp terminals moulded into the body. The ribbon wire is placed on top of the "terminals" and the plastic bar is placed over the wire. When the bar is squashed down by squeezing the connector in a vise, the wire is forced down on the V-knives. The knives simultaneously pierce the wires' insulation. When the bar is fully seated each wire is sitting at the base of the V-shaped terminal, with plastic insulation between the terminals.

There is no difficulty in assembling a ribbon connector if you take your time. The wire must be trimmed straight across, and a large scissors beats most other kinds of cutter. Then, the wire must be positioned precisely over the terminals and held in place while the bar is positioned and the first pressure is applied. If the wire drifts out of position you can end up with some V-knife terminals cutting through a few wires, a short or two, or some open connections. If possible, just force the bar down by hand to hold it in position, then place the whole connector in a small vise, as shown in the photograph, and close the vise until the bar is completely seated.

It's a lifetime connection, so don't attempt to salvage a used or defective ribbon connector, because it usually won't work. One of the terminals is bound to get bent askew and won't seat around its wire; you'll connect everything together and then spend hours troubleshooting inoperative equipment.

If you're lucky, the other end will take a matching ribbon connector; or if it's a different connector, it will use the exact same wire order. If you're unlucky, which is more than likely, the wires on the other end won't be in the same order. What you must do is use a "cable type" connector which was initially intended for multi-wire *round* cable—the stuff with which we're usually familiar.

Cable-type connectors usually have solder terminals, though some of the "industrial grade" cable connectors utilize crimp-type connectors that require a special tool that costs between $100 to $250. Do not get talked into any kind of sockets using "push in" crimp terminals; you'll cause unbelievable damage if you get one in the wrong connector hole and then try to get it out.

If you must use solder-type terminal connectors on both ends of the wire, your best bet is to use multi-wire *round* cable. But if one end of your cable can be a ribbon connector, then use ribbon cable, and wrap both sides inward where it's to enter the clamp of a solder-type connector. Wrap several turns of plastic tape around the ribbon wire's "fold", pass it through the clamp and shell, and solder to the connector terminals.

Usually, if you must use a solder-type connector, the wiring order will have no relationship to the order on the other end, so double-check each individual wire with an ohmmeter when it's installed. And when you check the latest wire, double-check the connection that preceeds it to make certain there's no unseen short circuit. As a rule of thumb, if your cable has a ribbon connector on one end and a solder connector on the other, install the wires at the solder connector in the order used at the solder connector, starting with the lowest number terminal—#1, or #2, etc. Forget about the other end. You're more likely to get tangled up in the order if you try to follow the order of the ribbon connector when installing soldered wires.

If you're making an RS-232 gender-reverser cable make certain the #1 terminal on connector at each end of the cable is correct. If you have it right, one end will have the #1 to #13 terminals at the top; and when you turn the "reverser" end to end, the other connector will have the #1 to #13 terminals on the bottom.

Hard to get connectors

As a general rule, Radio Shack stores stock an excellent assortment of ribbon connectors at reasonable prices. However, there are many common connector types they don't have, such as a ribbon or solder Centronics connector, and the 9-pin cable-type connector. Unfortunately, many local electronics parts stores charge up to 50% above *list* for the *special* connectors. One of the lowest-cost sources for unusual connectors is a data-supply accessories distributor, MISCO, Inc., Box 399-SP, Holmdel, NJ 07733. Write for their catalog. They have such items as Centronics connectors, 9, 25 and even 50 pin D-connectors, and they stock the D-connector hood large enough to accommodate an internal miniature switch for only $1.85. **R-E**

NEW HIGH-POWER OP AMP CHIP

Two Amperes of Output from DC to 4 MHz!

ROBERT F. SCOTT

I HAVE WONDERED, AND I SUPPOSE YOU have also, about the performance and the circuitry involved in those LSI audio-power amplifiers that are offered by a number of mail-order electronics supply houses. I haven't been able to come up with any technical data on those devices but was fortunate in running across an application note on a new and interesting device from National Semiconductor. It is the LH0101 low-distortion high-power wideband operational amplifier designed to deliver a high current into a variety of loads. It is conservatively rated at 2 amps with negligible crossover (zero-crossing) distortion. Frequency response is from DC to above 4 MHz. It is in a hermetically sealed TO-3 package. Table 1 shows the typical performance characteristics at 25°C ambient and a + 15-volt supply.

The LH0101, shown schematically in Fig. 1, has three basic sections: an op-amp, buffer amplifier, and power amplifier. The op-amp uses a BI-FET configuration to take full advantage of the superior DC performance offered by the FET input and the desirable slew rate, settling time, and low bias-current characteristics of this type of device. In addition, the internal frequency compensation makes the BI-FET an ideal around which to design a power amplifier.

Most power amplifiers designed for high current output over a wide frequency range are either designed for Class AB or Class B operation. Both of those designs have a tendency to produce crossover distortion. For minimum crossover distortion, a power amplifier must maintain a low output impedance throughout zero-crossing. To do that, the push-pull output transistors must smoothly drive the load, alternately switching current-sinking and current-sourcing duties at the crossover point.

In a Class-B configuration, both output transistors are completely cut off at the crossover point. Thus, output impedance is relatively high and crossover distortion is severe. In a Class-AB design, both output transistors are biased on during no-load conditions, thus providing a low output resistance and thereby eliminating crossover distortion.

However, in a Class-AB design, crossover distortion can develop with high-level input signals. For example, when the input-signal voltage causes full

TABLE 1

Parameter	Conditions	Value
Output current		2A
Input offset voltage		5mV
Input bias current		50pA
Input offset current		25pA
Input resistance		$10^{12}\Omega$
Large signal voltage gain		200V/mV
Output voltage swing	$R_L = 100\Omega$	±12.5V
	$R_L = 10\Omega$	±11.6V
	$R_L = 5.0\Omega$	±11V
Slew rate	$A_V = +1$	10V/µs
Full power bandwidth	$A_V = +1, R_L = 10\Omega$	300kHz
Small signal rise time	$A_V = +1, R_L = 10\Omega$	100 NS
Small signal setting time to 0.01%	$V_{IN} = 10V, A_V = +1$	2µs
Gain bandwidth		4 MHz
Harmonic distortion	$f = 1kHz, P_O = 1W$ $R_L = 10\Omega, A_V = +1$	0.005%
	$f = 20kHz, P_O = 1W$ $R_L = 10\Omega, A_V = +1$	0.05%

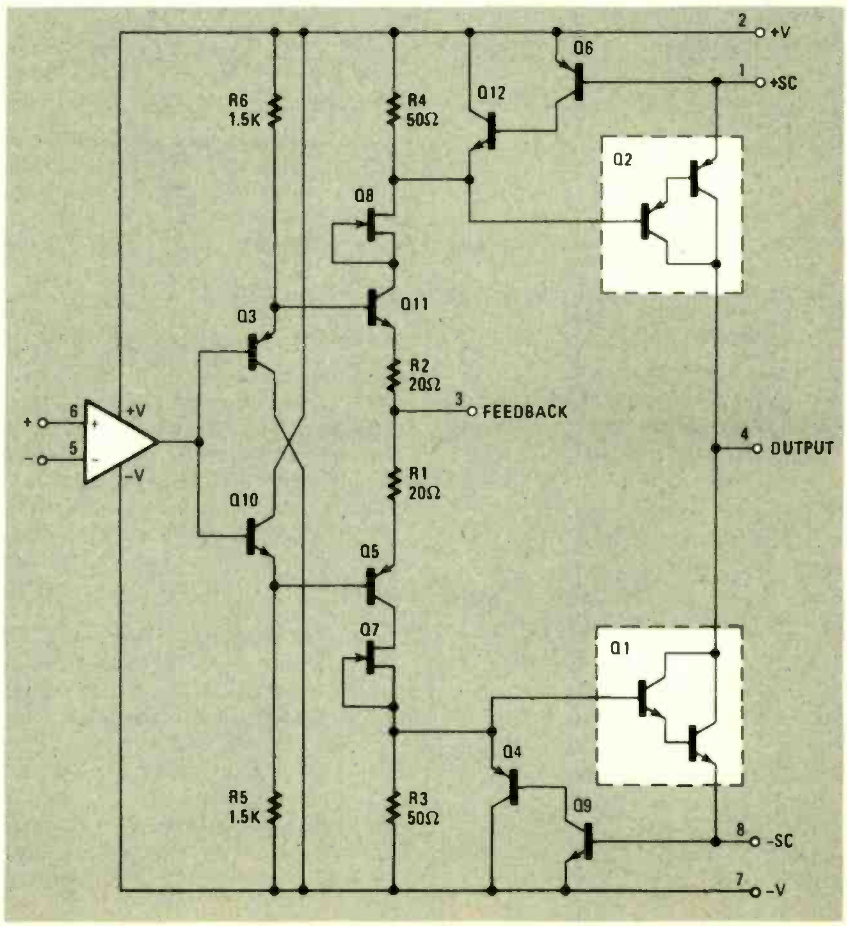
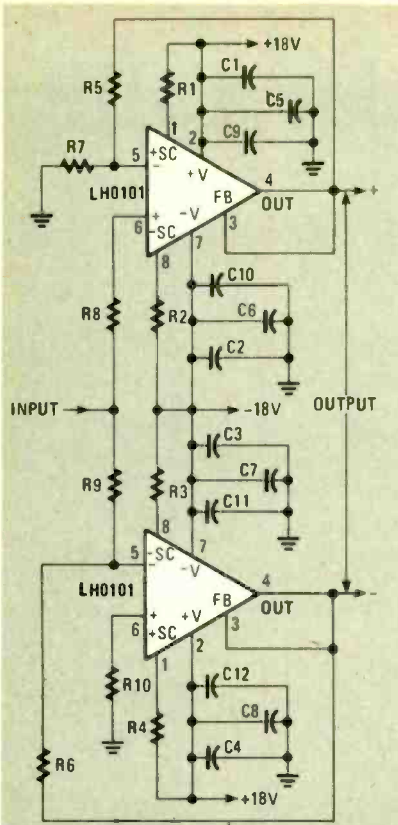


FIG. 1



R1-R4	CURRENT LIMIT RESISTOR	0.15Ω, 2W
R5	FEEDBACK RESISTOR	5K
R6	FEEDBACK RESISTOR	15K
R7-R10	INPUT RESISTORS	10K
C1-C4	BYPASS CAPACITORS	47μF, 25V ELECTROLYTIC
C5-C8	BYPASS CAPACITORS	10μF, 25V TANTALUM
C9-C12	BYPASS CAPACITORS	0.1μF, 25V CERAMIC

FIG. 2

output current to be delivered to the load, the increased base-emitter voltage of the driving transistor tends to bias the resting transistor off. Now, when the input signal reverses polarity, so that the output swings negative, the amount of crossover distortion, if any, depends on how fast the resting transistor can turn on and assume its share of duty cycle. The condition worsens as the frequency of the input signal increases.

The output stage of the LH0101 combines both Class B and Clas AB designs to achieve smooth distortion-free switching at the crossover point.

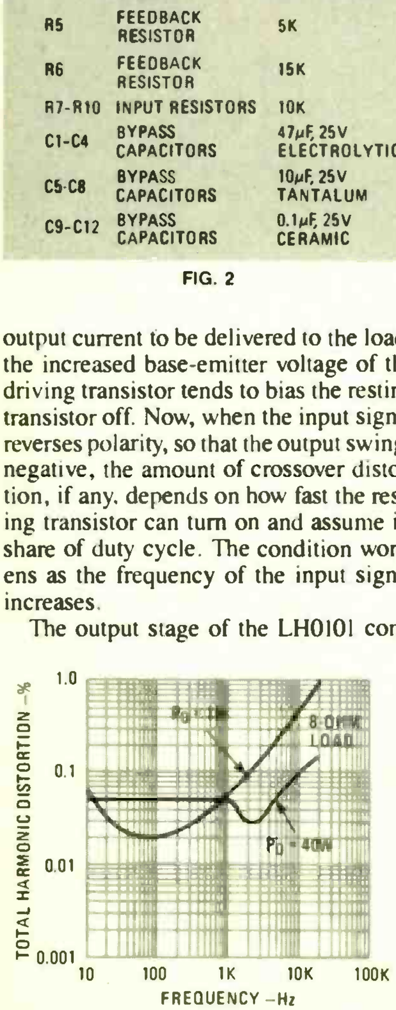


FIG. 3

The buffer stage of the LH0101 (Fig. 1) is a unity-gain current amplifier consisting of transistors Q3-Q11 and Q5 and Q10. Operating in the Class AB mode, what the buffer does is to provide distortion-free drive during the zero crossing. Bandwidth extends beyond 50 MHz to eliminate the possibility of bandwidth-induced distortion.

FET's Q7 and Q8 limit the buffer-stage output current to 50 mA. However, the output stage, consisting of Darlington transistors Q1 and Q2, is set up so that both transistors turn on as the ouput-load current reaches 25 mA. Under operating conditions, the buffer drives the load at currents up to 25 mA. Above that point, the output stage takes over, delivering power up to the rated output limit. Thurs, the power-driving ability of the buffer stage is used to "smooth" the turn-on delay of the output stage and eliminate crossover distortion.

Transistors Q6 and Q9 are in the circuit to prevent the output stage from being over-driven. Current-sensing resistors (R_{SC}) may be connected between the supply and sc terminals to set the limiting level. A drop of approximatley 0.6-volt across a sensing resistor turns on either Q6 or Q9. That in turn, turns on Q12 or Q4, respecitvley, to prevent excess base current from driving the output stage beyond the design limit. Current-sensing resistors $R_{SC} = 0.6/I_{SC}$. When $I_{SC} = 2$ amps, $R_{SC} = 0.3$ ohms.

Low distortion 40-watt power amp

Figure 2 shows how two LH0101's can be used in a bridge configuration to obtain maximum available power output from a specified supply voltage. Amplifier distortion curves are shown in Fig. 3. A slew rate of 10 volts-per-μs extends the full-power bandwidth to beyond 100 kHz.

Application precautions

In this and other high-current high-power amplifiers, particular attention must be given to ground connections and the length and diameter of PC traces carrying high currents. Keep them short to minimize the development of error voltages. Figure 4 shows a suitable method of circuit grounding. The heavy lines represent paths or traces carrying high currents.

The importance of minimizing error voltages can be seen as we examine the current-sensing circuitry in the amplifier in Fig. 2. The current-sensing resistors are R1, R2, R3, and R4; 0.15-ohm, 2-watt units that develop the 0.6-volt needed to trigger the current-limiting circuit. A PC trace with a resistance of only 10 milliohm (0.01 ohm) carrying 2 amps will develop a 20-mV error voltage. Add to that the possible error voltages that may develop across the 5-milliohm resistance of a good

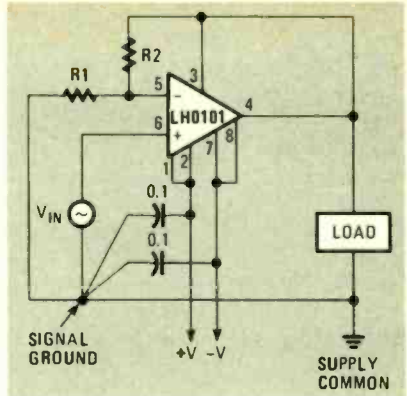


FIG. 4

solder joint and the 10-milliohm resistance of a socket contact.

A heat sink is a *must* to keep the LH0101's operating temperature within a safe range. It should have a thermal resistance of 3.5°C-per-watt ambient. A typical heat sink with that rating, and suitable for a TO-3 device package, is the Thermalloy 6141. It should be mounted with a mica insulator and a liberal application of a thermal-contact fluid or silicone grease.

Other applications

The LH0101 is ideally suited for service as a programmable current source, coaxial cable driver, CRT yoke driver, and a driver for inductive loads. For information on adapting the device to those applications, refer to Application Note AN-261—*Low-Distortion Wideband Power Op Amp and LH0101 Power Operational Amplifer Data Sheet* available from National Semiconductor, 2900 Semiiconductor Drive, Santa Clara, CA 95051. **R-E**

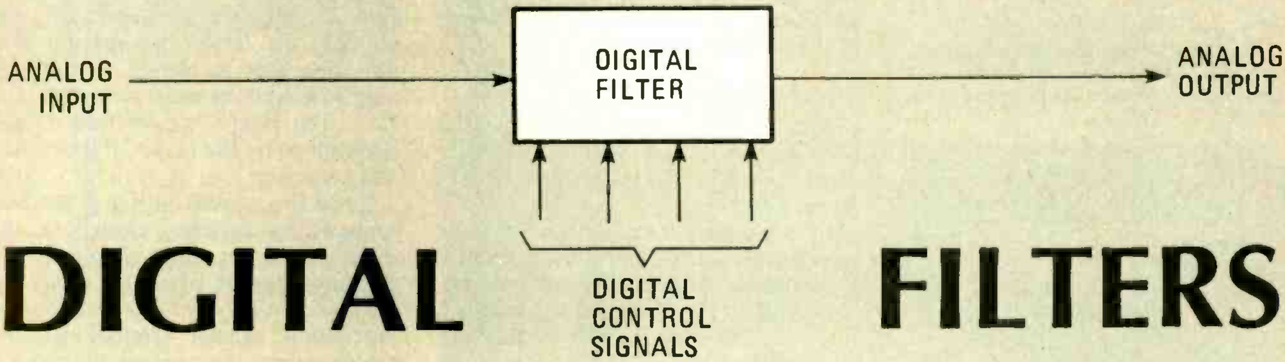
DIVIDE-BY-FOUR-PRESCALER

The RCA CA3199E divide-by-four prescaler takes signals in the VHF/UHF band (up to 1.3 GHz) and reduces them to low-frequency logic levels. The device's high sensitivity eliminates the need for preamplification in most cases. Applications include digital frequency synthesis in VHF/UHF receivers, frequency standards, and as high-frequency dividers in UHF timers and counters.

Accepting either single- or double-ended AC-coupled input signals, the CA3199E provides complementary emitter-follower outputs at standard ECL levels. With unloaded outputs, the typical logic 1 level is 4.2 volts while the logic 0 is 3.4 volts. The device operates from 5 ±0.5 volts. The nominal input signal is a 100 mV sinusoidal waveform in the range of 100 MHz to 1000 MHz; the maximum RMS input voltage is 0.5 volt.

Transition time of logic output is 0.6 ns for both risetime and falltime. In an 8-pin mini-DIP, the device is $2.79 at the 100-piece level—RCA Solid State Div., Box 3200, Somerville, NJ 08876. **R-E**

WHAT'S INSIDE DIGITAL FILTERS



Filtering an analog signal using digital techniques is becoming more and more commonplace. Here is a look at digital filters and how they work.

ARTHUR MAKOSINSKI

TRADITIONALLY, ACTIVE AUDIO-FILTER designs have used either L-C or R-C networks in combination with phase- or gain-compensating amplifiers. While such filters are relatively simple and economical when designed for one or two frequencies, they become complex and expensive if required in large numbers, as, for instance, in a ⅓ octave audio-spectrum analyzer. A device with a 20-Hz to 20-kHz range would require over 30 separate bandpass filters, or 360 precision capacitors and resistors for filter-tuning alone. That is in addition to the problems of achieving adequate temperature and amplitude stability, as well as maintaining acceptable reliability.

With the development of digital IC's in the late 60's, designing digitally controlled audio filters became possible. One of the first designs considered, was the digitization of the old mechanical commutating-filter; that filter is shown in Fig. 1.

Commutating filter

How the commutating filter works can best be understood by considering the simple low-pass section of Fig. 2 as an integrator with a time constant $\tau = RC$. If n such sections are cascaded and sequentially switched at a rate of f times per second, the net time-constant increases by n, so that the new time-constant $\tau = nRC$. That will yield a 3 dB low-pass response at $f_{LOW\ PASS} = 1/(2nRC)$.

If a signal at the commutating frequency, f_C, is now applied to the filter, each individual capacitor sees a particular—and fixed—average voltage (the voltage is dependent on the phase of the input frequency) each time it is switched into the circuit. Each capacitor therefore charges to a fixed voltage, and as the individual capacitors are switched in, or commutated, the original signal is reproduced as a series of discrete values or steps.

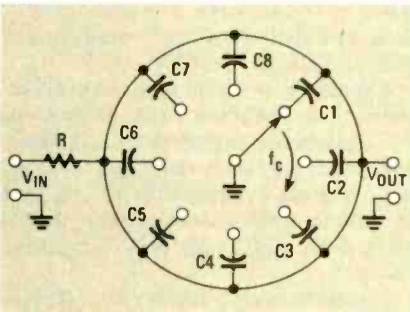


FIG. 1—A MECHANICAL commutating filter. If the input signal is equal to the switching frequency, the filter would reproduce the input signal at the output as a series of steps.

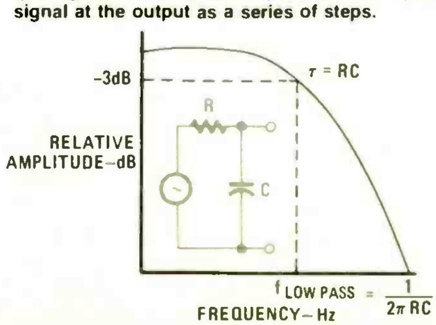
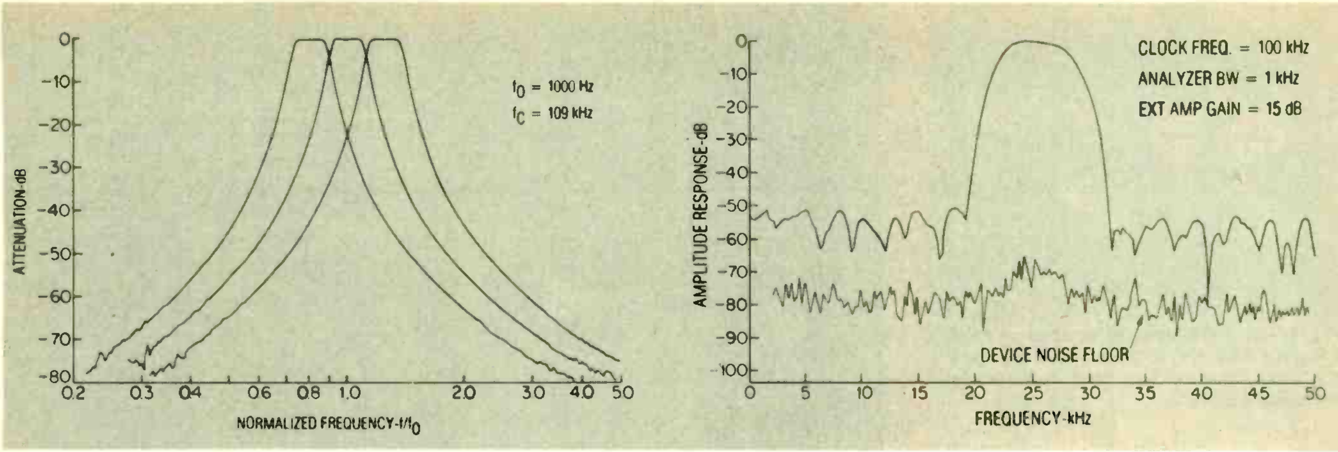


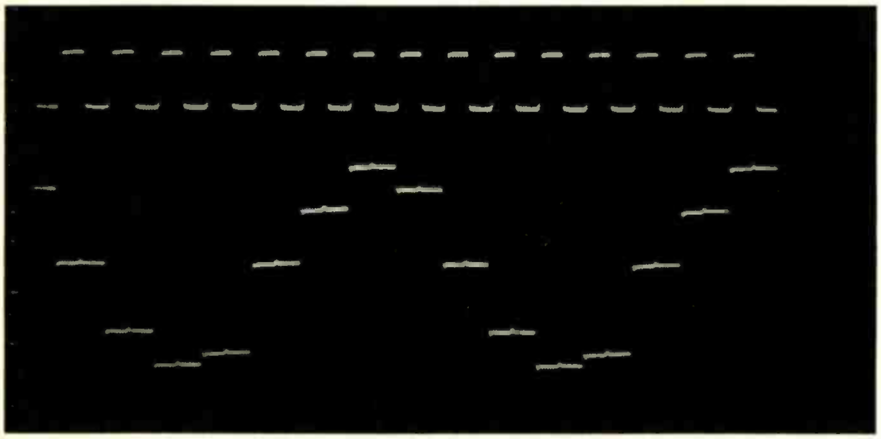
FIG. 2—THE RESPONSE of a simple low-pass filter is shown here. The time constant of the curve is determined by the values of R and C.

The commutating filter is often called a comb filter because it will only pass signals with a frequency of f_C—the resonant frequency of the filter—and its harmonics. That response is shown in the graph of Fig. 3. If, however, only the resonant frequency is desired, low-pass filters can precede or follow the commutating filter, attenuating the other "teeth" of the comb.

In modern commutating filters, the commutating is done by shift registers or counters. Standard transistors, or FET's, can be used to switch the capacitors. Figure 4 shows an eight-section commutating filter in which the necessary sequential switching is done by a combination of a CD4040 BCD ripple counter and a CD4051 BCD-to-decimal decoder. The CD4040 counter is triggered by a squarewave clock signal. As the counter advances, on the negative-going clock transitions, the first 3 bits of its 12-bit BCD output are connected to the BCD input-lines of the CD4051 decoder. That IC translates the BCD code into sequential decimal steps that switch the internal CMOS transistors on and off; those transistors, in turn, switch the connected capacitors. In that circuit, the filter's frequency is a function of the clock rate, and the number of poles, or sections, in the filter. In



THE BANDPASS CHARACTERISTICS of a Reticon R5604 switched-capacitor filter is shown in *a*. Contrast that to the frequency response of the Reticon R5602-3 transversal filter, shown in *b*.



THE CLOCK INPUT to a commutating filter, and the resulting output is shown here. The signal input to the device is a sine wave.

R5602 Transversal Filter Family Data Sheet for details), let's take a brief look at how it works.

Basically, the IC uses a new MOS charge transfer technique to form a monolithic bucket brigade. The bucket brigade is a chain of N-channel MOS transistors connected to small monolithic storage capacitors. The input signal is sampled, and the sampled charge is transferred from one capacitor to the next by alternately switching the MOS transistors.

As the sampled charge is transferred, it is simultaneously summed with a fixed analog reference. Thus, at every clock transition an alternate pattern of signal samples and reference charges are shifted forward. By multiplying the sampled and reference values by pre-programmed weighting factors and combining them at the output, various responses can be simulated.

The Reticon transversal filters contain a 64-section bucket brigade, as well as timing and output circuitry. Like the switched-capacitor filters, transversal filters are available in several configurations including low-pass and bandpass filters.

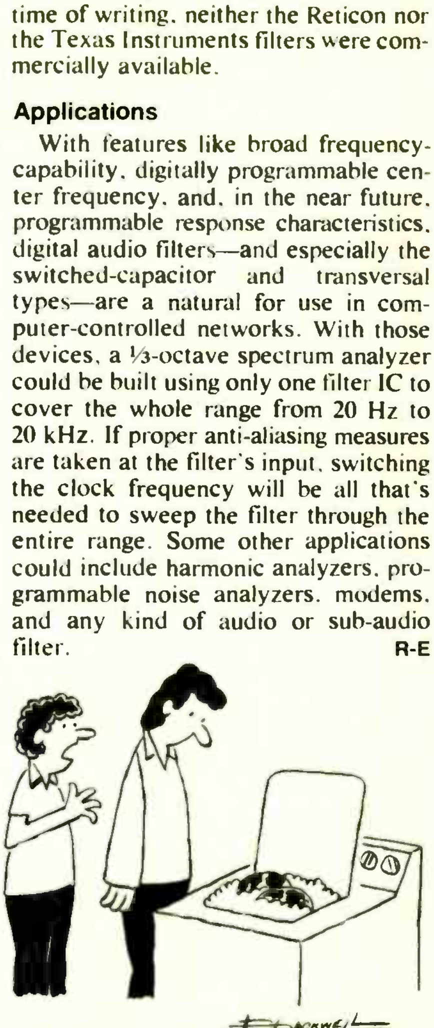
The filters have linear phase response and skirts, with a 150 dB-per-octave roll-off rate. The same aliasing problems found in switched-capacitor filters can impair the transversal filter's performance if input circuitry is not carefully designed. The Reticon R5602 family requires more outboard circuitry than their switched-capacitor counterparts, as well as a +15-volt power source. They cost $40.00 each in quantities of less than 10.

Presently, a general limitation with the transversal filters is their poor low-frequency response, which, in turn, is a function of the minimum sampling (clock) frequency required to shift the capacitor voltage levels along the bucket brigade. That "refresh" rate must be fast enough not to allow loss of charge in the capacitors due to leakage. Currently, those filters can be used down to input frequencies of at least 1 kHz.

Recently, Reticon reported work on a transversal filter IC that uses double polysilicon low-loss capacitors, extending the low-frequency response down to 50 Hz; the high-frequency limit is 125 kHz. The IC has a dynamic range of over 65 dB and, what is perhaps most remarkable, it offers digitally programmed characteristics. Texas Instruments (PO Box 225474, Dallas, TX 75265) has also developed an advanced 1024-stage transversal filter with an 8-bit programmable response-characteristic and Q, in addition to a 60-dB dynamic range, 50-dB stopband attenuation, and a 1-MHz maximum filter frequency. No mention was made of the low-frequency capability. At the time of writing, neither the Reticon nor the Texas Instruments filters were commercially available.

Applications

With features like broad frequency-capability, digitally programmable center frequency, and, in the near future, programmable response characteristics, digital audio filters—and especially the switched-capacitor and transversal types—are a natural for use in computer-controlled networks. With those devices, a ⅓-octave spectrum analyzer could be built using only one filter IC to cover the whole range from 20 Hz to 20 kHz. If proper anti-aliasing measures are taken at the filter's input, switching the clock frequency will be all that's needed to sweep the filter through the entire range. Some other applications could include harmonic analyzers, programmable noise analyzers, modems, and any kind of audio or sub-audio filter. **R-E**



"Oh! You mean you wanted me to clean the videodiscs with the disc-washer?"

ALL ABOUT

VLF Active Antennas

Because of poor antenna performance, the low frequencies are, as a rule, neglected by shortwave listeners. This series of articles will show you how you can overcome those problems and hear what you've been missing. The principles we'll discuss can even be used for reception up to 30 MHz.

R.W. BURHANS

GENERAL-COVERAGE COMMUNICATIONS receivers that are capable of continuously tuning from 10 kHz to 30 MHz are becoming ever more popular. However, users are often disappointed with their performance at the extreme low end of the spectrum—but it's not always the receiver that's to blame. Often, poor VLF (*Very Low Frequency*) performance is due to the use of an untuned, random-length antenna. Such antennas are often used because of the difficulty of building a full-size VLF antenna. As, we'll soon see, however, full size antennas, aren't always necessary for good reception at low frequencies.

This series of articles will introduce you to practical active-antenna systems that are physically very short. For example, Fig. 1 shows some experimental wide-band active antennas using whips that are just one-meter long. The casual SWL or VLF-LF listener with an appropriate receiver will get good results using those—provided that appropriate attention is paid to such things as antenna location, interference considerations, circuit construction, and ground systems.

Active antenna basics

In this discussion, we will restrict ourselves to active systems using vertical whips. Loop antennas are very useful but tuning, coil changing, and an entirely different type of circuitry are needed for that type of active antenna system. Short whips are usually easier to make and operate, but have the disadvantage of being more sensitive to local noise (power-line noise, for example). Loop antennas are directional—they have to be oriented with respect to the signal for best sensitivity. On the other hand, vertical whips are nal—sensitivity is not affected by the antenna's orientation.

Typical active antenna preamplifiers operate primarily as impedance converters or current amplifiers—they convert a small input-signal voltage at a high-impedance input to nearly the same voltage at a low-impedance output. A coaxial cable is connected from the output to the receiver's low-impedance antenna input (typically 50 to 500 ohms). As is common in many TV antenna-mounted preamplifiers, the power for operating the active preamplifier uses that same coaxial cable. There are, however, basic differences between the VLF-HF systems and the TV-type active preamps. For example, the VLF-HF active antenna must have a higher input impedance and more attention must be paid to the details of the amplifier's dynamic range and distortion. Another difference is that the frequency range covered by the VLF-HF preamplifier is a couple of orders of magnitude greater than that covered by the TV-FM units.

Active antenna preamplifiers mounted at the base of a short whip antenna are most often used at low frequencies (10 kHz to 100 kHz). There, the antenna length is much less than .001 wavelength. The general rule in airborne or marine VLF communications, or Omega and Loran-C navigation systems is to use a short active-antenna system .

Antenna sensitivity

Let's now introduce the concept of *effective length* (l_e). (In low-frequency usage, that is sometimes referred to as effective height). The effective length of an antenna is equal to the ratio of the voltage at the antenna output terminals to the field strength of the input signal (measured in volts/meter). In equation

form that is stated as:

$$\frac{V_{OUT}}{E_i} = l_e$$

The ratio of the effective length to the physical length (l) is a measure of the antenna efficiency. For example, an antenna with a physical length of 100 cm could have an effective length of 20 cm. The resulting output signal strength E_o would then be only one fifth that of the input.

The effective-length-per-unit-length of an active antenna can be estimated by determining the input capacitance of the system. That input capacitance includes the antenna-mount capacitance, C_m; the input-wiring capacitance, C_g, and the antenna-whip capacitance, C_a. (See Fig. 2-b.) The relationship is:

$$\frac{l_e}{l} = \frac{C_a}{C_a + C_m + C_g} \quad (1)$$

A typical one-meter long whip antenna might have a measured C_a of about 10 pF over a flat ground plane. Also, an antenna mount might have a fixed capacitance of C_m = 5 pF and the input wiring and active circuit capacitance might be C_g = 8 pf. The efficiency for a system with those values would be:

$$\frac{10}{10 + 5 + 8} K = \frac{10}{23} K = 0.434\ K \quad (2)$$

The factor K (which was assumed to be equal to 1 in equation 1) is a measure of the nearby shielding or coupling effect of the local ground plane (trees, structures, buildings, etc.). In practice, K is always less than one. A value of 0.75 might be obtained with a top-hat capacitive-loaded vertical antenna mounted on a pole or structure such that the local ground plane slopes away from the antenna on all sides. Values of K as low as 0.1 might be possible for a low horizontal wire with trees or buildings close to and higher than it. For example, let's presume that the K of equation 2 was equal to 0.5. The effective length would then be 0.434 × 0.5 = 0.217 meters. That is typical of what is actually observed with a medium-quality active antenna with a length of 1 meter. Another way of thinking about that antenna is to say that its efficiency, in terms of converting the input field strength to a corresponding level at the output terminal, is about 21.7%.

Because of the coupling factor, an active antenna mounted up in the clear will generally outperform an antenna mounted near obstructions. At VLF frequencies, a hill or mountain 0.5 km away from the antenna can reduce the antenna's sensitivity. Precision measurements of the phase and amplitude of 100-kHz Loran-C signals, made while flying over hilly terrain at low altitudes, can yield information about the variations of ground conductivity and terrain contours, which are related to K.

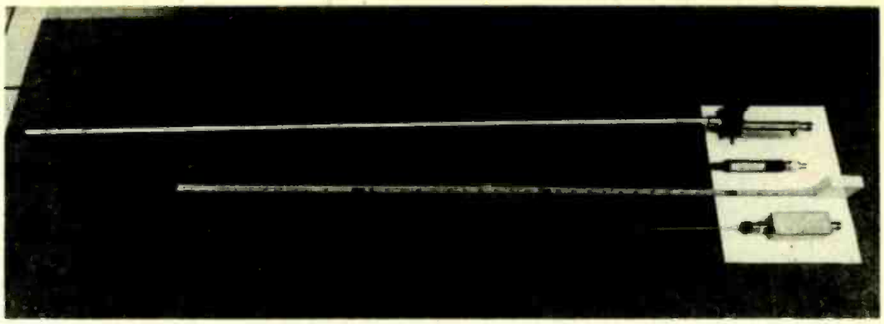


FIG. 1—EXPERIMENTAL WIDE-BAND ACTIVE ANTENNAS. The ones shown here are approximately one meter (39.47 inches) long. The tape measure is pulled out to 41 inches.

Input impedance

Active antenna receiving preamplifiers at frequencies of about 10 kHz have a high input impedance (greater than 1 megohm). That is because of the low antenna capacitance (C_a). Thus, the whip antenna can be considered to be a voltage source with a high internal impedance when coupled to the preamplifier input terminal (see Fig. 2). That internal impedance becomes lower as the frequency of operation is raised—reaching a value around 10,000 ohms at the AM broadcast band (1-MHz region).

If a short whip were connected directly to a 500-ohm receiver input terminal, a LF signal would be greatly attenuated as a result of the mismatch. For example, let's look at what would happen to a 10 kHz signal. The reactance of C_a for a 1-meter whip would be about 1.6 megohms at 10 kHz. Without an active preamplifier, the attenuation would be about 500/ (1.6×10^6 + 500) ohms, or roughly −72 dB! If, on the other hand, an active preamplifier were used, the same 1-meter whip would provide ample signal at 10 kHz, as the source would be much more closely matched to the load.

The effective capacitance of a wire antenna is approximately 10 pF/meter. Thus, at 10 kHz, a 30-meter wire antenna directly connected to a 500-ohm receiver-input terminal is a 50,000-ohm reactance. Another way of looking at that is to say that the antenna efficiency is 500/50,000 = .01, or 1%. At 10 kHz, our 21.7%, 1-meter active antenna looks much better than that 30-meter wire.

As we go higher in frequency, up to the 30-MHz region, the impedance of the 1-meter whip decreases to the point where it could be connected directly to a low-impedance receiver input. Hence, active, high-input-impedance antenna systems are most useful at the VLF-LF range (usually below 500 kHz); at those frequencies they can perform as well as a very-long-wire antenna that is connected directly to the receiver's low-impedance input.

Antenna noise levels

In airborne applications, for aerodynamic considerations and to minimize interference, it is desirable to use as small an antenna as possible in the VLF range. A recent FAA report suggests a minimum effective length of about 20 cm when operating at 100 kHz (Loran-C). An active antenna with a 20 cm l_e will provide an output signal level of 20 μV across a 50-ohm receiver input terminal when it is immersed in a 100 μV/meter electric field.

The antenna noise level found in a receiver is a function of the receiver bandwidth. A typical Loran-C reciever might have a noise level of perhaps 1000 μV/m. Thus, a weak Loran-C signal may be buried in noise to the 100 μV/1000 μV, or −20dB S/N level at the antenna input,

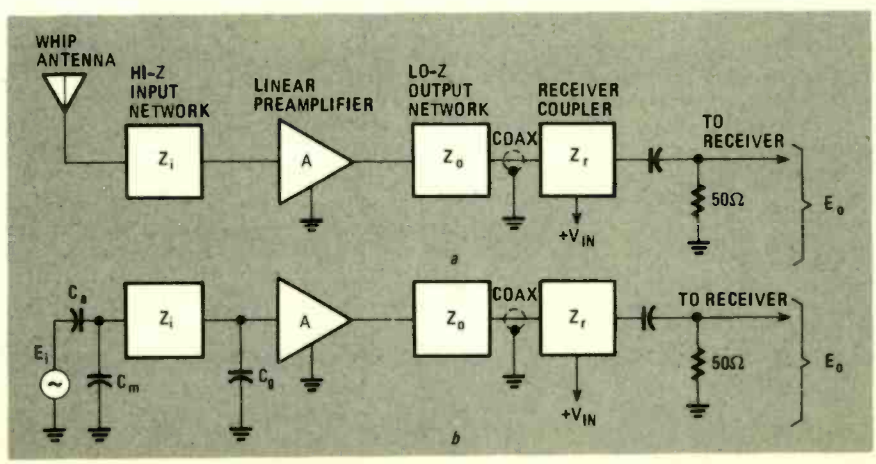


FIG. 2—BLOCK DIAGRAM OF AN ACTIVE ANTENNA is shown in *a*. The whip antenna is replaced by its equivalent circuit in *b*.

even though the total signal and noise level (S + N) is quite high at the preamp output. That is a general characteristic of most VLF-LF receiver systems. The antenna noise is much larger than the receiver-circuit noise levels by at least an order of magnitude.

Figure 3 is a chart that shows the magnitude of the atmospheric noise level (in the midwestern United States at 170 kHz) as a function of the receiver bandwidth. Summer afternoons are dominated by the noise of thundershower spherics. They produce a typical noise level of 100 μV/m (40 dB above 1 μV/m) in a receiver with a 400-Hz bandwidth. In the morning, summer noise levels are lower. Lower still are the winter noise levels, which are usually less than 1 μV/m. However, in the winter, the antenna becomes less sensitive despite the reduced noise level. That is due to the lower conductivity of ice and frozen ground. For example, propagation of VLF signals is very poor over a large ice mass like the Greenland ice cap. The action is similar to that of a carbon wedge inserted into a microwave waveguide.

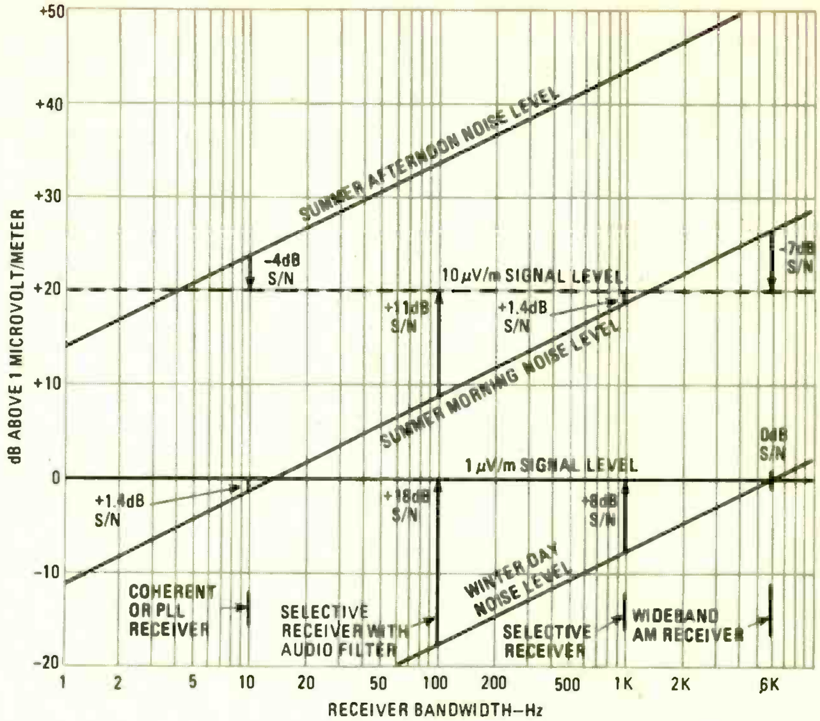


FIG. 3—ANTENNA NOISE LEVELS are a function of the receiver's bandwidth and differ from season to season as well as with the time of day.

Intermodulation distortion

We want an active-antenna system that will ensure that the signal heard on the receiver is not some spurious response of the preamplifier or the receiver itself. That may be rather difficult in some urban areas, where the general RF-"pollution" level is high over the entire VLF through HF spectrum. We do not want our antenna system to amplify strong signals that are in the passband of the active antenna but *not* on the frequency we are interested in receiving.

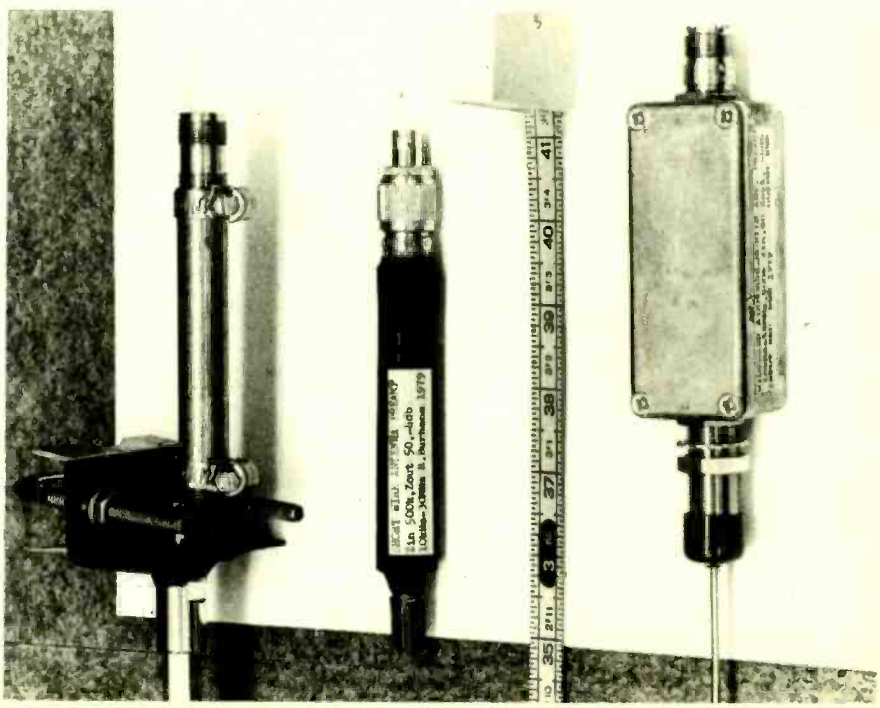
Achieving those goals is difficult in practical wide-range semiconductor preamplifier circuits. That's because they suffer from problems caused by second- and third-order intermodulation distortion products that are created by small non-linearities in the active preamp.

Second order distortion

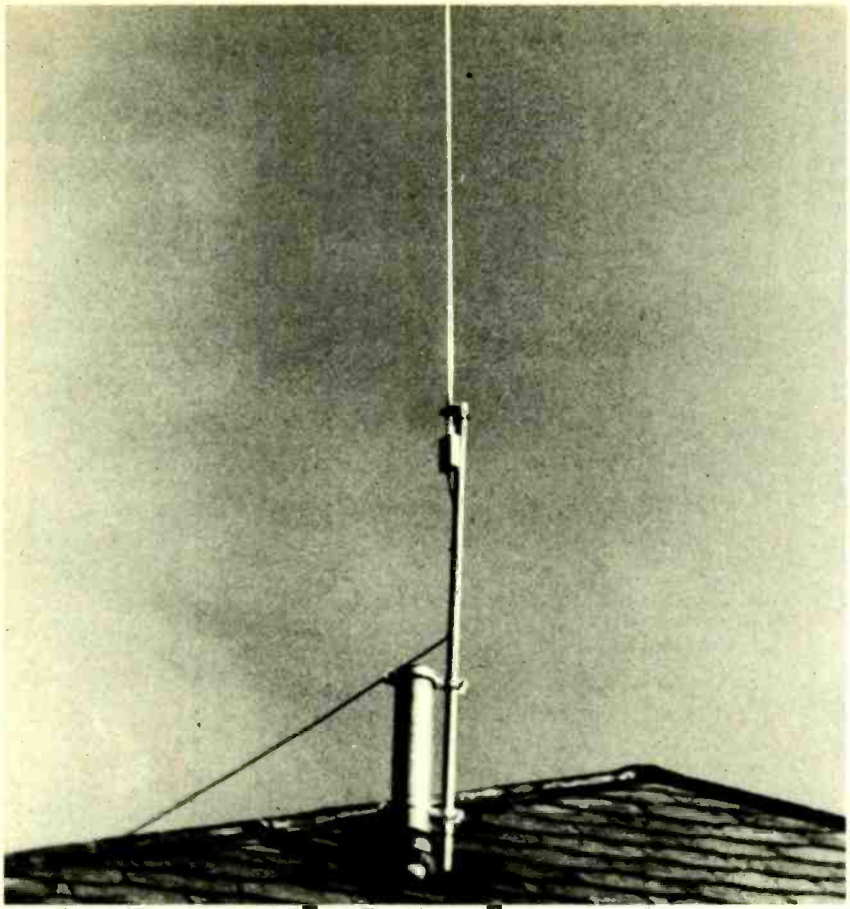
Suppose we have an active-antenna system connected to a receiver tuned to 370 kHz in the LF beacon band. Let's also suppose that there are local broadcast-band transmitters on 1340 kHz and 970 kHz that produce a difference frequency of 1340 − 970 = 370 kHz. If the active-antenna preamplifier is not perfectly linear—and it never is in practice—then at some high signal level, a mixture of the two broadcast-band AM signals will be superimposed on the desired 370-kHz beacon signals. If the listener is located close to the AM transmitters, the interference signal level might be quite high. It increases by 20 dB every time that the strength of the signals causing the interference increases by 10 dB. The problem can be reduced by using semiconductor circuitry that is more linear, or by using high-impedance traps and low-pass filters connected directly to the active-antenna input circuitry.

Third order distortion

Third order distortion can be a more severe problem. It occurs when a strong local AM broadcast-band signal mixes or multiplies with a weaker signal producing interference frequencies of $2f_1 - f_2$ or $2f_2 - f_1$. Suppose f_1 is a weaker signal on 700 kHz and f_2 is a strong local signal on 1340 kHz. Then $2f_1 - f_2$ = 60 kHz and $2f_2 - f_1$ = 1980 kHz. If we tune our receiver to each of those frequencies, signals will be heard faintly in the receiver. The one at 60 kHz is particularly troublesome, since it is right on top of a normal VLF time signal from WWVB and produces annoying fading that coincides with the signal variations from the broadcast stations.



ACTIVE ANTENNA PREAMPLIFIERS can be made very small.



An active-antenna system presents few mounting-problems.

TABLE 1

Harmonic number	Frequency—kHz
1	15.734
2	31.468
3	47.203
4	62.937
5	78.671
6	94.406
7	110.140
8	125.874
9	141.608
10	157.343
11	173.077
12	188.811
13	204.545
14	220.279
15	236.014
16	251.748
17	267.482
18	283.217
19	298.951
20	314.685
21	330.419
22	346.154
23	361.888
24	377.622
25	393.357
26	409.091

That type of two-tone interference increases by 30 dB for every 10 dB increase in the level of the two interference signals. The large number of broadcast-band stations, and the thousands of LF beacons in the continental United States (as well as the world), means that there are many potential interference sources that could cause problems for VLF-LF receiving setups.

Harmonics and overload

Another common type of interference that plagues all types of reception setups is simple harmonic multiplication. In other words, a strong signal on 250 kHz can produce weaker harmonic signals at 500 kHz, 750 kHz, etc. At the VLF-LF range, that problem is usually not as much of a concern as those mentioned above, since the interference caused by second, third, etc. harmonics is usually not as severe as that caused by second or third order distortion. Also, the higher the harmonic number, the weaker the interference signal will be.

Input preamplifier overload can occur when a locally strong station is transmitting at a frequency that falls within the antenna's passband. That problem can sometimes be cured by using traps or input low-pass filters, or by shorting the whip to ground with a remote, weatherproof, low-capacitance relay. However, it is very difficult to get rid of a signal from a nearby amateur or CB transmitter if the active antenna is designed to operate in the same frequency band.

Other interference

Most TV receivers radiate some horizontal-oscillator signal (15.734 kHz); that problem is especially severe in modern solid state and IC sets. The harmonics from that source, up through 400 kHz, can often be heard in a VLF-LF receiver. A list of the TV-oscillator harmonic frequencies up to 409.091 kHz range is shown in Table 1. If your communications receiver lacks a precision digital readout, those interference signals can be used for frequency markers in the VLF-LF range. Sometimes, however, those signals can interfere with the reception of an important beacon. In the case of Loran-C, for instance, the interference from TV harmonics at 94.406 kHz and 110.140 kHz have been reported to disturb the operation of some marine Loran-C receivers near marinas in populated areas; in such situations, audio or notch filters can be used to reduce that problem.

Harmonics from 60-Hz power-line-operated systems can also cause interference. For instance, the 170th harmonic of 60 Hz is 10.200-kHz, which happens to be the Omega navigation-system frequency. That, as you might imagine, can cause problems, especially when an Omega receiver is poorly located with respect to power lines or faulty power-line ground systems. Rusty marine vessels that use 60-Hz power systems have reported problems with those harmonics when operating Omega receivers while at sea.

In some cases, better grounding of house-wiring systems can help reduce interference from power systems. Active antennas work best when some ground reference is provided at the antenna base. That's because any antenna that is very much shorter than one-quarter wavelength acts like an electric field probe that measures the potential difference between itself and its ground plane. Thus, good grounds are always a necessity and they can eliminate many reception problems. As to what type of ground system to use, a cold-water copper-pipe system or deep-driven copper rods and heavy conductors will do; but a large number of copper radial-wires laid out around even a short pole-mounted whip will provide marked improvement in VLF reception.

A wide variety of other types of interference are often heard throughout the VLF-HF region; their sources include garage-door openers, microwave ovens, motor controllers, personal computers, and TV-set remote tuners. The active circuitry contained in such devices often radiates signals at frequencies between 40 and 200 kHz. Many microcomputer systems radiate strong harmonic energy in the 1- to 30-MHz range. Some control systems are vibration-sensitive and can be frequency- and amplitude-modulated by room or household noises. Those signals cause interference that is independent of the type of active or passive antenna used on the receiver.

The active antenna systems that we will discuss here are used with a one-meter long whip. That helps reduce the sensitivity to local noise from sources such as power lines. Because of the active antenna's high input-impedance and low output-impedance, it is more efficient than a simple wire antenna in converting a received signal at the antenna to a corresponding voltage level at the receiver's antenna terminals.

In general, the properties that we want our active receiving antenna to have are: high input-impedance, low input-capacitance, low output-impedance, and minimum distortion/high linearity.

Another objective is to keep the circuit as simple as possible. A single-stage JFET amplifier has the best combination of properties for active antenna preamplifier applications—and it allows the circuit to be kept relatively simple. (This is not to suggest that there might not be better, more complex circuits, using several semiconductors or IC's.)

Wide-band amplifier circuit

The JFET that we have chosen to use is the Siliconix J-310 (or U-310 in metal can). That JFET is often used as a grounded-gate transmission-line amplifier for TV and FM reception (at a 75-ohm input/output level). The J-310 will usually handle short-duration static surges up to 100 volts or so without damage, so a single low-capacitance neon bulb can provide input static-charge protection. That is of value since semiconductor diodes usually have a much higher junction-capacitance when used as protection devices and, if used, would increase the input capacitance of the preamplifier.

In our application as an active VLF-HF preamplifier, the J-310 is used in a common-source common-drain configuration with inductive feedback (that improves the linearity and lowers the output impedance). Figure 1 shows our wideband circuit for the range of 10 kHz to 30 MHz. Note that the feedback from drain to source is large because of the low resistance of the transformer and its 1:1 turns ratio. (We will discuss how to wind that transformer in Part 3 of this series; that part will contain actual construction details.) For the circuit to operate properly, the transformer's output should be opposite in phase to its input (with respect to ground).

The amplifier circuit is intended to be used with a 1-meter vertical whip. The antenna and its mount capacitances serve as part of an input filter. The input capacitance of the JFET is quite low (about 7 pF). The 2.2-μH inductor at the gate of the JFET serves as a lowpass filter or trap, resonating with the junction and circuit (including antenna) capacitances at a frequency near 30 MHz. That input filter aids in reducing FM-VHF interference over a range of 50 to 500 MHz where the 1-meter whip acts like a resonant antenna.

Receiver coupler

The receiver coupler both provides power to the preamplifier and extracts the signal from the coaxial transmission line (from the preamp). A wideband receiver coupler is shown in Fig. 2. Capacitor C1 and inductor L1 form a highpass L-section filter (with about a 10-kHz 3-dB rolloff). Resistor R1 is used to ensure that the preamplifier output sees a low-impedance load no matter what sort of receiver is connected. Resistor R2 is used for matching to a receiver with a higher input impedance. That resistor would cause a signal loss of 6 dB if the input impedance to the receiver were 500 ohms.

The coupler circuit provides DC power to the preamp through the coaxial cable. Power sources less than about +8 volts will reduce the dynamic range and linearity of the amplifier. The power dissipation of the JFET using a +8-volt supply will be about 200 mW. The rating of the J310 at 25°C is about 360 mW maximum. In practice, we have not burned one up even when operated with a +12 volt supply for an extended length of time.

The active antenna preamp is like a Class-A amplifier (where the output has low distortion, but the power furnished by the DC power supply is much greater than the power dissipated in the load). However, some distortion does ultimately appear in the output at high input-signal levels. That is due to the fact that a JFET biased in that way cannot be made perfectly linear over a wide dynamic swing of the output voltage. Other modes of operating the JFET with different biasing have been tried, but they have not resulted in any significantly better performance. So, in a sense, the circuits of Figs. 1 and 2 are of the "simpler is better" type.

Intermodulation distortion

A wideband active antenna covering from 10 kHz to 30 MHz has poor performance with regard to IMD (*In*ter*M*odulation *D*istortion) because little input filtering is provided. Interference will be noted especially if the observer is close to strong AM broadcast-band transmitters. The standard method for evaluating the intermodulation response of a receiver is to measure the 2nd and 3rd order intercepts.

Figure 3 shows a plot of the output power of the two fundamental signals (f_1, f_2) versus the output power of the second order and third order distortion products. (We discussed intermodulation distortion products in the first part of this series, which appeared in the February issue of **Radio-Electronics**). Those are shown as a function of the power of a two-tone input signal.

One thing we should mention first is that when the input signals are too large, the amplifier output will not follow the input linearly. That is called *gain compression* and can be seen in Fig. 3.

If the linear portions of the curves are extended, they will eventually cross each other. That is shown in Fig. 3, where the curves are extended by dotted lines and cross at an output level that cannot be reached by the amplifier. The point where they cross is called the *amplifier intercept*. The input and output coordinates where they cross give you the input and the output intercepts.

In general, the higher the intercept

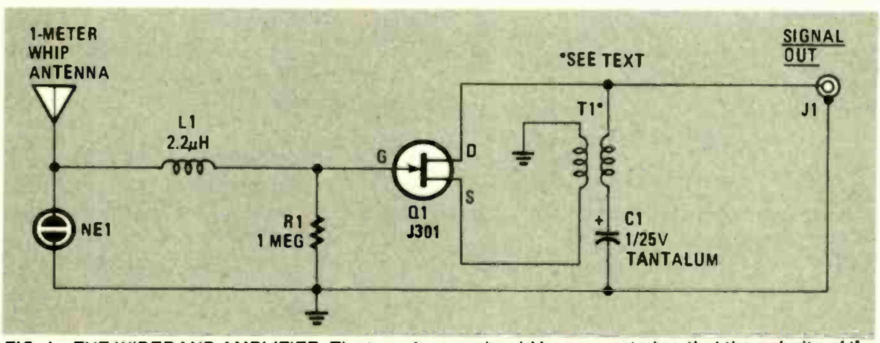


FIG. 1—THE WIDEBAND AMPLIFIER. The transformer should be connected so that the polarity of the output is opposite in phase to that of its input.

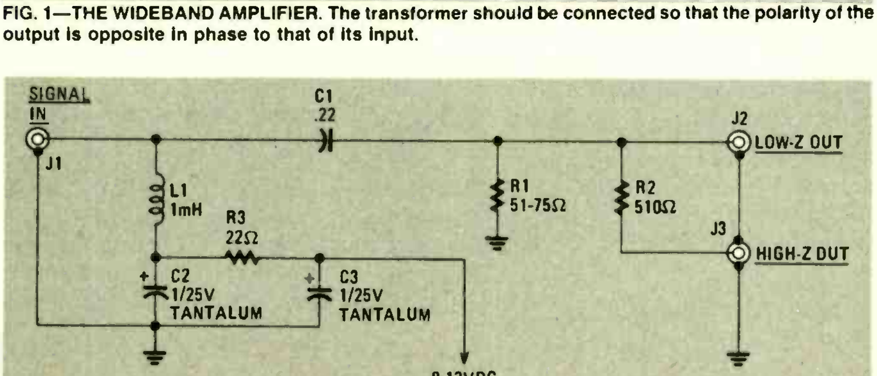


FIG. 2—THE RECEIVER COUPLER both provides power to, and extracts signals from, the amplifier, as well as acting as a highpass filter

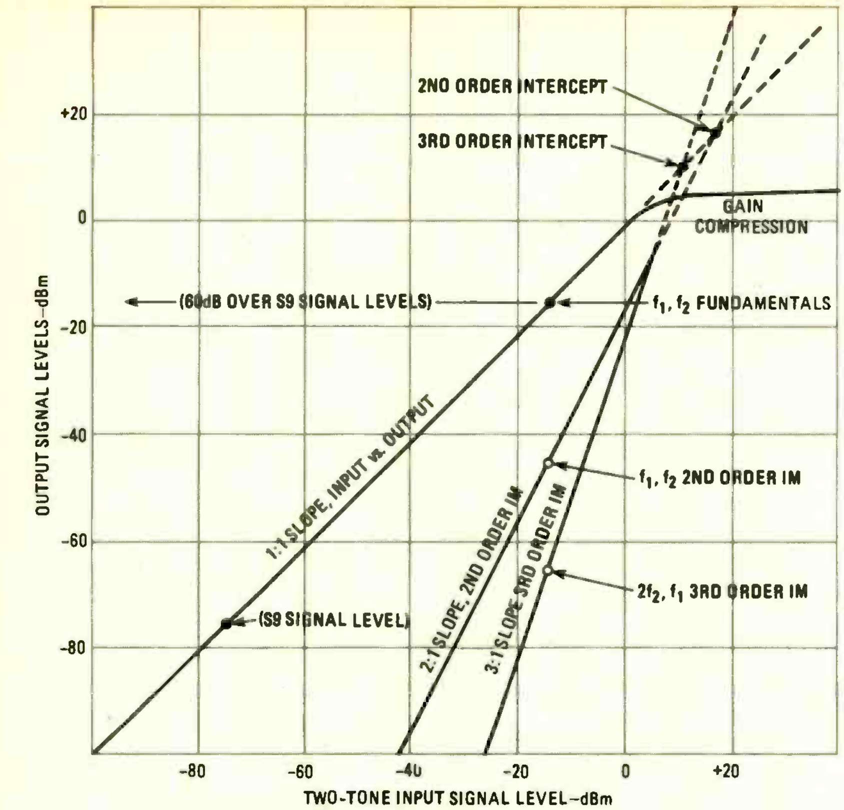


FIG. 3—THE HIGHER THE INTERCEPT POINTS, the better the amplifier's intermodulation rejection.

point is on the graph, the better the amplifier's capability. Those measurements are best made with a sensitive spectrum analyzer, but an approximate idea can be obtained by using a receiver and recording the S-meter readings with appropriate signal-generator sources. The relatively low number of only + 10 dBm for the 3rd order intercept indicates that the active antenna should be used over a wide frequency range only where the local interference level is not severe. The antenna, of course, might be used in a high-signal area but the observer has to exercise some caution in making sure that the IM signals are not obscuring some desired signals on the same frequency.

For the wideband case of 10 kHz to 30 MHz, those intermodulation-distortion measurements suggest that only a short antenna of perhaps 1 meter or even less will provide the least amount of spurious responses—increasing the antenna length will only tend to increase the distortion level. Longer antennas should be used only when the active preamplifier is provided with some form of input and/or output filtering to reduce the out-of-band interference effects. With added input filtering, an active antenna with a 1-meter whip can provide less IMD because the input filter reduces the likely interfering signals before they have a chance to operate on the preamp input circuitry.

Although the wideband active antenna should not be used with anything longer than a 1-meter whip in areas of high adjacent-channel interference, longer antennas—perhaps up to 10 meters—can be tried in a "quiet" location for operating in the VLF-LF range. However, when using long antennas in the HF region there is an additional interference problem because the antenna is resonant at more than one frequency. One rule to follow here is to keep the length of the antenna less than 1/10 wavelength at the highest frequency used for a wideband system. Although that is short at the highest frequency, an antenna of that length used with the wideband preamp will perform almost as well as a 48-inch top-loaded vertical connected to a 50-ohm system (as in mobile CB radios at the 27-MHz region). A primary reason for using an active-antenna system is to provide good performance over a wide range with small physical size. Thus, if the antenna is to be used only for the CB range, it would be simpler to use an ordinary CB antenna and avoid all of the wideband problems.

Amplifier circuit—VLF and LF

At frequencies below about 500 kHz, the amplifier circuit is modified to provide input filtering and higher voltage-gain. Figure 4 shows the modified circuit. Two input inductors and the circuit capacitances form a lowpass filter with a cutoff frequency near 450 kHz (see Fig. 5-a). The choice of those inductors is somewhat critical because the preamp's operation depends partly on the resonant frequency of the coils, the distributed capacitance, and the capacitance of the windings to the shield housing. To reduce mutual coupling, the coils are connected in series with their windings opposing each other. Therefore, they still can be mounted close together on a small circuit board with no interstage shield. That arrangement provides at least another 30 dB of attenuation for broadcast-band signals directly at the input to the preamplifier where the problem of intermodulation starts. A single inductor can be used, but it will not provide quite as sharp a cutoff for interference from the AM broadcast band.

The output transformer is an ultra-miniature audio-output transformer with a 200-ohm center-tapped primary and an 8-ohm center-tapped secondary. (We will talk more about that transformer when the series continues.) The output transformer has good response to at least 400 kHz, even though it was originally intended for audio-frequency use. The smaller amount of feedback applied from drain-to-source results in higher voltage gain of about + 6 dB at the expense of slightly less power gain, or a higher output impedance when compared to the 1:1 wideband toroid. However, we use the iron core transformer because of its low cost as well as the lowpass output filtering provided.

When used with a 1-meter whip, the VLF-LF version of the active antenna—with an input lowpass filter with about a 450 KHz rolloff—provides higher intercept points with respect to broadcast-band interference (although it is about the same for interference from other frequencies). If you are located in a reg-

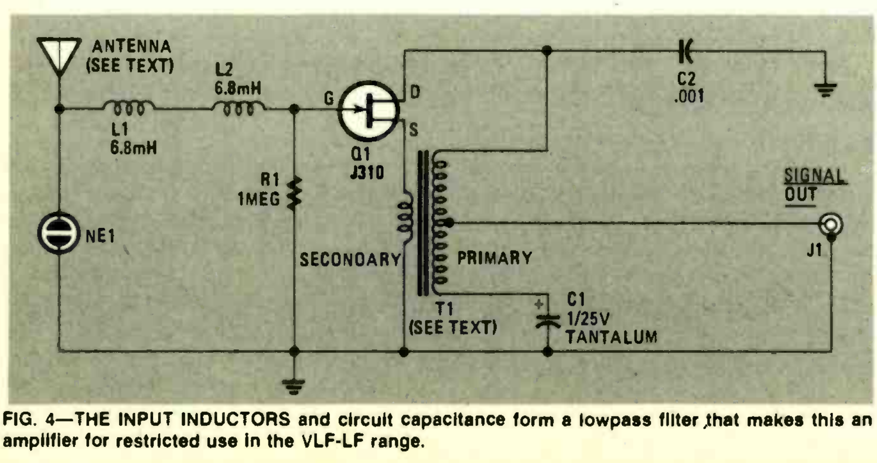


FIG. 4—THE INPUT INDUCTORS and circuit capacitance form a lowpass filter that makes this an amplifier for restricted use in the VLF-LF range.

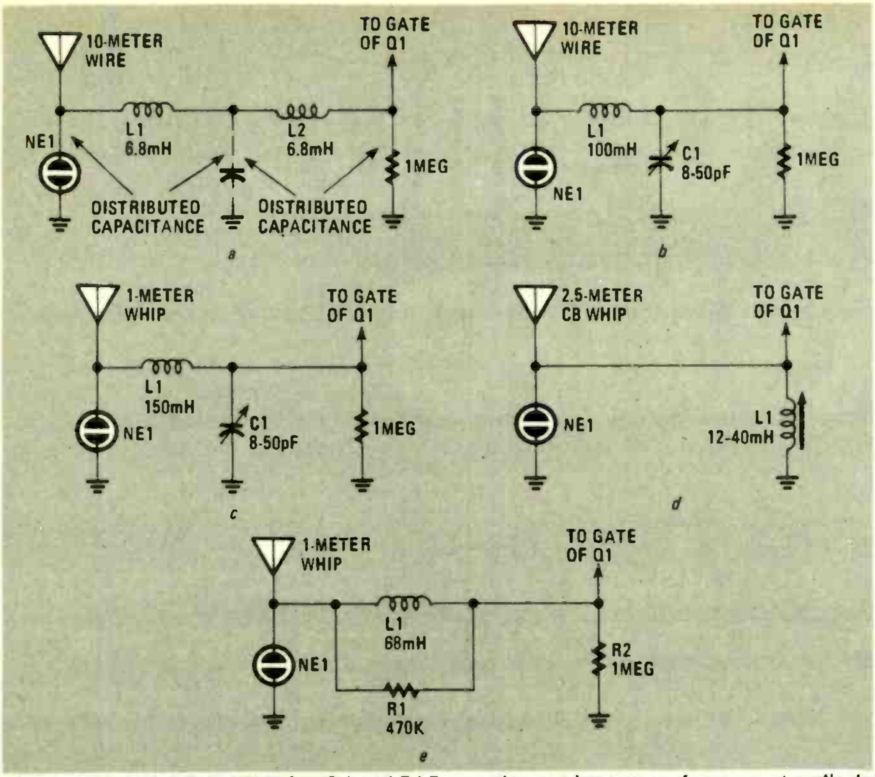


FIG. 5—VARIOUS INPUT NETWORKS for VLF-LF operation can improve performance at particular frequencies or increase the antenna's selectivity.

ion free from high-power broadcast-band transmitters, then you can use the preamplifier of Fig. 4 with longer antennas. However, a point is reached with any active system where merely increasing the antenna size does not improve the overall signal-to-noise ratio because the atmospheric noise level increases at the same rate as the signal.

Resonant input circuit

Figure 5 illustrates various high-impedance input networks for restricted use in the VLF-LF region (such as Loran-C only, or WWVB, or for the 160 kHz–190 kHz experimenters' license-free band). A series inductor with a small input tuning capacitor can be used to further reduce interference and increase the antenna performance. A miniature trimmer-capacitor with a tuning range of 8 to 50 pf placed from the gate to ground, directly across the 1 megohm input resistor (see Figs. 5-b and 5-c) provides a means of tuning the series inductor for a peak at the desired frequency range. The result is a sharp, high-frequency cutoff with a more gradual low-frequency rolloff. The inductor was chosen to be self-resonant (remember, real inductors also have capacitance) at a somewhat higher frequency than the top of the desired tuning range. That technique will work for some pot-core or slug-wound inductors but will usually not work well with large toroids, as they have too much distributed capacitance at VLF. It is also possible to shunt a slug-tuned inductor from the gate to ground (as in Fig. 5-d) but the preamp will then require a larger housing. For that parallel-tuned case, the 1-megohm resistor can be removed because the inductor provides the ground return for the gate. The antenna is then connected directly to the gate terminal with the inductor chosen to resonate with the antenna, input-circuit, and antenna-mount capacitances. The minimum of external tuning capacitance provides the highest Q (most selective) antenna in this application. For DX hunting in the low-frequency experimenters' band (at 180 kHz), a narrowband antenna with a Q of more than 50 can be achieved with a parallel-tuned circuit.

One problem with using a tuned circuit is that it restricts the remote applications of the active antenna. That is because the antenna must be located conveniently so that it can be retuned. However, for covering some fixed frequency (such as the experimenters' band) the antenna system can be aligned on the bench and then mounted for unattended operation. When tuning those systems, it is advisable to temporarily mount the preamplifier assembly in a fairly clear area (preferably where it will be permanently located) to avoid nearby capacitive coupling, which might detune a very selective system.

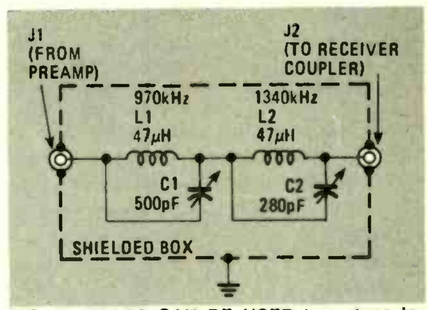


FIG. 6—TRAPS CAN BE USED to reduce interference from broadcast band stations—in this case from stations at 970 and 1340 kHz.

One technique for broadbanding a tuned circuit is to place a resistor in parallel with the inductor (See Fig. 5-e). Resistor values in the range of 50K to 500K ohms can help broaden Loran-C systems where a wide bandwidth is necessary.

Traps

Series-connected transmission-line traps tuned to local broadcast-band stations and placed just ahead of the receiver coupler can improve the IMD somewhat and reduce overload or gain-compression problems (see Fig. 6). The tuning capacitors must be isolated from ground and the inductor must be chosen so as to have a reactance greater than 50 ohms at the desired notch frequency. Dual traps are possible. For example, Fig. 6 shows a trap for 970 kHz and another for 1340 kHz connected in series. The combination of input lowpass filters at the antenna and traps at the preamp output can usually

TABLE 1

Parameter		Whip 1	Whip 2	Flat Top
Physical Height	(h_m)	1m	2m	10m
Antenna Capacitance	(C_a)	10pF	20pF	118pF
Fixed Capacitance	($C_m + C_g$)	15pF	15pF	15pF
Voltage Gain at Preamp	(A_v)	1 (0dB)	1 (0dB)	2 (+6dB)
Estimated Ground Coupling Effect	(K)	0.7	0.7	0.05
Effective Height	(h_e)	0.28m	0.80m	0.88m
WWVB Reading on YAESU FRG-7700		S6	S9	S9+
Estimated E-field for WWVB (from NBS chart)	(E_i)	150 μV-per-m	150 μV-per-m	150 μV-per-m
Output S+N for 60kHz WWVB at Preamp	($E_o = E_i \times h_e$)	42 μV	120 μV	132 μV
Estimated (S+N)/N during 60 Hz "quiet hours"		+10dB	+20dB	+20dB
Overall Noise Rating		good	fair	poor
IM Distortion Rating		fair	poor	very poor

provide sufficient attenuation for cases of severe interference in the VLF-LF band from stations in the broadcast band.

A summary of some measurements made with different antennas at 60 kHz for WWVB reception is shown in Table 1. It should be noted that a 2-meter vertical whip is about equivalent in sensitivity to the much larger flat-top antenna. However, the flat top is much more susceptible to noise and interference, even when it is operated with a lowpass filter at the preamp input. The effective-height estimate may not be the same over the entire frequency range. For example, the flat top appears to have an effective height of about 2 meters at 200 kHz but less than 0.9 meters at 60 kHz. That is because of K—the shielding effect and conductivity of the local ground terrain, which includes all the trees, power lines, and building structures. However, we are still able to operate the antenna even down to the 10.2 kHz Omega frequency with reasonable success and it is used routinely to check GBR on 16 kHz for VLF propagation conditions. (GBR is a high-power military VLF station from Great Britain.) In practice, it is always wise to check for IM effects at the specific frequency range that you plan to use the antenna. Sometimes they are severe but only at relatively narrow frequency ranges usually not in the VLF range.

For general wideband surveillance, the 1-meter whip with an effective height of about 30 cm is the best antenna of all, because it has fewer IM interference effects and less local noise from the power lines.

A general conclusion from all of the experiments is that the local environment and the ground-conductivity effects of nearby structures are the most important factors in determining antenna sensitivity. Small changes in antenna location can produce remarkable differences in the antenna's performance.

Another observation is that the best location for a short whip is invariably up high in the clear. (That can especially be seen in aircraft applications where a very short vertical whip is used with remarkably good performance.)

Low-frequency experimental radio station operators have reported good results in mobile operation with reception of 160 to 190 kHz signals using 2.5-meter CB whips and parallel-tuned input networks. We have conducted similar experiments with Omega and Loran-C receivers in mobile vehicles where the only problems were those of shielding from buildings or when driving under bridges or near power lines. An additional problem in mobile operations is harmonic radiation from the vehicle's AC alternators.

Active receiving antennas can offer a surprising improvement in the capabilities of your receiver. However, as we will show you, building one does not have to be difficult.

The active-antenna system consists of three main parts: a whip antenna, a preamplifier, and a receiver coupler. The whip antenna is directly attached to the preamplifier, and both are remotely mounted. The receiver coupler is mounted at the receiver, and is connected to the preamplifier by a length of coaxial cable. Let's now take a look at the components of the system in more detail.

Wideband preamplifier

The wideband preamplifier circuit was discussed in the March 1983 issue of **Radio-Electronics.** Its schematic is reproduced in Fig. 1.

The wideband preamplifier is assembled on a printed-circuit board. The foil pattern of that PC board is shown in Fig. 2, and its parts-placement diagram is shown in Fig. 3. You should note that there are some "extra" pads near the input terminal. They are there to accommodate different input filter networks and/or variations in the size of the components used. The board is intended to fit snugly in a 1¼ × 2 × 1 inch drawn-steel case, although it can be used, of course, with a larger box. The only "fussy" component is the toroidal transformer.

The toroidal transformer is wound by first measuring out two 15-inch lengths of different-colored, 30 gauge, solid, insulated, wire-wrap wire. Those wires are twisted together about 8 turns-per-inch, and then that cable made up of the twisted pair of wires is wound for 17 turns on an Amidon (12033 Ostego St., North Hollywood, CA 91607) part No. FT50-75 (or similar) ferrite core. The windings should be tight, with a small gap at the start/finish point. The wire is held in place at the ends with a small drop of cement, and about 1 inch is left for connection to the circuit board. The insulation at the ends of the wires is stripped back about ½ inch for soldering to the board.

One important note is that the windings should oppose each other. What that means, is that while one wire at one end of the two-wire cable is connected to ground, the other wire at the same end is connected to the drain of the JFET. To furthur clarify that, Fig. 3 shows a dot at the one end of each winding—the dots are at a common end of the cable.

After the transformer wires are connected through the circuit-board holes, the core assembly should be cemented to the board perpendicularly. Be sure to follow Fig. 3 and make sure that the necessary jumper wires are also connected on the board for the wideband version (a version of the preamp for restricted VLF and LF use uses the same circuit board, but some different components).

The lower 3-dB point (where the response of the preamp drops 3 dB from its maximum) is at 10 kHz, where the toroidal transformer has an inductance of about 1 mH. At high frequencies, the core material effectively disappears, and the response might be good to 100 MHz or so. However, the 2.2 μH input inductor (L1)—along with the board, the JFET capacitance, and the steel case—limits the preamp's upper 3-dB point to about 30 MHz. That helps to reduce interference from signals outside the desired band—say, TV and FM signals.

The receiver coupler

The foil pattern of the receiver-coupler board is shown in Fig. 4. (The receiver-

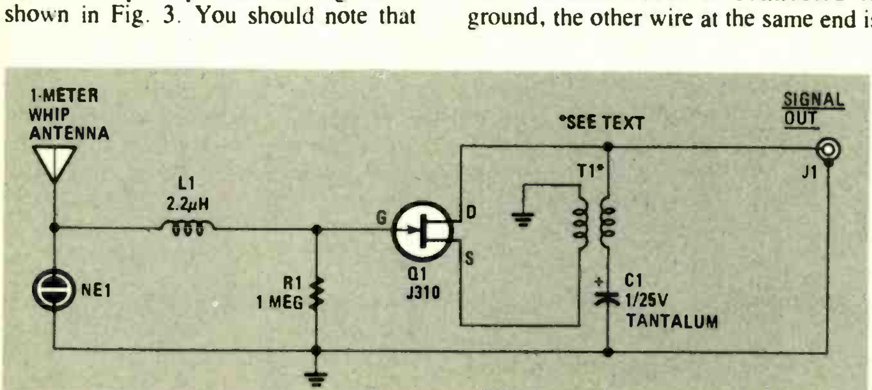


FIG. 1—WIDEBAND PREAMPLIFIER SCHEMATIC. The neon bulb, NE1, provides adequate input static charge protection.

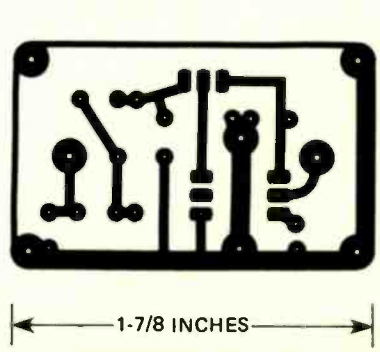


FIG. 2—FULL SIZE foil pattern for the the preamplifier circuit-board.

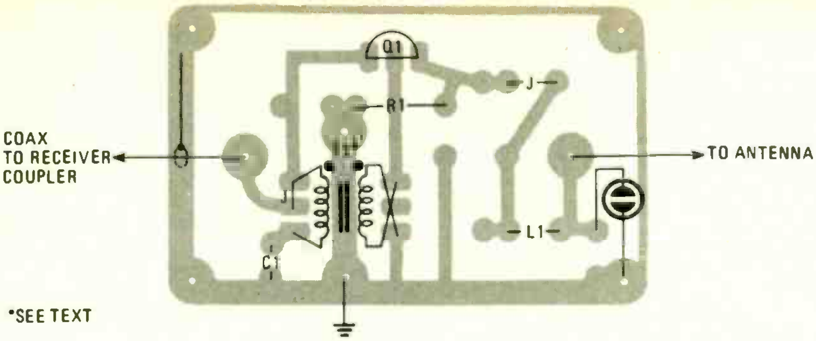


FIG. 3—PARTS-PLACEMENT DIAGRAM for the wideband version of the preamp.

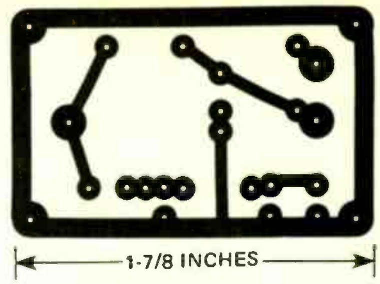


FIG. 4—FULL SIZE foil pattern for the receiver-coupler circuit-board.

coupler circuit was discussed in Part 2 of this series, in the March 1983 issue of **Radio-Electronics**. The schematic of the receiver coupler is reproduced here in Fig. 5). The board's parts placement is shown in Fig. 6. The board for the receiver coupler is the same size as that used in the preamp, and can be mounted in a similar case, if desired. In addition to the coaxial input and output terminals, a twisted pair of insulated wires are included for the power-supply leads (8–12 volts) and are fed through a small grommet or hole in the receiver-coupler case. We will not discuss the construction of a power supply.

Preamplifier for VLF-LF

The circuit for the VLF-LF preamplifier was discussed in Part 2 of this series, in the March 1983 issue of **Radio-Electronics.** For your convenience, we have reproduced the schematic of that circuit in Fig. 7.

The circuit board for restricted VLF-LF operation is the same as the one used for the wideband preamp. (of course some components are different, and the jumpers that were used in the wideband case are not used here.) The parts-placement diagram is shown in Fig. 8. The RF chokes are short, encapasulated types that are designed for vertical PC-board mounting. The winding "polarity" or the start of the windings are indicated in Fig. 8 by black dots and on the choke package by a label dot and a longer lead.

The output transformer that we chose will fit exactly into the holes indicated, with the correct winding polarity already provided. Therefore—unlike the toroidal transfomer—it is unnecessary to cross over the transformer leads.

If you are in doubt about which side of the transformer is the primary or secondary, check with an ohmmeter. The higher resistance reading (around 20 ohms) will be the primary winding.

Preamplifier variations

In Part 2, we discussed several different resonant input circuits that could be used to provide low-frequency cutoffs, or to yield operation at a small, fixed band of frequencies. (The input networks were discussed in the "Resonant input circuits" section of Part 2.) The preamplifier can be modified with one of these input networks with relative ease. For example, a microminiature trimmer-capacitor can be soldered on the foil side of the board, directly across the 1-megohm input resistor (R1) after the board is mounted in the box. One possible source for the inductors and capacitors is Mouser Electronics (11433 Woodside Ave., Santee, CA 92071), although other suppliers can be found by checking the ads in the back of this magazine.

You may have to bend the leads or change the part orientation if a particular component will not exactly fit the board holes. If you use 100–150-mH RF chokes (for a tuned amplifier for 60-kHz to 100-kHz operation), they will be quite close to the board edges because of their larger size. That will alter the circuit capacitance somewhat when the board is placed inside the box. The small trimmer capacitor—on the foil side of the board—can be used to compensate for that.

For wideband, lower-Q circuits with no trim capacitor, it may be necessary to check the response of the preamp after temporarily mounting it in the shield/case. The board can, of course, be used in a much larger box, with larger inductor assemblies, but keep in mind that for maximum antenna sensitivity with a minimum antenna height (in other words, for maximum efficiency), the input capacitance at the antenna terminal should be as low as possible.

Table 1 shows the results of tests made

PARTS LIST
WIDEBAND ANTENNA PREAMP

R1—1 megohm, ¼ watt
C1—1 µF, 25 volts, tantalum
Q1—J310 FET (Siliconix or equivalent)
NE1—NE99 neon lamp
L1—2.2 µH (Mouser 43LS226 or equivalent)
T1—Bifilar wound transformer on Amidon FT50-75 core or equivalent (see text)
Miscellaneous:PC board, case, coaxial connectors, hardware, etc.

PARTS LIST
VLF-LF ANTENNA PREAMP

R1—1 megohm, ¼ watt
C1—1 µF, 25 volts, tantalum
C2—0.001 µF, ceramic
Q1—J310 FET (Siliconix or equivalent)
NE1—NE99 neon lamp
L1, L2—6.8 mH (Mouser 43LH268 or equivalent)
T1—Audio transformer (Mouser 42TL004 or equivalent)
Miscellaneous:PC board, case, coaxial connectors, hardware, etc.

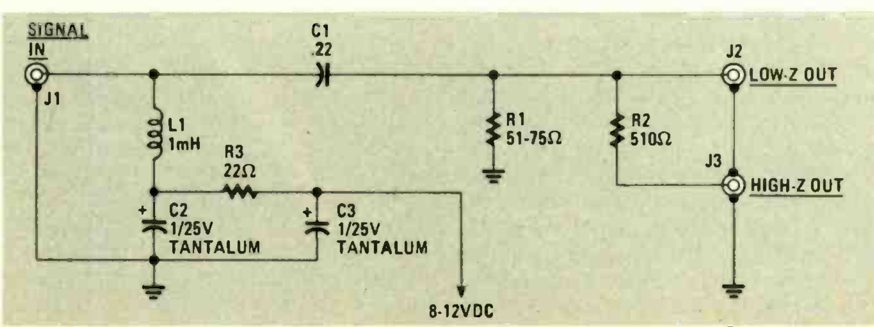


FIG. 5—The two outputs can be used to match the coupler to your particular receiver. They also make it easy to use the coupler with a receiver and monitor the coupler output with a scope at the same time.

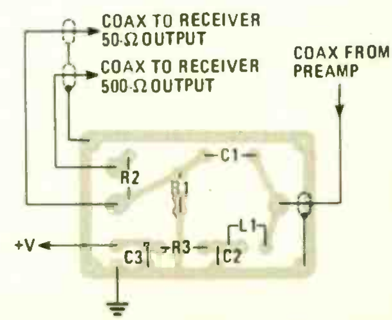


FIG. 6—PARTS-PLACEMENT DIAGRAM for the receiver-coupler board.

TABLE 1

Frequency/Application	3-dB Bandwidth	Antenna length	C_a	L	C2	Gain
180 kHz Experimenters' Band	170–190 kHz	10 meters	120 pF	33 mH	.001	+20 dB
180 kHz Experimenters' Band	175–185 kHz	1 meter	10 pF	39 mH	.001	+15 dB
100 kHz LORAN-C	95–105 kHz	1 meter	10 pF	120 mH	.01	+6 dB
100 kHz LORAN-C	91–108 kHz	10 meters	120 pF	100 mH	.01	+12 dB
60 kHz WWVB	55–65 kHz	10 meters	120 pF	150 mH	.01	+10 dB
60 kHz WWVB	58–63 kHz	1 meter	10 pF	300 mH	.01	+6 dB

For information on availability (including custom-built active-antenna preamps and coupler assemblies), send a SASE to R. W. Burhans, 161 Grosvenor St., Athens, Ohio 45701

PARTS LIST
RECEIVER COUPLER

All resistors are ¼ watt, 5% unless otherwise specified
R1—51 ohms
R2—510 ohms
R3—22 ohms
C1—0.22 µF, Mylar
C2, C3—1 µF, 25 volts, tantalum
L1—1 mH (Mouser 43LR103 or equivalent)

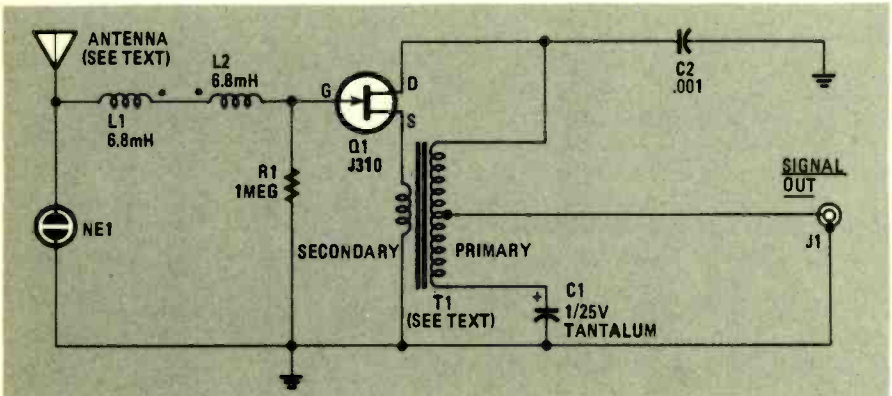


FIG. 7—THE INPUT INDUCTORS and circuit capacitances form a lowpass filter that makes this amplifier for restricted use in the VLF-LF range.

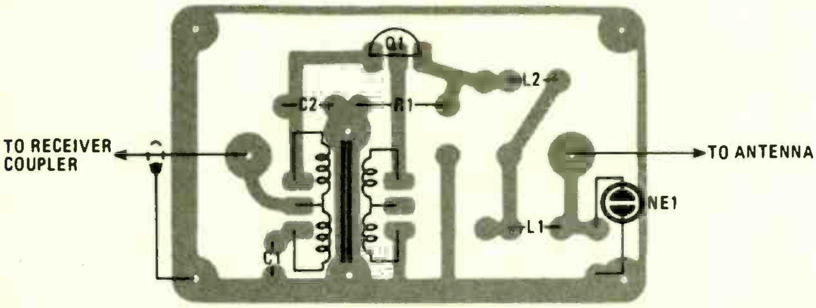


FIG. 8—PARTS-PLACEMENT DIAGRAM for the restricted-use (VLF–LF) version of the active antenna preamp.

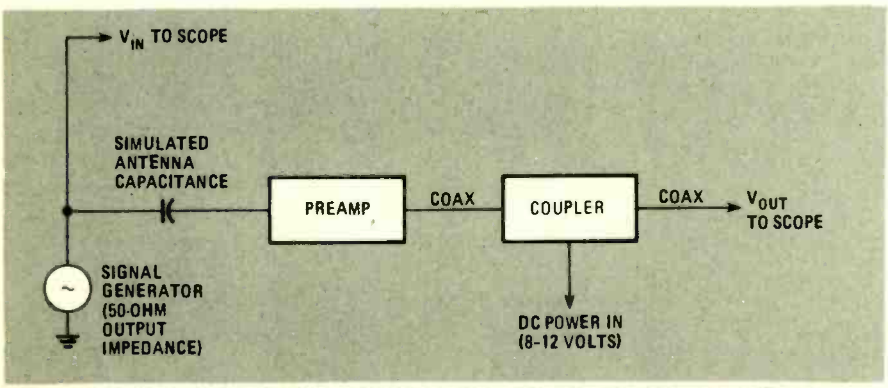


FIG. 9—USE THE APPROXIMATION of 10-pF per meter to determine the antenna capacitance.

with different inductor-capacitor combinations for covering different segments of the 60–200 kHz range. (See Part 2—Figs. 1, 4, and 5 for the particular circuits.) Note that in some cases the value of the preamp's output capacitor (C2) at the drain of Q1 is changed to improve the low-frequency cutoff.

Bench testing

A signal generator and suitable oscilloscope are used to observe the response of the active antenna system with a setup as shown in Fig. 9. When tuning any of the amplifier variations on the bench, or when checking the response of the amplifier, a small coupling capacitor—of a value equal to the expected antenna capacitance—is connected to the input terminal of the preamp. (A vertical or slant-wire antenna will have an approximate capacitance of about 10 pF-per-meter.) That will roughly simulate the response of the electric field at the antenna. A tuned preamp assembly can be aligned on the bench and then the antenna can be plugged in for operation. The input/output response obtained this way will fairly-well resemble the response that you will obtain in the field—except for the K factor that is dependant on the local ground-shielding effect.

Preamp and coupler housing

The amplifier and coupler boards have been designed to fit in a small cast aluminium or drawn-steel case such as Mouser part No. 537-M12 for compact assembly. (See Fig. 10.) The circuit boards are held in place in the boxes by short, solid jumper wires that are soldered to the antenna input terminal and to the coax receptacles. The ground connections can be either short jumper wires to the ground lug on the cable receptacle or the circuit board ground can be directly soldered to inside edges of the drawn-steel case.

The case should be mounted on an angle bracket for bolting to a short mast. A press-in or solder-in type RCA phono receptacle (Mouser part No. 16PJ051) is soldered on the inside of the box for the antenna terminal. That has a capacitance of only 5 pF at most, and it is suppled with a ceramic spacer. The output coax connector can be a UHF type. We have used SO-239 type receptacles by breaking off the flanges and pressing into a hole carefully reamed to fit. The output coax connector can be a single-hole-mounting type that uses a nut on the inside of the case. However, that takes up room inside the case and the PC board will have to be further cut and filed. Whichever type of connector you use, make sure you solder it to the inside of the case.

Prior to mounting the connectors, the box should be degreased with solvent, polished with steel wool both inside and out, and (after soldering the connectors) it should be painted *outside* with automobile primer and finally with a clear

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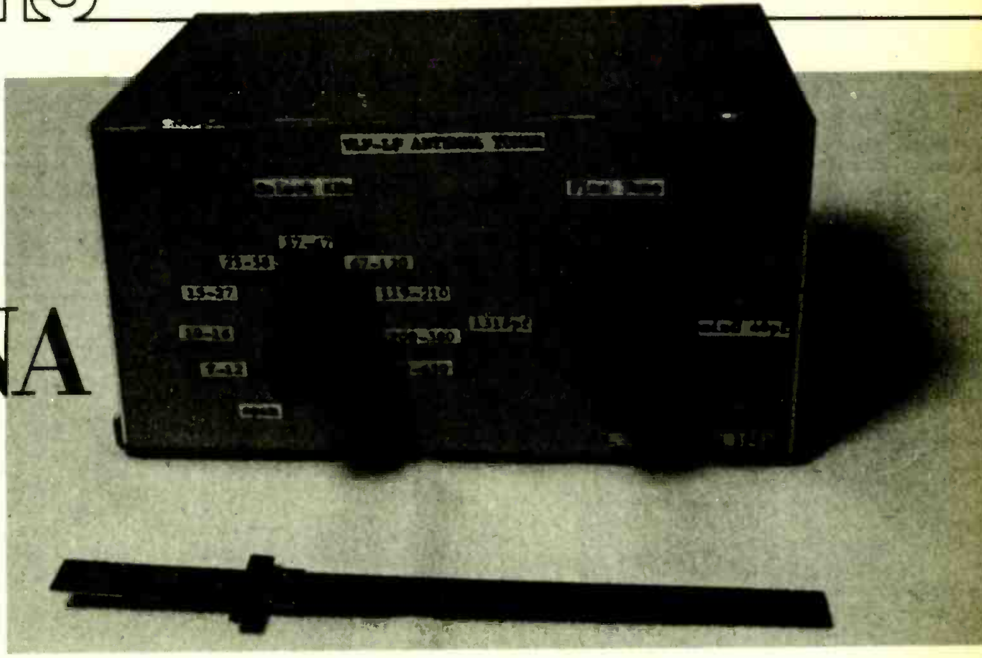
BUILD THIS

PASSIVE ANTENNA TUNER FOR VLF-LF



One way to improve the performance of VLF-LF antennas is through the use of a passive antenna tuner. Here's the theory, and some ideas on how to use it.

R.W. BURHANS

A *passive* antenna-tuner for random-length wires in the 10 kHz to 30 MHz usable range is a good approach to the problem of good signal reception in lieu of an active antenna. Commercial models are available, but they are usually designed for the medium- and shortwave bands above 150 kHz; only one system claims to be effective all the way down to 10 kHz.

Since the greatest reception problems are encountered at low frequencies, let us discuss the design of selective antenna tuners covering the range of 10 kHz to 500 kHz.

Antenna lead-in

It is interesting to consider the idea of locating the antenna tuner at the receiver, with the antenna wire connected by a length of coaxial cable to the receiver and tuner as illustrated in Fig. 1. One problem at low frequencies is that the shunt cable-capacitance, C_c, in parallel with the antenna capacitance, C_a, reduces the sensitivity by the factor: $C_a/(C_a+C_c+C_t)$. By choosing a length of relatively high impedance, low-capacitance cable, it is possible to design a tuner that takes into account the cable capacitance as part of the tuner network, and that can operate with up to 50 feet (about 15 meters) of cable separating the antenna wire from the receiver and tuner. That antenna will be less effective than an active-antenna preamplifier system for the same length of antenna wire, but there will be fewer problems of intermodulation distortion because of the high selectivity, and no active preamplifier is involved. The

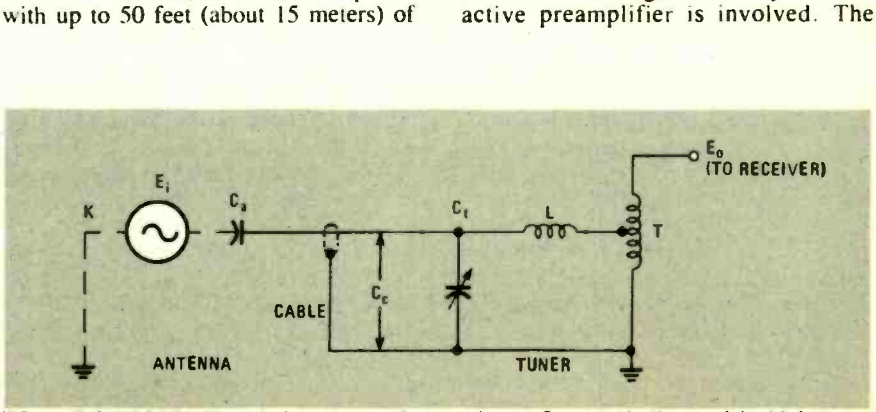


FIG. 1—IT IS IMPORTANT to take into account the capacitance, C_c, added by the coaxial cable between the antenna and tuner.

TABLE 1

Frequency range (kHz)	Inductance (mH)
10-16	150
15-27	68
23-38	33
37-67	10
67-120	3
119-210	1
208-380	0.3
380-630	0.1

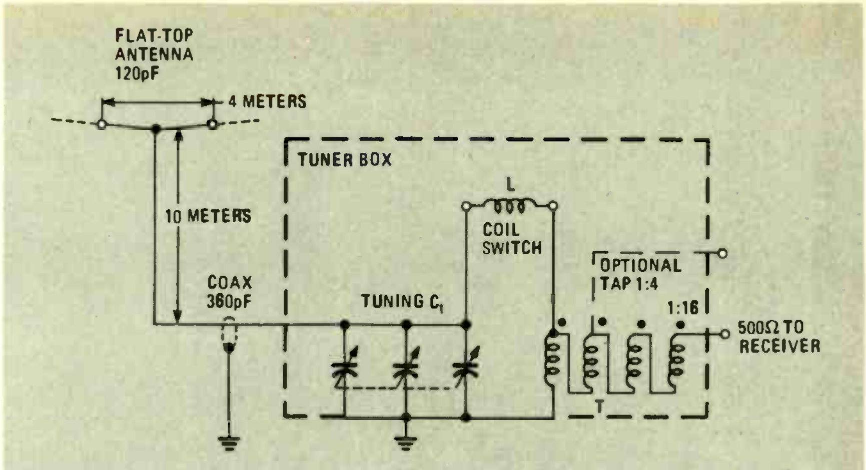


FIG. 2—THE VALUE OF INDUCTOR "L" can be determined from Table 2. In practice, several inductors would be present, only one of which would be switched into the circuit at a given time.

TABLE 2

Midband frequency (kHz)	Loss (db)	Q	Bandwidth (kHz)	Inductance (mH)	Inductor part number
13.9	−24	47	0.3	150	Mouser 43LJ415
20.1	−17	92	0.22	68	Mouser 43LJ368
30.1	−15	56	0.54	33	Mouser 43LJ333
52.7	−10	53	1.0	10	Mouser 43LH310
93.6	−9	36	2.6	3	Mouser 43LH233
168	−8	22	7.7	1	Mouser 43LH210
298	−9	12	24.	0.3	Mouser 43LR334
518	−9	12	42.	0.1	Mouser 43LR104

advantage of having the antenna tuner located at the receiver is obvious. The coaxial lead-in helps reduce local-noise pickup since the antenna wire can be located away from power lines, home appliances, and other noise sources.

Design considerations

To design such a tuner system we must first measure or estimate the total minimum capacitance, including the antenna, cable, and minimum tuning capacitance. A relatively-high-value tuning capacitor is required, having a value several times greater than the total minimum capacitance. We chose a 3-gang variable capacitor, each section having a range of about 12 to 440 pF, like those found in older-style AM radios (commonly referred to as 360-pF units). They are still available new at rather high prices, but similar devices can often be found at surplus-electronics-parts stores.

Taking all the components together, the total minimum capacitance is:

Antenna capacitance	120 pF
Cable capacitance	360 pF
Minimum tuning capacitance	36 pF
Total minimum capacitance	516 pF

The total maximum capacitance (with the tuning capacitor fully meshed) is:

Antenna capacitance	120 pF
Cable capacitance	360 pF
Maximum tuning capacitance	1320 pF
Total maximum capacitance	1800 pF

Tuner circuit

Now that we have estimated a capacitance range for the tuning circuit of 516–1800 pF, a set of inductors is needed that will resonate with that capacitance at the frequencies we're interested in. The ratio $\sqrt{1800:516}$ gives us the tuning range for a given fixed inductor in the circuit—a range of about 1.86:1 for each coil. A set of inductors that will provide the results we're looking for over the range of 10–500 kHz can be chosen from Table 1. The inductors are connected in series with the antenna and cable lead-in, along with a very-low-resistance toroidal coupling-transformer designed to match a 500-ohm load at the receiver as shown in Fig. 2. The inductors are selected so that each frequency range will overlap the next slightly; that means an inductance change of less than $(1.86/1)^2$ between each set of coils selected for this example.

The wideband-output coupling-transformer takes the place of an additional set of parallel inductors to match the receiver's input impedance. In addition to the capacitive-divider loss at the antenna input, the transformer in series with a high reactance coil adds an insertion loss at the low-frequency end. That is, in part, compensated for by a higher Q. That selectivity decreases at higher frequencies, but gain increases. When connected to the 500-ohm receiver input-terminals, the low-impedance-input tap point of the output transformer looks like a 30-ohm load to all the coils. That is about the best that can be achieved because of the very wide variation in reactance and L/C ratio of the input network, but the overall performance is quite satisfactory, considering that we are using a single output-transformer to cover the range of 10 kHz to over 500 kHz.

The coil arrangement uses a multiple-position selector to switch frequency ranges and has a constant bandwidth-characteristic for each coil. That is, the Q for a given coil will be highest at the minimum capacitance-setting, decreasing by an amount equal to about the tuning ratio at maximum capacitance. The results obtained using low cost RF-choke-type inductors with the 120-pF antenna are shown in Table 2. The antenna used was a 10-meter-high, four-meter flat-top.

Input-capacitance variations

If you use an antenna wire or cable with more or less capacitance than the one we did, the inductance ratios will have to be computed for a different set of coils. The cable we used was surplus marked "FT&R Corp. Type K 109," and measured only 8 pF/ft. Thus, 45 feet of cable had a capacitance of 45 × 8 = 360 pF. For other high-impedance cable such as RG62, with a capacitance of 13.5 pF/ft., 360/13.5, or 27 feet, would be used with the same variable capacitor and coil-set. You may be able to find some high-impedance, low capacitance cable of the type used in automobile-radio installations. Each different system will involve a session of L-C calculations to match inductances and capacitances to the frequency range desired.

The following two formulas will help in those calculations:

$$f = \frac{10^6}{2\pi\sqrt{LC}}$$

$$L = \frac{10^{12}}{(2\pi f)^2}$$

TABLE 3

Frequency	10 kHz	400 kHz
Capacitive loss factor $C_a/(C_a+C_c+C_t) = C$	−23dB	−12dB
Ground loss factor estimate = K	−26dB	−14dB
Measured network loss with antenna & cable capacitance = N	−24dB	−9dB
Antenna-to-receiver Z loss-factor, direct, no cable $500/X_{C_a}$ = A	−49dB	−17dB
Antenna sensitivity without tuner or cable = K + A	−75dB	−31dB
Antenna sensitivity with tuner and cable = K + N	−50dB	−23dB
Net improvement in sensitivity (K + N) − (K + A)	+25dB	+8dB

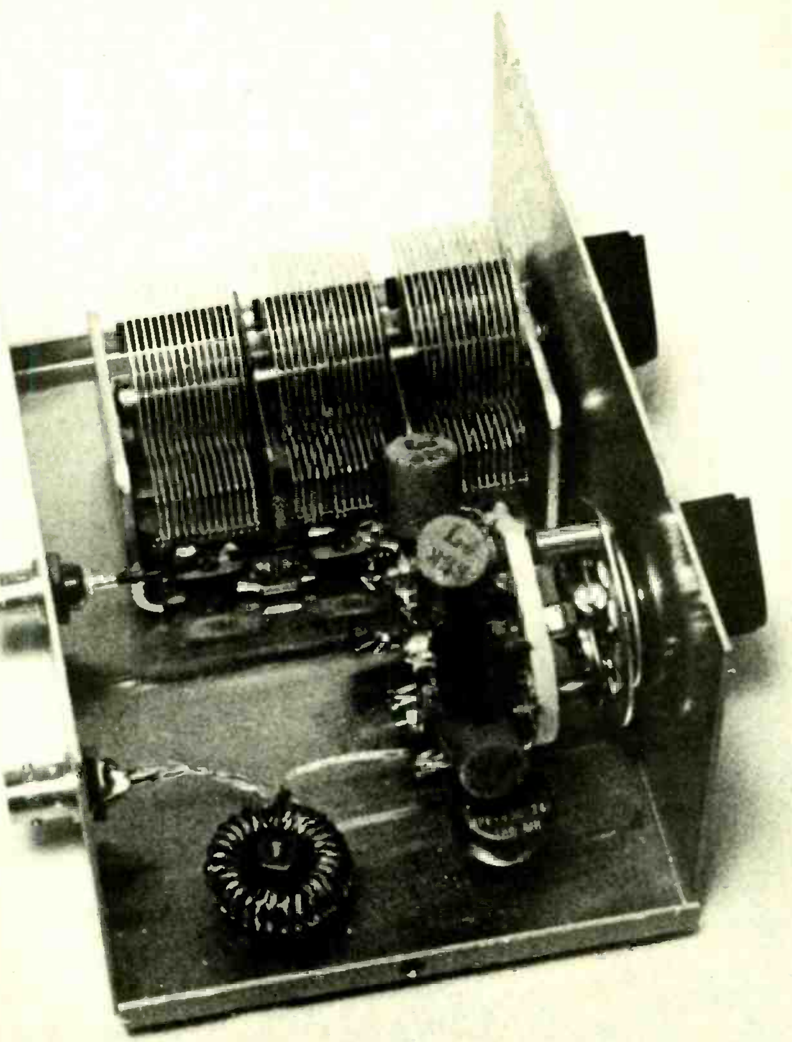


FIG. 3—INTERIOR OF THE AUTHOR'S prototype tuner. Note inductors mounted on rotary switch.

where f is the frequency measured in kHz, L is the inductance measured in μH (1000 μH = 1mH), and C is the capacitance in pF.

Performance data

Table 2 illustrates well the Q and mid-band loss of the tuning network with the antenna and cable connected; the figures were determined on the bench using a signal generator. Actual antenna performance will be somewhat worse than indicated by the loss factor because it will also be affected by the ground coupling K factor. (See Part 1, in the February 1983 issue of **Radio-Electronics.**) In our tests, K varied from .05 (an additional −26 dB) at 10 kHz to about 0.2 (−14 dB) at 400 kHz.

An estimate of overall efficiency made by comparing the wire antenna connected directly to the 500-ohm input of the receiver with the same antenna connected through the coaxial cable and tuner to the receiver, is illustrated in Table 3. From that table you can see that there is an overall improvement of 25 dB at the bottom of the VLF band (10 kHz), which decreases to only 8 dB at the high end of the LF band (400 kHz).

The high antenna-loss factors shown are typical of what happens when a random wire is connected directly to a 500-ohm receiver-input. The tuner provides an obvious improvement that is roughly proportional to the Q of the tuned circuit. In addition to increased sensitivity, the antenna tuner also provides high selectivity with practically none of the preamplifier or receiver IM problems noted with active antennas. On the other hand, active-antenna systems have better sensitivity.

The antenna tuner's narrow bandwidth requires that it be peaked whenever you shift frequency. That's easy to do if you have an S-meter, or you can listen for an increase in the signal- or background-noise level from the receiver as you adjust the tuner. For experimenters who wish to vary that method of antenna tuning, there are many factors to consider. The antenna's Q is limited by both the coils used and the series resistance of the network. That means that, even with the very best of inductors, the series resistance of the high-impedance cable and the output transformer, as well as the ground resistance, will ultimately affect performance. At the higher frequency-ranges, a lower Q is inherent in the system because of the lower coil reactance compared to the resistance in the system. Another variable is

PARTS LIST—PASSIVE TUNER

- C_t—three-gang tuning capacitor, 12–440 pF per gang (Allied 695-4200 or similar)
- T—quadrifilar toroidal transformer, 28 turns of four No. 30 insulated wire, twisted four-turns-per-inch on Amidon FT82-75 (or similar) core
- L—RF-chock-type inductor(s) (see Tables 1 and 2)
- **Miscellaneous:** high-impedance low-capacitance coaxial cable, rotary switch, metal enclosure, connectors, etc.

the turns ratio of the output transformer.

One possible improvement that could be made after inspecting the data in Table 2 would be to switch the tap on the output transformer for a 4:1 ratio for the frequencies below 50 kHz, where the coils' resistance and loss are much higher. The 16:1 tap could be used for the coils for 50 kHz to 500 kHz, where the loss is relatively constant at 9–10 dB. That change would result in a lower Q for the larger inductors, but a net improvement in power transformation to the receiver as suggested in the circuit shown in Figure 2.

Figure 3 shows the parts placement in the experimental version of the antenna tuner. The inductors are mounted radially around the switch, with the output-transformer toroid toward the rear of the housing near the receiver-output terminal. The prototype shown had an extra non-standard inductor at the lowest-frequency switch position for reception below 10 kHz.

Antenna-capacitance measurement

Most experimenters own a signal generator, oscilloscope, and frequency counter. They can be used to get a good estimate of the antenna's capacitance by following the method shown in Fig. 4. That is a simplified return-loss method where a small series-resistor takes the place of a 3-dB hybrid transformer. The resistor should have a value much lower than the reactance of the inductor at the frequency at which the measurement is made. Resistors in the range of 50 to 100 ohms, together with inductors having known values between 5 and 10 mH, can be used for antenna-capacitance measurements over the range of 10–500 pF for frequencies between 50–500 kHz. It is a good idea to make a preliminary estimate of the antenna capacitance by using the approximation of 10pF/meter of antenna length for wire antennas, and to use that figure as a rough guide to values for use in the initial test. After estimating the antenna's capacitance, the resonant frequency can be checked by substituting a capacitor of about the same value as that calculated for the antenna.

In our case, the flat-top antenna was terminated on a back porch, where it was easy to connect various pieces of test apparatus—and even a receiver—directly to its base. Variations on the substitution method can be used to measure cable capacitance with known inductors, or for unknown inductors with known capacitors, or even for coil distributed-capacity, using difference methods with known capacitors in parallel.

Mutually-coupled antennas

An interesting effect occurs when a tuned wire antenna is placed very near a short wideband active-antenna whip. The vertical active-antenna system is mounted at ground level, directly underneath the flat-top antenna at a distance

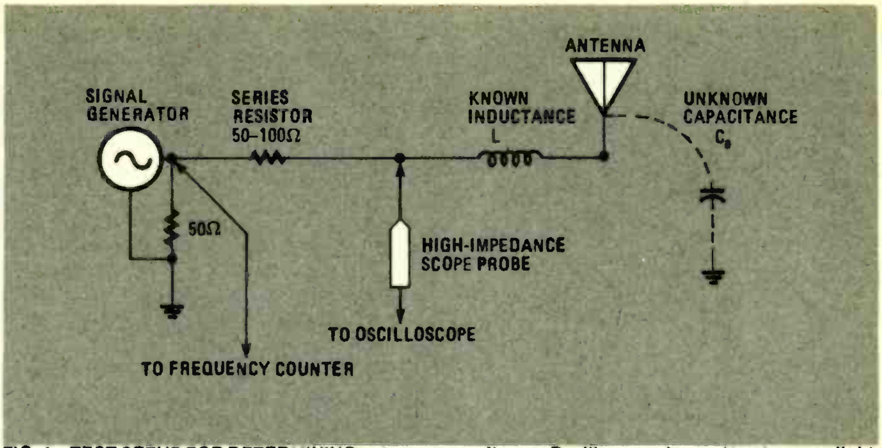


FIG. 4—TEST SETUP FOR DETERMINING antenna capacitance. Oscilloscope is used to observe slight dip in response at resonant frequency of system as frequency of signal generator is slowly varied.

of 5 to 10 meters (about 15–30 feet). The flat-top is connected to the tuner, but the output of the tuner is terminated with a resistor instead of the receiver. The active-antenna system is connected to the receiver as illustrated in Fig. 5. You may find that the amplitude of received signals is increased by 20 dB or more when the passive flat-top antenna tuner is tuned to resonance at the same frequency. That is an example of very-near-field mutual coupling. The active whip at ground level can be tuned for considerably increased sensitivity by placing it very near another tuned-antenna system.

That phenomenon could possibly be used to make directive VLF-LF arrays with very close spacings of 1/1000 wavelength or less between several tuned antennas and the excited active probe. Such a system, though, would probably require good series-inductors, and would be difficult to tune—the relative phase-change between antennas would be very steep because of the high Q of the tuned circuits.

VLF observers report many unusual antenna-effects due to things like drain pipes, gutters, power lines, telephone cables, trees, etc. Most of those can probably be accounted for by mutual-coupling phenomena, but are difficult to estimate or compute because of the unknown field-boundary conditions at a given location.

As we have seen, a single series-tuned inductor can improve the efficiency of a short-wire antenna at the VLF-LF range by 20 dB or more compared to the wire alone when connected to a typical 500-ohm receiver-input terminal. Local-noise pickup can be reduced by using a length of low-capacitance cable to connect the antenna to the receiver/tuner.

A dominating feature of passive VLF-LF short-wire antennas is their relatively high loss compared to the theoretical field available in space above the antenna. To offset that, though, an antenna tuner provides a considerable reduction in interference, along with high selectivity and no intermodulation distortion at the receiver input. It also offers improved sensitivity, compared to the antenna without a tuner. **R-E**

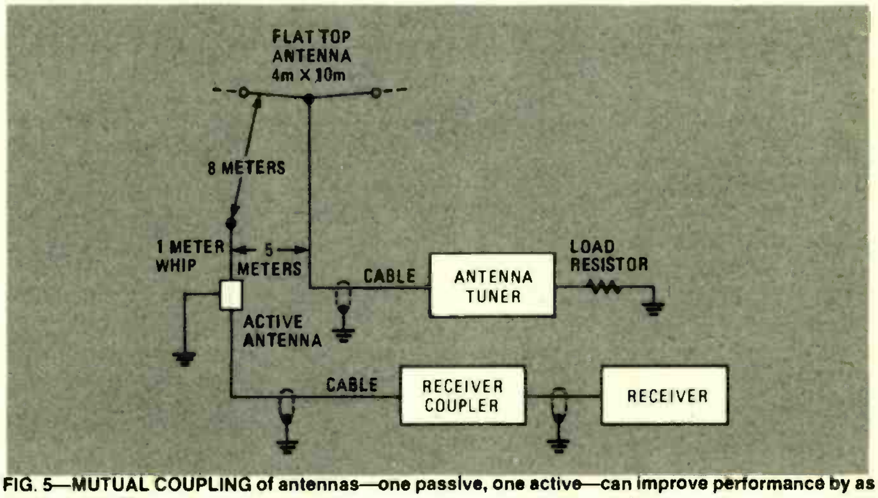


FIG. 5—MUTUAL COUPLING of antennas—one passive, one active—can improve performance by as much as 20 dB.

The INS and OUTS of BUYING MAILORDER COMPONENTS

Often, the hardest task in building a project is obtaining the various parts that you need. Keeping a well-stocked junk box can save you a considerable amount of time, effort, and money!

KARL T. THURBER, JR., W8FX

ONE OF THE MOST REWARDING WAYS TO GAIN EXPERIENCE IN ELECTRONICS IS to build electronics projects. Besides the satisfaction of accomplishment, you learn a great deal in the process involved.

Today, it isn't an easy matter to obtain the right parts, at the right time, and at the right price. The search for and selection of electronic components for projects can be a very disheartening job, particularly when it's seemingly impossible to obtain certain parts, or the price you must pay for them is excessive. You *can* get the parts you need, when you need them, and at a reasonable price, if you are willing to take an organized approach to parts procurement and do a good deal of preparatory spade work before picking up soldering iron and pliers.

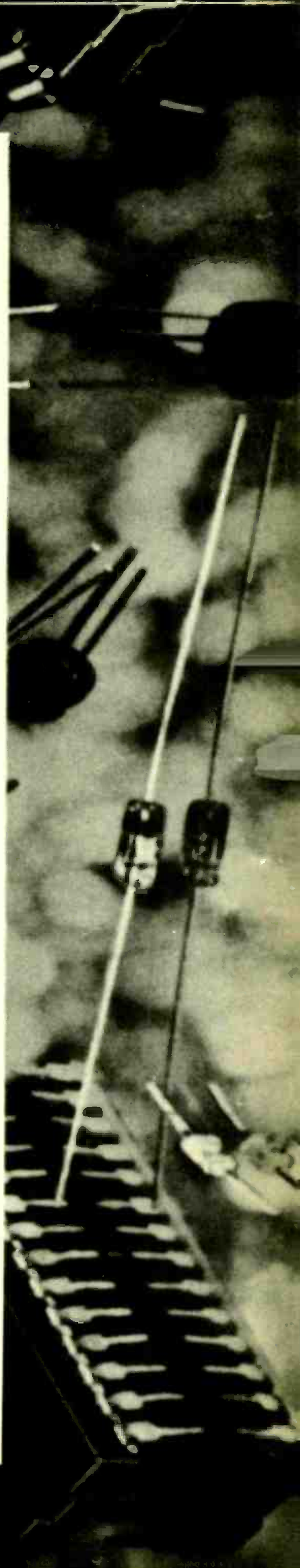
In this article, we will examine the need to get organized for the task; look at parts-selection criteria and the question of substitutions; review various sources of parts; and discuss details of component identification and testing.

As you'll see, once you have a clear view of the process, shopping for parts is no longer the formidable challenge it might otherwise be.

Catalogs and reference material

Before buying parts, it pays to be organized—to have done some pre-planning before you start looking for specific parts for a given project. Some of the things you can do in advance include laying in a good store of catalogs, reference sheets, and reference books; buying-in-advance "staple" and bargain-priced parts; and setting up a well-stocked junk box.

It surley pays to accumulate a broad range of catalogs. No builder's library is complete without them. With a little effort, you will find that virtually any desired part, or a usable substitute, will be listed in *some-one's* catalog or cross-reference. You may also find that a single firm may



have all, or almost all, of the parts required for a given project, eliminating the need for repeated shopping forays or inefficient orders to a number of mail-order firms. Having a number of catalogs at hand also allows ready price comparisons between firms.

Having a good reference file, or recent issues of major electronics publications such as **Radio-Electronics;** amateur magazines such as *CQ*, *Ham Radio*, and *QST;* and a variety of computer-oriented magazines, *Byte*, *Microcomputing*, and *Popular Computing* will provide a good background. The magazines also list the addresses of the major suppliers, along with their ordering policies. Of course, single-page magazine ads can't include a supplier's full stock, and are no substitute for the catalogs themselves.

Another reason for obtaining the larger catalogs is that those serve as excellent reference files for various components, and often provide good sources of cross-reference data, particularly for solid-state components. Note that many of the distributors offer two or more catalogs, such as a consumer-type catalog oriented to hi-fi or CB, and an industrial catalog that would normally be more suitable.

In addition, you should acquire the factory service manual, schematic diagram, and component parts list for any item of electronics gear you buy. A surprising quantity of semi-professional and professional-electronics equipment is sold today with no more than a *user's manual*, which is of little help in servicing and parts replacement. Obtaining the proper manuals and parts lists while equipment is currently being manufactured is much easier than trying to obtain such materials later on, when needed information may no longer be readily available.

To facilitate original construction, it's worthwhile to have on hand a selection of standard reference books and manuals, as well. The publications required, of course, will depend upon the particular type of project work undertaken. Some of the more important, all-round useful reference texts include the Editors and Engineers' *Radio Handbook*, the *Master Tube Substitution Handbook*, *Transistor Substitution Handbook*, *TTL Data Book*, *Transistor Specifications Manual*, and *Reference Data for Radio Engineers;* the ARRL *Electronics Data Book* and *Radio Amateur's Handbook*, and several others. A handy cross-reference manual is the *Archer Semiconductor Reference Handbook*, a useful guide to Radio Shack's semiconductors that's also a substitution and cross-reference guide for more than 100,000 solid state devices. Another Radio Shack reference is Forrest Mims' *Engineers Notebook*, which contains tried-and-tested applications for most popular linear and digital IC's. Other helpful parts information sources are Motorola's *Semiconductor Cross-Reference Guide* and *Discrete Hybrid Components Handbook*, Sylvania's *ECG Semiconductor Replacement Guide;* and RCA's *SK Replacement Guide*.

Photos courtesy of Radio Shack and GC Electronics.

Buying in advance of needs

Is stocking parts in advance of specific project needs a good idea? It's true that with a few judicious purchases, you can stockpile many of the components needed for future projects. On the other hand, an apparent bargain isn't one, unless there's a real prospect of the part or parts ultimately being used.

BUYING LARGE ASSORTMENTS of components and hardware can result in savings, but only if the parts are likely to be used.

Mail-order dealers offer all kinds of special deals—hardware assortments, resistors, knobs, transistors, IC's, potentiometers, transformers, diodes, capacitors, and various surplus components and assemblies. Many of those offerings are indeed bargains, if carefully surveyed and even more carefully purchased. It's generally worthwhile to take advantage of quantity offerings and specialized assortments, tempering one's enthusiasm for a "good deal" with a realistic expectation of when, and if, the contemplated bulk purchase will likely be put to use. A small investment in component assortments usually represents money well spent; however, there is usually little that can be done about a poor choice—you take what you get and hope to be able to use most of it.

For initial stock-up, some useful components include poly-bag assortments of disc ceramic, mica, and small electrolytic capacitors; low-wattage resistors; diodes, and hardware. On the other hand, assortments of precision resistors, large electrolytic capacitors, IC's, and transistors are probably *too* specialized and may not represent good value. The key to selecting true bargains lies in choosing components that you are most likely to use in your projects.

There are some cautions to keep in mind. Buying in advance of your needs is intended to build an inventory of common parts, not to produce specific parts for an intended project. It's unusual to find just what you need for a particular project from a grab-bag assortment. Whenever you need a *specific* part, order *that* part.

Carefully note the makeup of parts assortments. Are the parts offered all of one (possibly oddball) value, or are they of different values? What are the tolerances and power ratings? Are the leads full-length or too-short PC-board length? Are the components new, used, or surplus; tested or untested; firsts or seconds; marked or unmarked; old or fresh; usable or dubious?

All of those considerations play an important part in determining whether buying in advance of needs is a worthwhile approach or a waste of money.

Acquiring a junk box

Most builders have a junk box that can be a handy and money-saving device for both construction projects and repair jobs. Not only does the well stocked junk box satisfy convenience and economic needs, but it can also provide a valuable educational experience in component identification and substitution practices for the beginner.

Assembling a useful junk box is a prime objective of most electronics hobbyists. The accumulation gives you the parts you need for projects, when you need them, at reasonable prices—sometimes even at *no* cost. While you may have to spend some money to acquire a foundation, it's possible to accumulate a large assortment of components inexpensively, if you aggressively search for bargains.

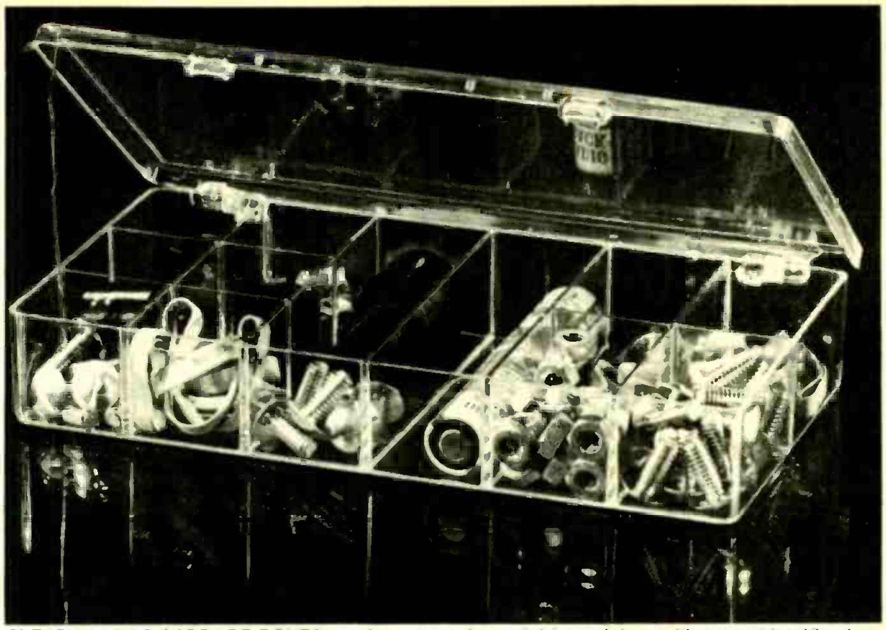
ELECTRONICS FLEA MARKETS often are a good place to acquire parts at a reasonable cost.

The sources for junk box parts are myriad, and they include local purchases, surplus/salvage, mail order, flea markets, auctions, and other sources. Probably the best, lowest-cost way to build an initial parts inventory is to salvage usable components from junked electronics gear. Components such as switches, potentiometers, coils, diodes, transformers, resistors, and capacitors are often salvaged from such equipment. In earlier days many of those components could be obtained from old radios, defective TV sets, discarded amateur equipment, and government surplus gear—components large and small being saved with the expectation that they could be used again in some future project.

Those were the good old days, and by and large, junked gear—particularly that of the tube-type variety—provides a shrinking source of junk box parts. With the advent of solid-state equipment, printed circuits and specialized transistors, and IC's, it's harder to "recycle" those components into useful junk box parts than it was 15 or 20 years ago. The trend in junk box acquisition is toward judicious buying of discrete components in advance. We've already discussed parts-selection tips and cautions, and they apply equally to purchases for the junk box.

Regardless of what methods are used to procure for the junk box, the components—particularly the smaller, easily damaged ones—should be carefully segregated by type and value, and placed in labeled jars, plastic drawers, or even small boxes—whichever suits your particular style. The key is that the storage procedures used should allow fast and positive recovery of the parts when needed. Components that can be tested should not be used without first checking their electrical condition, regardless of how good they may look physically. We'll delve into component identification and testing later; suffice it to say at this point that a multimeter and grid-dip oscillator are two very important testing devices for builders.

A final point on junk boxes: After you've developed a respectable junk box, don't hesitate to *use* it for your projects or repairs. You will save money using "pre-owned" parts, and the risk of improper substitution of a part in a circuit is *usually* not too great (except to that particular part). Even if a substituted junk box part fails, a good deal of learning has taken place!



CLEAR PLASTIC STORAGE BOXES can be extremely useful for quick, positive part identification.

Developing the parts lists

Most published projects include an itemized parts list that identifies the various components' size, value, and nomenclature, as well as required voltage, current, and power-handling capability. Some parts lists even state brand names and recommend sources for hard-to-find and critical components.

Even when a clear and definitive parts list is provided, you should carefully review the construction project, looking closely at the schematic diagram, photos, and explanations of special circuitry and parts requirements. In many cases, the author will point out critical components that should not be changed. Based on your judgment, other parts may be substituted, possibly from existing junk box stocks. We'll talk more later on the question of parts substitution and how far one can deviate from specified values without affecting performance.

The author's parts list should trigger you to work up additional subsidiary parts lists. Those may logically take the form of lists showing which parts are best procured from your junk box; which are best procured by mail-order; which are best acquired from surplus or salvage sources, and which can be purchased locally. After checking your junk box, look over the local purchase and surplus lists next, with unavailable items added to the mail-order list. In large, complicated projects, it may also be useful to have each list further divided by type of component for convenience in searching for the required parts.

From practical and economic standpoints, it's often wise—even necessary—to make appropriate component substitutions. We'll turn to those next.

Parts selection and substitution

As the prices of individual components increase, it's important to "make do" with the parts you have on hand. It's possible to substitute components within limits, and yet have a device function as intended. Besides the financial advantages of using existing stocks, it's a real time saver to be able to use on-hand components rather than having to shop for new ones. Also, it's worthwhile to get a feel for the range and types of substitutions that can be made so as to develop flexibility when shopping for components—since local suppliers and mail-order houses will not always have exact specified components in stock.

Many inexperienced electronics enthusiasts have an unnecessary fixation on obtaining the exact parts and values indicated in a construction piece, fearing that the finished equipment will not function correctly if any liberties are taken with the stated parts list. Usually such fears are exaggerated. Unless a "mirror image" of the item is required, *identical* parts are not needed. In most cases, parts substitutions can be made, within reasonable bounds. Component specifications are not "graven in stone," as the saying goes. There is usually a tolerance range within which the hobbyist may work. Sometimes those are stated, though mostly they are not. The trick to intelligent parts substitution, of course, lies in knowing just what the boundaries of wise substitution are.

Obviously, if the construction article's author or circuit designer has highlighted critical components, you shouldn't change them. Special-purpose or close-tolerance IC's, transistors, tubes, capacitors, resistors, and other parts are best not substituted. But in many cases the component specified is what the designer had on hand, and represents an arbitrary specification. So, bearing in mind that most hobbyists are also experimenters, when you have trouble finding components with the exact specifications, try some substitutions of your own, using a combination of good judgment and close attention to available reference guides, catalogs, and substitution manuals. You may not have the experience to ascertain whether or not you'll be successful in making the substitution, but you'll never know unless you try!

Most components, such as resistors, capacitors, inductors, transformers, and transistors, have *ratings* that are important. Those include power and maximum voltage and current ratings. The ratings of substituted components should be equal to or greater than those specified for the project. Generally speaking, over-rated components *can* be used in electronics projects. For example, a 1-watt resistor can be substituted for a ½-watt resistor of the same value without concern, unless the larger physical size of the 1-watt unit causes a space problem.

Active devices, such as transistors, are more difficult to substitute on a "rating" basis, due to the multiplicity of rating parameters involved. Still, similar guidelines hold for those components, as long as the substitute has equivalent design parameters. One must be cautious in trying to substitute components with overrated ones when the device is to perform a specific function at a particular value of current or voltage. In such a case, a "larger" unit would not be satisfactory. Zener diodes and other current- and voltage-regulating devices, for example, would fit into that category.

Making a proper "ratings" substitution is a great deal easier than making a "value" substitution. Each type of component is affected by different rules and guidelines, so it's worthwhile to look at each individually:

1. Resistors. Fixed resistors are often easily substituted. Unless specified otherwise, fixed resistors commonly have a tolerance of ± 10 or 20%. Knowing that, you can usually safely substitute any resistor. If no tolerance is specified, working in the ± 10% or 20% range is usually safe. One general exception is high-voltage power-supply bleeder resistors—those can be as much as 25% lower or 50% higher than specified.

In some applications, metal-film precision resistors, manufactured to tolerances of ± 1% or better, are required. That type of resistor is frequently specified for high-stability/ultra-low-noise circuits in computers, voltage dividers, test equipment, and active filters. The stated tolerance must be maintained when substituting those types of resistors.

Frequently, you can find resistors in your junk box that can be adapted for a substitution, using series and parallel combinations whose net resistance is close to the desired value. Resistors connected in series have the total resistance of the sum of the resistors—two 2000-ohm resistors in series have a total resistance of 4000 ohms. To find the effective resistance (R_t) for resistors in series use the formula:

$$R_t = R1 + R2 + R3 + ...$$

Two or more resistors can be connected in parallel to obtain the desired circuit resistance. When you do that, total resistance is always less than the lowest value used in the combination. Use the following simple formula to calculate the value of two resistors connected in parallel:

$$R_t = \frac{R1 \times R2}{R1 + R2}$$

There are two major kinds of fixed resistors: composition or carbon, and wire-wound. Normally, do not use wire-wound resistors in circuits carrying RF since they have a certain amount of inductance that can upset the associated RF circuit. However, carbon-type resistors of the appropriate power rating can be used to substitute for wire-wound types.

2. Potentiometers. Substitutes can usually be made having somewhat higher or lower values than those specified. Surplus pots can be bargains, but physical characteristics such as shaft length and type of shaft are important. Consider: Is the unit for screwdriver adjustment, or is the shaft designed to accept a knob? What about the pot's electrical characteristics, such as the "taper"—is it usable? Pots with "linear" or "audio" tapers are the types most frequently called for in construction projects. And is an on-off switch required on the control?

One caution: Wire-wound pots are frequently found in surplus. Those pots are most suitable for low-frequency, high-power applications, not for delicate solid-state circuitry. They are not for circuits that require high precision (resolution). Thus, for most work, standard carbon-composition pots represent the best selection.

When shopping for new pots, quality is paramount; cheap materials are synonymous with inferior performance, often evidenced by a pot that is hard to turn because of high-friction bearings. Cheap imports should be avoided; stick to top-quality pots in all construction projects.

3. Capacitors. Fixed capacitors come in a surprising variety. There are mica, Mylar, silver-mica, ceramic, oil-filled, paper, and electrolytic types. Each has specific applications. Mica types (especially silver-micas) and zero-temperature-coefficient ceramics are usually specified where low losses and high stability are essential; normally, you should not substitute other types for them. Probably the best all-round capacitor for general purpose use is the Mylar polystyrene type—also one of the cheapest, and typically available for values between 5 pF and 0.5 µF.

Standard tolerance ratings for most project-grade capacitors is ± 10 to 20%, though for some inexpensive general-purpose ceramic capacitors (including disc types)it's as wide as − 30% to + 100%. Exact capacitance is relatively unimportant in typical bypassing/filtering and coupling applications, and you can easily deviate as much as 50% from the spec value without trouble, sometimes much more (except at VHF and UHF). Mylar polystyrene capacitors also run in the 10–20% tolerance range, with 5% Mylars readily available, and 2.5% and 1% units available at somewhat higher prices.

As with resistors, capacitors can be substituted in series or parallel to yield different equivalent values, though the combining effects are the opposite to those of resistors: capacitors in series act like resistors in parallel, while capacitors in parallel act like resistors in series.

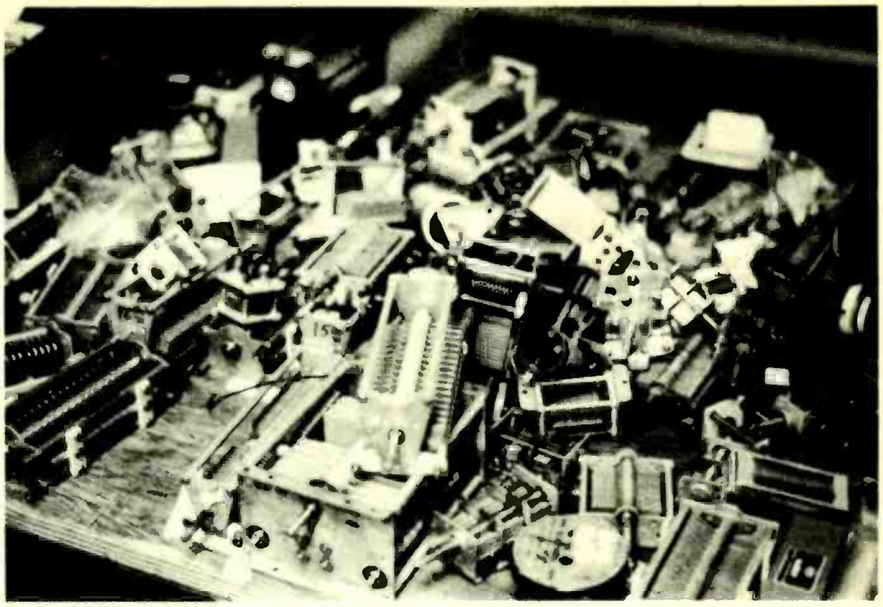
When two capacitors are placed in series, the total capacitance is less than that of either one, as determined by the simplified formula:

$$C_t = \frac{C1 \times C2}{C1 + C2}$$

Capacitors are additive when placed in parallel:

$$C_t = C1 + C2 + C3 + ...$$

Another handy formula is one to use when you need a lower value of capacitance and want to find the value needed to place in series with an available unit to



APPROPRIATE SUBSTITUTES can be found for most electronic components, including variable capacitors. Flea markets are a good source for those components.

obtain the desired value. That value is given by the formula:

$$C1 = \frac{C2}{(C2/C_t)-1}$$

The voltage-handling capability of the resulting capacitor chain should be considered, as should power-handling capability of series/parallel resistors. A standard electronics text should be consulted for more on that.

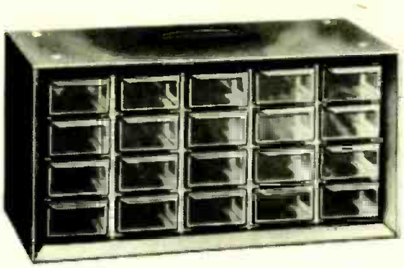
Most capacitors above 1 µF are aluminum electrolytics and are polarized. Tolerances tend to be fairly loose because filtering and coupling applications usually don't call for precise values. Those types are often available with capacitances of 100,000 µF or more, though usually at very low voltage ratings at those high capacitances. A related though more expensive capacitor is the tantalum type. The tantalum capacitor is generally superior to the standard electrolytic, and boasts tighter tolerance, smaller size (for equivalent capacitance), and lower leakage.

Except in specialized applications, such as in timing circuits where tantalums are generally preferred over aluminum electrolytics, exact capacitance isn't terribly important. When substituting, it's generally wise to err on the side of too-high capacitance rather than too-low. Surplus oil-filled types can normally be substituted for electrolytics having equivalent characteristics.

Substitutions are also possible with variable capacitors. The main considerations here relate to minimum and maximum capacitance. As a general rule, you can substitute a capacitor having a greater capacitance than the value specified. It may also be possible to substitute a variable capacitor that has somewhat less range than that specified, if you can determine the actual tuning range required in the circuit. That involves figuring the amount of circuit inductance and amount of capacitance required for a given tuning range, and is best done with the aid of a device such as the ARRL *LCF Calculator*, or using a computer. Note that junk box variables can be modified to become lower-value capacitors simply by removing rotor plates, and multi-section receiving variables can be paralleled to get higher capacitance.

In high-voltage circuits, be sure you observe maximum operating voltages that depend on plate spacing. Plate spacing should be equal to or greater than that specified by the designer, or you can refer to a catalog to convert spacings to voltage-handling capacities. Knowing the voltages in the circuit, you can easily check to see if your particular substitute is adequate for your purpose.

4. Diodes. Besides resistors and capacitors, you'll often be faced with making substitutions for diodes of various kinds, both rectifier and small-signal types. The



A 20-DRAWER CABINET such as this is ideal for maintaining a well-organized junk box.

former are generally specified according to their maximum current and reverse breakdown ratings. It's possible, in many instances, to come up with a suitable replacement without having to resort to checking a data book. The 1N4148 is a good all-around small-signal type diode to have in the junk box as it is able to meet a wide range of substitution needs.

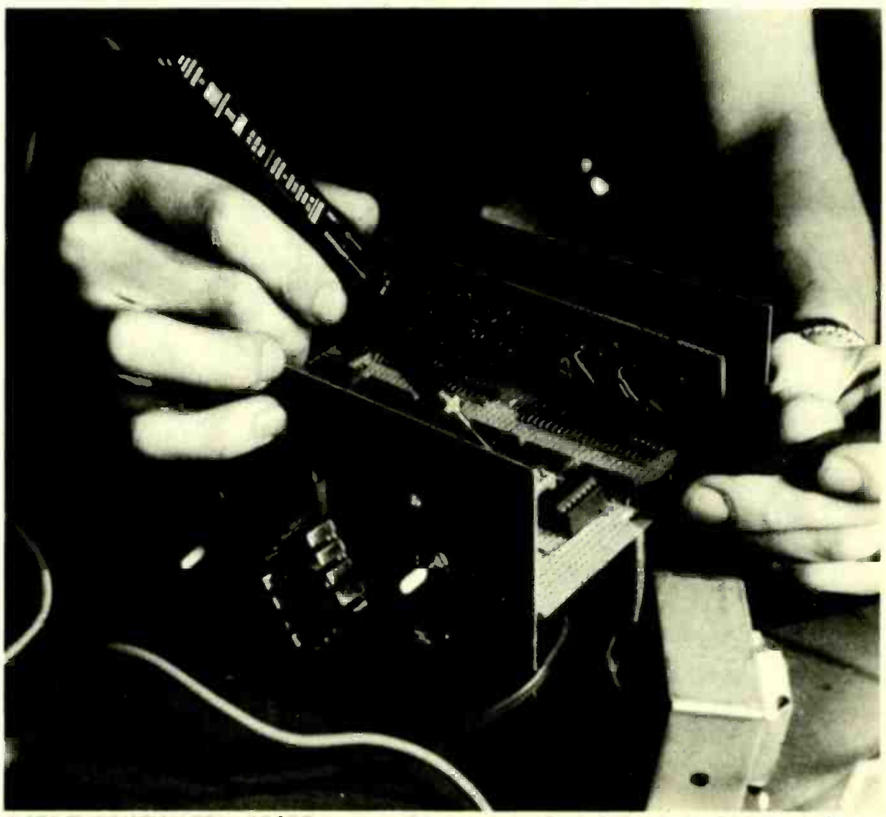
5. Transistors. Besides diodes, other types of discrete semiconductors that present substitution questions include bipolar transistors, FET's, SCR's, and UJT's. As with diodes, practically everyone sells some transistors, but few distributors stock each and every part number, particularly highly specialized and Japanese types.

Many transistor suppliers and manufacturers overly emphasize the difficulty of transistor substitution. From a practical standpoint, the many different types of transistors and related economic considerations make it imperative that some substitutions be attempted. You'll need a transistor data book to determine proper specifications; once those numbers are available, you can apply them to select appropriate substitutes. Even using abbreviated substitution guides such as found in the Radio Shack catalogue can make the purchase of bargain-priced blister-pack replacement transistors practical and useful.

6. Integrated Circuits. The silicon chemistry of integrated circuitry constitutes a key element of most sophisticated electronics construction projects. Because of their importance and widespread use, those devices are sold by most electronics suppliers. The devices range over a wide spectrum, and include linear, CMOS, TTL, DTL, ECL, LSI, and other types. The variety encountered precludes stocking up on any but the most common types.

There is little latitude in substituting IC types. A circuit specifying a particular IC usually requires *that* particular IC. In fact, it's usually not worthwhile to salvage IC's from scrap equipment unless the IC's can be clearly identified and there is some prospect of actual use for that particular device.

However, it's important to point out that IC designations often include alphabetical prefixes that simply indicate the device's manufacturer. There is no need to use an IC made by a particular manufacturer if the same basic device is available from other firms. You'll find that IC suffix letters aren't terribly critic-



A MULTI-FUNCTION TEST PROBE, such as the one shown here, is handy for finding good components in surplus or salvaged equipment.

TABLE I—COMPONENT SUBSTITUTION GUIDELINES

The following constitute *general* guidelines for substitution of the most-used components: resistors, capacitors, inductors, rectifier diodes, and transistors. Refer to the text for discussion of other factors that should be considered in making parts substitutions, and for guidelines for other components.

RESISTORS

Resistance value: within ±20% of that specified.

Resistance tolerance: equal to or better than specified, but usually not critical.

Power rating: equal to or greater than specified.

CAPACITORS

Capacitance value: within ±20% of that specified, except in critical timing and tuning circuits.

Capacitance tolerance: equal to or better than specified, but usually not critical.

Voltage rating: equal to or greater than specified, or twice the maximum supply voltage.

Type: generally not important except in critical timing and tuning circuits.

COILS/INDUCTORS

Inductance value: within ± 20% of that specified.

Current rating: equal to or greater than specified.

RECTIFIER DIODES AND BRIDGE ASSEMBLIES

Current rating: equal to or greater than specified.

Reverse breakdown voltage: equal to or greater than specified.

TRANSISTORS

Type: as specified (PNP or NPN, etc.).

Collector current rating (I_c): equal to or greater than specified.

Reverse breakdown voltage: equal to or greater than specified.

Gain (Beta or hf_e): equal to or greater than specified.

Power rating: equal to or greater than specified.

Cutoff frequency: equal to or greater than specified.

Case style: usually not important.

NOTE: *A transistor data book must be consulted for determining most of the specifications necessary for making substitutions.*

al, either. They usually indicate a change in the internal IC configuration that does not alter the basic function, though the suffix letter may indicate the package style. But, if you find a letter (or two) inserted between some of the numbers, it may indicate a significant modification that precludes easy substitution. In such cases, it's wise to consult a data book, paying particular attention to possible changes in pin numbering.

7. Power transformers and chokes. When your project requires a very specific transformer, it may be best to order it directly from the manufacturer or his distributor.

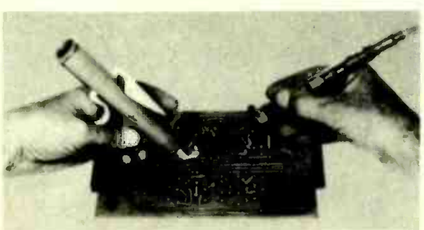
On the other hand, if specs aren't too tight, or it's possible to connect windings in various configurations to obtain required voltages, it may pay to take advantage of specials and closeouts by mail-order distributors—though transformer offerings are usually limited in variety. Industrial surplus dealers generally have the best selection; transformers with the most unusual characteristics can turn up in surplus.

One of the main considerations in making transformer substitutions is adequate current/power handling capacity. You can substitute if the transformer in question has the same voltage rating with more current-carrying capacity, but it's risky to go the other way. However, if the transformer is rated in terms of continuous duty, and its intended use will be intermittent, a rating reduction of up to about 25% may prove to be quite acceptable.

Minor primary and secondary voltage substitutions can be made without adverse effect. If you have a transformer that delivers a higher voltage than you want, you can drop the voltage with a series resistor or a voltage-divider system.

As for power-supply chokes, substitutions are usually easy. The specified value of a filter choke can usually be regarded as a minimum value. The inductance of chokes in series is additive; conversely, chokes in parallel function like resistors in parallel. The amount of capacitance required in a power supply is affected by the power-supply choke inductance—the choke and electrolytic capacitor work together to bring ripple down to an acceptable level.

In addition to inductance ratings, you must also take into account the current the choke must carry. Of course, you can use a choke with a higher current rating than specified. Using a somewhat lesser-rated choke is probably OK, unless the choke is rated at less than 75 % of expected current. The inductance becomes less if more current is drawn through the choke than the unit is rated for, thus reducing the choke's filtering effectiveness.



A DESOLDERING TOOL makes removing parts from a surplus or salvaged piece of equipment simple.

8. Switches. Substituting switches can be tricky because of the numerous possible switching configurations and applications. You can always use a switch that has more contacts or sections than are required for a given circuit, as long as it has an adequate voltage rating. Often that information can be obtained from manufacturers' and distributors' catalogs. Similar considerations apply to relays, but selection criteria are complicated by relay coil voltage and current, and other operating characteristics.

9. Tubes. Most contemporary circuitry has abandoned the once-common vacuum tube, though a few tube designs survive, and there is still demand for tubes for replacement purposes. Tubes are becoming extremely expensive and difficult to find, and few are still manufactured in the United States. One good, low-cost source of once-common receiving tubes is *Cornell Electronics Company*, 4217 University Avenue, San Diego, CA 92105; the firm stocks a wide variety of bargain-priced receiving tubes. *Radio Shack* also provides a special-order service that includes about 2000 different types. If you don't have the tube you need, of course, you'll have to buy it. But a quick check of a tube-substitution manual, or the ARRL's *Radio Amateur's Handbook* (it lists different tube types and possible substitutions if available) may prove worthwhile.

10. Other components. There are many other components that the project builder will find useful to keep in his junk box or bench stock for the purpose of convenient substitution in construction projects.

We can't treat all of them here. But some that come to mind include plugs, jacks, audio and IF transformers, transistor and IC sockets, battery clips, terminals, hardware, alligator and crocodile clips, meters, connectors, chassis, PC boards, and cabinets.

In many instances your best guide to making intelligent substitutions is simple, ordinary common sense, as well as an understanding of when not to use substitute parts but to go out and acquire a specified part.

Getting into the practice of breadboarding project circuitry will not only help refine a circuit before commitment to a final design, but will make substitutions easier because it gives you a chance to double-check your choices. Solderless breadboards eliminate a great deal of the trouble involved in circuit development and make desk-top experimentation—and substitution—much easier.

Table 1 lists popular component substitution considerations in tabular form.

Parts sources

Once you have a good feel for the types of parts you'll need and a knowledge of possible substitutions, the next step is to select the right sources for those components.

Selection criteria generally run along lines of price, quality, and availability. Usually it's not possible to eat your cake and have it too when filling a list of materials: You'll have to make your buying decisions based on which combination of the three considerations is most important to you at a given time. For example, if you *must* have a particular part immediately to finish a project you may have to pay several times as much for it as you might under less-pressing circumstances.

Parts sources can be divided into five major categories, each having a different mix of the price/quality/availability equation. The first source is that of local purchase, including brand name, over-the-counter distributors and electronics specialty stores. Second is surplus/salvage. Third is electronics mail order. The fourth source is that of electronics hamfests, computerfests, flea markets, and auctions. The last is a "catch-all" of non-conventional sources of components—more on that later.

1. Local purchase sources are many and varied. In the so-called good old days, most parts were purchased locally, at least for those living in or near large metropolitan areas. Most cities had firms dealing in brand-name parts, others, in military surplus, and still others in salvaged components. Specialized emporiums sold, at bargain prices, the most-needed components—resistors, capacitors, tubes, inductors, transformers, sockets, gears, dials, cabinets, test equipment, and chassis, *ad infinitum*. Today, very few cities have more than a few walk-in electronics distributors' outlets, other than franchised ones. In fact, probably the only "classic" radio row that is still thriving today is Tokyo's gigantic Akihibara electronics district, which may be described as an updated solid-state version of New York's Cortland Street radio row of 1940's and 1950's vintage.

There is little hope for the revival of the radio row. For the most part, local purchase means the lone over-the-counter electronics distributor. Such distributors specialize in selling electronics parts, mostly to radio and TV repairmen. Some also sell CB, audio, and computer equipment, but are rarely equipped to provide a wide selection of project components at popular prices. The main advantage of such distributors and franchised outlets is, simply, *availability*. If you're more interested in price than fast delivery, you'll probably want to save money by ordering parts by mail. But if you need a part fast, all you have to do is to make a trip to the store to obtain it.

To locate a convenient local source of supply, consult the Yellow Pages of your local telephone directory. Check under "*Electronics Equipment and Supplies*". That listing may be followed by the notation "Wholesale and Manufacturers" or "Retail". Also look under "*Television and Radio Supplies and Parts*". Note that many hard-to-come-by parts can be located by going to the company distributor in your area—particularly for semiconductors. Motorola and RCA have outlets in many cities, and it may be possible to obtain the particular item needed from the local distributor, or he can order it for you if out of stock. Again, check the Yellow Pages for addresses and phone numbers.

Several larger radio distributors (especially those also doing a substantial mail-order business) issue periodic catalogs, usually free. Many of these run to several hundred pages, and can be thought of as encyclopedias of highly useful information.

2. Surplus/salvage. Using surplus and salvaged components can be a money-saver and convenience for the electronics hobbyist. There's little doubt that the least expensive source of needed parts is old electronics equipment that can be salvaged.

Surplus isn't quite what it used to be, however. In the distant past, sources of surplus equipment were many. Those included war-surplus emporiums, mail-order military salvage firms, local radio and television dealers, and electronics schools. Government property disposal and surplus-sales programs have been good sources of classic salvage, equipment that can be stripped of useful components and/or converted into useful electronics equipment.

Much of the classic market has dried up: What is available is not terribly useful for contemporary construction projects. World War II and 1950's-vintage equipment is no longer in good supply, and most of that type of equipment isn't appropriate, anyway.

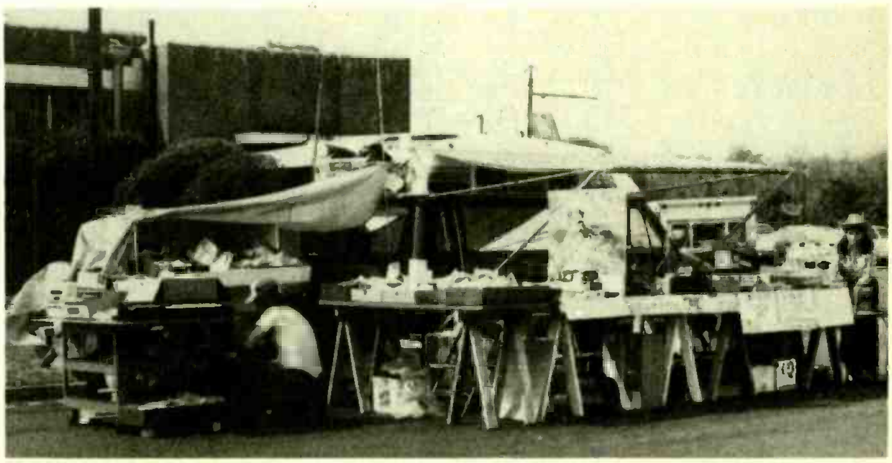
Still, there are opportunities to obtain such components and equipment. Just check the Market Center section in the last 30 pages of this magazine.

There is something of a renaissance of surplus today, but the times and technologies have changed. Although using classic surplus can take the edge off the high cost of building projects, the action today lies in *industrial* surplus. There is a great deal of commercial, civilian-type surplus advertised in the electronics magazines alongside more conventional, brand-name components. Original sources are many, but include excess production quantities, overstocks, obsolete product lines, bankruptcy liquidations, CB components closeouts, etc., all available at bargain-basement prices that represent but a fraction of original prices or replacement costs.

3. Mail-order. While there's little hope for revival of the radio row, the rapid growth of mail-order electronics houses, coupled with the convenience of the toll-free telephone number and instant bank-card credit, have largely filled the void left by the demise of in-city stores. In fact, the central radio row has largely been replaced by stacks of catalogs, flyers, and sale sheets announcing merchants' wares.

Mail-order firms tend to specialize in specific kinds of components, assemblies, or equipment. Each firm and the catalogs that represent it have distinct personalities. Some companies handle only brand-new, factory component lines, sold individually. Some companies specialize in specific types of parts, concentrating on transistors and IC's, resistors, capacitors, or inductors. Others sell only manufacturers' overruns and surplus-parts inventories by the lot or package. Others are genuinely non-specialized, selling a smattering of all types of components.

A very specialized type of supplier, often overlooked, is the kit manufacturer. While primarily packagers of electronics kits, kit makers also maintain extensive inventories of components for current and superseded kits sold by the companies. The kit manufacturer can usually be relied upon to furnish an exact replacement or close substitute for an ailing component in any of his kits. In some cases, one-of-a-kind parts for non-kit construction projects can be obtained from the kit manufacturer if the part can be found in one of the construction manuals.



ELECTRONICS FLEA MARKET and hamfest dealers, such as this one, are among the best sources for low-cost parts.

Buying electronics components by mail requires care. Keeping in mind a few buying pointers will save later grief:

1. Know the company and its reputation.

2. Be aware of the firm's warranty, return, and restocking policies.

3. Use current catalogs and magazine advertisements, and check with the firm to see if critical components are actually in stock.

4. Carefully check your order before mailing it or calling it in, and take special care with telephone orders to help insure that the firm knows exactly what you want. Check arithmetic carefully!

5. Place general correspondence or questions not directly pertaining to the order on a separate sheet of paper.

6. Use the dealer's part numbers in addition to generic part numbers, if those are available.

7. Include a remittance that will be adequate to cover the order, plus postage, handling charges, and tax, but don't use a blank check. Use a money order, cashier's check, or charge-card number to speed delivery.

8. Observe minimum-order requirements to prevent being embarrassed later.

9. Ask that very small parts be sent first class mail, larger ones by UPS.

10. Keep a copy of your order, charge-account slips, and cancelled checks.

11. Tell the firm what you will take in the way of substitutions and if you will accept credit slips for items that are out-of-stock.

12. Consolidate small orders for savings in the cost of the parts themselves as well as postage and handling charges.

13. Be specific on how urgent the order is. Say something like, "Ship everything in stock within 10 days and cancel balance of order," or "Ship partial immediately and ship balance when available."

Mail-order houses generally offer good service, but there are built-in delays in the "system" that often mean that receipt of your parts may be several weeks away. The pointers above should help you get your order in the least possible time, however.

The biggest mail order complaints focus on substitutions and back-orders. Notwithstanding what may be advertised in a direct-mail flyer or catalog (which may have been composed many months ago), suppliers frequently don't have all of the advertised components in stock. That is especially true of solid-state components such as transistors, diodes, and IC's, and closeout, one-of-a-kind or especially bargain-priced components. Specific "kill" instructions should make your time sensitivity and amenability to backordering clear to the order filler. But what do you do about the problem of substitutions?

The best advice is to state clearly what you will accept in the way of substitutions—not very easy in the case of most transistors and IC's, that may not be readily substitutable. It's probably better to state on your order that you won't ac-

TABLE 2—SELECTED LISTING OF MAIL ORDER ELECTRONIC PARTS DEALERS

Advertisers in Radio-Electronics Magazine are listed in bold type

Active Electronics Sales Corp.
PO Box 1035
Framingham, MA 01701
617-366-0500

ADVA Electronics
Box 4181
Woodside, CA 94062

Advanced Computer Products
PO Box 17329
Irvine, CA 92713
714-558-8813

Alaska Microwave Labs
4335 E. 5th Street
Anchorage, AK 99504

All Electronics
PO Box 20406
905 S. Vermont
Los Angeles, CA 90006
213-380-8000

Aldelco
27890 Milburn Avenue
Baldwin, NY 11510
516-378-4555

Altex Electronics
618 W. Sunset
San Antonio, TX 78216
512-828-0503

Arizona Electronic-Surplus
6835 N. 16th St.
Phoenix, AZ 85016
602-266-9758

Babylon Electronics
4811 Myrtle Ave.
Sacramento, CA 95841
916-334-2161

B&F Enterprises
119 Foster Street
Peabody, MA 01960

Barry Electronics Corp.*
512 Broadway
New York, NY 10012
212-WA5-7000

B.G. Micro
PO Box 280298
Dallas, TX 75228
214-271-5546

Bullet Electronics
PO Box 401244
Garland, TX 75040
214-278-3553

Chaney Electronics, Inc.
PO Box 27038
Denver, CO 80227
303-781-5750

Components Express
1380 E. Edinger
Santa Ana, CA 92705
714-558-3972

Concord Computer Products
1971 So. State College
Anaheim, CA 92806
714-937-0637

Dealin Electronics
735 Loma Verde
Palo, Alto, CA 94303
413-493-5930

Diamondback Electronics
2083 12th St.
Sarasota, FL 33577
813-953-2829

Digi-Key Corp.
Highway 32 South
Thief River Falls, MN 56701
218-681-6674

Dokay Computer Products
3250 Keller St., No. 9
Santa Clara, CA 95050
408-988-0697

Edlie Electronics, Inc.
2700-DP Hempstead Turnpike
Levittown, NY 11756
516-735-3330

EICO
108 New South Road
Hicksville, NY 11801

Electronic Distributors, Inc.
4900 Elston Avenue
Chicago, IL 60630
312-283-4800

Electronic Mart
90 E. Water Street
Chillicothe, OH 45601
614-773-1313

Electronic Surplus, Inc.
1224 Prospect Ave.
Cleveland, OH 44115
216-621-1052

ETCO Electronics
North Country
Shopping Center
Plattsburgh, NY 12901
518-561-8700

Etronix
14803 N.E. 40th
Redmond, WA 98052
206-881-0857

Fair Radio Sales Co., Inc.*
1016 E. Eureka
Box 1105
Lima, OH 45802
419-227-6573

Fordham
855 Conklin Street
Farmingdale, NY 11735
516-752-0050

Formula International, Inc.
12603 Crenshaw Blvd.
Hawthorne, CA 90250
213-973-1921

Gladstone Electronics
901 Fuhrmann Blvd.
Buffalo, NY 14203
716-849-0735

Gemeni Electronics
473 W. State Rd.
Altemonte Sp., FL 32701
305-819-9292

Godbout Electronics
Box 2355
Oakland Airport, CA 94614
415-562-0636

Hal-Tronix
PO Box 1101
Southgate, MI 48195
313-285-1782

Heath Co.
Benton Harbor, MI 49022
616-982-3200

Hitech Electronics
4425 W. Sepulveda Blvd.
Torrance, CA 90505
213-371-2160

cept *any* substitutes, rather than to say that you will—unless you're willing to go to the trouble of specifying the acceptable substitutions for every single part on your order.

At the risk of confusing the order-filler with your range of substitutes, it may be wise to list one or two equivalents you will accept should a *critical* part requested be out of stock. Most dealers will comply with your request if your instructions aren't too complicated. Obviously, for unique items, or for pieces of *equipment*, you would not normally want to consider substitutes at all, or would require that you be contacted before authorizing the firm to ship a substitute of its choice.

To minimize the impact of minimum-order levels, stock-outs, and substitutions, consider judicious buying in advance of needs with respect to widely-used components and investigate the possibility of combining parts orders with those of friends or associates.

Table 2 lists representative mail-order electronics suppliers, including those firms which specialize in surplus.

4. Flea markets and auctions. Taking a somewhat less-conventional approach to parts acquisition, the flea-market circuit probably represents a very inexpensive source of electronics parts and supplies. Since one can rarely predict in advance what is likely to be encountered at a flea market, this source is generally best suited to junk-box building—for accumulating an inventory of parts for future projects.

Many amateur radio clubs and computer groups sponsor hamfests and conventions that include well-developed flea-markets. Regular distributors and direct-mail firms sell their wares at these functions, so that the hobbyist is presented with a selection of both new and surplus components, assemblies and equipment from which to choose. Some of the larger events include the *Dayton Hamvention*, *Birminghamfest*, *Atlanta HamFestival*, *Ak-Sar-Ben auction (Omaha, NE)*, *SAROC (NV)*, and *Hamfest Chattanooga (TN)*. Dozens of lesser-known events occur regularly around the country, most being held in the good-weather season from April through October. Many amateur and some computer publications list them.

Auctions, usually conducted in conjunction with flea-markets and frequently as part of ameteur radio and computer club meetings, also represent another source of parts. Usually, however, the focus is on surplus *assemblies* rather than individual components; whatever components are included are usually grouped together and sold in lots. Those factors make auctions somewhat less attractive for small-scale buying for construction projects.

Another point: Flea markets and auctions also provide good outlets for your own junk box, which may ultimately become too bloated and may need some weeding out to make room for future purchases.

5. Other sources of supply. Sometimes, items required for a particular con-

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Integrated Circuits, Unlimited
7889 Clairmont Mesa Blvd.
San Diego, CA 92111

International Electronics
435 First Street
Solvang, CA 93463

Jameco Electronics
1355 Shoreway Road
Belmont, CA 94002
415-592-8097

JDR Microdevices, Inc.
1224 Bascom Avenue
Campbell, CA 95008
408-995-5430

JAVANCO
150 Second Avenue
South Nashville, TN 37201
615-224-4444

H.J. Knapp of Florida, Inc.
4750 96th Street
St. Petersburg, FL 33708
813-392-0406

MCM Electronic Parts
858 Congress Park Drive
Centerville, OH 45459
614-434-0031

McGee Radio
1901 McGee Street
Kansas City, MO 64108
816-842-5092

Meshna, Inc.
PO Box 62
E. Lynn, MA 01904
617-595-2275

MHZ Electronics
2111 W. Camelback
Phoenix, AZ 85015

Mikos
PO Box 955
El Granda, CA 94018
415-728-9121

M-M Electronic Sales
2300 1st Avenue
Seattle, WA 98121

Mouser Electronics
11433 Woodside Ave.
Santee, CA 92071
714-449-2229

New-Tone Electronics
PO Box 1738
Bloomfield, NJ 07003
201-748-5089

Olson Electronics
2850 Gilchrist Road
Akron, OH 44305
216-798-1000

Omnitron
768 Amsterdam Ave.
New York, NY 10025
212-865-5580

Ora Electronics
18215 Parthenia St.
Northridge, CA 91325
213-201-5848

Page Digital
1858 Evergreen
Duarte, CA 91010
213-357-5005

Poly Paks, Inc.
PO Box 942
S. Lynnfield, MA 01940
617-245-3828

PPG Electronics
791 Red Rock Rd.
St. George, UT 84770
801-628-3627

Priority One
9161 Deering Avenue
Chatsworth, CA 91311

Quest Electronics
PO Box 4430C
Santa Clara, CA 95054
408-988-1640

R.F. Gain, Ltd.
100 Merrick Road
Rockville, Centre, NY 11570

Radio Shack
One Tandy Center
Ft. Worth, TX 76102
(Consult your local directory for the store nearest you)

Ramsey Electronics, Inc.
2575 Baird Road
Penfield, NY 14526
716-586-3950

SCR Electronics
5303 Lincoln Ave.
Cypress, CA 90630
714-527-2554

Semiconductors Surplus
2822 N. 32nd Street, Unit 1
Phoenix, AZ 85008
602-956-9423

Simple Simon Electronic Kits
3871 S. Valley View, Suite 12
Las Vegas, NV 89103
702-322-5273

Slep Electronics Co.*
Highway 441
PO Box 100
Otto, NC 28763

Solid State Sales
PO Box 74
Somerville, MA 02143
617-547-4005

Sparton Electronics
6094 Jericho Tpk.
Commack, NY 11725
516-499-9500

Space Electronics Co.*
35 Ruta Court
S. Hackensack, NJ 07606

Stavis Electronics
912 Touhy Ave.
Park Ridge, IL 60068
212-692-5223

Suntronics Co. Inc.
12621 Crenshaw Blvd.
Hawthorne, CA 90250
213-644-1149

Surplus Electronics
7294 N.W. 54th Street
Miami, FL 33166
305-887-8228

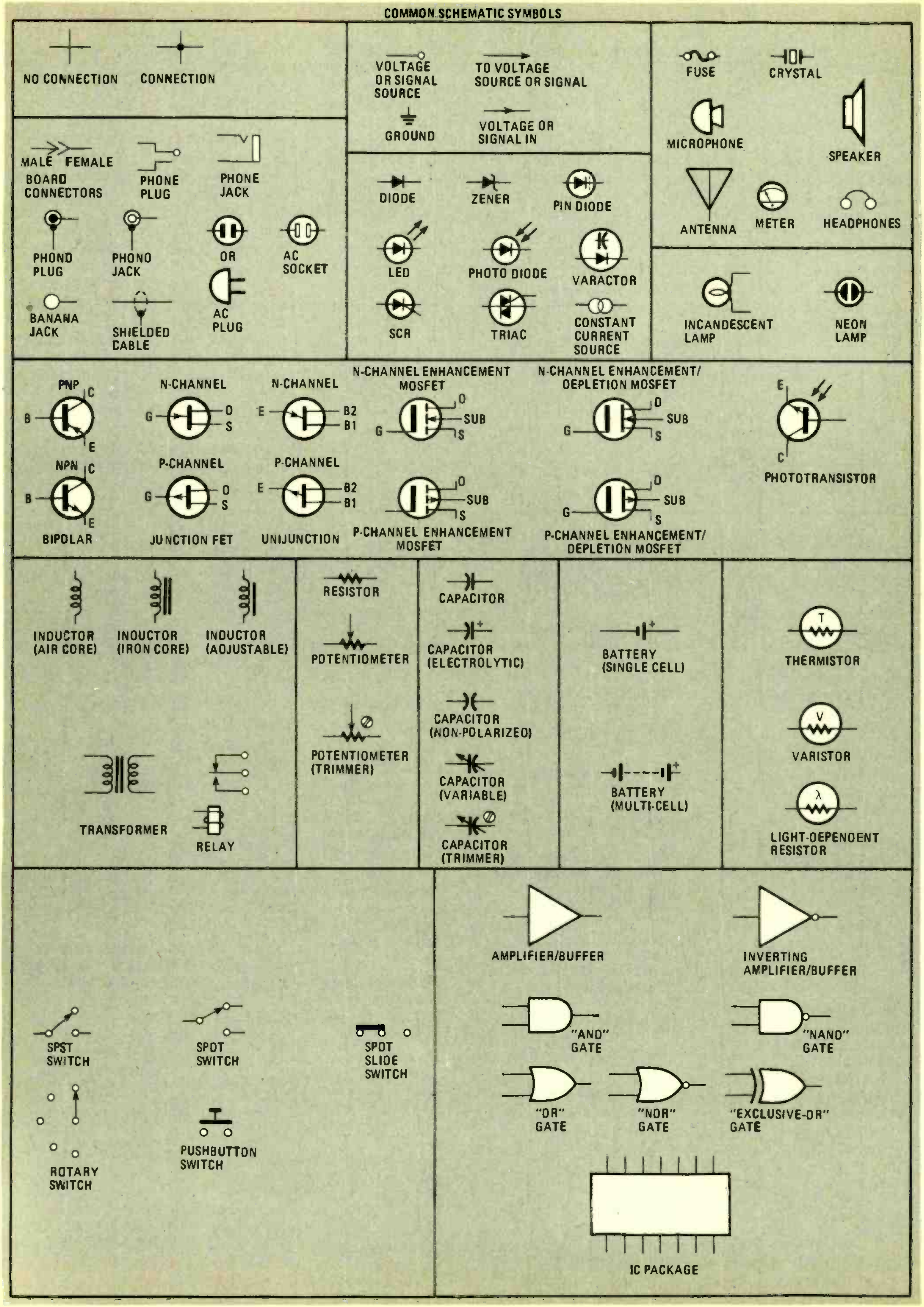
Tri-Tek
7808 N. 27th Ave.
Phoenix, AZ 85021
602-995-9352

Vermont Electronics
312 W. Vermont
Anaheim, CA 92805

Westland Electronics
37387 Ford Road
Westland, MI 48185
313-728-0650

*Specializes in "classic" military surplus

TABLE 3—SCHEMATIC SYMBOLS



struction project will not be electronics components at all. One should always be alert for non-electronics sources of supply, particularly in the local area; there are a number of unique or unusual items that can be purchased locally for use in electronics construction projects.

Some of these possible sources are: hardware stores (for aluminum stock); office-supply houses (boxes and enclosures); electric supply houses (wire and switches); discount stores (CB parts, batteries, and hardware); and plastics dealers (panels). A little ingenuity and creativity will surely turn up many more non-conventional parts sources.

Component identification and testing

For the most part, components purchased from local sources and from mail-order firms are labeled and packaged so that there is a minimum of difficulty in proper identification. Transistors usually have the identification stenciled-on, or they are mounted on cards; IC's are labeled; resistors and capacitors imprinted with a standardized color-code; transformer leads colored, and diodes coded. Notable exceptions include some grab-bag and bulk offerings, which may present such problems in identification that purchase is not advisable unless one is highly knowledgeable of the particular components involved and has the capability to measure a wide range of component values.

Identifying the values of unknown parts can be a risky proposition. It may be possible to do so with the help of specialized data tables and color-code keys appearing in reference texts, as well as calculating aids and test equipment. For example, the ARRL *Handbook* has a section on coding and values for a number of components, such as composition resistors and various types of capacitors, including mica, molded paper, and tubular ceramics; tubular encapsulated RF chokes; pilot lamps, and wire. Also listed are mechanical construction data, including numbered drill sizes and standard metal gauges.

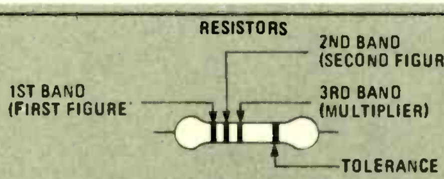
Identifying the values of totally unknown or unmarked components is difficult, but can be made possible using such devices as a multimeter and grid-dip oscillator or noise bridge. Aids such as the ARRL *LCF Calculator* are helpful in the identification of unknown coils and capacitors.

Table 3 shows the various schematic symbols used to identify electronics components in this magazine. Table 4 lists the major resistor and capacitor color-coding schemes. Table 5 shows some of the prefixes often used in electronics and what they mean.

It doesn't take a lifetime involvement in electronics to develop a sizeable junk box. However, bear in mind that when assembling parts for a project, many components may be defective, including those sold by reputable mail-order firms. Using salvaged and bargain-priced components is a convenience and money saver, but reasonable precautions should be taken to insure that only good parts make it to your workbench. Completed projects can't work right with bad IC's and shorted transistors, leaky capacitors, off-value resistors, and other defective components. Worse, a single faulty component can cause the failure of good parts, as well as generate many hours of workbench time spent in troubleshooting. The proverb, "An ounce of prevention is worth a pound of cure," definitely applies when you are working with electronics components.

While it's impractical to test all components 100%, it's wise to at least spot-check *new* components before they find

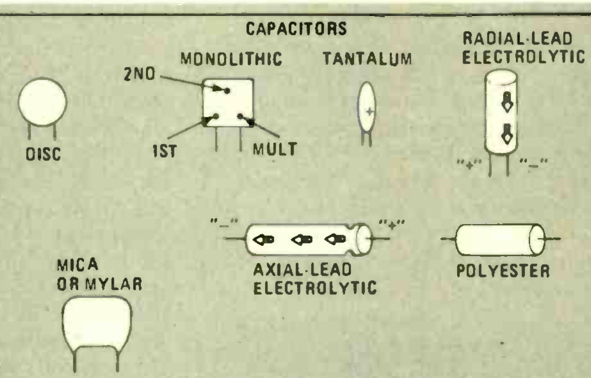
TABLE 4—COLOR CODES



COLOR	FIRST BAND FIRST FIGURE	SECOND BAND SECOND FIGURE	THIRD BAND MULTIPLIER	FOURTH BAND TOLERANCE
BLACK	0	0	None	–
BROWN	1	1	0	–
RED	2	2	00	–
ORANGE	3	3	000	–
YELLOW	4	4	0 000	–
GREEN	5	5	00 000	–
BLUE	6	6	000 000	–
VIOLET	7	7	0 000 000	–
GRAY	8	8	00 000 000	–
WHITE	9	9	000 000 000	–
SILVER	–	–	–	10%
GOLD	–	–	–	5%

RESISTOR VALUES CAN BE DETERMINED FROM THE COLOR BANDS ON THEM. THE FIRST TWO BANDS INDICATE THE FIRST TWO DIGITS OF THE VALUE. THE THIRD BAND INDICATES THE NUMBER OF ZEROES THAT FOLLOW. THE FOURTH BAND, SEPARATED FROM THE OTHERS, INDICATES THE TOLERANCE.

SOME PRECISION RESISTORS MAY HAVE THE VALUE PRINTED ON THEM. IF THE LETTER "R" APPEARS, AS IN "2R7," IT REPRESENTS A DECIMAL POINT (THE VALUE WOULD BE 2.7 OHMS).



THE POLARITY OF TANTALUM AND ELECTROLYTIC CAPACITORS IS USUALLY CLEARLY INDICATED BY "+" AND/OR "–" SIGNS. THE POSITIVE END OF AXIAL-LEAD ELECTROLYTICS IS FREQUENTLY CRIMPED SLIGHTLY.

THE VALUES OF MOST CAPACITORS ARE CLEARLY MARKED. SOME MONOLOTHIC CAPACITORS USE A THREE-DOT COLOR CODE—THE COLORS REPRESENT THE SAME VALUES AS THOSE USED ON RESISTORS, AND ARE READ IN THE SAME WAY. THE VALUE IS GIVEN IN PICOFARADS; MULTIPLYING BY 1,000,000 WILL GIVE THE VALUE IN MICROFARADS.

MANY CERAMIC DISC CAPACITORS USE MORE CRYPTIC CODING. FREQUENTLY THE VALUE WILL BE INDICATED BY A THREE-DIGIT NUMBER SUCH AS "102." THE FIRST TWO DIGITS REPRESENT THE FIRST TWO DIGITS OF THE VALUE; THE THIRD IS THE MULTIPLIER. THE RESULT WILL BE IN PICOFARADS—MULTIPLY BY 1,000,000 TO OBTAIN THE VALUE IN MICROFARADS. IF A CAPACITOR IS MARKED "1K," ITS VALUE IS 1000 PICOFARADS (.001 μF).

LETTERS ON DISC CAPACITORS INDICATE TOLERANCES AS FOLLOWS:
"NPO" OR "Z": +80%, –20% (THIS IS THE MOST COMMON TOLERANCE.)
"J": ± 5%
"K": ±10%
"M": ±20%

their way into your parts bin and completed projects, and to closely scrutinize *used* parts before they go into stock. Though the junk box is a wonderful storehouse of goodies, components are of little value unless they are in good shape.

Clearly, parts which show signs of burning or charring should be discarded, and old, dust-encrusted components should not be stocked or used in construction projects. It's also wise to weed out defective parts with your multimeter. Check resistors for gross discrepancies in measured resistance; capacitors for shorts and excessive leakage; and transformers, coils, and chokes for open windings. Many transistors and diodes can be checked using an inexpensive transistor checker, and tubes—if you're still using them—can have performance checked on a tube checker. Not much can be done with IC's, however, short of plugging them into a given circuit—though IC testers are available.

Occasionally, you'll find duds in even newly purchased components. Most distributors and mail order houses will make good on them, in response to a polite request for replacement. With bargain-priced IC's and transistors, however, where the risk of bad components runs fairly high, it's a good precautionary measure to order *two* of each semiconductor if the price is right. If both are good, fine—and you can keep the second unit as a spare or use it in a subsequent project.

Let's take a look at some of the ways in which many common components can be defective, and describe methods of checking them for proper performance.

1. Resistors. For most construction purposes, resistors are useful if they measure within ± 20% of color-coded value. However, used ones should be checked for value before being placed in a circuit.

Ordinary carbon-composition resistors change value over time, and they often suffer the effects of too much heat being applied in soldering. Precision resistors, such as 5% types, may eventually become 10% or 20% types, after long periods in damp storage. Cracked resistors should be discarded, since they tend to open up or become unstable when they heat up in normal operation.

Wirewound resistors are more stable than composition resistors, but they may suffer from cracking of the hard ceramic shell or breaking of the internal resistance wire. Usually when a wirewound type is defective, it's open and is easily checked. Wirewound slide resistors often develop shorts between turns, which reduces resistance, or develop an open circuit at the point where the tap connects.

Older deposited-film carbon resistors often suffer from aging, while newer metal-film types are considerably more stable. Still, those types can be ruined by a scratch on the outside of the shell which interferes with the spiral grooving that is cut into the resistance coating, and which determines the unit's resistance.

2. Potentiometers. The resistance element of pots should be checked using the ohms function of a multimeter by placing the leads across the outer terminals of the pot to insure that it's not open, and that it is of the proper resistance. Following that check, the leads can be connected between an outer and the adjustable-arm terminals to make certain that the movable contact isn't open or intermittent. The pot shaft should be rotated slowly while watching the meter. The meter should change its reading smoothly; if the needle jumps erratically, the pot is noisy or, in some cases, may have an open circuit over part of its rotation. At the same time you can easily determine the taper of the pot. While contact sprays may restore a unit, it's preferable to discard the unit and use another one. The on/off switch that is part of many control assemblies should also be checked for proper functioning.

3. Capacitors. Most capacitors that fail do so because they have shorted internally. Capacitors that have experienced voltages at or near their breakdown voltages, and a lot of heat, are particularly vulnerable to shorting, and should be checked carefully.

Paper, Mylar, ceramic, and similar types of .001 µF or greater can be checked using the highest ohms range on a multimeter. Connect the probes across the leads of the capacitor in either direction. Since such capacitors are not polarized, it doesn't make any difference which way the leads are connected. If the capacitor is normal, the meter needle should suddenly deflect toward zero the moment the leads touch the capacitor, than rapidly drop back toward the high-resistance end of the scale as the capacitor charges. A shorted capacitor is indicated by the meter pointer remaining at the low-resistance end of the scale, while an open capacitor will not deflect toward zero.

The capacitor may also be checked for leakage by noting the value of resistance on the meter after about five seconds of charging. The leakage resistance should be 10 megohms or greater if the capacitor is usable. That check may be all that can be done for capacitors of less than .001 µF, as the meter "dips" are very small with low-value capacitors. Since those capacitors rarely change much in value because of storage conditions, the leakage test should suffice.

Caution is paramount when evaluating used aluminum electrolytics. They have a limited shelf life, and once they dry out, they can't be used. A defective electrolytic can easily destroy itself by drawing excessive current, heating up, and ultimately shorting out.

To check on an electrolytic's condition, apply DC voltage gradually, observing correct polarity, and beginning with a voltage equal to about 10% of the capacitor's rated voltage—working up to the full rated voltage while monitoring leakage current. A 1000-ohm resistor can be used to limit charging current and to provide a safe means of monitoring the leakage current without risking damage to the power supply or multimeter, should the capacitor short out under test. The leakage current can be found by first measuring the voltage drop across the resistor, then using Ohm's law to determine the leakage current in milliamperes. While allowable leakage current is a function of the capacitance and working voltage, 5 mA represents a good working figure. Capacitors with substantially greater leakage should be discarded. **Caution: Be sure to discharge the capacitor before handling it.**

Electrolytics of the "dry" tantalum type don't usually suffer from aging problems, though high-capacitance, high-voltage tantalums are expensive and rare. Salvaged units may be checked in a similar manner to the method described above.

4. Diodes. Usually, a quick check using the ohms scale on a multimeter is enough to determine the usability of silicon and germanium diodes. The diode should be checked in both the forward and reverse directions; in the forward direction the R × 1 or R × 10 scale should be used. The negative terminal of the multimeter is connected to the cathode, and the positive terminal is connected to the anode. The reading in the forward direction should lie between 50 and 500 ohms. Reversing the meter leads should result in a reverse resistance greater than 1 megohm.

TABLE 5— MULTIPLIER PREFIXES

The table below lists the multiples and submultiples of fundamental electronic units, such as the henry, watt, farad, ampere, etc. The following prefixes, conversion multipliers and abbreviations will be particularly useful:

Prefix	Abbreviation	Multiplier
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico ("micro-micro")	p	10^{-12}

The above table will be used most when working with capacitor and inductor/coil values.

A TRANSISTOR TESTER, such as the one from Heathkit shown here, should be used to check all surplus and salvaged transistors before use.

5. Transistors and IC's. Transistors can take long-time storage in the junk box without deterioration, but each salvaged transistor should be checked, as a minimum, for leaks or shorts before it is wired into equipment. If available, a transistor checker should be used for more comprehensive checking.

Check with caution, since careless checks with a multimeter can destroy a transistor. Usually it's safe to make careful measurements on a transistor with a meter whose voltage between probe leads is less than 4 volts. The R × 1 and R × 100 ranges should be safe to use.

For example, it is readily possible to check for a defective power transistor using only a multimeter. Emitter-to-collector resistance should be high with the probes applied in either direction. On the other hand, when the probes are placed on either the base-to-emitter or base-to-collector circuits, a low resistance would be obtained one way and a high resistance the other. Actual resistance values obtained aren't critical, since the spread between the high and low measurements is so great that you'll have no trouble spotting the difference. If readings differ from those described, there is probably something wrong with the transistor and it should be discarded. It's also possible to identify and sort unmarked bipolar PNP and NPN transistors, though we won't go into the details here.

Far better is a transistor tester. It is not terribly expensive, and allows more sophisticated measurements to be made with reduced risk of damage to the semiconductor.

Look for a unit that will evaluate conventional (bipolar) transistors, diodes, electronics outlets can be used for casual checking of emission and for shorted elements. Most ordinary tube testers will not test special-purpose or transmitting tube types, however.

8. Other components. Many used, surplus, and junk-box-type components can be judged from their physical condition, but many cannot. For example, switches can usually be checked using the ohmmeter function of a multimeter if the switching scheme is known or can be determined from inspection; intermittent, broken, or shorted contacts can often be determined from a combination of visual and electrical inspection. Meters can be checked for calibration by comparison with another known good meter, or a well-calibrated multimeter. Acceptability of the meter depends, however, not just on calibration but also on a reliable (non-sticking) display—often a problem with meters that have been abused or stored improperly. Note that it's usually worth the try to attempt to fix a malfunctioning meter, *if* extensive disassembling and reassembling can be avoided. Otherwise, it will usually cost more than the price of a new meter to have factory experts recondition or repair the defective unit.

Check RF coils and chokes for open circuits using a multimeter's ohms function. Those devices are wound with fine wire that may become broken in storage or shipment, and in the process of unsoldering those components, the ends of the winding often are unsoldered from the terminals.

Note that the DC resistance of RF chokes is frequently given in catalogs: If the measured resistance is less than 80% of the rated resistance, there may be shorted turns, which will result in degraded performance.

FET's, SCR's, triacs and UJT's. It should test them in-circuit with color-coded leads supplied, or out-of-circuit with built-in sockets. The unit displays gain (DC beta), transconductance (G^m), and leakage current. Shorted and open units can also be identified.

There is no simple way to test IC's. In-circuit substitution is often required. However, logic probes are available that can be used to detect and indicate high and low logic levels in TTL or CMOS circuitry.

6. Power transformers and filter chokes. Iron-core transformers and chokes are susceptible to insulation deterioration from humidity. The windings should be checked for continuity and coil-to-core shorts, using the ohms function on a multimeter. Insulation resistance, coil to frame, should be in excess of 50 megohms. A lower reading suggests that the insulation has deteriorated to the point where life expectancy of the unit may be shortened.

A power transformer should be checked under application of rated voltage and current. Rated input is applied to the primary winding and secondary voltages are read using the AC voltmeter function of the multimeter. The secondaries should be "loaded down" with a suitable resistance that causes the rated current to flow through the winding; this resistance can be calculated using Ohm's law. The transformer shouldn't be overloaded, even in testing—overheating as a result of overloading is the primary cause of insulation failure.

7. Vacuum tubes. Used or unknown-condition vacuum tubes should be checked before use. Using a standard vacuum-tube manual to determine pin connections, the tube can be checked for filament continuity using the ohms function of a multimeter. That will tell nothing about actual in-circuit performance, so a tube tester should be used to assess performance short of actual substitution in a working circuit. If you don't have a tube tester, the free testers still found in some drugstores, supermarkets, and franchised

We have shown in this article that it *is possible* to buy the components you need, when you need them, at prices you're likely to be able to afford. Although the problems involved are great in this day of double-digit inflation, they're by no means insurmountable.

We've indicated that those challenges can be met with an organized approach to parts buying, a working knowledge of parts selection and substitution criteria, a good feel for parts sources, and a familiarity with component identification and testing procedures.

We've only scratched the surface. But this article should give you an introduction to the considerations involved when lining up parts for that next construction project.

Buying electronics parts? ... Why, if you follow the hints we've given you in this article, it's almost fun! **R-E**

ALL ABOUT PAGERS

Pocket pagers keep you from missing important calls, even when you are miles away from your telephone! Here is a look at pagers and paging systems, and how they get those calls through!

PETE DeHAAN

YOU'RE IN A CROWDED RESTAURANT, there's talk and laughter all around you, when suddenly a *BEEP, BEEP, BEEP* fills the room. The roar subsides as curious heads turn to find the source. "*Mr. Jones,*" says a disembodied voice, "*please call your office.*"

As Mr. Jones gets up and heads toward a phone, the talk at your table turns to the merits of pocket pagers—beepers, as they are sometimes called. You start to add your opinion, when you stop short. What exactly *is* a pager, anyway?

If you look about you, you're sure to spot them—carried by doctors, salespeople, maintenance crews, computer technicians, and others. Even your favorite TV crime-fighter may "pack" a pager on occasion. Let's examine how pagers work.

Basically, a pager is an FM receiver with a tone decoder and audio amplifier. In order to activate or set off a pager, some additional equipment is needed: a transmitter to signal the pager, a controller to turn on the transmitter and encode the signaling information, and a means for input to the transmitter. Before we discuss paging equipment, let's take a fast look at the radio frequencies used by paging services.

Frequencies used

The FCC (*F*ederal *C*ommunications *C*ommission) permits paging within several bands of frequencies in the RF spectrum. Those bands, however, are used for other purposes in addition to paging. The bands are divided and allocated by the FCC for such diverse functions as public safety, industrial communications, land transportation, public radio, etc.

One group of frequencies where paging is permitted is in the VHF (*V*ery *H*igh *F*requency) range and is commonly referred to as "low band;" it covers 30 to 50 MHz. Also in the VHF area is the "high band," with a range of 147 to 175 MHz. Farther up the frequency spectrum are the UHF (*U*ltra *H*igh *F*requency) band segments allocated for for paging: 406 to 420 MHz, 450 to 512 MHz, and areas in the 800-MHz band. Also being considered for paging are frequencies in the 900-MHz range. Again, those bands are not used exclusively for paging; many other types of transmissions are FCC-authorized for those frequencies.

As you can easily see, there are many frequencies that can be used for paging, and there are a number of different paging systems as well. They range from private business in-house systems to the offerings of RCC's (*R*adio *C*ommon *C*arriers), which are available to the public. Even though private users (industry, business,

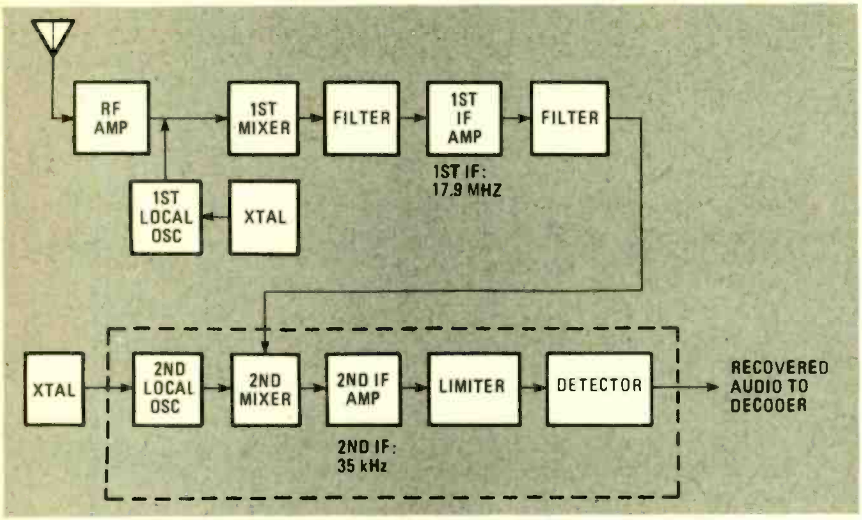


FIG. 1—RECEIVER USES TWO IF-STAGES (17.9 MHz and 35 kHz) to step signal down to a frequency where it can easily be limited and demodulated.

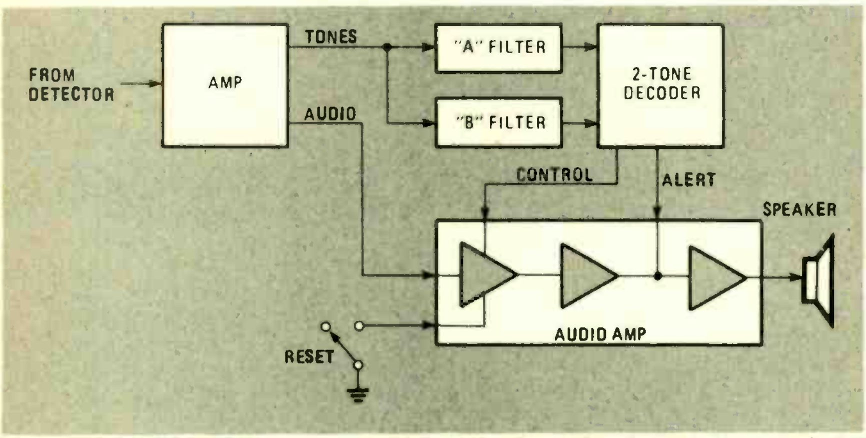


FIG. 2—TWO-TONE DECODER uses two sharply tuned bandpass filters to isolate tones required to activate pager. First stage of audio amplifier is not keyed unless tones are successfully decoded.

etc.) are permitted to own their own paging systems, they often choose not to. The reason is that they must file for, and be granted, a license by the FCC. They must also purchase and maintain their own equipment. Since that is both expensive and time consuming, many potential private users have, instead, sought the services of a local RCC. In that case, the user generally pays a fixed monthly rate to the RCC, which is, in turn, responsible for all equipment and licensing. For that and other reasons, independent RCC's across the country serve about 85% of the paging market. The most common frequencies of the RCC's are two VHF high-band frequencies referred to by the industry as P-5 and P-6—152.24 and 158.7 MHz, respectively.

Because of its widespread use, we will concentrate on the RCC format and examine the operation of a typical VHF high-band pager.

The pager receiver

As stated earlier, a pager is simply an FM receiver with a tone decoder and audio amplifier. The receiver portion is a dual-conversion FM receiver. It must not only be very sensitive, to provide wide-range coverage, but must also be highly selective to reject unwanted and interfering signals.

Figure 1 shows a block diagram of a typical pager. When a signal arrives at the pager's antenna, it is coupled to the input of the RF amplifier. The RF amplifier must have a high gain-factor because, at times, the RF signal level at its input may be only slightly higher than the noise level. The RF amplifier will amplify both the wanted and unwanted signals; however that stage's high gain will greatly increase the difference between them. The relationship of the two signals within the receiver is referred to as its signal-to-noise ratio, and is an indication of the receiver's sensitivity. The output of the RF amplifier is fed to a stage called the *first mixer*.

Also fed to the first mixer is the output of the *first local oscillator*. Its frequency is established by a crystal, and is 17.9 MHz lower than the frequency the receiver is tuned to (also crystal-controlled). The purpose of the mixer is to combine the two input frequencies. The result is four signals at the mixer's output; one is the original input signal, another the local-oscillator signal, and the others the sum and the difference of those two.

Both the sum and the difference signals contain the same modulation information as the original signal, but it is only the 17.5-MHz difference signal that is needed for the *conversion* process. (The signal is converted to a lower frequency because it is easier to work with there than at a higher one.) A crystal filter is used in a bandpass configuration to attenuate the three unneeded signals and pass the modulated 17.9-MHz difference-signal. That leaves a signal having a lower frequency, with the original modulation intact, and accomplishes the first (or high) conversion of the dual-conversion process.

The difference-frequency of 17.9 MHz is referred to as the *first intermediate-frequency* (first IF). The signal is then further amplified by the first-IF amplifier and filtered a second time to further improve IF selectivity (the rejection of the three unwanted signals).

The conversion process is then performed a second time. That step is referred to as *low conversion*. The amplified and filtered first-IF signal is fed to the second mixer, along with the output of the crystal-controlled second oscillator. The second mixer produces a difference frequency of 35 kHz, which is amplified and fed to the limiter. That stage limits the amplitude of the signal to a constant level, as required by the detector. The detector removes the 35-kHz second-IF carrier, recovering from it the modulated audio. The recovered audio is then passed on to the decoder and audio-amplifier circuitry. The process of recovering the audio from the modulated second-IF signal is called *demodulation*.

Decoder operation

The decoder, shown in block form in Fig. 2, must check for a series of received and demodulated audio tones. Each pager in a system will respond to one, and only one, specific group of tones. Not only does the decoder check for a particular series of tones, but it also looks for them to appear in a specific sequence.

Since the audio recovered from the FM signal is low in level, it must be amplified before being fed to the decoder filters and the audio amplifier. If the pager is in its normal (STANDBY or RESET) mode, it is waiting for the audio tones that will enable it and cause it to "sound off." In the case of the decoder shown in Fig. 2, only two tones are needed to make it decode successfully.

In the RESET mode all of the audio (tones and speech) may be present at the inputs of both the audio amplifier and the two filters. The filters, which are highly selective bandpass arrangements, will not pass any speech, since they require steady tones at the frequencies to which they are tuned in order to produce an output from the decoder.

The first stage of the audio-amplifier IC is normally off. When a tone matching the frequency of the "A" filter is received, that filter passes the signal to the decoder. The decoder is then enabled. If the proper "B" tone follows, the "B" filter will pass it on the decoder. The decoder will recognize the "match" and will produce an "alert" signal that is fed to the last amplifier-stage of the audio IC. That amplifier, which is always on, will drive the speaker, and the familiar "*beep, beep, beep*" will be heard. Once the alert has sounded, the CONTROL line enables the first section of the audio-amplifier IC and the voice message is received. When the caller has finished speaking, the amplifier is reset to mute the speaker. The pager is then back in the RESET or STANDBY mode, awating another page.

Some pagers, known as *tone-alert* pagers, do not have the capability of handling a voice message. They merely output an alert tone that informs the user to call some pre-arranged number, such as his office, answering service, home, etc. The tone-alert pager circuitry is similar to that of the tone-plus-voice model, but the audio amplifier is configured differently to handle only an alert tone and there is no provision for processing a voice signal.

A second decoding method, the *five-tone* format, uses five distinct audio tones transmitted as a rapid pulse-train. There, the decoding process can be compared to the two-tone format, though the circuits are much more complex. There are two advantages to the five-tone format. The first is that there are more than a million unique encode/decode combinations. The other is that the decoding information can be transmitted in approximately half a second, while the two-tone format requires up to four seconds. That adds up to quite a time saving for systems that are heavily used.

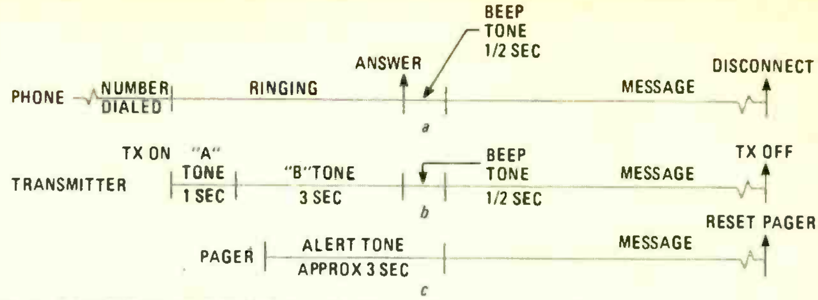


FIG. 3—SEQUENCE OF EVENTS involved in making a page as they occur at (*a*) telephone, (*b*) transmitter, and (*c*) pager.

The paging process

Now that we know what's inside a pager, let's see how paging works. Refer to Fig. 3 as we discuss just what is involved in the paging progress.

In most cases RCC customers can reach a pager on a direct-dial basis (although sometimes a dispatcher must be called; he will, in turn, manually process the paging). A person wishing to page someone merely has to dial a telephone number; each pager is assigned its own, along with the unique set of audio tones required to activate it.

The phone call is channeled through the phone company's central office and then on to the RCC's paging-control equipment. The controller searches its memory for the frequencies of the audio tones required to activate the pager associated with the number dialed. That information is found within milliseconds and the paging controller turns on the transmitter. It also generates the proper tones, which it sends to the transmitter. The transmitter modulates its RF carrier with those tones, transmitting the page-signal.

If the pager is within range of the transmitter, it decodes the signal and emits an alert tone. At the same time, the paging controller "answers" the line and returns to the calling party a short beep tone, which is a signal to the caller to begin speaking. The length of his message can vary from system to system, but is usually about ten seconds. Although that seems short, it is really quite adequate to repeat a short message or phone number two or three times. It is just a matter of seconds from the time a number is dialed until the pager user receives a message.

Some pagers—the tone-alert models—are not able to handle voice messages; instead, they merely beep. With that type of system, the caller hears a beep tone that indicates that the page has been processed, and then receives an interrupted busy tone.

Pros and cons

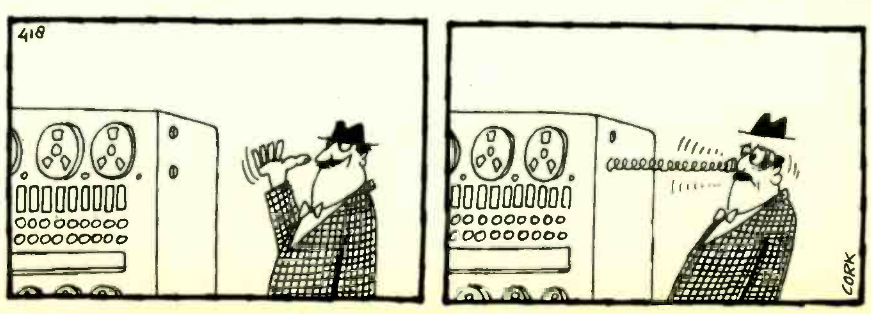
A pager can be a great time and money saver to its user. A page can prevent a wasted trip, or ask the user to make an extra stop before returning home or to the office. It is also invaluable to someone who may be away from the office when an important customer, or a patient needing immediate attention, calls.

In these days of economic downturn, pagers are enjoying an increase in popularity. Businesses have been forced to cut costs and to search out and eliminate inefficiencies. Many firms have found that pagers save time—and, therefore, money amounting to many times the monthly pager-rental fee. I'm sure you'll agree that an investment with that kind of return is rare today.

One shortcoming of pagers is their relatively short range—typically 15 to 25 miles. Range can vary with transmitter power, terrain, and atmospheric conditions, and is sometimes related to the number of times the pager has been dropped! Pages may be difficult to receive in some rural areas. To reduce the problem, many RCC's are, or soon will be, simulcasting their pages from several strategically placed transmitters. That naturally increases a device's useful range.

For instance, many RCC's in the state of Michigan and from nearby areas have devised an inexpensive manual wide-area paging system. While the details are too involved to go into here, you can now have a pager in Michigan that will be useful and effective over most of the state.

Finally, a preliminary agreement has been reached to form a national radio-paging system using geosynchronous satellites. The participating companies are National Public Radio and Mobile Communications Corporation of America. Under the proposed system, users would phone pages into their local paging companies as usual. Those companies would then relay the pages to National Public Radio's Washington D.C. control center. From there, they would be uplinked to Westar IV and downlinked to the appropriate ground station. The ground station would then relay the page to the appropriate local paging company which transmits it in the usual manner. **R-E**



GUITAR AND BASS TUNER

Build this "electronic pitch-pipe" and you'll be able to tune your guitar or bass without disturbing your audience or other performers...and without having them disturb you.

JAMES I. JARNAGIN

ONE OF THE GREATEST PROBLEMS ENcountered by guitar and bass players—especially when performing before an audience—is tuning up. Most musicians in bands or combos use a piano or organ as a pitch reference. If there is no keyboard player, its members usually just tune up against one-another, and hope they wind up in close to the right key.

This tuner has a pitch reference for each string of a standard six-string guitar: E (high), B, G, D, A, and E (low). The unit accepts regular stereo headphones, and the pitch-reference signal is heard in one channel. The instrument being tuned is also plugged into the device, and its amplified output drives the other channel.

Volume controls are provided for both the instrument and the pitch reference, and can be adjusted to override the noise in any room, while the headphones isolate the audience from the tuning-up process. There's also a STEREO/MONO switch. When in the STEREO position, the device operates as described above. However, in the MONO position, the pitch reference and instrument signals are mixed and heard in both channels.

Because of the low frequencies involved, an electric bass is more difficult for most musicians to tune than is a standard guitar. Many times the bassist prefers to tune to a chord, rather than a single-note pitch reference. The tuner provides him with major-triad chords for each bass string: E, A, D, and G. The E (low), A, D, and G guitar-pitches can be used for single-note references.

Circuit description

The heart of the circuit, whose schematic shown in Fig. 1, is IC2, a 50240 top-octave generator. That device uses a single input-frequency to generate all twelve notes of the musical scale. The input signal is provided by IC1, a 4001 quad 2-input NOR gate. Two sections of that IC are used to form an oscillator that runs at approximately 2 MHz. The frequency can be adjusted by trimmer potentiometer R2.

Dual D flip-flops, IC3-IC7, are used as frequency dividers. They divide down the upper-octave frequencies from IC2, thus generating the lower-frequency notes required for the pitch references.

The chords for the bass pitch-references are composed of three notes each. Those notes are taken from various outputs of IC2-IC7 through isolation diodes D1-D12.

All signals are routed to the TONE switch, S3. The wiper arm of that switch is connected through R7 to the input of audio power-amplifier IC8, an LM386. The resistor acts as a volume control for the pitch reference. Another LM386, IC9, serves as an amplifier for the instrument being tuned, with R10 acting as its volume control. The outputs of IC8 and IC9 are coupled, through C5 and C12 respectively, to the headphone jack, J1. Switch S2 STEREO/MONO is used to mix the reference and instrument signals at IC9 for mono operation. Power is supplied by eight "AA" cells connected in series.

Construction

A single-sided PC board (see Fig. 2) was used in the author's prototype. The layout, however, is not critical and other methods of construction, such as wire-wrap, can be used. Sockets should be used for the IC's to eliminate the hazards sometimes encountered when working with CMOS.

The component layout is shown in Fig. 3. Be careful not to use too much heat when soldering the components, and observe the polarities of the electrolytic capacitors and diodes. After all other components have been installed, insert the IC's in their sockets, being sure that they are oriented correctly.

The amplifiers should be shielded from the frequency dividers to prevent extraneous signals from getting into the audio section. The shield can be made from one-inch-wide tin, as shown in Fig. 4.

A drilling guide for the metal case is shown in Fig. 5. Note that all holes are ⅜-inch in diameter except for the ¼-inch hole for the STEREO/MONO switch, S2, on the rear panel. The other hole on the rear panel is for the pitch-reference output jack, J3. Rotary switch S3 is mounted in the center hole on the front panel. All labelling is done using rub-on dry-transfer letters, which should be protected by a thin coat of lacquer. The completed unit is shown in Fig. 6.

Adjustment and operation

Use R2 to calibrate the device, using a recently-tuned piano or a tuning fork as a

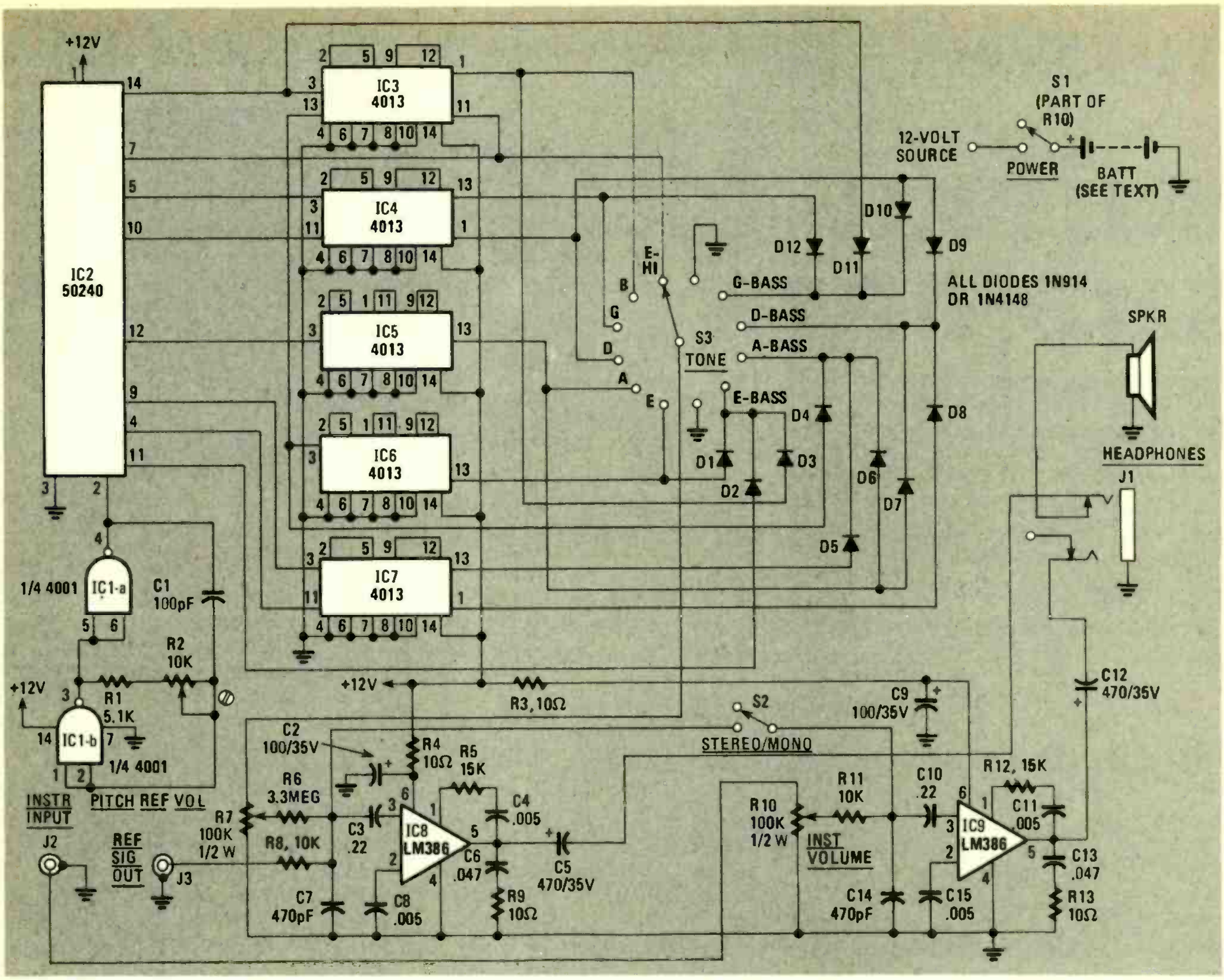


FIG. 1—HIGH-FREQUENCY OUTPUTS of IC2, a top-octave frequency generator, are divided down to frequencies used for instrument tuning by IC3-IC7.

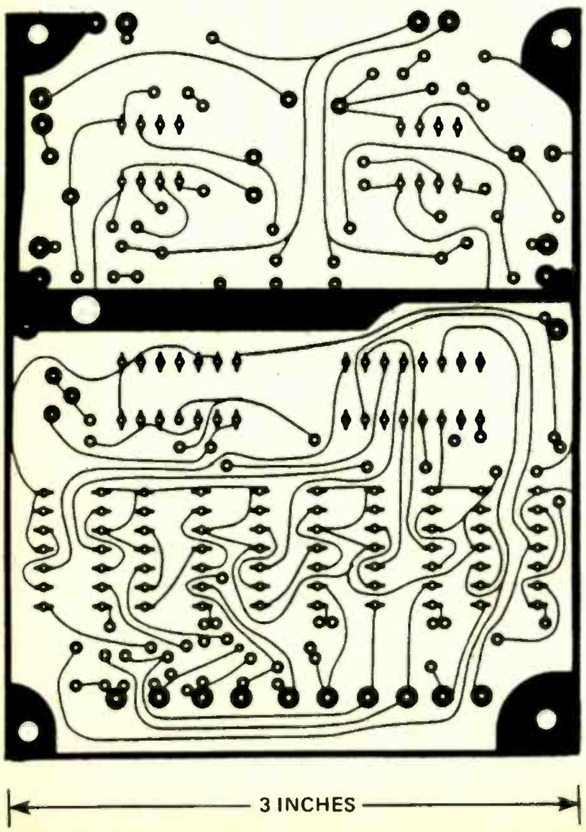


FIG. 2—WHILE TUNER CAN BE HAND-WIRED, a printed-circuit board (left) will make for neater construction.

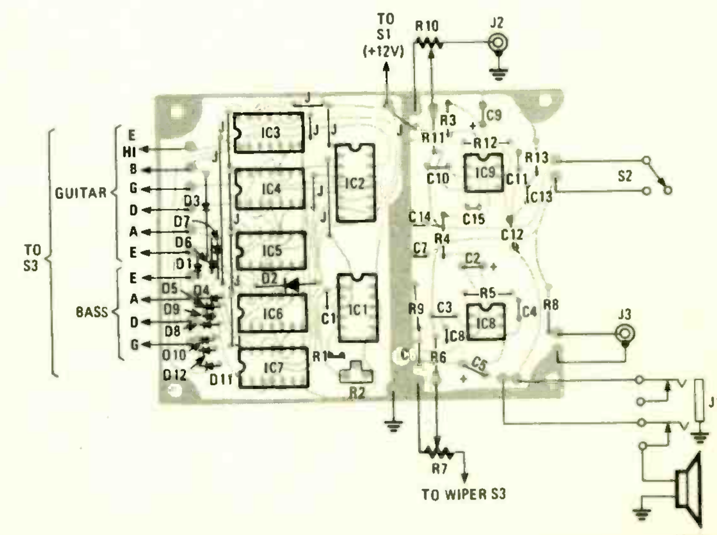


FIG. 3—DO NOT FORGET to install the 11 jumper wires on the component side of the board.

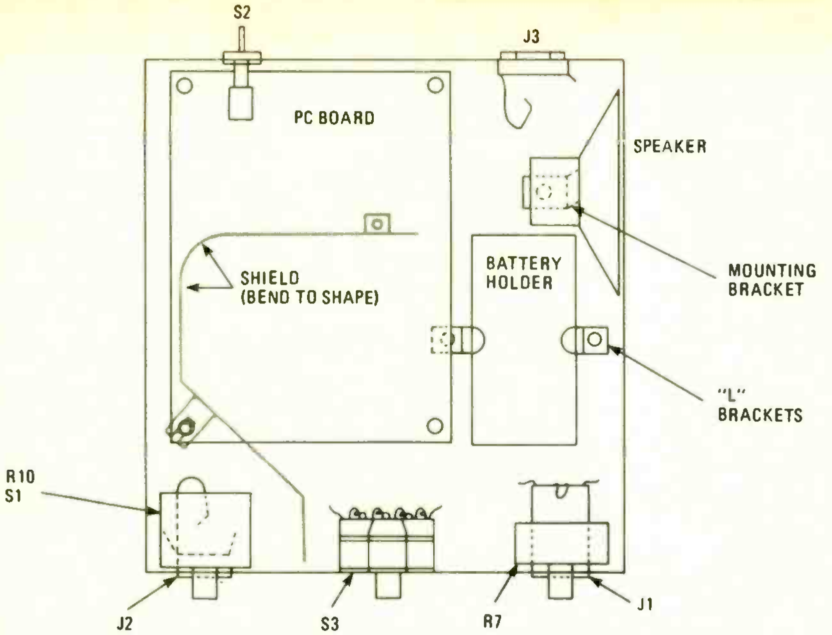


FIG. 4—MOUNTING LOCATIONS for off-the-board parts. Note shield, made of one-inch-wide tin, that keeps noise out of amplifier circuits.

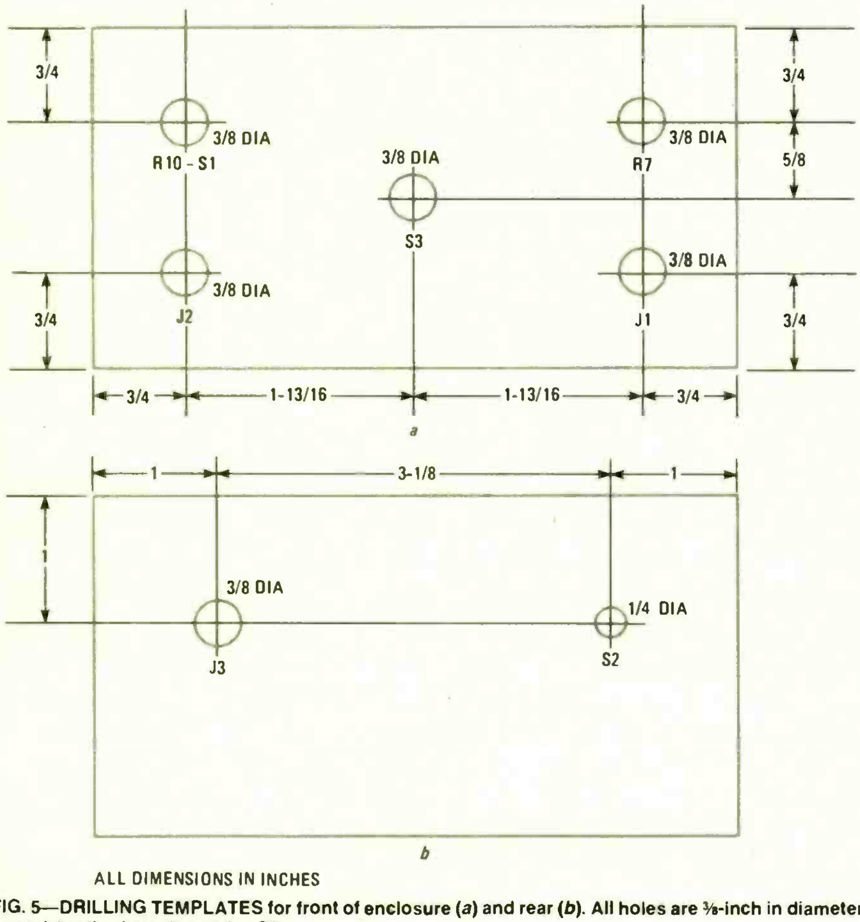


FIG. 5—DRILLING TEMPLATES for front of enclosure (*a*) and rear (*b*). All holes are ⅜-inch in diameter except for the ¼-inch one for S2.

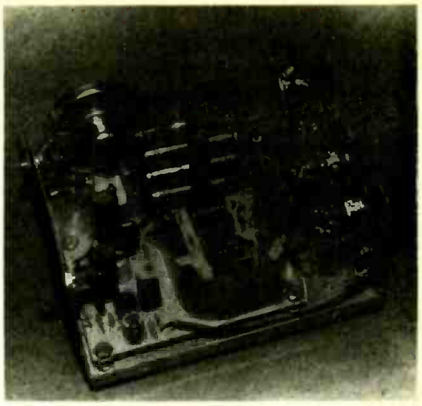


FIG. 6—AMPLIFIER SHIELD is clearly visible in photo of completed unit. Also note battery pack and vertical mounting of some diodes and resistors.

PARTS LIST

All resistors ¼-watt, 5%, unless otherwise specified
R1—5100 ohms
R2—10,000 ohms, trimmer potentiometer
R3, R4, R9, R13—10 ohms
R5, R12—15,000 ohms
R6—3.3 megohms
R7, R10—100,000 ohms, ½-watt, panel-mount potentiometer, audio taper (S1 is part of R10)
R8, R11—10,000 ohms
Capacitors
C1—100 pF, 50 volts, ceramic disc
C2, C9—100 μF, 35 volts, electrolytic
C3, C10—.22 μF, ceramic disc
C4, C8, C11, C15—.005 μF, ceramic disc
C5, C12—470 μF, 35 volts, electrolytic
C6, C13—.047 μF, ceramic disc
C7, C14—470 pF, ceramic disc
Semiconductors
IC1—4001 quad 2-input NOR Gate
IC2—50240 top-octave generator
IC3–IC7—4013 dual D flip-flop
IC8, IC9—LM386 low-voltage amplifier
D1-12—1N914 or 1N4148
S1—SPST switch (part of R10)
S2—SPST miniature toggle switch
S3—single pole, 12-position, rotary switch (Radio Shack 275-1385 or equivalent)
J1—3-conductor N.C. ¼-inch stereo phone-jack
J2, J3—2-conductor N.O. ¼-inch phone jack
SPKR—8-ohms, 2-inch diameter
BATT—8 "AA" cells in series
Miscellaneous: PC board (optional), IC sockets, battery holder, sheet tin, enclosure, knobs, wire, etc.

reference. Any of the single notes selected by S3 can be used for calibration, and all the other pitch-reference notes will fall into place. No further adjustment is necessary.

To use the tuner, plug a set of stereo headphones into J1. Next, insert the plug from the guitar or bass into J2. Place S2 in the STEREO position, and adjust volume controls R7 and R11 so the volume of the instrument is about the same as that of the pitch reference. You should be able to hear the beat signal produced by the difference in frequencies between the two. Tune the string until the beat note just disappears.

If the beat is difficult to hear, try listening for it with S2 in the MONO position. If that is done, both signals—pitch reference and instrument—will be heard from each earpiece.

Old strings on an instrument may also cause the beat signal to be difficult to hear. In that case, simply tune until the two tones sound close or—better still—get a new set of strings.

The beat signal is much more difficult to hear with a bass guitar; however, that instrument can be tuned very accurately using the chords selectable by S3. R-E

REPAIR ANTIQUE RADIOS

Repairing an old radio and restoring its original performace and looks can be a source of pride. Let's take a look at the basics of this rewarding and challenging hobby.

RICHARD D. FITCH

WHILE MOST COLLECTIBLE RADIOS ARE NOT OLD ENOUGH TO BE classified with antique furniture, many of them can be called antiques in their own right. You may be young enough to think that a radio from the thirties or forties is old. And, if you are a newcomer to the hobby of collecting radios, it is good to start with radios from that era because there are plenty to choose from. Often, you can even get such a radio for free. But, can it be restored?

As with any type of restoration, the task begins with what you have to work with in the first place. There are many old radios that are not worth restoring. (Of course, any radio that you identify with in some special way *is* worth restoring.) Also, some old radios are considered to be more of a classic than others (such as the cathedral-cabinet table model) and are more in demand. If you find one of these "classics" cheap, take it—no matter what the condition. Later, you may find another, and make one complete, working set.

When restoring an old radio, it is important to keep it as original as possible. That applies to everything from the chassis and parts to the knobs and the finish on the wood cabinet. That does not apply if you want only a working conversation piece and not a truly-restored radio. Any good cabinet can be fitted with a working radio chassis with a little alteration. Remember that proper ventilation and insulation must be observed. Although you might not have the rich, deep tone of the original, any modern radio in a cabinet from the thirties in daily use in your home will attract much attention.

Where to find old restorable radios

Radios that can be restored are all around—but not in your local TV and appliance store. Try the classified ad columns, flea markets, and garage and yard sales. There are also many ads in magazines dedicated to this hobby. One example is *The Horn Speaker* (9820 Silver Meadow Dr., Dallas, Texas 75217). Some of your friends and relatives may have an old radio lying around for the asking. Of course you have to know what to look for when trying to find a radio to restore. We'll go into that next.

First, the radio should be old (whatever is old to you) and should have most if not all of its parts. The cabinet will be the first thing you will see. Can the cabinet be refinished to some semblance of its original condition? (Only knowing your own limits and abilities in wood-working and refinishing can answer that.) Are the knobs there? If not, you can most likely get some that fit and look original.

The big question is: Does it play? Ask the seller if he can play the old radio for you, or at least turn it on. If the old radio hasn't been played for years and the line cord and plug are corroded, you will have to rely on just what you can see. That will include the speaker assembly, the chassis, and the cabinet.

The speaker assembly

The speaker assembly is a monstrous arrangement in old radios. Along with the cone and the voice coil, there is a field coil and impedence-matching transformer all mounted on a massive frame (see Fig. 1). That array, called an electrodynamic speaker should be intact, even if it needs a little work. While it may be possible to replace the dynamic speaker with a PM (*P*ermanant *M*agnet) type, it will take much from the originality. The most visible problem might be the speaker cone. Finding a fifty-year-old radio with a speaker cone that is not warped or torn will be rare. If the cone isn't torn badly, it can usually be repaired with a little speaker cement, available in any parts shop. A warped speaker cone is not as obvious as a torn cone, but it is just as easy to repair.

Any radio that has not been used for many years is likely to have at least one of those speaker-cone problems. Checking for a warped speaker cone is a fairly simple procedure. With the set off and unplugged, of course, remove the speaker and examine the cone. (The wires are usually long enough to turn the speaker around without having to cut them.) A warped cone can cause an off-center voice coil. To determine if the voice coil is off center, apply a slight pressure around the center of the cone as shown in Fig. 2. If a scratching noise is heard, the voice coil is off center. That test must be done very carefully or you may put your finger through the cone. If you hear the scratching noise, all is not lost, for there are a few things that can be done to re-center the voice coil. Some old sets have small set-screws in the center of the cone that need simply be adjusted to re-center the voice coil. Also, the outer edge of the cone may be reglued to the frame to solve the problem.

Even if your speaker cone is completely tattered there is still hope. There are still a few places around that re-cone speakers. The cost of re-coning the old speaker will not be much more than buying a PM speaker and you will avoid the electrical and physical conversion problem. Also, keeping the set original will always be an asset when showing or discussing your restored set to knowledgable people.

If you are unable to pass a signal through the speaker because of unrelated problems with things such as tubes, line cords, etc., make a continuity test of the speaker components. With the set off and unplugged, check the voice coil, field coil, and both sides of the output transformer. Any inexpensive ohmmeter can be used, as the exact resistance is not important at this time. If you should fail to find continuity at any one of those points, the problem may be less than an inch away. The soldered connection where the coil or transformer is joined to the lead wire is the most likely culprit. You might have to carefully remove a little paper from the transformer to get to the connection. Even if there is no obvious break at the connection it still may have built up corrosion or a resin block. All those connections should be re-soldered to make a good contact so they will cause no future problems.

The chassis

You can get a wealth of information from the chassis just by looking at it. Naturally, the first question to ask is whether or not all the parts are there. It will be easy to see if there are any tubes missing. Finding tubes for those that are missing will be one of the easier chores. Many old sets had the tube number stamped on the socket or on the chassis near the socket. It might be your good fortune to find a legible diagram with all pertinent information (such as the model number, IF frequency, tube locations, and filament diagram where applicable) fixed to the inside of the cabinet. Missing chassis parts other than tubes can create big problems. If an exact or a similar schematic isn't available, finding out what was in that hole with the wires hanging out will challenge even an expert. Large, tapped, wire-wound resistors, capacitors, IF transformers, and coils are some of the parts that may have been ripped from a chassis over the years. Unless you have full schematic information or for some reason want the set very badly, pass it up if it has parts missing other than tubes and knobs.

Some old radios seem to withstand age better than others. Where a radio was stored is especially responsible for its condition, as is the quality of material used in its manufacture. One chassis may be completely corroded and have a cabinet warped beyond repair, while another of the same vintage—maybe even of the same make—will appear like-new. A corroded chassis can entail a lot more work than a warped cabinet and can make the project not worth your while. What's so serious about a corroded chassis? There are two big problems—the tube sockets and potentiometers. If the tubes are corroded in the sockets, removing them without any further damage to the tube or socket will take much patience—and a lot of solvent. And, you will still have a rusted socket when you are finished. To answer any question about the extent of the corrosion, you will have to remove the chassis from the cabinet for a look underneath. Often the underside of the chassis will be spared the corrosion and rust that was evident on top.

Cabinet restoration

How well the cabinet can be restored is limited mostly by your own ability. If you enjoy woodworking and do it well, almost any cabinet can be restored. Even a cabinet with the plies separated can be re-glued. It is important that you take care to preserve any decals or designs (like that shown in Fig. 3) on the front of the cabinet. Before removing the finish, try restoring it with polish. However, if the finish must be removed, light-sand over those areas. Sometimes, furniture polish will restore an old finish and cover up minor scratches. If there are any deep scratches or dents, wood filler can be used. However, since the wood filler will rarely match the original cabinet, it will have to be tinted after the final finish is started so that it won't show through.

Before attempting any work on the cabinet, be sure to remove everything from inside. Also, all removable name plates, decorative speaker bolts, and even the grill cloth should be removed. Getting sanding dust and paint products on the chassis parts will not do anything to improve your old radio. If any parts of the cabinet are beyond restoration, they may be able to be replaced by a patient woodworker. That will apply most often to the bottom of a cabinet that absorbed moisture because it was stored in a damp place. Just be sure to replace any vent holes that were in the original cabinet, because an old radio with its big tubes and wirewound resistors radiates considerable heat.

Troubleshooting old radios

Troubleshooting old radios is not much different than troublehooting new radios. (And it is just as important to be familiar with all safety procedures.) Many old radios have the grid cap conviently sticking out the top of the tube envelope.

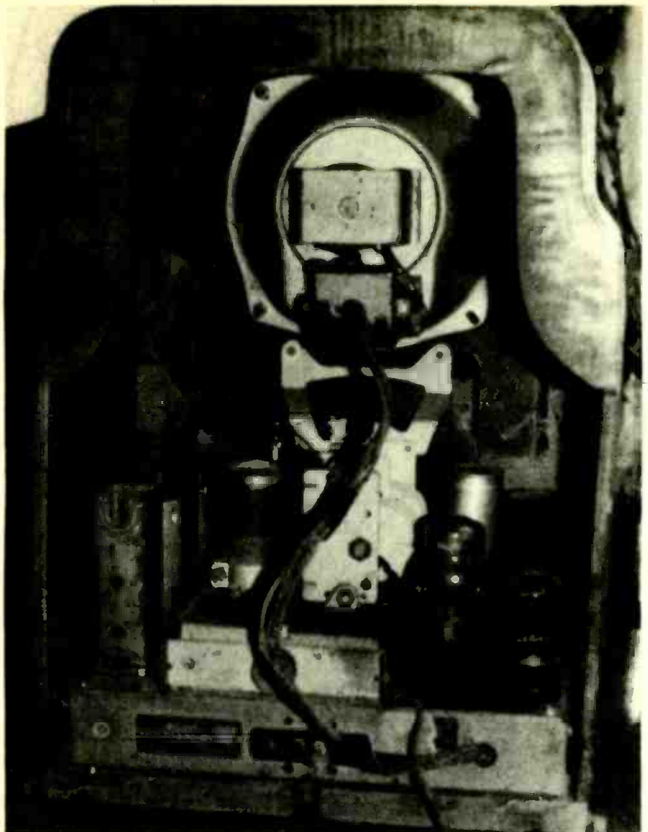


FIG. 1.—MAKE SURE WHEN BUYING an old radio that all chassis parts are included. Without a schematic it may be impossible to identify a missing part.

FIG. 2.—THERE IS A SIMPLE TEST to determine whether or not the speaker's voice coil is off center.

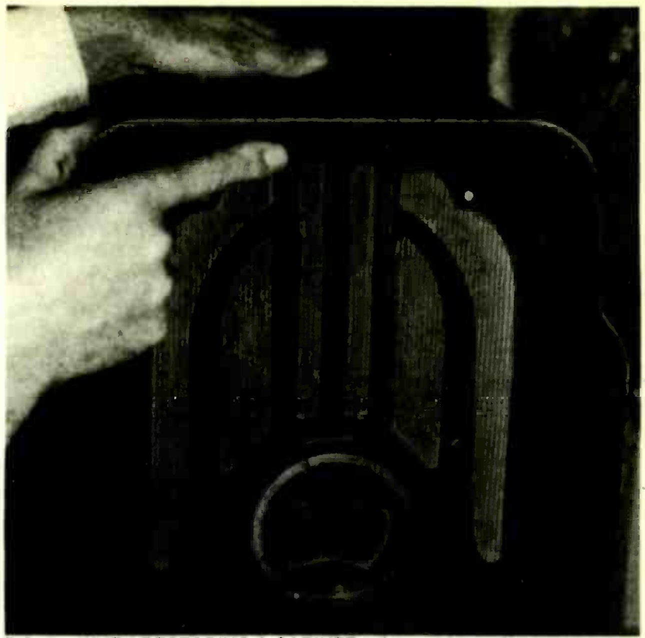


FIG. 3.—WHEN RESTORING A CABINET, take great care to preserve any decals or designs.

FIG. 4.—A TUBE TESTER can save you a lot of time and aggravation, especially if you buy a large numbers of used tubes.

That permits a signal injection or circuit-disturbance test without even removing the chassis from the cabinet. Most of the rest of the parts are similar to those in newer radios, but are much larger, of course.

When you select an old radio to restore, don't be surprised if it lights up but doesn't play. Even if there is just some slight hum from the speaker don't give up hope. There are a few factors to consider on early models that should be checked. If there is no built-in aerial, there should be a terminal on the back of the chassis for connection to an external one. (The radio might play weakly or not at all if it was designed to use an outside aerial.) Any piece of wire can be attached to the terminal screw for test purposes.

Keeping the equipment original is not as difficult as it sounds. The band switches, potentiometers, coils, and even IF transformers can be dismantled and repaired. As with speakers, the most likely problem with an intermediate-frequency transformer that will not pass a signal is a poor connection. Remove the transformer's shield and carefully resolder all of the connections. (A turn can even be taken from the winding if more of the hair-like wire is needed to make a good connection to the trimmer terminal.) If you have to remove the trimmer screw to clean it, you will want to reset it as closely as possible to its original position. You can do that by counting the turns as you screw it down as far as it will go. Then remove the screw and clean it and the trimmer if needed. Replace the screw and turn it as far in as it will go, then back it off the number of turns needed. You will probably have to align the entire set after the IF transformer work.

There isn't much that can be done to repair a bad tube. A partial solution is a good collection of used tubes. Also, there are still some mail-order houses offering old tubes. Even some long-established repair shops have some tubes for early sets. One source for tubes and information that comes to mind is Puett Electronics (P.O. Box 28572, Dallas, TX 75228). A tube tester with an older roll-chart, like the one shown in Fig. 4, is a priceless piece of equipment for the old-radio buff.

Even if restoring your nostalgic radio ends up costing you more than the radio did when it was new, the pleasure of restoring it and the pride of accomplishment can far outweigh the cost. And, if that's not enough, you can expect many offers to buy your restored radio. **R-E**

BUILD THIS

FREQUENCY MULTIPLIER FOR YOUR COUNTER

Here's an easy way to add low-frequency accuracy—and speed—to your counter. No modifications are required.

GARY McCLELLAN

FOR YEARS THERE HAVE BEEN PLENTY OF devices like prescalers available to extend the high-frequency range of the average counter. But for those of us who work with audio frequencies, the selection of add-on's hasn't been so great and that can cause a problem when you try to measure something like a 20-Hz signal accurately.

Most of the time the counter reads "20," but it frequently jumps to "19" or "21." That's a total of 10% error (5% above, and 5% below), and not very good if you're trying to get a precise reading. The usual solution is either to use a counter that has a ten-second timebase, or that has period-measurement capability. Such counters are usually fairly expensive, though. But wait—there's a far-lower-cost solution to the problem, and it requires no modifications to your counter!

The audio-frequency multiplier described here allows you to measure signals from 10 Hz to 40 kHz accurately and quickly using your existing counter. The multiplier is a little box that goes between your test cable and counter. With it you can multiply the frequency of the incoming signal by a factor of ten or a hundred for easier reading. Now, the 20-Hz signal mentioned earlier can be read on your counter as "20.15"—a hundredfold improvement in resolution.

The frequency multiplier offers a lot more than increased accuracy. It will give you readings more quickly than a counter with a ten-second timebase. My expensive "system-type" counter will display frequency values every 20 seconds, and invariably, the first reading will be wrong. It's usually better to allow three readings for best accuracy—and that takes a full minute! By contrast, the frequency multiplier will give an accurate reading of a 20-Hz signal within just six seconds—and that includes the two-second update time of the typical inexpensive counter. Furthermore, the circuit responds to small changes faster than my expensive counter, and the speed increases as the frequency being measured does. If you hate to stand around and wait for the display on an expensive counter to be updated, you're bound to like this device.

Many expensive counters have period-measurement capabilities, which means fast, accurate, display of *time*, but some calculation is needed to convert that figure to frequency. The frequency multiplier gives a direct readout of frequency without time-consuming calculations. (To be fair, though, if the signal frequency is not stable—if it jitters a bit—the figure derived from the period measurement will be more accurate.)

It's tough to estimate project costs these days, but you should be able to build the frequency multiplier for under $15; quite possibly for under $10 if you have a well-stocked junk box. Costs are kept down by using common, low-cost IC's and parts. There's one board to "stuff," with four IC's on it, and little else. The board is installed in a cabinet along with a few more parts, and that is about all there is to it. The prototype was built in one afternoon, and there is no reason why you can't build the frequency multiplier about as quickly.

How it works

The frequency multiplier is basically a PLL (*P*hase *L*ocked *L*oop) circuit, and is similar to the Programma 1 synthesized pulse-generator featured in the October 1980 issue of **Radio-Electronics**. Many of the same IC's are used, and the circuit design is similar, but the thumbwheel switches are replaced by a single switch for × 10 or × 100 output. Also, the input signal replaces the 100-Hz reference used in the Programma 1. Refer to Fig. 1 as we look at how the frequency multiplier works.

Low-frequency signals appearing at the input pass through the GAIN potentiometer, R101, which permits the frequency multiplier to handle a very wide range of signal levels. Then, the attenuated signal drives IC1, which shapes it into a square wave. That signal drives phase detector IC2.

Another part of the same IC also serves as a VCO (*V*oltage *C*ontrolled *O*scillator). It accepts a DC voltage from the phase detector and generates a square-wave signal. The VCO can generate signals ranging from under 100 Hz to over 400 kHz without any switching. From the VCO, the signal-path branches out.

One branch takes the signal to IC3, a NAND gate. That gate acts as a switch, and allows signals to pass to the frequency counter *only* when the PLL is locked onto a good signal. That suppresses the stray readings you would normally get without an input signal, or with signals the device can't handle. The output from the VCO also drives two divide-by-ten counters, both of which are contained in IC4. The outputs from the dividers are selected by S101, the MULTIPLIER switch. The output selected drives the phase detector, which generates the DC control-voltage for the VCO. Thus, a simple PLL circuit, that can generate frequencies ten times or a hundred times the input frequency, is formed.

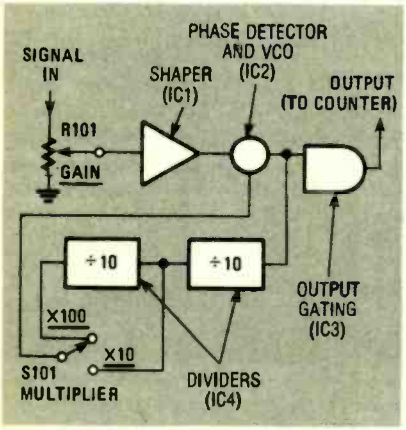


FIG. 1—MULTIPLICATION FACTOR is determined by number of divide-by-ten counters used.

Let's look at some of the finer points of the circuitry. Refer to the schematic diagram in Fig. 2 for details. The shaper amp consists of a fast CMOS CA3130 op-amp, IC1. Its high-frequency response is reduced by C3 so the circuit won't oscillate, yet will have flat gain over its 10-Hz to 40-kHz input range. The inputs of the op-amp are biased to half the supply voltage by R1 and R3, eliminating the need for a split (positive and negative voltages) power supply.

Resistors R4 and R5 set the hysteresis or "trip" point for the circuit, which is about 350 mV. The output signal is a nine-volt square wave that drives the phase-detector portion of IC2. The phase detector compares the signal with that from the MULTIPLIER switch, and outputs a DC voltage at pin 13 of the IC. That drives a network known as a *loop filter*, which smooths out the pulses from the phase detector, giving a clean DC-signal.

The VCO input is at pin 9 of IC2, and the timing capacitor that sets the frequency range is C5. The VCO output appears at pin 4, and drives both IC3 and IC4. Resistor R9 and capacitor C7 form another filter to "debounce" the signal from pin 1 of IC2 (which indicates that the PLL is locked onto the signal) so that it can enable IC3-a's NAND gate whenever a good signal is present at pin 4 of IC2. Resistor R10 is included so that the charge on C7 won't blow IC3 when the power is turned off. The output of IC3 is reduced by R11/R12 to about 900 mV peak-to-peak, which is a comfortable level for most counters. The remaining circuitry consists of a standard CMOS dual divide-by-ten counter, IC4.

Components

Because most people will want to raid their junk boxes for parts for the multiplier, let's discuss substitutions. Since most of the component values aren't critical, some substitutions can be made. The exceptions to that are resistors R1 and R3, which bias the op-amp. If you have to substitute for them, you must make sure that the values of both substitutes are identical. Another area you should watch is the loop filter. Try to use the values indicated for C6, R7, and R8 if you can. (If you have trouble finding a 1.8K resistor for R8, you can either combine two resistors in series or parallel to get the correct value, or use a 1.5K or 2K one.)

Also, be sure to use a tantalum-type capacitor for C6. If you use an electrolytic, with its higher leakage, the performance of the multiplier will suffer. Finally, C5 must be 220 pF—it sets the VCO range, which is critical.

Aside from observing those precautions, you are free to make reasonable substitutions from your junk box. Remember to test the parts before installing them; that can save troubleshooting later.

Construction

A PC board will make construction a lot easier and will help to insure that the device will work the first time it is tried. You can also use perforated construction-board, but be careful with the parts layout—you are

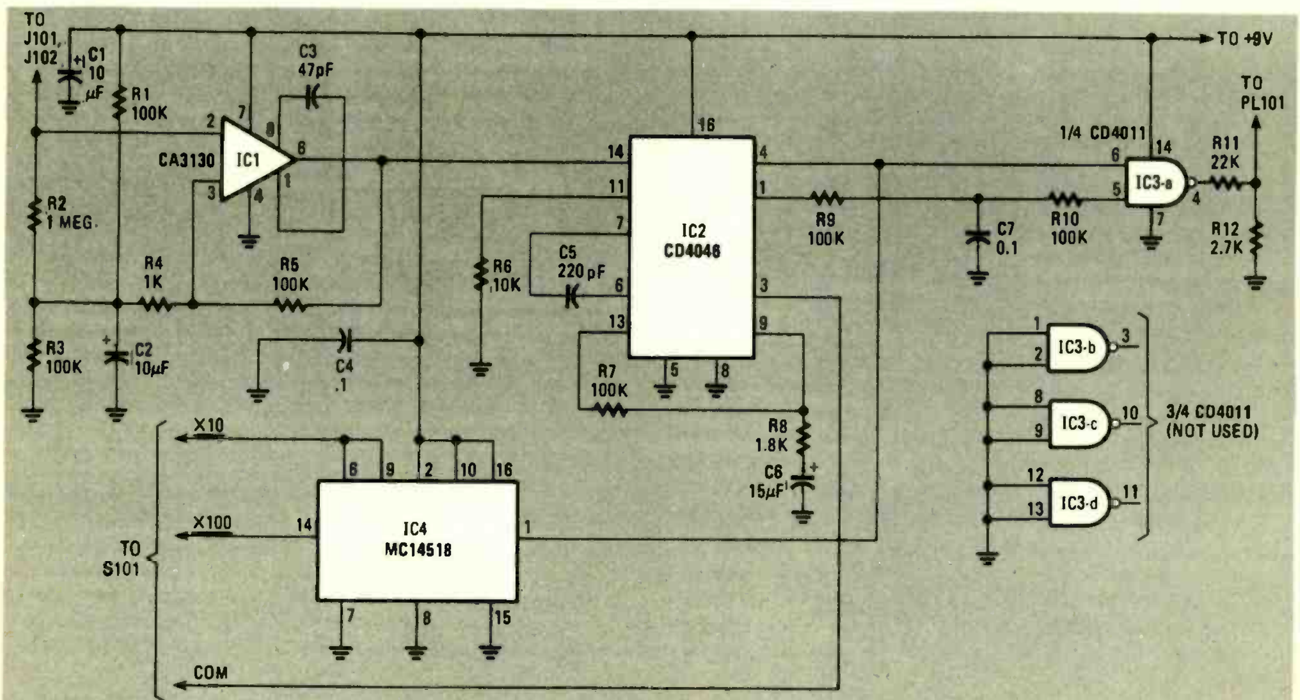


FIG. 2—A LOGIC-HIGH OUTPUT from pin 1 of IC2 indicates that the PLL is locked and allows IC3, a NAND gate to pass the pulse string from IC2's pin 4.

working with high-gain analog circuitry and noisy digital-circuitry. The PC-board layout shown in Fig. 3 is ideal for the circuit, and you may want to copy it even if you use point-to-point wiring.

Start construction by installing the board-mounted components. Refer to Figs. 4 and 5 as you proceed. Position the board as shown in Fig. 4 and leave the board in that position until you are finished with it.

Install an 8-pin IC socket at the IC1 location. Be sure to orient any pin-1 identification (notch or dot) on that socket so that it points up. Then install a 16-pin socket with its pin-1 identification pointing down at IC2, and another, pointing right, at IC4. Finally, install a 14-pin socket at IC3 so it faces to the right.

With the four IC sockets in place, next come the resistors. Start at the IC1 socket. Install a 1-megohm resistor at R2, and then a 1K resistor next to it at R4. Move down and install a 100K resistor at R3. After that, install two 100K resistors at R1 and R5, at the "tail" end of IC1.

The second batch of resistors is located around IC2. Install a 10K unit at R6 first, then a 100K resistor between it and IC2 at R7. Move up and install a 1.8K resistor at R8. Then, on the other side of IC2, install two 100K units at R9 and R10. At the right edge of the board install a 2.7K resistor at R12, and a 22K one at R11. Stop at that point and check your work. Correct any mistakes you may find before going farther.

Next come the capacitors. Start near IC1 as you did with the resistors and install a 10-μF electrolytic or tantalum capacitor at C2. Note that the positive side faces R2. Install a 47-pF ceramic disc at C3. Install a 10-μF electrolytic or tantalum at C1, making sure that the positive side points toward IC4. On the other side of IC2 install a 15-μF tantalum capacitor at C6 with its "plus" sign pointing toward the 1.8K resistor, R8. Then below it install a 220-pF disc at C5. Finish up by installing 0.1-μF ceramic discs at C7 and C4. Be sure to check your work after all the capacitors are installed.

Install a wire jumper near pin 1 of IC2 and then cut five pieces of hookup wire, each about three inches long. Strip both ends of the wires, and solder one to each of the five pads marked with asterisks in Fig. 6. The remaining connections to the board will be made when it is installed in the box.

Connect S101 as shown in Fig. 6 and then finish up the board by installing the IC's. Install the CA3130 at IC1, a CD4046 at IC2, a CD4011 at IC3, and a MC14518 (or CD4518) at IC4. Double check to be sure the IC's are installed correctly; if they're in backwards, they'll probably be damaged when power is applied to the board. Set the board aside temporarily.

The enclosure comes next. Figure 5 shows how the case-mounted components can be laid out. One thing we did that needs comment concerns the input jacks. In our laboratory, all the connectors are of the BNC type, so that's what was used for J101. For some applications, though, an RCA-type jack is preferable, so J102, connected in parallel with J101, is of that sort. Use whatever best suits your needs.

You can install the PC board in the box using long (about 1½ inches) threaded spacers behind S101 and R101. If you can't locate the spacers, use "L" brackets to fasten the board to the top of the box. Don't mount the board in place, yet, though; there's still a bit of wiring left to be done. Refer again to Fig. 5 for details.

Start by mounting and wiring the GAIN pot (R101). Attach one end of a 0.1 μF Mylar capacitor (C101) to the wiper of the potentiometer. As indicated in Fig. 6, the ground lug of the pot should be connected both to the ground wire coming from the board *and* to the case. The "hot" end of the control should be connected to the center connectors of J101 and J102. The other end of C101 should be connected to the board as shown in Fig. 6.

Connect the left-hand (as seen in Fig. 6) battery wire (−) to the switch mounted on the pot (S102), and wire a transistor-battery snap between that switch and the other battery-pad on the board. Mount S101 on the case and install the board. Finish up by attaching PL101 to one end of a three-foot length of thin coaxial cable (like RG-174/AU) and the other end of the cable to the points indicated in the parts-placement diagram *on the foil side of the board.* Tack-solder the shield of the cable to the ground plane of the board. Position C101 so it doesn't short against anything.

Check over your work for shorts and other potential problem-causers, and correct anything that's amiss. Install a 9-volt battery and you're ready to go.

Applications

Using the frequency multiplier is easy.

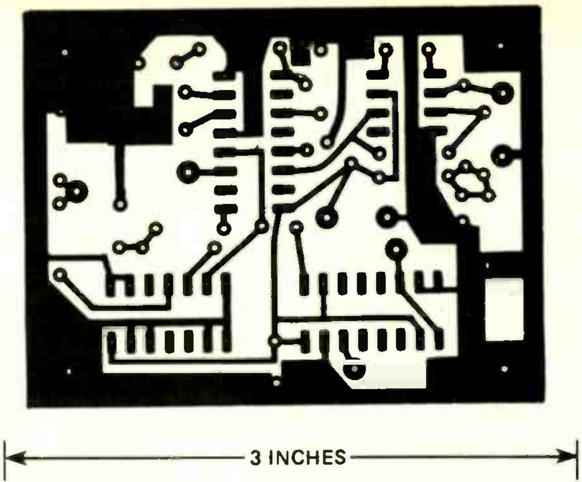


FIG. 3—FULL-SIZE foil pattern for frequency multiplier can be used for making your own PC board.

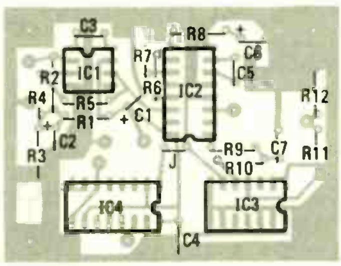


FIG. 4—MAKE CERTAIN that IC's and polarized capacitors are oriented properly. Failure to do so can cause sensitive parts to be destroyed.

PARTS LIST

All resistors ¼-watt, 5%
R1, R3, R5, R7, R9, R10—100,000 ohms
R2—1 megohm
R4—1000 ohms
R6—10,000 ohms
R8—1800 ohms
R11—22,000 ohms
R12—2700 ohms
R101—1 megohm, potentiometer, linear taper with SPST switch (S102)

Capacitors
C1, C2—10 μF, 16 volts, electrolytic or tantalum
C3—47 pF, ceramic disc
C4, C7—0.1 μF, 16 volts, ceramic disc
C5—220 pF, ceramic disc
C6—15 μF, 16 volts, tantalum
C101—0.1 μF, 100 volts, Mylar

Semiconductors
IC1—CA3130AE CMOS op-amp
IC2—CD4046 CMOS PLL
IC3—CD4011 CMOS quad 2-input NAND gate
IC4—MC14518 or CD4518 CMOS dual synchronous ÷10 counter
J101—female BNC connector, chassis-mount
J102—RCA phono jack, chassis mount
PL101—male BNC connector
S101—SPDT toggle switch
S102—SPST switch (part of R101)
B1—9-volt transistor battery

Miscellaneous: PC board, cabinet (LMB type CR-332 or similar), 1½-inch spacers, 9-volt battery snap, battery clip, IC sockets, wire, solder, etc.

The following is available from Technico Services, PO Box 20HC, Orangehurst, Fullerton, CA 92633: Etched and drilled PC board (MULT), $6.00. Kit of all parts *excluding PC board* (MULT-P) is available for $35.00 from: ABC Electronics, 2033 La Habra Blvd., La Habra, CA 90631. CA residents please add 6% sales tax; foreign orders please add $1.00 for shipping.

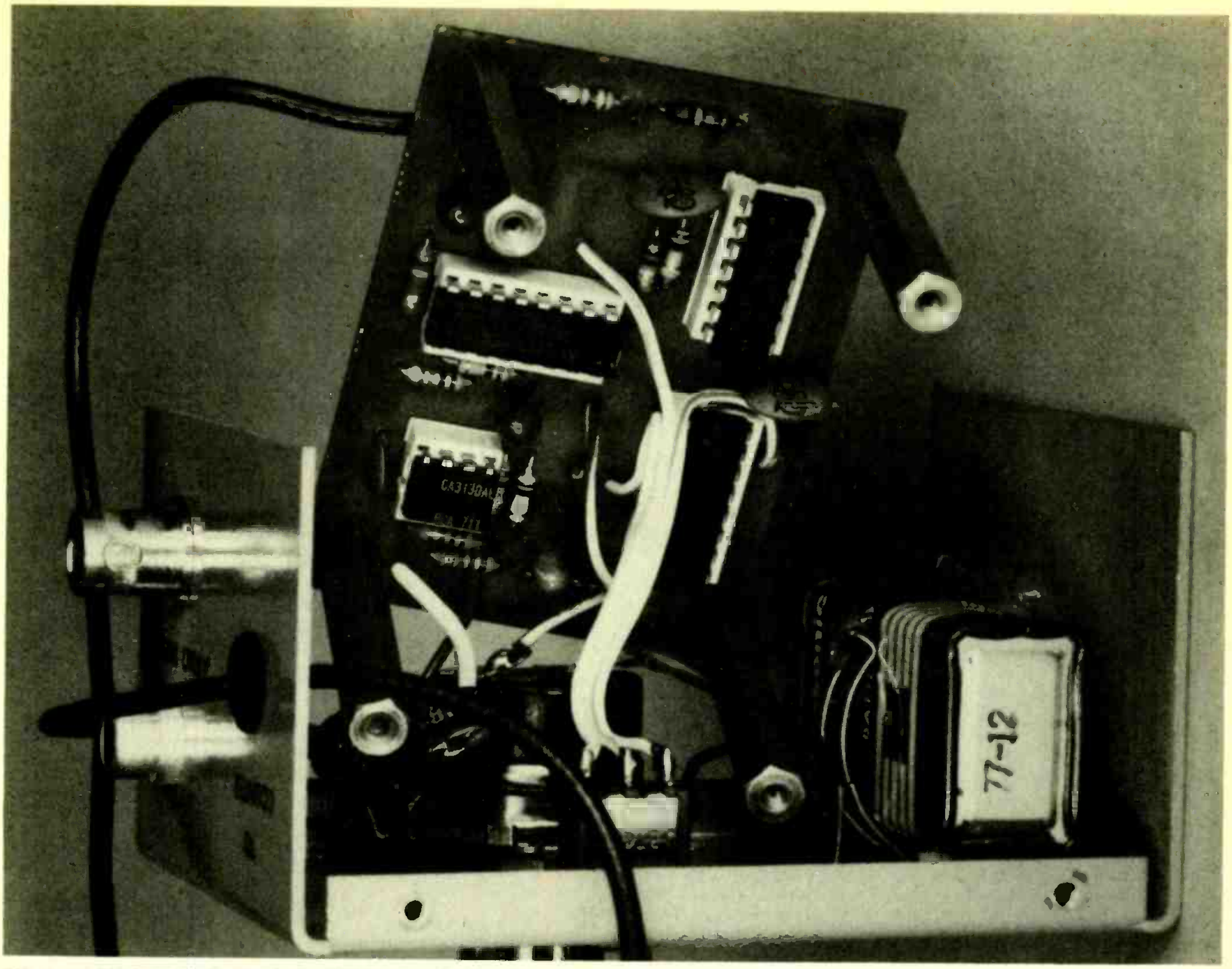


FIG. 5—1½-INCH threaded spacers are used to attach PC board to top of case.

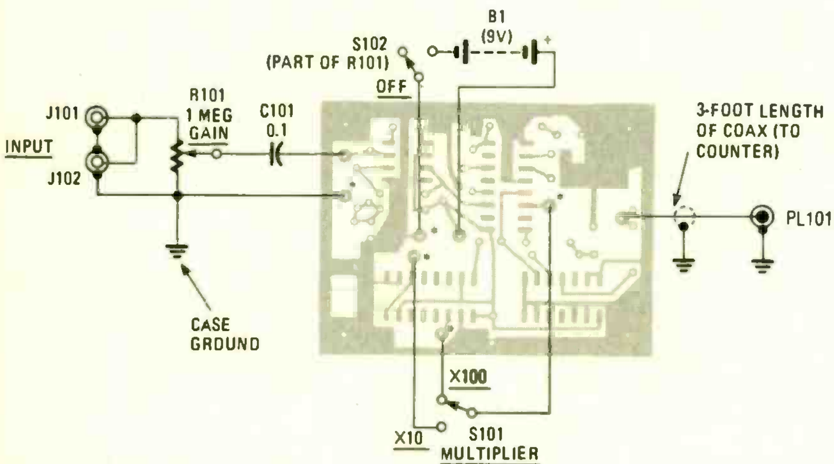


FIG. 6—CONNECTIONS TO CASE-MOUNTED parts. Shield of coax used for output is tack-soldered to ground foil on bottom of board.

Simply connect the audio signal to be measured to J101 or J102 and connect PL101 to your counter. Set the MULTIPLIER switch to ×10 and advance the GAIN control until the counter gives a stable reading. Note that advancing the control beyond that point will have little or no effect. If you need better resolution, and the frequency you're measuring is 4-kHz or lower, switch the MULTIPLIER to ×100.

Here are a few tips that you may find helpful. When you look at the display on your counter, remember to mentally shift the decimal point one place to the left when you're using the ×10 range, and two places to the left when you're using the ×100 range. A reading of "200" on the ×10 range will represent "20.0" and a reading of "2000" on the ×100 range will represent "20.00." That will soon become automatic.

The frequency multiplier does have some limitations. For example, the VCO range of the unit is 100 Hz to 400 kHz. That means that with the MULTIPLIER switch set to the ×10 position, the input frequency must be between 10 Hz and 40 kHz, since 40 kHz × 10 is 400 kHz—the upper limit of the VCO. Similarly, on the ×100 range you are restricted to a range of 10 Hz to 4 kHz. If you are not within those limits, there will be no reading on the counter.

Because the current drain (500-750 μA) on the battery is so light, you may wonder how you'll know when to change it. Replace it when the upper frequency-limit starts to drop, and you can no longer get outputs in the 300-kHz to 400-kHz range. The maximum range will drop with the battery voltage. Another clue that it's time for battery replacement is the multiplier's suddenly refusing to multiply. That's a sure sign that it's time to change the battery.

Finally, for those of you who would like (or need) more gain, it can be increased simply by making the value of R4 (1K) smaller. Nothing else need be changed. R-E

Extra-Low-Power PILOT LIGHT

This flashing light tells you that it is time to turn off the power switch!

BY EVERT FRUITMAN

HOW MANY TIMES HAVE YOU REACHED FOR A PIECE OF battery-operated equipment only to be disappointed upon finding the batteries drained, because someone had forgotten to turn it off? Some kind of pilot light might have saved the day, and the batteries! But a pilot light wasn't used because of the current it consumes. Even a light emitting diode (LED) with a current-limiting resistor, Fig. 1, represents a moderate drain on the battery when compared to the circuit's normal battery load.

Cheer up! The Extra-Low-Power Pilot Light does just what its name implies. It draws very little power from a battery and its periodic flicker serves as a reminder for the user to turn off the portable equipment. Its wide range of operating voltage, (5-30 DC), and small size make it versatile enough to be added to almost any project that might require its use. Of course, it could be added to new equipment too! There is, or was, a LED chip on the market made to do almost the same thing. I ran into three little problems with it. It has a limited voltage range; it was expensive, and it wasn't always available. The first problem was solved with a Zener diode in series with the power-supply line. The last problem was solved with the circuit shown in Fig. 2. The

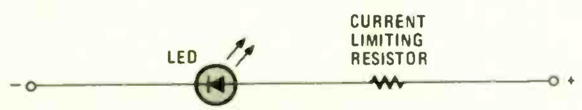


FIG. 1—HERE'S A TYPICAL light-emitting diode (LED) circuit that usually draws approximately 20 milliAmperes. The LED light is on continuously when power is supplied, causing a severe battery drain when left running over night. Often the pilot light consumes more power than the equipment itself would when left on after being used. What a way for a battery to go!

middle problem remained the same unless you salvaged parts from the junkbox—then the price is right.

The circuit, Fig. 2, consists of a simple cross-coupled free-running oscillator with an LED in between the battery and the collector of Q2. As the transistors, Q1 and Q2, are alternately switched on and off, so is LED1. The values of resistance and capacitance are chosen so that minimum current is drawn in the off mode, and LED1 is off longer than it is on during each cycle. An added feature of that design is that electrolytic capacitors are not needed. The values for the resistors specified in the Parts List express a wide range of ohms because the circuit is not too critical, and the experimenter may select those values he currently possesses (different from those in Fig. 2) so that project cost may be kept very low. Also, the chances are that you may be able to

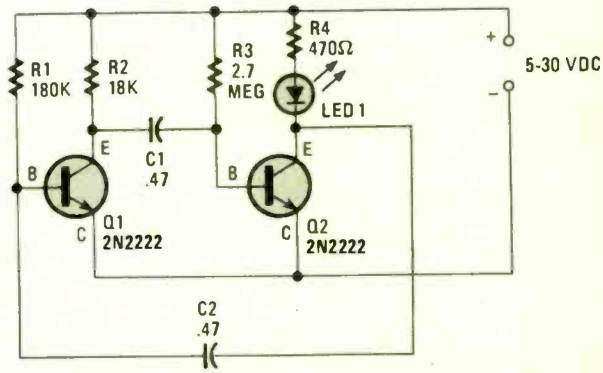


FIG. 2—THE EXTRA-LOW-POWER PILOT-LIGHT circuit is nothing more than a free-running multivibrator designed to keep power consumption down—way down! Values are not critical, and most any NPN transistor can be used in this project.

assemble the project this very evening from parts presently in your junkbox.

Typical current drain using a 10-volt power supply runs from less than one-half mA (.5 mA) in the off mode to about 14 mA during the on mode, or light burst. At 5-volts DC the drain is a quarter of a mA (.25 mA) and 3 mA, respectively. The higher the voltage, the faster the Extra-Low-Power Pilot Light blinks. That friendly colorful wink from LED1 (you pick the color) could be enough of a reminder to save you the loss of perfectly good batteries, and the use of valuable equipment when you need them most. **SP**

PARTS LIST FOR EXTRA-LOW-POWER PILOT LIGHT

C1, C2—.47-µF, 50-WVDC disc or tubular capacitor
LED1—Light-emitting diode, your choice of color
Q1, Q2—2N3904, 2N2222, ECG123, or most any suitable replacement types of NPN, general-purpose, low-power transistor
R1—180,000-ohm, ¼-watt composition resistor
R2—18,000 to 22,000-ohm, ¼-watt composition resistor
R3—1.7 to 4.7-Megohm, ¼-watt composition resistor
R4—470 to 620-ohm, ¼-watt composition resistor

Note: Resistors may be either 20%, 10% or 5% tolerance. Perfboard or printed-circuit board materials, wire, cement, solder, hardware, etc.

ELECTRONIC MAIL VIA SATELLITE

NEITHER RAIN, SLEET, SNOW, NOR KILLER satellite.....No, they haven't replaced that old motto—yet! But as the postal service moves into the era of modern communications, killer satellites might prove to be more of a threat than the gloom of night.

Most of us tend to believe that innovations in mail delivery ended with the Pony Express. (In fact, the Pony Express was faster in many cases than today's mail service.) That's because most modern "improvements" in the mail service do nothing more than get a pair of hands to do more work. That's not to say that there have not been any improvements in automation, but letters still arrive by hand, are often moved by hand, and are delivered by hand.

But now there's a new postal service, called INTELPOST, that moves a letter thousands of miles in a matter of minutes by taking advantage of the very latest in computer and satellite technologies. INTELPOST processes your letter or other document through optical scanners, computers, and a full-time channel on Comsat's INTELSAT IV-A satellite. Almost instantly, your documents can be flashed across the ocean. The actual processing of a document or letter up to 8½ × 14 inches takes only 1 minute and it costs you only $5 per page.

In many cases you might find that you can send a letter overseas and receive a response in less time than it normally takes a letter to travel from your local mailbox to your local post office. Now that is definately an improvement in the postal service—and I would not hesitate calling INTELPOST a true innovation.

How it's done

Figure 1 shows the links in the chain. An INTELPOST computerized service center in the U.S., an earth station, the satellite, and an earth station and INTELPOST-equipped service center on the other side of the world.

All you have to do to take advantage of the service is to carry or deliver your document to an INTELPOST service center where it is placed on an optical scanner. In a matter of seconds the scanner converts a full page of ordinary typewritten text into electrical signals that are stored in a computer until an overseas circuit and service center are cleared for reception. The computer then sends an encoded representation of your document to an earth station in Virginia, which transmits your document to the satellite, which relays it to the receiving station. The received signal is forwarded to a service-center computer, which decodes the signal and passes the plain text output to a facsimile printer where a black-and-white reproduction of the original document is created. The printout itself can often be sharper and of higher contrast than the original.

You can even specify the time you want the letter delivered at the other end in, say, London. Your business associates, friends, or family, can go to their local London INTELPOST post office and pick up a letter you might have mailed as little as an hour earlier; then almost instantly they can send a reply back to you. If they're not in that much of a hurry, they can have your letter delivered with the regular or special delivery mail.

As you might expect, considerable effort goes into security. First, the computer at the service center encodes the transmission using the highest encoding level developed by the Dept. of Defense. (I assume and hope that it means no one is going to crack the code.) Second, only one employee handles your exposed document at each end: the one who puts it on the scanner and the one who takes it off the facsimile printer.

Getting the document to the post office is a minor problem if you're not located in the metropolitan New York or Washington, D.C. areas. You can use Express Mail service to the nearest INTELPOST station, or you can send it there by regular mail. If you mail in your documents, they are returned to you at no charge after transmission.

Presently, the direct satellite path from the U.S. is to Great Britain, the Netherlands, Germany, and Argentina. INTELPOST also handles transmissions to Canada by wire. A Pacific satellite will soon open the service to Australia.

From conversations with our postal-service people, the limitation of the service appears to be the availability of dedicated satellite channels. It is expected that much of the overseas mail will be handled by the computer-satellite link when more channels become available. Certainly, the $5 cost is competitive—particularly for business documents—and the speed and the reliability of the copy is something phenomenal.

Now imagine the next step in this process. Instead of delivering your document to the post office facility, you simply dial the INTELPOST computer on your phone and transmit your document to the computer from your own word-processor. The signal then goes overseas by satellite where the receiving computer dials the addressee's phone and sends your document into his or her word processor or computer. And the bill goes on your VISA or MasterCard. Now *that's* real electronic mail. **R-E**

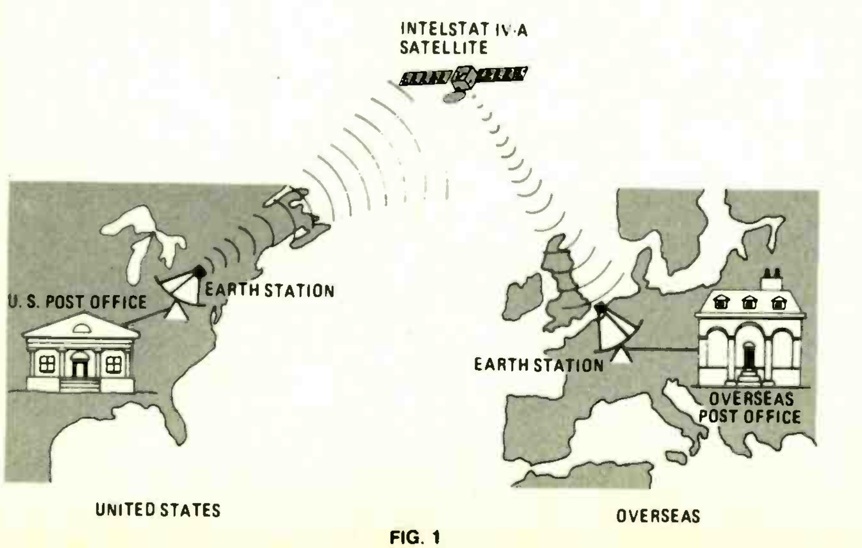


FIG. 1

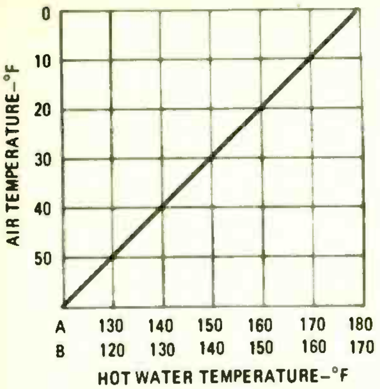


FIG. 3—WATER TEMPERATURE versus air temperature. At every point along this line, the sum of the air and water temperatures is the same.

continued from page 16

to control the operation of IC12, a 555 timer configured as a Schmitt trigger. A 723 precision voltage regulator, IC7, is used to provide V_{CC}, a regulated +6 volts, for IC12. The output of IC12 (pin 3) depends on the voltages at its pins 6 and 12. If the voltage at pin 6 is ⅔ V_{CC}, or 4 volts, IC12's output will go high. If the voltage at pin 2 is ⅓ V_{CC}, or 2 volts, IC12's output will go low.

The output from IC12 drives Q1, which is used to control the operation of RY1, a normally closed relay. Ideally, RY1's contacts should be rated at 20 amps, but if such a relay is unavailable, a DPDT relay whose contacts are rated at 10 amps may be used; the contacts are tied together to double the rating. That's what was done here.

Relay RY1's contacts are wired in series with the aquastat water-temperature control contacts. Note that the aquastat's contact circuit will have to be broken for that to be done.

The 3½-digit temperature readout is an Intersil 7107 evaluation kit. That kit comes complete with all necessary components and a PC board, but not a power supply; an appropriate supply is shown in Fig. 2-b. As supplied, however, the meter's full-scale reading is 200 millivolts; it must be modified for this application so that the full-scale reading is 2.00 volts. That can be done by changing the value of three of the components in the evaluation kit. Those changes are C2 from 0.47 µF to .047 µF, R1 from 24K to 1.5K, and R2 from 47K to 470K.

PARTS LIST

All resistors ¼-watt, 5%
R1, R3—5000-ohm potentiometer, lienar taper
R2, R4—16,000 ohms
R5, R8—9100 ohms
R6, R9—1000-ohm potentiometer, linear taper
R7, R10—4300 ohms
R11—20,000-ohm potentiometer, linear taper
R12—33,000 ohms
R13—10,000-ohm potentiometer, linear taper
R14—13,000 ohms
R15—31.5 ohms (see text)
R16-R21—100,000 ohms
R22—500-ohm potentiometer, linear taper
R23—510 ohms
R24—5600 ohms
R25—24 ohms
R26—820 ohms
R27, R34—50,000-ohm potentiometer, linear taper
R28, R30—15,000 ohms
R29, R31—10,000 ohms
R32, R33—20,000 ohms
R35—1000 ohms

Capacitors
C1-C4—1000 µF, 50 volts or better, electrolytic
C5—.014 µF, ceramic disc
C6—100 pF, ceramic disc
C7, C8—4.7 µF, 25 volts or better, electrolytic
C9—.01 µF, ceramic disc
C10, C11—2200 µF, 1600 volts or better, electrolytic

Semiconductors
IC1—LM7805 5-volt positive voltage regulator (National)
IC2—LM7905 5-volt negative voltage regulator (National)
IC3—LM334 constant-current source (National)
IC4—LM329 6.9-volt reference voltage, temperature stabilized (National)
IC5, IC6—AD590 temperature sensor (Analog Devices)
IC7—723 linear voltage-regulator (Intersil)
IC8—324 quad op-amp (National)
IC9-IC11—741 op-amp (National)
IC12—555 timer (National)
IC13—7107 evaluation kit (Intersil)
Q1—RS276-2017 NPN transistor (Radio Shack), or equivalent
D1-D8—1N4001
D9—1N1202
D10—1N4004
LED1—jumbo red LED
J1-J4—banana jacks
RY1—DPDT relay, 12 VDC, 160 ohm coil, Radio Shack 275-218 or equivalent (see text)
S1—DPDT switch
S2—SPST switch
S3—SPDT switch (part of R13)
S4—DPDT switch
Miscellaneous: Perforated construction board, enclosures (see text), copper piping (see text), wire solder etc.

Construction

Construction is straightforward and can be done using any technique. The prototype was built on perforated construction board, using point-to-point wiring with good results. Once the unit is built, but before it is housed or installed, it must be aligned.

To align the temperature sensors you'll need an accurate thermometer as well as a voltmeter. Making sure that the area that you are working in is not subject to sudden changes in temepratures (caused by drafts, etc.), place the thermometer and the sensors next to each other. Turn the controller on and place it in the AUTOMATIC mode. With the meter's positive lead connected to J1 and the negative lead to ground, adjust R6 until the meter reads exactly 4.6 volts. Next, connect the meter's positive lead to J4 and adjust R9 for 4.6 volts.

Once those adjustments have been made, connect the meter's positive lead to J1 and the negative lead to J3, and adjust R3 until the meter's reading agrees with the measured temperature. Remember—the voltage across those jacks has been scaled so that 10 millivolts equals 1°F. For example, an 80°F temperature would be read on the meter as 0.8 volts. After that has been done, connect the meter's positive lead to J2 and the negative one to J4, and adjust R1 until the meter reading agrees with the measured temperature. Finally, verify that the output of IC9 is twice the measured temperature. That is, if the measured temperature is 65°F, there should be 1.3 volts on pin 6 of IC9.

Next, we need to adjust the output of IC10 so that it is 4 volts when IC9's output is 1.8 volts. To do that, place the controller in the manual mode, and adjust R11 so that the voltage at the junction of R12 and R13 is 4.6 volts. Then adjust R13 so that you get a 1.8-volt output from IC9. Finally, adjust R27 for 4 volts at pin 6 of IC12.

The last adjustment to be made is to adjust the lower temperature-limit. Here we were interested in a temperature differential and selected a combined air- and water-temperature drop of 15°F. That differential is one that was convenient for our situation; any that works well for you can be used. In any event, the adjustment is made in the same manner. Adjust R13 until the IC9's output measures 1.65 volts (1.8 − .15). When that is done, simply adjust R34 until 2 volts is measured at pin 2 of IC12.

Final assembly and installation

With the exception of the readout's power supply, the unit was housed in a 12 × 12 × 4-inch recessed light-fixture box lined with asbestos. The readout's power supply was housed in a separate 5 × 7 × 3-inch metal case. Both units were mounted on the boiler using ⅝-inch standoffs. All external wiring, other than the sensor wires, must be enclosed in BX or conduit.

The outside air-temperature sensor was enclosed in a 3 × 2 × 1-inch case, such as the one shown in Fig. 4. A 5⁄32-inch hole was drilled in the bottom so that air could reach the sensor. A small hole was also drilled in the top for the cable. The sensor's cable should fit snugly through the hole, and any spaces sealed against leaks. Connections inside the case, of course, were soldered and insulated. The unit was fastened under a windowsill on the north side of the house.

Placement of the water-temperature sensor was not that simple. It would have been ideal if the sensor could have been placed in the same well as the aquastat, or if the temperature could be measured at the boiler's case. However, neither approach was feasible: the first due to insufficient space and the second due to temperature lag.

Figure 5 shows an acceptable solution.

continued on page 131

continued from page 96
plastic spray. When painting the box, temporarily cover the connectors with masking tape to avoid getting paint on them.

To mount the circuit board in the drawn steel case, solid copper wires (22 to 20 gauge) are soldered to the center terminals of the antenna and coax connectors. Those wires are then bent to align with the holes on the circuit board. It is necessary to file the edges of the board to round the corners, in order for the board to fit inside the case. The board is then slipped down over the input/output wires so that the foil side of the board faces outside and the components inside. The board should be about 3/16 inch below the outer edge of the box for clearance. The ground of the board is then tack-soldered at a couple of points to the inside of the cleaned box. Be sure to solder the input/output wires to the terminals on the foil side and cut off all excess length from component leads.

The receiver-coupler box can be assembled in a very similar manner. Again, the fit can be compact, although it will be somewhat crowded if UHF fittings are used. It is better to use RCA phono connectors for all the coax fittings and to use shielded phono plugs with good quality RG-58U cable for interconnecting the preamp to the coupler and the coupler to the receiver. However, it is common practice to use the old-fashioned large size UHF fittings for RF, even though the metal-sleeve RCA phono types are much more compact and convenient to use. You can also use BNC type cable fittings and receptacles if desired. Some commercial systems even use type-N RF fittings for the antenna mount in place of the RCA solder-in receptacle.

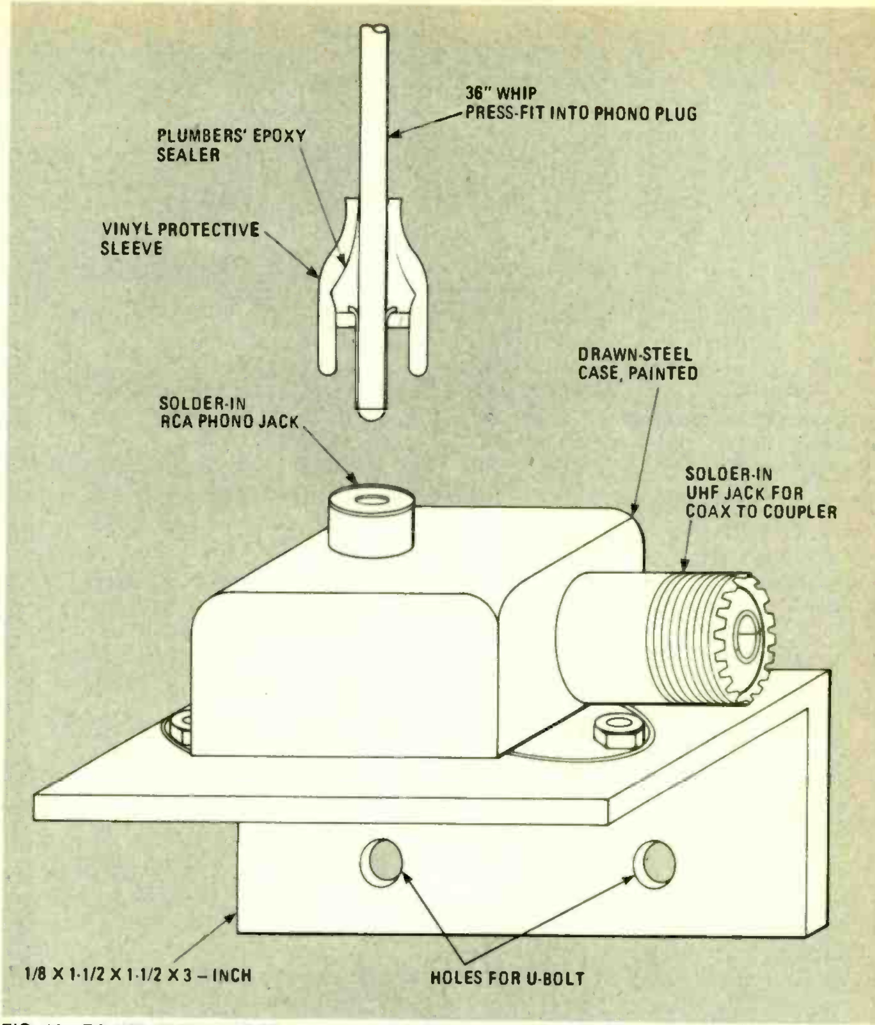


FIG. 10—TO WEATHER-PROOF the case, seal all joints and drill a small bleed hole for drainage.

Final assembly

For a short whip antenna, a mobile VHF-type stainless steel whip about 36 inches long will fit inside the typical RCA phono plug connector pin for a tight press fit. If that type of whip is not available, a copper-coated welding rod can be substituted and soldered into the phono-plug pin. After the antenna is mounted in the plug's center pin, the fitting is sealed with plumber's epoxy putty and a vinyl sleeve pushed down over the whole assembly to aid in waterproofing. A wire antenna can also be used—it is soldered to the center pin, and the phono connector is sealed similarly. For final assembly and mounting of both the antenna connector and the coax output connector at the preamplifier, we wrapped the connector with Coax-Seal, a putty-like tape, for extra waterproofing. The preamp box is bolted to the angle bracket and the joint sealed with cement or a gasket made from Coax-Seal tape. As an extra precaution against water in the box, a small bleed hole is drilled directly under the box mounting area to drain away any moisture that may enter the assembly.

Your receiver may have an auxiliary-output power source already available. For the RF input, the observer should first try the 500-ohm output from the coupler box at the VLF-LF region. More signal can sometimes be developed if the other output of the coupler is used. That indicates that the receiver is not too sensitive to antenna output-impedance. In all cases, the appropriate receiver input-terminal that is designed for the frequency range should be used. The 50-ohm coupler-output is almost always required for receivers operating in the range of 2 MHz to 30 MHz.

It may be convenient to connect a monitor oscilloscope to the 500-ohm output of the coupler and use the 50-ohm coupler terminal to drive the receiver. The scope display is useful for monitoring interference and the dominating signals in your area. By selecting various scope sweep-rates, you can get an approximate indication of the frequency of the various signals that are present. Thus, once you figure out what is causing the interference (for example, you may be able to see 60-Hz harmonics), then you can take steps to minimize it. Do not forget, however, that a wideband preamplifier is sensitive to all frequencies present at the antenna input bandwidth—not only the ones you want to amplify. **R-E**

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you like to listen to, you can line up all the pre-sets and go from one to the next as the evening progresses.

Antennas

All portables are equipped with telescoping whip antennas for shortwave (also used for FM if the radio has that band). While the whips are adequate for strong stations like the BBC, Radio Moscow, Radio Nederland, Radio Australia, and many others, you will be able to hear more stations and overcome more adverse propagation conditions with the help of an external antenna when you're at home. And all portables, including the shirtpocket radios, have provisions for attaching an external antenna.

Basically, an antenna's function is to intercept as much extremely low power radio energy (signals) as possible. Therefore, antennas that are high, long, and located as far away from trees or buildings will be most effective.

Outdoor wire antennas meet those requirements and are easy to install. Wire length for a receiving antenna is not critical, but the longer it is the better. Several commercially made antennas have tuned "traps" to help peak the wire's performance on the shortwave frequencies. Even if apartment, condominium, or aesthetic rules won't allow an outdoor antenna, you have the option of running wires in the attic, along exterior-wall baseboards, etc.

There is another type of indoor antenna that doesn't need any long lengths of wire, and can be almost as effective as an outdoor aerial: the active antenna. That type of antenna consists of either a telescoping whip or dipole antenna fed to the receiver through a tunable amplifier. The amplifier boosts the signal intercepted by the shortened antenna. The *MFJ-1020* active antenna (from MFJ Enterprises) with its short 21-inch whip far outperforms a receiver's built-in whip. Stations barely audible on the built-in antenna can be heard comfortably with the help of that active antenna. As with many active antenna amplifier sections, there are connectors to use the amplifier with external wire antennas for superb performance if you later add an outdoor wire.

A recent addition to MFJ's line is the *MFJ-1024* outdoor active antenna. A 4½ foot telescoping whip and its small RF amplifier can be mounted inconspicuously outdoors, and connected to the control unit located next to the receiver via 50 feet of coaxial cable (which is supplied).

Gilfer Shortwave, a mail-order shortwave specialist, offers two active antennas made by Datong, one each for indoors and outdoors. Both are dipoles (i.e., two short antenna elements emanating from a central preamplifier box) and can be mounted horizontally, which often reduces atmospheric and local electrical noise in the receiver, while also being less conspicuous.

Unlike local radio stations, which are limited in their range, international shortwave programs can join you on your travels, literally anywhere in the world. Often the sound of a familiar commentator or program will help you feel more "at home" even if you're far from home. And the latest generation of portable shortwave receivers let you take it all with you. **R-E**

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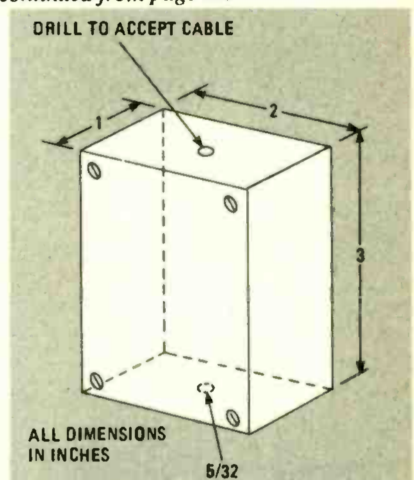

FIG. 4—THE AIR TEMPERATURE sensor is mounted in a box with these dimensions and mounted outdoors.

An offset connector was made by soldering together a ½-inch elbow, a short length of ½-inch pipe, and a ½-inch T-connector. Then a ½-inch copper end cap was drilled to accommodate a length of ⅜-inch (O.D.) copper pipe. The pipe was passed through the hole as shown, and soldered. Finally, a copper plug was soldered at the bottom of the ⅜-inch pipe. To place the sensor, the

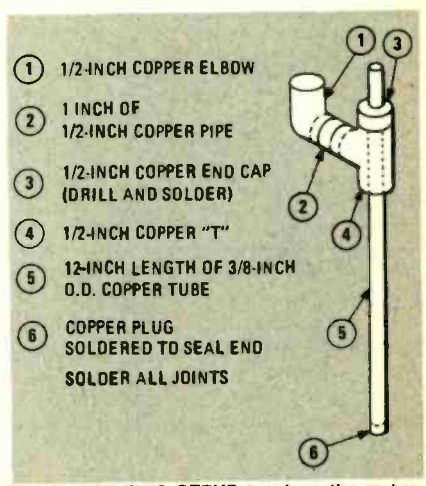

FIG. 5—USE THIS SETUP to place the water-temperature sensor. With it, temperature readings will be accurate, and normal boiler operation will be maintained.

water supply to the boiler was shut off and the expansion tank drained. With the expansion tank drained and the boiler indicating zero pressure, the boiler was also drained to about one half of its capacity. The expansion tank's ½-inch copper feed-pipe was cut at about four inches above the boiler's outside metal enclosure. The ⅜-inch pipe was then inserted into the boiler through the bottom half of the expansion tank's pipe, and the top half of the expansion pipe was fitted into the open end of the elbow. After soldering the top half of the expansion tank's pipe to the elbow, and the bottom half to the open end of the "T", the drain valves were closed and the boiler's water supply valve reopened. The boiler was then started and the radiators bled to release air pockets.

The water-temperature sensor was connected to the controller, using No. 22 gauge high-temperature insulated wire. Connections to the sensors were soldered and insulated. The sensor was inserted into the ⅜-inch pipe and the correct depth of insertion was determined by setting the aquastat's upper temperature limit at 150°F and moving the sensor up and down inside the pipe until the temperature readout agreed with the aquastat setting at the instant of boiler shut off.

For most installations, the aquastat circulator control should be set at 120°F; where you set the aquastat's high temperature limit depends on location and other factors. In our house, we found that a water temperature of 150°F was sufficient for heating even in zero-degree weather. With that arrangement, the controller automatically controls the water temperature at outside temperatures of 20°F and higher. When the outside temperature drops below 20°F, the boiler maintains the water temperature at 150°F. That setup allowed for an 18-percent reduction in fuel use over the last year. In that time, there have been no problems or malfunctions with the system other than a defective toggle switch. **R-E**

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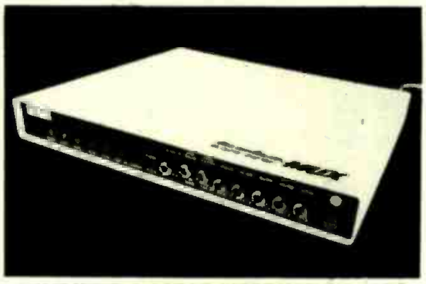
tested on thousands of cars and has proven to be dependable and trouble-free. It is fully guaranteed, costs only $49.95 each, postage paid and can be ordered from **Matthews Exquisite Gifts,** MO. Dept., 344 Hoe Avenue, Scotch Plains, NJ 07076.

MODEM ENHANCER, the *turboMUX,* is designed for owners of 212A modems, and doubles the throughput of a 1200-baud modem. It provides two types of improvements: 2400-baud full-duplex throughput, and the operation of a 2-channel statistical multiplexor.

The *turboMUX* has 2 channels. It attaches via standard *RS-232-C* interfaces, to the 212A modem on one end, and to the data-terminal equipment on the other. When one channel is used, it accepts data at 2400 bits per second. As a multiplexor, each channel receives data at a minimum of 1200 baud and up to 2400 baud, for a total data throughput of 2400 bits per second. The *turboMUX* unit compacts the data for transmission over dial-up lines.



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To double the 212A modem's throughput, the *turboMUX* unit uses a data-compaction algorithm. For phone-line inconsistencies, the *turboMUX* unit provides error detection and re-transmission facilities.

The *turboMUX* is priced at $995.00. (At $1,275.00, the *turboMUX* unit offers a 20-channel statistical multiplexor that can operate with the 212A modem.)—**Chung Telecommunications, Inc.,** 4046 Ben Lomond Dr., Palo Alto, CA 94306.

WAVEFORM ANALYZER, model *SC61,* is the first instrument to automate completely every conventional scope measurement for the purpose of obtaining faster, more accurate waveform analysis than is possible with conventional scopes.

The automatic readout eliminates the time-consuming graticule counting and calculating for conventional scope measurements. That total automatic readout is an exclusive. All measurements are made through one probe, available on both channels, eliminating any extra time-consuming lead hookup. Peak-to-peak volts, TIME and 1/TIME are also featured for any waveform section using a variable bar called "DELTA MEASUREMENTS."

For a limited time, the model *SC61* is priced at $2995.00.—**Sencore, Inc.,** 3200 Sencore Dr., Sioux Falls, SD 57107.

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television reception. The television industry, although not pleased about losing yet another TV channel, agreed that 12 clear channels were preferable to 12 shared channels. If they had to lose a channel, they preferred that it be Channel 1, because its absence would have the least impact on commercializing television.

The FCC went along with the television industry's position, and on June 14, 1948, Channel 1 was deleted from the allocation plan. Channel 1's frequencies were assigned to the fixed land and mobile services. At the same time, the FCC decided not to renumber the channels—that's what happened to Channel 1! **R-E**

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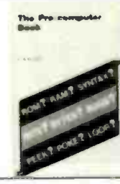

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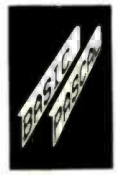

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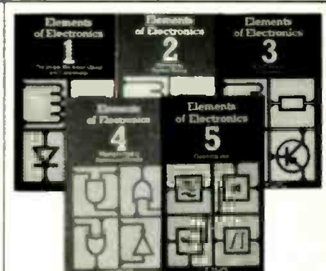

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