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THE CB CROSSOVER POINT

I felt the pulse of the CB industry this past February at the second annual Personal Communications 2-Way Radio Show, where some 380 manufacturers exhibited their newest CB transceivers, antennas and accessories. It was strong, though beating a little slower than in the recent past. Clearly, the crossover sales point from 23-channel CB transceivers to 40-channel units had not yet been reached in February, although indications are that it will have happened by the time you read this.

A transition period is, of course, a natural state of events, especially when the old and the new are running side by side, with the former sold at spectacular discounts. What we were watching at the PC-77 trade show was “tomorrow,” while “today” was having its last hurrah in the marketplace. Making my way through the exhibit hall, I became aware of a few 40-channel misconceptions shared by some dealers and distributors—and perhaps passed on to their customers. Two of them were: 40-channel CB transceivers only produce two watts of r-f output power and they exhibit inferior modulation. Both are fallacious, of course!

Now, really, there is simply no reason why, given good design, expanding a band of frequencies a paltry 150 kHz should influence r-f power output or modulation capability. Sure, a warmed-over 23-channel design that exhibited poor automatic modulation limiting to begin with won’t be able to hack it, though passing FCC type-acceptance tests. (These are actually being performed now. The “good old days” of passing tests by submitting paper results to the FCC are over, thankfully.) However, we’ve tested enough new 40-channel rigs to verify that they can provide as much r-f carrier output power and modulation throughout the new, expanded band as the 23s. Moreover, the new rigs are decidedly less prone to overmodulate owing to improved modulation limiters. This means fewer cases of voice distortion and, more important, less splatter to interfere with adjacent channel communication.

Interestingly, the foregoing points were emphasized by a major CB radio manufacturer at a Show press meeting. Furthermore, a spokesman analyzed the signal strength required at the receiver for a standard 10-dB signal-to-noise ratio in a typical urban environment to illuminate another advantage for 40-channel rigs. Assuming a typical receiver sensitivity of 0.5 microvolts for 10-dB (S + N)/N, about 14.5 microvolts of additional signal strength is required for the current 23 channels to make the standard due to interference from on-channel users; 15 microvolts more at the receiver is needed to combat adjacent-channel interference, for a total of 30 microvolts. In contrast, the upper new channels require only a total of 1.5 microvolts to receive an intelligible communication, the manufacturer estimated.

As a consequence of the above, the communication range with the upper new channels is estimated to be four times that of the lower 23 channels (30 microvolts/1.5 microvolts = 20 times = 26 dB). Typical area coverage on the new channels (actually, 80% of the upper new ones, since some are still within splatter distance of the original 23) would, therefore, be enlarged about 16 times.

For CB'ers trying to get through during rush-hour traffic, the upper 17’s on a 40-channel AM rig might be considered to simulate the effectiveness of single sideband on one of the less popular lower 23 channels. So, though 23-channel transceivers are tremendous bargains (and hard to resist), right now, 40 channels is the way to go to fully appreciate the utility of the citizens band.
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About damping, bi-amping and the Crown DC-300A

Because of inertia, speaker transducers over-react to amplifier signals. This can be minimized by speaker design, but it can't be eliminated entirely. In the process, the transducers feed spurious signals back into the signal processing units.

A good amplifier is designed to control excessive transducer excursions by reducing — and absorbing — the unwanted signals generated by such excursions. It's part of a process audio engineers call damping. The Crown DC-300A power amplifier, in addition to its other well-known specifications, has a damping factor of 700, which means it should easily control speaker excursions. (A rating of 400 is considered good.)

But in a standard hi-fi stereo system, the DC-300A can't do all the damping it was designed for. The sound is a little muddier than it should be.

Why? Because the speaker crossovers — with their own impedance — get in the way. The amp is not directly hooked up to the transducers.

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The DC-300A now damps excessive transducer excursions efficiently. Which can mean crisper, cleaner sound.

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There can also be less distortion, since harmonics of low-frequency distortion cannot feed to high-frequency transducers through the crossover.

Are you interested in how to use all the power and performance of a Crown DC-300A amplifier? Write. We'll send you information about the Crown VFX-2A, a two-channel variable-frequency crossover that makes bi-amping easy. Plus reprints of some articles that may help you decide if bi-amping is for you.
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MAY 1977
New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

PRESIDENT 40-CHANNEL CB TRANSCEIVER
The “Zachary T” 40-channel CB AM base-station transceiver from President Electronics features a new automatic speech compression circuit and a PLL in the frequency synthesizing system. The compressor is designed to provide consistent high-level modulation, while the PLL circuit is said to provide better on-frequency response than is possible with a conventional synthesizer. Selectivity is rated at –65 dB. Controls include volume, r-f and mike gain, anl (with manual override) and PA/CB switches. Also on the front panel is an S/r-f meter. Back-panel jacks provide for both ac and dc power input, antenna connection, and hookup of PA and external speakers. The earphone and mike jacks are up front. The transceiver also features a LED numeric channel display. $249.95.

SANSUI HIGH-POWER STEREO RECEIVER
Sansui’s high-power Model 9090DB AM/stereo FM receiver is rated at 125 watts/channel (8 ohms) minimum rms at no more than 0.1% THD. The power amplifier is direct-coupled throughout, with fully complementary parallel push-pull OCL circuitry. Twin power meters provide convenient output power monitoring. Built in is a Dolby noise reduction system that can be used for both encoding and decoding for full flexibility. The tuner section features a PLL IC multiplex demodulator that provides improved stereo separation on FM. FM sensitivity is rated at 9.8 dBf (1.7 µV) and capture ratio and alternate-channel selectivity are rated at 1.5 and 85 dB, respectively. A front-panel microphone jack, with its own level control, permits mixing any selected source with the microphone signal for use in PA systems. $750.

CIBCO CB PERFORMANCE MONITOR
A constant CB performance indicator that features light-emitting diodes for easy monitoring of SWR and transmitter output power is available from Cibco Division of Southwest Factories, Inc. The Model CPI II in-line monitor employs a green LED that indicates transmission output of 3.5 watts or more. A red LED comes on when reflected power exceeds a 1.8:1 SWR. (The red LED doubles as a speech modulation indicator.) Indications are produced automatically by pressing the microphone switch. In case of trouble, the red LED flashes an immediate warning. Hence, shorting or theft of the antenna is immediately evident, preventing damage to the output transistors in a CB transmitter. The monitor comes with a PL259 connector for easy installation between transceiver and antenna. $19.95. Address: Cibco Div., Southwest Factories, Inc., 3801 Willow Springs, Oklahoma City, OK 73112.

MICRO-ACOUSTICS PHONO CARTRIDGE
The Model 282-e stereo phono cartridge from Micro-Acoustics has a unique design that is said to enable it to track warped records 25% better than competitive cartridges. It is also said to be immune to the effects of cable capacitance and not to be tonearm sensitive. The cartridge is fitted with a 0.002 × 0.007 mil elliptical diamond stylus. Frequency response is rated at 5 to 20,000 Hz ±2 dB, tracking force range at 0.75 to 1.5 grams, separation at nominally 25 dB at 1000 Hz (15 dB at 10,000 Hz), and output voltage at 3.5 mV/channel at 5 cm/s peak recorded velocity. Load requirements are not critical and can be anywhere in the range from 10,000 to 100,000 ohms. Similarly, cable capacity is not critical at 100 to 1500 pF.

AMI MICROCOMPUTER KIT
American Microsystems, Inc., is offering its S6800 µP in kit form for computer hobbyists. The top-of-the-line Model EVK 200 kit contains all necessary components for complete construction, including a preprogrammed ROM for system monitor and general software utilities. Only a power supply and suitable I/O devices are required for operation. Level-control circuitry, baud-rate generation (50 to 9600 baud), and adjustability are built into the basic board. The CPU is the AMI S6800 eight-bit chip, with an instruction execution of 2 µs and memory access time of 575 ns. The system provides four available interrupt vectors and three types of DMA. A 1-MHz clock provides a 100-µs and 1-ns timer. Also on-board are the I/O interfaces and an EPROM programmer (EPROM device included), $495. (Also available fully assembled as Model EVK 300 for $765.)

AVR LOGIC PROBE
The Catch-A-Pulse logic probe from AVR is compatible with RTL, DTL, TTL, CMOS, MOS, and with microprocessors using 3.5-V to 15-V power supplies. Thresholds are automatically programmed for multi-logic-family operation. The memory circuit for single or multi-pulse detection resets automatically. LED’s indicate high and low levels, open-circuit logic, and pulses. Designed for carrying in a shirt pocket, the probe has a protective cap for the top, and a removable coiled cord. $24.95.

KOSS ELECTROSTATIC STEREOPHONES
The Model ESP/10 electrostatic stereo headphones made by Koss plug into an electrostatic energizer unit that can be operated on as little as 25 watts of continuous power per channel. The energizer, which accommodates two sets of headphones, has semi-
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The 6800 is not beautiful, but “Oh Boy” is it functional. That plain black box is strong and it has an anodized finish. This is the hardest, toughest finish you can put on aluminum. Most others use paint, or other less expensive finishes. The 6800 does not have a pretty front panel with lights and multicolor switches. This is because the lights and switches are not only expensive, and unnecessary, but also a great big pain to use. We don’t crank up the 6800; we use an electric starter—a monitor ROM called Mikbug. He automatically does all the loading for you without any time wasting switch flopping. So in the 6800 system you don’t buy something expensive (the console) that you will probably want to stop using as soon as you can get your hands on a PROM board and a good monitor.

That’s another thing. Mikbug® is a standard Motorola part. It is used in many systems and supported by the Motorola software library in addition to our own extensive collection of programs. It is not an orphan like many monitor systems that are unique to the manufacturer using them and which can only run software provided by that manufacturer. Check the program articles in Byte, Interface and Kilobaud. You will find that almost all 6800 programs are written for systems using a Mikbug® monitor. Guess how useful these are if you have some off-brand monitor in your computer.

The 6800 will never win any beauty prizes. It is like the Model “T” and the DC-3 not pretty, but beautiful in function. It is simple, easy to use and maintain and does its job in the most reliable and economical way possible. What more could you want?

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Riotous Red, Lily White, Big Blue, Sand Tan, Cat Black, Down Brown, Grizzly Gray, Machine Green, and Yellin' Yellow are the colors of a new line of CB "Colorwhip" mobile antennas from MayCom. The antennas and mounts can be purchased in matching or mixed colors to complement or coordinate with the vehicles on which they are installed. The patented fiberglass whips come in 4' and 6' (1.2 and 1.8 m) lengths with top-loaded, helically wound radiators, plastic sheaths, and chrome-plated brass ferrules. Prices are $10.25 and $11.25, respectively. No-drilling Model GW-7 trunk mounts are also available in color for $13.45.

HEATH HIGH-BAND SCANNING RECEIVER
The Model GR-1131 high-band scanner from the Heath Company monitors any combination of eight channels in the "emergency-services" public-safety band between 146 and 174 MHz, including those from the U.S. Weather Service. The receiver scans each channel, stopping at any that is active, and resumes scanning after the transmission. A priority channel feature checks the channel in which the user is most interested every four seconds and automatically switches to it if there is activity there. Features include channel lockout buttons, lighted channel indicators, automatic/manual channel selection, and a four-pole crystal filter for good selectivity. For crowded areas, an optional eight-pole filter is available. Also featured are a built-in telescoping antenna and provision for an external antenna. Ac or 12-volt dc operation. $89.95.

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MAY 1977
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You may control, digital other signal through recorder. Both voice and tape sound communications provide data measurement products featured include the Model 530 semiconductor test instruments. Produces the company's complete line of discrete semiconductor test instruments. Products featured include the Model 530 semiconductor tester with unity-gain frequency measurement up to 1500 MHz. Technical specifications provide data on in-circuit and out-of-circuit tests, applied test currents, indicator, calibration and limiting in-circuit shunt values. Applications for each model are also discussed. Address: B&K Precision, 6460 W. Cortland Ave., Chicago, IL 60635.

GUIDE TO SOLDERING ALUMINUM
A 6-page brochure from Multicore Solders provides information on soldering aluminum. Performance information including a table on the solderability of various wrought and cast aluminum alloys is presented with application and technical data, joint recommendations and soldering techniques. Technical specifications and performance of the company's Alu-Sol 4SD are also discussed. Address: Multicore Solders, Westbury, NY 11590.

CB ANTENNA CATALOG
A new catalog SP-4 from Antenna Incorporated describes its line of Citizens Band antennas and accessories. Specifications are provided for each base and mobile antenna with similar styles listed together for easy reference. Replacement parts and accessories are also included. The catalog, Form SP-4, is available from Antenna Incorporated distributors.

VOLTAGE DROP MEASUREMENTS
"Forward Voltage Drop Measurements" is the title of Tech Tips 4-6 from Westinghouse. The 3-page article, written to assist in making accurate measurements on power diodes and thyristors that can be used as a quality control check or matching criteria for operating devices in parallel, utilizes a simplified diagram of a test circuit and explains ways to avoid inaccurate measurements caused by pulse widths, duty cycles, peak currents, mounting and measurement techniques. Address: Semiconductor Division, Westinghouse Electric Corp., Youngwood, PA 15697.

EXACT REPLACEMENT GUIDES
Thordarson Meissner, Inc. offers two new cross-reference replacement guides for CB radios and TV sets. "TV Replacement Parts Guide" Form TVPG 9 and "CB Replacement Parts Guide" Form CBRG 2 include 127 new exact electronic replacement products recently made available by the company. Guides are available from Thordarson distributors.

WIRE-WRAPPING AND TOOL CATALOG
Catalog 36G is the new 58-page catalog from O.K. Machine and Tool Corp. which describes its line of Wire-Wrapping tools and machines. Additions to the line, including circuit boards, closures and instrument cases, are described; an illustrated section explains the technology of Wire-Wrapping. Address: O.K. Machine and Tool Corp., 3455 Conner St., Bronx, NY 10475.

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THE DECONTAMINATION SQUAD

For the past few months (whenever I've remembered to), I've been asking people how they care for their phonograph records. Their replies have been highly individualistic. On the one hand we have the manic camp, systematized to the point where they feel vaguely uncomfortable listening to a record that has not been put through an elaborate cleaning ritual, whether they can hear any noise or not. (I number myself among this group.) At the other extreme are those joyous devil-may-cares who may blow on a disc several times (quite ineffectually, no doubt) as they carry it to the turntable, but otherwise hardly give the matter a thought.

In my circle, almost everyone who takes records seriously owns some sort of cleaning appliance for them. Velvet- or plush-covered pads and specially designed brushes are common (choice of pad or brush seems to depend on intuitive "feel" for the cleaning process), as are Dust Bugs and similar devices. These may or may not be used religiously. I have seen some Dust Bugs so begrimed that their use would probably be a hazard rather than a help to the condition of any decent record, so the benign-neglect approach is not always inappropriate.

Ask the Experts. Why, after all these years, is record hygiene still a matter of guesswork rather than science? The question would be a fascinating one if its answer weren't so obvious. Ask the phonocartridge manufacturers, whose interest in properly maintained records is readily apparent: "You know, we've always been meaning to look into that. We use the Whatchamacallit, or at least there's one at every testing station, and it seems to do okay. But then again, in the absence of a suitable control sample..." Ask the record companies: "All our records are clean and defect-free when they leave the plant, and with reasonable care..." In other words, no one—or at least no one who doesn't intend to manufacture a record-cleaning device of his own—has the time to undertake the research necessary. And no wonder, because when you think about it, such a research project turns out to be fairly formidable.

A few hardy types, including some of my eminent colleagues in the press, have made yeomanly attempts to settle the issue in the laboratory. Their tests have generally taken two forms. The first is to play the dirty record, count (somehow) the number and severity of the ticks and pops presumably caused by dirt, then clean the record with the device under test, and play it again to note the improvement, if any. The trouble here is that the very process of playing a record alters its noise content. According to theory, certain dust particles will become embedded in the vinylite material by the stylus pressure—embedded too firmly for removal by any practical cleaning device. Hence the cleaning device under test faces the handicap of working with a record that has already been damaged by being played when dirty. But then, if you go on to play the record several more times, the severity of the "tick" caused by the embedded particle may abate considerably, as repeated passages of the stylus smooth the blight on the groove wall. Play the record with a different stylus and the "tick" may disappear altogether, because the stylus rides lower or higher in the groove.

Testing approach number two involves the visual inspection of the dirty and cleaned record with a high-magnification device such as a scanning electron microscope. Here the problem is that on one hand, you can't be sure that what you do see will cause noise. (Certain particles will be nudged aside or missed by the stylus.) On the other hand, what you can't see may cause noise. (An invisible residue of the cleaning agent may gum the stylus and/or raise the base noise level.) Also, there is the considerable drawback of the time involved in examining the whole record—or even a significant portion of it—with high magnification. And time is critical, because with each passing moment the record acquires a little bit of new dust.

Common to both tests are such quandaries as how do you manage to use the cleaning device consistently (most of...
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them are hand operated), and how do you establish an adequate control sample of the record. It has been shown repeatedly that "identical" pressings of the same record are far from identical to the stylus and the record-playing environment. According to one theory, the vinyl-like material of a record takes on a molecular "set" when it is molded, so that the entire disc—or certain random sections of it—acquires a permanent static charge. If the charge distribution varies from pressing to pressing (as it logically should), you have no hope of getting identical pressings.

**The Mechanism of Dirty Discs.**

The laboratory is revealing but not always authoritative about the record-cleaning question. The reported experiences of long-time record users are valuable but difficult to verify. At this point we need a working hypothesis of how records get dirty so that we can consider what ought to be done to get them clean again. Surprisingly, there is no universal consensus on the "mechanism" of dirty discs, but here is the theory to which I generally subscribe.

First, there are airborne particles. These settle on the record as they settle on everything, and remain there unless disturbed. Perhaps they are attracted and held in place by some "net" static charge molded into the record. Then there is grosser debris, from the jacket liner or the turntable mat. This is highly visible and hence disturbing, but most of it is too big to penetrate the record grooves and thus is probably harmless. However, its persistent presence suggests that smaller, invisible bits lie within the grooves themselves.

Next comes the record-playing process, which nicely parallels the workings of a Van de Graaff generator. The intimate contact of stylus and groove (much more intimate with the superior tracing and tracking of today's cartridges) builds up some surface voltages on the disc that are probably quite impressive. These are local charges, but they apparently cooperate with any net charges present in various ways. With your record cleaner you can drag a dust particle some inches away from its location on the record surface, only to have it break free and skip back to its precise point of origin.

When the record becomes surface-charged it acts on dust, certain colloids, and anything else available just as an electrophoretic acts on a pith ball. The charges give rise to three noise-producing mechanisms. First, they hold dust motes in place where they can be played by the stylus and pounded into the vinyl. No casual puff of breath or swipe of record cleaner will effectively dislodge them. Second, they create noises—sometimes quite alarming ones—in themselves, by freely discharging through the phono cartridge. Cartridges and arms suffer in their susceptibility to this, but in a dark room you can often see sparks generated as a record is played, accompanied by loud "bam" sounds through the speakers. In milder cases the static discharges are virtually indistinguishable from noise created by dust contamination.

Third, the colloids attracted by the charges often build up to form a tar-like coating on the grooves that interferes with tracing and ultimately gums up phono styli. The irreparable Percy Wilson studied the atmosphere's content of such substances and their effects on discs. Ponder his results for a few minutes and you'll begin to sense the onset of black-lung disease.

**On to the Bizarre.**

More recently, Bruce Maier of Dishwasher has documented the effects of fingerprints (always to be avoided) on records, and also raised the subject of certain fungi that subsist on vinylite and that are actually encouraged by the use of some record-cleaning solutions. I was not at all impressed by Dr. Maier's ideas until, several years ago, I visited Singapore, one of the brisker hi-fi markets of today and, being a mere ninety miles from the equator, a miasma of heat and humidity.

There, in the home of a prominent audiophile, I saw my first—heaven help us!—green record. According to my host, the algae-like growth forms within a few days. He takes his records to the washroom and uses soap and water to combat it. (I noted few other green records in Singapore, so perhaps he was doing something Dr. Maier wouldn't have approved of.)

**Getting wet.**

Many record listeners (Singaporeans excepted) endorse a high-humidity environment as being ideal for the static problem. They place open jars of water beneath their turntables' closed dust covers, or spend a fortune on a large and quiet humidifier. I advise against this. My first reason (another will be discussed later on) is obvious: rust! Back when I could manage long vacations, I summereed in a little cottage not twenty-five feet from a quiet seaside harbor. Hardy two years had passed before my tonearm (a crim-ingly expensive model) began to show characteristic brown stain creeping out of its pivot housing. Most of the arm was aluminum, stainless steel, and/or chrome plated. Unfortunately, the pivot bearings weren't (and few are, for excellent reasons).

Some record-cleaning devices deliberately apply a moisture slick on the record surface and let the stylus plow through that. If there's anything wrong with these appliances (aside from the above) it's hard to detect. In the opinion of some, the stylus cantilever acts as a wick to draw fluid up toward the cartridge. I've never heard anyone complain about this, however. Perhaps what's most suspicious is that the "wet cleaners" tend to remove all noise, including that which is molded into the record as groove imperfections. This effect has been ascribed to surface tension, viscosity, and the fact that sound wavelengths are different in water than in air. Or perhaps it's simply a function of the fluid's lubrication. No one seems to know for sure, but a significant number of audiophiles—particularly those with overbright systems—seem to swear by wet playing.

**The Author's Approach.** I suspect you were interested in my own record-cleaning techniques, and I thought you'd never ask. With the record rotating on the turntable, I begin with an anti-static device such as the Discwasher "Zerostat" pistol, which produces clouds of positive and negative ions when the trigger is squeezed or released. This treatment is simply to release the debris particles being held by static charges, which then can be scooped up by a velv- et or plush cleaning pad. (Some claim that such a pad won't scoop unless its bristles are slanted, but my experience suggests that a curvature in the contour of the cleaner accomplishes the same thing as a slanted pile). A little moisture will help the dust particles adhere to the bristles, and I am indebted to a reader for pointing out that open-mouthed breathing on a record will lightly fog it with condensed pure water vapor. So I breathe on the record as I brush.

As the record plays I use a device similar to a Dust Bug, but with a difference. Some years ago, at the height of a very humid summer (remember the objections raised to humidity earlier), I came up against an unaccountable, steady "thththth" sound on a record I knew was intrinsically good and well cared for. What?! Could it be static, encouraged by the high humidity to dis-
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charge through the cartridge in a rather relaxed fashion? Within ten minutes I had acquired one of the record-tracking/cleaning devices that has conductive bristles intended to be grounded at the tonearm or preamp input. To my frustration, I found that the annoying sound disappeared within a few moments of my lowering the bristles to the record surface, and reappeared a few moments after I had raised them. Needless to say, I held onto this contraption, and it has been doing a fine job ever since. This is my idea of how to clean records; I welcome comments.

As long as this article has been, it has left out some pertinent points: the how and whys of stylus cleaning; the efficacy of the new friction-reducing record sprays; the “dust-bug” brushes that come attached to cartridges; the reason some records seem to be more static-prone than others; and the ways in which cartridge/tonarm choice and alignment can affect the annoyance factor of record noise (they can, apparently). I don’t have firm responses to any of these (implied) questions, but I do have opinions, which will be forthcoming later on. In the meantime, let me give you several warnings:

(1) Don’t rashly buy a record cleaner meant to be used while the record is playing if your turntable has limited torque, as many belt-drive units do. Dust-Bug-type devices are usually okay, but the ones that span an entire LP will or which are driven off the turntable itself may make it impossible for your record player to get up to speed.

(2) Don’t use the turntable’s dust cover as a record cleaner. Laboratory tests have shown pretty conclusively that many dust covers provide an excellent path for acoustic feedback. Keep the cover removed or at least raised when you play a record. It is meant only to keep the turntable clean when it is not in use, and I don’t know of any responsible turntable manufacturer who claims that it is otherwise.

(3) Experiment with anything meant to be applied to a record cautiously. All solvents and even distilled water are suspect with many, although they are beloved by some. When you feel you must evaluate a record-treating substance, dose one half (180 degrees) of a good record with the stuff and leave the other half untreated. At 33 1/3 rpm you should be able to detect the transition from the one side to the other (at 45 rpm things may happen too fast). And be prepared to buy a new record just in case your experiment doesn’t work.
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ANY PEOPLE are aware, at least in general terms, of some of the effects that room reflections and resonances have on the perceived frequency response of a loudspeaker. For example, the bass response varies widely as one moves about the room, usually being strongest at an opposite wall or corner or close to the woofer, and weakest in the center of the room. High frequencies, on the other hand, are progressively absorbed by room furnishings as one moves away from the speaker. High-frequency level can also change greatly at different angles between the listener and the speaker.

There are ways to circumvent these problems, and even put them to good use, when measuring loudspeaker performance. Most designers, though, choose to test a speaker in an anechoic chamber (a room whose interior surfaces absorb essentially all sound impinging on them, and reflect little or nothing to a microphone placed in the chamber). In this way, the characteristics of the speaker can be determined, free from interaction with its surroundings.

In the case of headphones, the audible results are closely related to the dimensions of the wearer’s ear cavity, and the manner in which the earpieces fit the pinna or external ear. These are analogous to the relationship of the room to the loudspeaker. Although anechoic measurements might be possible with headphones, they would be of little practical value since the ear affects the frequency response through the entire audio range.

It is possible to measure headphone response directly on a human head by means of probe microphones inserted into the ear cavity. This is valuable for psychoacoustic and physiological studies, but clearly is of no use to someone wishing to evaluate a headphone. It would be convenient to have a “standard ear,” on which any phone could be checked. Even if such an ear were not identical to any specific human ear, it would provide a test bed on which to make comparative headphone measurements.

There are standard artificial ears—several different types, in fact. Some have been shaped to correspond roughly to the external human ear, but others merely present a flat surface to the headphone’s ear cushion, with a cavity drilled in the center to expose the end of a calibrated capacitor microphone that simulates the eardrum. This is the basic configuration of the ANSI standard headphone coupler, which we use in slightly modified form for our headphone tests.

The original purpose of the standard coupler was to measure headphone response in the speech frequency range (300 to 5000 Hz). It was recognized that resonances in the coupler cavity would produce severe response changes at higher frequencies. The standard coupler has a 6-cc cavity, simulating the volume of a typical ear. The shape of this cavity is subject to slight modification to suit the particular type of headphone being tested.

Experiments made by Koss Electronics indicated that a good correlation between measured frequency response and the subjective headphone response would be achieved with a slight modification of the shape of the coupler cavity (keeping its volume at the standard 6 cc). The Koss coupler, which we use for our tests, conforms to the 1949 ANSI standard, except for the details of the cavity shape. It is a flat plate coupler into which our test microphone fits snugly. When the headphones are mounted on the coupler stand, the normal tension of the headband provides sealing around the ear cushion of the measured earpiece, equivalent to what would exist with normal wearing.

Although the Koss coupler makes it possible to measure headphone frequency response through the full audiable range, it has a few extrinsic high-frequency resonances that make measurements less reliable above 10,000 Hz. Our coupler has been calibrated by Koss, with the aid of a calibrated set of its ESP-9 electrostatic phones. This enables us to check the performance of the test set-up and also provides an absolute calibration of sound pressure level (SPL), since the output of the ESP-9 phones is known at a particular frequency and drive level.

To measure the frequency response of a headphone, it is placed on the coupler and driven from an amplifier whose input is derived from our General Radio frequency-response plotter. The microphone output goes directly to the graphic level recorder input, and the chart reads out directly in dB on the SPL scale (referred to 0.0002 dyne/cm²). The voltage across the phone is set to a value recommended by the manufacturer (usually in the range of 1 to 3 volts) and a swept response measurement is made using a fast chart speed (25 inches per minute) and moderate pen damping (pen speed, 3 inches per second) to smooth out small variations caused by the coupler.

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ly to a Hewlett-Packard 3580A spectrum analyzer, on which all significant harmonic amplitudes can be measured. Impedance is measured by driving the phones through a fairly high resistance and plotting the voltage across them on the chart recorder. The resistance axis of the recorder chart is calibrated against a precision standard decade resistor, substituted for the headphones.

Interpreting the frequency-response curve of a headphone measured in this way is not as easy as we would like it to be. Sometimes the response is relatively flat over most of the audio range, and this is always associated with a phone which has a smooth, natural sound. Sometimes there will be one or more huge peaks (as great as 30 dB in amplitude) in the upper midrange. Such a phone always sounds harsh and unnaturally colored. The difficulty is in the intermediate cases, which comprise the majority of phones. Their response curves often have rather sizable peaks or holes in the range of a few kilohertz. These cannot easily be separated into true headphone response and the coupler response. Many of these phones sound excellent, virtually indistinguishable from some which test much better, while others that are seemingly not too different sound mediocre.

Thus, as with speakers, the only way to buy a headphone is to listen for yourself. With headphones, you have the advantage that the listening room is not a part of the equation, so the phones will sound the same in your home as at the dealer’s showroom. Since the physical “fit” of a headphone can be as important as its sound, a personal selection is highly desirable. Test reports can be a guide to those phones that are worthy of your consideration, but response curves should never take priority over the judgment of your own ears.

**SENNHEISER MODEL HDI 434 INFRARED HEADPHONES**

Cordless headphones provide unfettered personal listening.

With these innovative, cordless, stereo headphones, the listener can be free at last from the tether that attached him to the headphone jack. In the past, most attempts at designing cordless hi-fi headphones failed to meet the high quality sound needs of the home listener. The various cordless approaches tried were plagued by poor sound quality, high noise levels, and inability to handle stereo program material. The new Model HDI 434 infrared stereo headphones from Sennheiser have solved most of the technical problems.

The Model HDI 434 is actually a headphone “system” that consists of rather large (but lightweight) phones and a separate infrared transmitting unit. No physical connection is needed between the phones and transmitter, nor are there antennas or other appendages on the phones themselves. The only link between the phones and the transmitter is an invisible infrared beam. The transmitter plugs into the headphone jack of any amplifier, tuner, or tape deck.

The infrared transmitter measures 8”W × 3.15”D × 0.7”H (20.3 × 8 × 1.8 cm), and the headphones weigh 13.5 oz (420 g) including battery. Prices: $209 for the Model HDI 434 phones and $184 for the SI 434 infrared transmitter.

**General Description.** The earcups of the headphones house magnetic open-air drivers. The earcups are designed to provide little or no isolation from external sounds. The semirigid headband has a padded adjustable inner band that rests on the user’s head.

On the rear of the right earcup are a pair of slide-type controls for separately adjusting the volume levels in the two earcups. A slide-type switch allows selection of normal stereo listening, channel-A mono through both earcups, or channel-B mono through both earcups. A separate switch controls power to the headphones from its own 9-volt battery. The left earcup has no controls; it houses the battery that powers the phones. A clear plastic on the front edge of the right earcup protects an infrared sensor that picks up the invisible beam radiated by the transmitter.

Across the front panel of the transmitter is a row of 12 light-emitting diodes (LED’s) that generate the invisible infrared carrier beam. A separate LED, located at the far left of the panel, is used as the power-on indicator for the line-powered transmitter. The pushbutton power switch is located at the far right of the front panel.
You may have noticed that few turntable manufacturers call your attention to the critical role of the tonearm in record playback. Dual is an exception. Whatever the shape, materials, or mechanics of a tonearm, the goal is always the same: to maintain the cartridge in the correct geometric relationship to the groove, and to permit the stylus to follow the contours of the groove walls freely and accurately. Whenever the stylus cannot follow the groove undulations, it will gouge its own way. And as we have frequently reminded you, there's no way to repair a damaged record. Every tonearm designer should consider geometry, mass, balance, resonance, bearing friction, and the accuracy and stability of settings for stylus force and anti-skating. However, despite the simple fact that the shortest distance between two points is a straight line, some designers are more concerned with appearance. Hence, the curved tonearm, whose deviations between pivot and stylus simply add mass, reduce rigidity and increase the likelihood of resonance.

Dual engineers have always designed for optimum performance. The essential differences in approach and results are indicated below. You might keep all this in mind when you are considering your next turntable. Chances are you'll want it to be a Dual.

**United Audio Products, 120 So. Columbus Ave. Mt. Vernon, N.Y. 10550**

Exclusive J.S. Distribution Agency for Dual

The curved tonearm may appear longer than the Dual tonearm, but both actually have the identical effective length and horizontal tracking angle.

---

**Dual 1249. Single-play/multi-play. Belt-drive.**

Fully automatic start and stop, plus continuous repeat. Mosc Selector parallels tonearm to record in single-play; 6% pitch-control; illuminated strobe; cue-controlled; viscous-damped in both directions; multi-calibrated anti-skating. Less than $230.

**Dual 510. Similar except semi-automatic. Less-in-groove sensor Tonearm lifts automatically at end of play and motor shuts off. Less than $200.**

**Dual 502. Semi-automatic. Less sensor strobe and pitch-control. Less than $160.**

Specifications (DIN B3): Rumble, >56dB; Wow and flutter, <±0.05%

**Gimbal-mounted Dual tonearms pivot horizontally and vertically on identical sets of pivot points and high-precision low-friction bearings. Bearing friction: vertical, <0.007 gram. horizontal, <0.015 gram.**

Stylus force, applied by long coiled spring around vertical pivot, remains perpendicular to record even if turntable is not level.
In operation, the transmitter is placed in a location where its beam will cover the preferred area of the listening room. Then, with the headphone worn in the usual manner, the stereo program is heard just as with conventional headphones. The big difference here is that the listening volume is set by the slide controls on the right earcup.

It is important to have a sufficient, but not excessive, modulation level driving the transmitter. This is accomplished by turning up the volume control of the audio component that drives the transmitter until the glowing LED on the latter suddenly begins to flash, and then backing off slightly until the flashing just ceases. Thereafter all volume level adjustments are made by operating the controls on the phones.

The stereo program is carried over the infrared beam on two subcarrier frequencies—95 KHz for the left channel and 250 KHz for the right channel. The specifications call for a 30-kHz deviation at 1-volt input to the transmitter and 50-kHz deviation at the 1.5-volt maximum allowable input. The headphones contain two FM discriminators that are tuned to the subcarrier frequencies and are capable of demodulating signals with deviations as great as 50 KHz.

The specifications for the phones call for a frequency response of 20 to 20,000 Hz (no tolerance given) with less than 1% THD at 1000 Hz (at an unspecified level) and a maximum output capability of 108 dB SPL. The S/N ratio is rated at approximately 60 dB, and estimated operating life of the standard 9-volt battery is 100 hours.

**Laboratory Measurements.** We tested the acoustic performance of the phones on a modified ANSI headphone coupler in the usual manner. The transmitter was placed a few feet from the headset and driven directly from our General Radio response plotter. Having determined that a 1-volt drive level to the transmitter resulted in spurious "birdies" at frequencies beyond 12,000 Hz, we reduced the drive to 0.5 volt for the response measurement.

The midrange response was very flat, varying only \( \pm 1.5 \text{ dB} \) from 100 to 1700 Hz. The output rose at higher frequencies and was at or above the midrange level all the way up to our measurement limit of about 16,000 Hz. The low-frequency output, as is usually the case with open-air headphones, dropped off at a 12 db/octave rate below 100 Hz. The midrange SPL was about 105 dB, or 111 dB at the recommended maximum operating level of 1 volt.

The overload indicator glowed at a 1.15-volt input with frequencies of 1000 Hz or lower. Overload occurred at smaller signal voltages at high frequencies, reducing to 0.43 volt at 10,000 Hz and 0.32 volt at 15,000 Hz. The distortion of the acoustic output of the headphone was less than 1% for drive levels up to about 1 volt at 1000 Hz. With the phone's volume controls set to maximum, the distortion increased abruptly above about 1.2 volts. This was apparently due in part to overdriving the headphone amplifiers, since reducing the setting of the volume controls by 10 dB resulted in a more gradual increase in distortion, to 2% at 1.8 volts and 3.4% at 3 volts. Distortion is not a problem when using the phones, since it became appreciable only when the SPL exceeded a very loud 110 dB.

The S/N was measured relative to the output at 1000 Hz with a drive level of 1.15 volts. Without weighting, the S/N was 40 dB, and with CCIR weighting it was 54 dB. The stereo channel separation reduced with increasing frequency, from 40 dB at 100 Hz to 21 dB at 3000 Hz. It remained in the 18-to-21-dB range from 3000 to 15,000 Hz. The electrical impedance of the transmitter input was 100,000 ohms up to about 1000 Hz. It decreased to between 13,000 and 25,000 ohms in the 10,000-to-20,000-Hz range.

**User Comment.** Considered only as stereo headphones, we would rate these on a par with other Sennheiser phones we have tested. They are excellent, producing a clean, wide-range, transparent sound that could not be distinguished from conventional phones.

The listening volume was most satisfactory, and we heard no background hiss or other noise that was not in the program material. In other words, the...
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The best antenna going. And coming.

S/N of the infrared system was at least as good as that of the FM and commercial phonograph records we used for program sources.

The transmitter evidently radiates a fan-shaped pattern into the room, which does not reflect from room boundaries to any significant extent (unlike ultrasonic remote-control devices, whose output can be "bounced" off a wall to reach around a corner). This means that the phones must be in a direct line of sight with the transmitter, although distance does not seem to be a problem. (We covered 30 feet or more without difficulty.) However, if someone walks between the listener and the transmitter, the signal drops markedly or disappears altogether, delivering a burst of noise like that of an unmuted FM tuner when the signal drops out. Interestingly, a crackling sound occurred when the listener flicked a flint-type lighter, followed by noise when the lighter's flame appeared.

If one turns away from the transmitter, even to the side so that the left ear is closest to the transmitter, however, a loss of signal is likely to occur. We found this in some ways to be restrictive, although one quickly adjusts to the minor limitation. This occurs because the receiver sensor is on the front of the right earpiece. The answer, it would seem, would be to either place a sensor on each earpiece or mount a single one at the top of the rigid headband to prevent shadowing of the receiver as the wearer moves or turns.

Aside from the above, we were highly impressed with the concept used by these phones, as well as its execution. The system does a remarkably fine job without excessive weight or bulk. True, they are among the most expensive headphones you can buy, but they also do things that no other phones can. One simply has to experience the wonderful feeling of not being tied down to a headphone's umbilical cord to appreciate it. And, the sound is truly superb.

**Hirsch-houck Labs Report**

The Model PC-10 portable cassette recorder is part of Teac's new "Eos-teric" line. It is one of the new breed of true high-fidelity portable stereo recorders with all the features and performance quality expected of deluxe home cassette decks. It comes with a separate ac power supply for line operation and can be operated in the field from six D cells that fit within its case.

The recorder measures 11 1/2" W x 9 1/4" D x 3 1/2" H (29.2 x 24.1 x 8.9 cm) and weighs 11 lb (5 kg). Nationally advertised value is approximately $500.

**General Description.** The recorder features a direct-drive dc capstan motor that is servo-controlled through a phase-locked loop (PLL). This eliminates belts and flywheels; it starts up and brings the transport to final operating speed rapidly. (There is a separate dc motor for the tape hubs.) The PLL motor drive makes the recorder's operating speed relatively independent of supply voltage and temperature, the latter specified over a range of 32° to 140°F (0° to 60°C).

The cassette well is on what would be the top of the recorder when it is placed on a shelf or table. When the recorder is carried over a shoulder via its built-on strap, the cassette well is on the side for convenient loading and unloading. A small lever opens the cassette cover, while a firm push on the lever ejects the cassette. Located near the cassette well is a pushbutton-resettable index counter.

The control panel is dominated by two large VU meters, whose scales are labelled with the standard Dolby level mark at the +3 indexes. Between the meters is a PEAK LEVEL LED that flashes when momentary peaks reach +6 dB. The meters and PEAK LEVEL indicator function in playback as well as in the record mode.

The transport mechanism is controlled by two slide-type levers. The upper lever has STOP and PLAY positions, and next to it is the REC button that must be pressed before going to PLAY if a recording is to be made. The second lever has three positions. The left position is for rewind, center position for off, and right position for fast forward tape motion. Neither lever can be moved unless the other lever is in its stop (center) position. A PAUSE button is located just below the REC button. A red indicator comes on for the record mode.

The REC level controls for the left and right channels are concentrically ganged together. The lowest quarter of their adjustment range is marked in white as a warning that input signal levels are excessive if the controls must be set so low. Otherwise, the rest of the scales are in red for the right channel and green for the left channel. A small button below the level controls can be pressed to momentarily illuminate the VU meters or pressed and twisted to lock on the illumination. A similar button connects the right-channel meter to give an indication of battery condition.

Separate BIAS and EQ (equalization) switches are provided for setting the operating conditions to suit most tape formulations. The bias levels roughly correspond to those used with low-noise ferric-oxide and CrO₂ (or the chrome equivalent) tapes. The EQ characteristics conform to the standard 120- and 70-μs curves for these tapes. (The instruction booklet that comes with the recorder lists a number of suitable tapes and recommended switch settings.) The DOLBY NR switch turns on and off the Dolby B noise-reduction system, and the LIMITER switch turns on and off a peak limiter that takes effect at levels over +3 dB.

The positions on the MIC ATT switch are labelled 0, 15, and 30 (dB). With this switch properly set, it is possible to record very high sound levels without...
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May 1977
measure the overall record/playback frequency response. The curves obtained with Maxell's ferric-oxide UD-XL I and cobalt-treated ferric-oxide UD-XL II (designed to be used with "chrome" bias and equalization) tapes were typical of the recorder's performance with other high-quality tapes. The frequency response was a nearly straight line that sloped downward with increasing frequency. The total variation was ±3 dB from 35 to 12,500 Hz using UD-XL I tape and from 35 to 15,500 Hz with UD-XL II tape. The principal difference between the two tapes was not in their frequency responses but in their high-frequency saturation characteristics. When the measurement was made at 0 dB instead of the usual -20 dB, the UD-XL II tape delivered a much better high-frequency response.

The tracking error of the Dolby circuits between the recording and playback conditions (they are supposed to be exactly balanced at all levels and frequencies) was excellent. At levels of -20 and -40 dB, there was no more than 1 dB of change in response at any frequency when using the Dolby system.

A line input of 62 mV or a microphone input of 0.22 mV was needed for a 0-dB recording level. The latter increased to 1.6 and 8 mV when the mic ATT switch was set to its 15- and 30-dB positions, respectively. The microphone overload levels were 82, 550, and 1550 mV in the three positions of the mic ATT switch. The playback output from a 0-dB recording level varied somewhat with the tape used. The premium ferric-oxide tapes—Maxell UD-XL II and TDK SA—gave a 0.7-to-0.8-volt output, which roughly corresponds to the rated 0.775-volt output. However, the UD-XL I tape yielded a higher output at 0.93 volt.

The playback distortion from a 0-dB recording at 1000 Hz was 0.63% with UD-XL I and 0.8% with UD-XL II tapes. The 3% THD level was reached with respective recording levels of +6.5 and +5 dB. The PEAK indicator flashed at +5 dB. The recording limiter had no effect at 0-dB or lower levels, but it made a worthwhile reduction in playback distortion when the recording levels were well off-scale on the meters. For example, at +7 dB, with UD-XL II tape, the distortion reduced from 5.3% to 2.1% with the limiter switched in. At +10 dB, the distortion was a still-tolerable 3.5%, but at 20 dB it reached an unacceptable 10%. It is clear that the presence of the limiter is not a justification for entirely ignoring recording levels.

We were pleased to note that the VU

overloading the microphone preamplifier stages.

Set into the right side of the recorder is a well that contains the various input and output connectors, a slide switch for selecting either the microphone or line inputs, playback output jacks, a headphone jack, and a small volume control for the built-in speaker. There is also a jack for connecting the external ac power supply to the recorder.

The published performance specifications of this recorder are similar to those for a better-quality line-operated cassette deck. The recorder can be operated continuously for approximately two hours with six fresh D cells installed.

**Laboratory Measurement.** We used TDK AC-331 tape with 120 µs equalization and Teac 116SP tape with 70 µs equalization during our playback frequency response tests. In both cases, the response was flat within ±0.5 dB from 150 to 10,000 Hz, with a maximum departure from flatness of only 1 dB at the lower frequencies (which extended, respectively, to 63 and 40 Hz with the two tapes).

Several types of tapes were used to
meters were correctly named, at least with respect to their performance. Their ballistics matched the specifications for professional VU meters, with a 0.3-second, 1000-Hz tone burst occurring once per second to give exactly the same meter indication as a continuous tone of the same level.

With UD-XL I tape, the S/N referred to the 3% THD level was 56.5 dB unweighted, 60.5 dB with IEC A weighting, and 56.5 dB with CCIR/ARM weighting (the type preferred by Dolby Laboratories). With the Dolby system switched in, these figures improved to 61, 68, and 66.5 dB. With UD-XL II tape, the S/N was not quite as good, yielding readings of 55 dB unweighted, 59 dB IEC A weighted, and 56 dB CCIR weighted. The Dolby system improved these figures to 56.5, 65.5, and 66 dB. The noise level through the microphone inputs was 14.5 dB greater at full gain but much less with normal settings of the recording gain. Playing a 200-nanoweb/meter standard Dolby level tape provided meter readings within 0.5 dB of the Dolby calibration marks on the meters.

The measured wow was the 0.01% residual of our test equipment and tapes. Unweighted rms and flutter measured 0.145% in both the playback and combined record/playback tests. These figures cannot be compared to Teac’s own rating, which was based on a weighted measurement. The transport operated smoothly and reliably and moved a C60 cassette from end to end in about 84 seconds. The crosstalk between stereo channels was −45 dB at 1000 Hz, measured with a TDK AC-352 test tape. All these tests were made using an ac power supply.

**User Comment.** The overall performance of this recorder is squarely in the class of the better component-type cassette decks used in home hi-fi systems. In fact, with respect to distortion and noise levels, almost perfect playback equalization, and virtually ideal Dolby tracking, this recorder was superior to all but a handful of the component cassette decks we have tested.

Used in a fixed home hi-fi system, the recorder’s sound quality and handling convenience left little to be desired. Our only criticism of its operation concerns the eject lever. With the recorder slung over a shoulder, it is very easy to brush against the lever and inadvertently open the cassette door. Otherwise, this fine little recorder offers the best of portable and fixed operation, albeit at a price.
Auto Cigar Lighter Transmitter
It looks like the car's cigar lighter, since it's in the lighter slot. But the "Merc," developed by Mallard Manufacturing, Sterling, IL, is a one-ounce transmitter that, when pushed in just like a cigarette lighter, sends a coded signal that opens a garage door. The Merc (Mallard Electronic Radio Control) is said to work with any door opener on the market, and can be easily unplugged and moved to another car. Since it stays in the lighter slot, it isn't easily misplaced or, since it looks like the lighter, stolen. The Merc transmitter and companion receiver will sell for about $65 together.

Hearing-aid TV Captions
The Federal Communications Commission has given approval to an electronic system for producing captions on TV programs for hearing-impaired viewers whose TV receivers are equipped with the proper decoding accessory. While this gives the nod to manufacturers who wish to make the accessories, it does not require stations to supply the captions. PBS (Public Broadcasting Service) has been experimenting with the system for two years, but opposition has come from the commercial networks who want more time for testing. According to estimates presented to the FCC, the equipment to produce the captions will cost each station $30,000 to $50,000, and encoding the programs is expected to add another $1000 to $3400/hr to production costs.

"Citizens Band" Movie
"Citizens Band," a feature movie about the phenomenon of CB radio and its effect on the lives of some of the people who use it, is being filmed on locations in Marysville and Yuba City in northern California. The Fields Company production for Paramount Pictures release is to be a contemporary comedy-drama about the personal adventures of an interstate group of characters in everytown, U.S.A. The movie depicts various uses of CB radio, including heroic rescue operations in highways and air emergencies. All the principal performers who use CB radios in the picture were given CB equipment and operating instructions long before the start of production so that they would become accomplished CBers and play their roles authentically.

The "Leap Second" Year
To keep official time in step with the spinning earth, a leap second was inserted into the world's time at the end of 1976. By recommendation of the International Time Bureau in Paris, France, the leap second began on December 31, 1976, at precisely 23:59:60 Universal Coordinated Time. It ended at 00:00:00 on January 1, 1977, making the "leap second" part of 1976, not 1977. This additional second was inserted by all standard time organizations around the world, including WWV, WWVB, and WWVH in the U.S. The 1976 leap second was the sixth since the practice began in 1972, and is required because, in comparison with atomic clocks, the earth is slowing down enough so that the extra second is needed to keep the clocks synchronized to the spin of the earth to within one second.

WWV/WWVH Cutback
On February 1, 1977, the National Bureau of Standards discontinued broadcasts on the less-used frequencies of its two time and frequency radio stations. The affected frequencies are 20 and 25 MHz at WWV (Fort Collins, Colorado) and 20 MHz at WWVH (Kauai, Hawaii). Both stations will continue to broadcast on 2.5, 5, 10, and 15 MHz with no change in radiated power. Radio station WWV will continue broadcasting on 60 kHz with no changes. Broadcast equipment previously used on the discontinued frequencies will be converted to serve as back-up systems for the remaining frequencies, and will be automatically turned on if the primary transmitters or antennas fail. The NBS also announced that this partial discontinuance of service will be reviewed periodically as changes occur in radio propagation conditions, sunspot activity, etc. If conditions warrant, a resumption of service on the higher frequencies will be considered.

Video Equipment Bright Spot
Frost & Sullivan, a market research organization, has detected many long-term bright spots in consumer electronics, including video tape systems, video discs, video games, and video projection systems. Despite stiff competition from the Japanese and Taiwan manufacturers for the TV receiver market, Frost & Sullivan concludes that the U.S. can dominate the field of video entertainment systems because of its early start and sophisticated circuitry. The video game market, which checked in at $26 million in 1976, is expected to climb to more than $130 million by 1985. There are now more than 70 companies in the field. Video tape systems will be dominated by the Japanese, with a market peaking in 1980 before giving way to video disc systems. . . . If the industry agrees to standardization of software and hardware, says Frost & Sullivan.

Marine Guidelines for CB Monitors
The Coast Guard has established guidelines to assist volunteer CB-monitoring groups in relaying boating distress information. The guidelines are required to make sure a message gets through the various relay stations unchanged. The boatman can't reach the Coast Guard directly on CB because the Coast Guard doesn't monitor CB channels, a task left to REACT teams and other CB groups. The Coast Guard needs the following information: name and description of the boat, position, nature of the assistance required, number of persons aboard, radio frequencies available, name of the owner or operator and his home port and telephone number, and the name and phone number of the original contact for confirmation and callbacks.
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E. handic 43C - 4 ch/3w Hand-held CB - $99.95
F. handic 65C - 6 ch/5w Hand-held CB - $129.95
G. UCB - Universal Cassette, Recharge/Power Holder for Hand-helds - $19.95
H. handic S-12 - Selective Call for Base & Mobile - $79.95
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INTRODUCING SPEECHLAB
THE FIRST HOBBYIST VOCAL INTERFACE FOR A COMPUTER!

Now your computer can respond to vocal commands by the simple addition of a $250 single-board unit.

IMAGINE being able to talk to your computer and have it respond by way of a hard-copy device or by activating some external appliance! Computer hobbyists can now enjoy this facility by building "Speechlab," a new, low-cost (under $250) computer peripheral. To use it, all one does is plug the single Speechlab pc board into an Altair-bus connector (used by many microcomputer manufacturers), enter a special program, and the computer does the rest.

It's a state-of-the-art approach at a moderate cost.

One section of the program allows the user to "train" the computer to accept a vocal input (via a microphone), analyze the spoken word, and create a digitized version that is stored in memory. The second part of the program allows the user to speak to the Speechlab and have the computer generate the output selected for that particular sound.

The vocabulary size of Speechlab is a function of the speech recognition algorithm used and the amount of memory available. For the program used in this article, it is 64 bytes per spoken word.

The unique characteristics of Speechlab open many formerly closed doors. Since Speechlab will operate with any audio input (not necessarily a recognized language), a person who's vocally handicapped can operate almost any number of appliances (TV receiver, stereo system, solenoid-operated door,
etc.) using a repeatable sound such as a grunt. One can use Speechlab, too, as a vocal processor to add spoken commands to many computer games (such as the "Star Trek" game), or enter the world of artificial intelligence and advanced programming.

**Circuit Operation.** The basic block diagram of Speechlab is shown in Fig. 1. The audio input is amplified by A1 and applied to three 80-dB/decade rolloff band-pass filters F1, F2, and F3. These filters encompass the ranges of 150 to 900 Hz, 900 Hz to 2.2 kHz, and 2.2 kHz to 5 kHz, respectively. These ranges correspond to the frequency ranges of the first three resonances of the average human vocal tract.

Each filter is passed to a time averager (TA1, TA2, and TA3) to generate a voltage proportional to the level of the speech waveform within each band.

The amplified audio signal from A1 is further amplified by A2 to generate an unfiltered waveform that can swing ±2 volts about a rest level of 2 volts. This signal is also applied to a zero-crossing detector that generates a voltage proportional to the number of times the speech waveform crosses the 2-volt rest level in a given period of time, thus generating a measure of the dominant frequency in the speech signal.

These five voltages—TA1, TA2, TA3, A2, and ZCD—are fed to solid-state switch S1 along with three reference voltages used for calibration and self test. A computer output command selects one of these five voltages to be passed through S1.

The selected output from S1 is passed to a second solid-state switch (S2), and to a logarithmic amplifier (L1) that emphasizes the low-level signal before being passed to S2. Switch S2 can select either the direct output from S1, or the output from L1, and pass this selected signal to a 6-bit A/D converter where the voltage is converted to a digital value. The output of the A/D converter is fed to the computer data bus.

All operations of the Speechlab are controlled through a single I/O port (address AFhex). As shown in Fig. 2, six bits are used: bit-5 disables the 8-to-1 multiplexer (S1), and is used when switching between bands; bit-4 controls signal generator G1 which is used either to drive the microphone so that it acts like a miniature loudspeaker for prompting during voice input, or to drive the filters and zero-crossing detector during calibration and test; bit-3 selects either linear or logarithmic scaling of the voltage applied to the A/D converter; while bit-2, bit-1, and bit-0 select one of the eight signals from S1 for A/D conversion.

The input data word contains the 6-bit A/D output in bits 0 through 5, bit-6 is unused and is always 0, while bit-7 is the A/D converter status with a 1 corresponding to busy, and 0 corresponding to finished.

Speechlab is physically configured to occupy one slot in the Altair bus, and the complete schematic is shown in Fig. 3 through Fig. 7.

**Construction.** The two foil patterns (Speechlab uses one double-sided pc board) are shown half-size in Fig. 8. (Blow up to full size on film only.) Component layout is shown in Fig. 9.

All the components are mounted on one side of the board, with all the soldering done on the noncomponent side. Sockets are recommended for all IC's since most of them are MOS-types that may be damaged by improper handling. Integrated circuits IC1, IC4, IC7, IC8, IC9, IC15, and IC16 should be selected so they are capable of delivering a 4-volt output when using a 5-volt supply. Dual flip-flop IC14 can be from any manufacturer but Fairchild, as their truth table is somewhat different from the conventional table.

Start construction by installing the voltage regulator (IC6), all the discrete components, and the IC sockets—do not install the IC's at this time. Check the board for correct parts installation, and to make sure that there are no solder bridges between adjacent foil traces. Mount the board in an Altair bus connector, and check for the presence of 5 volts at the output of the voltage regulator and at the appropriate socket pins. Remove the board from the computer.

Install IC2 through IC5, IC10 through IC14, and IC17 through IC22. Install the board back in the Altair bus connector, and turn on the computer. Load the test program.

**Fig. 1.** The mic input is amplified, filtered and applied to S1 along with raw audio, zero-crossing detection, and three reference voltages. Output of S1 is computer selected by switch S2 for digitizing.

**Fig. 2.** Input and output port bit configuration.
Fig. 3. Amplifier 1/4IC9 takes either audio or tone from 1/4IC4 depending on computer command. IC1 circuits are used as raw audio amplifier and zero-crossing detector.

**PARTS LIST**

Unless otherwise noted, the following capacitors are 10% Mylar types, and all picofarad sizes are CM05 types.

C1, C16, C21, C43, C47, C49, C52, C57—0.0047 µF
C2, C31—100 µF
C3, C17, C20—270 µF
C4, C7, C8, C10, C12, C19, C27, C32, C33, C34, C35, C36, C37, C44, C55, C61, C62—0.1 µF, 25-V disc
C5, C14, C18, C24, C34, C60—0.01 µF
C6, C42, C45, C53, C56—240 µF
C9, C40, C48—0.022 µF
C11, C29—47 µF
C13—15 µF, 25 V tantalum
C15, C22, C51, C59—0.0015 µF
C23—0.0022 µF
C25, C26, C28, C38—1 µF
C30, C39, C46—0.047 µF
C41—0.1 µF
C50, C58—0.001 µF
D1, D3 through D6—1N4148 or 1N914 diode
D2—1N746 diode
IC1, IC4, IC7, IC8, IC9, IC15, IC16—LM3990 quad amp
IC2—4051 8-to-1 analog multiplexer
IC3—4016 quad analog switch
IC5—LM311 comparator
IC6—78M05 5-volt regulator
IC10—4024 7-stage binary counter
IC11, IC18—741C14 D-flop-flop
IC12—4050 hex buffer
IC13, IC22—4049 hex buffer inverter
IC14—4013 (see text) dual-D flip-flop
IC17—74LS30 8-input NAND gate
IC19—8097 three-state hex buffer
IC20—8093 three-state quad buffer
IC21—4001 NOR gate
MIC—Mura DX-121 dynamic microphone (part of stereo set Mura DX-242)

L1—22-µH choke

Unless otherwise noted, the following resistors are 1/4-W, 5%
R1—619,000 ohms, 1%
R2—1 megohm, 1%
R3—6810 ohms, 1%
R4—332,000 ohms, 1%
R5—200,000 ohms, 1%
R6—110,000 ohms, 1%
R7—R20—30,000 ohms
R8, R9, R10, R12, R14, R16, R104—1 megohm
R11—910,000 ohms
R13—2.7 megohms
R15, R48—10 megohms
R17, R18—20,000 ohms
R19, R22, R106—10,000 ohms
R23—1000 ohms
R24, R27—1.2 megohms
R25, R34, R39—470,000 ohms
R26, R38—750,000 ohms
R28, R31—100,000 ohms
R29—110,000 ohms
R30—39,000 ohms
R32—47,000 ohms
R33, R41—68,100 ohms, 1%
R35, R96, R102—75,000 ohms
R36—3.9 megohms
R37, R46—357,000 ohms, 1%
R40, R50, R52, R54, R56, R58, R60—10,000 ohms, 1%
R42—12,100 ohms, 1%
R43, R49—4750 ohms, 1%
R44—4320 ohms, 1%
R45, R47—681,000 ohms, 1%
R51, R53, R55, R57, R59—4990 ohms, 1%
R62—274,000 ohms, 1%
R63—7500 ohms
R64, R66, R72, R75—160,000 ohms
R65, R71—12,000 ohms
R67, R70—300,000 ohms
R68—931,000 ohms, 1%
R69—2 megohms
R73—620,000 ohms
R74, R76, R90, R92—62,000 ohms
R77—15,000 ohms
R78, R83, R84—147,000 ohms, 1%
R79, R80, R87—51,100 ohms, 1%
R81,R82,R89—174,000 ohms, 1%
R85—320,000 ohms
R86—680 ohms
R88—100,000-ohm pc trimmer potentiometer
R91—270,000 ohms
R93—249,000 ohms, 1%
R94—4300 ohms
R95, R97, R103, R105—360,000 ohms
R98, R101—320,000 ohms
R99—845,000 ohms, 1%
R107—158,000 ohms, 1%
R108—4700 ohms
R109, R111, R117, R119—82,000 ohms
R110, R115—5100 ohms
R112, R115—180,000 ohms
R113—549,000 ohms, 1%
R114—1.6 megohms
R118—510,000 ohms
R120—6800 ohms
R121—2000 ohms
Misc.—Sockets (one 8-pin, thirteen 14-pin, seven 16-pin), regulator mounting hardware, tie-wrap etc.

Note 1: The following is available from Heuristics Inc., 900 N. San Antonio Rd. (Suite C-1), Los Altos CA 94022 (Tel: 415-948-2542): complete kit of all parts including pc board, sockets, microphone, hardware manual, and 200-page lab manual, SpeechBasic, and assembly language programs at $249. (California residents please add 6½% sales tax.)
Fig. 4. Three bandpass filters and their associated time averagers. They encompass three ranges corresponding to frequency ranges of the first three resonances of an average human vocal tract.

program of Table I at 100 (hex). NOTE: all program data in this article is in hex.

You must jump to your monitor routine at address 0164-0165. Load address 195 with 05 and run the program. This will input the fixed reference voltage levels to the A/D converter and check the signal paths from switch S1 to the computer data bus.

After running this program, examine locations 200 through 20F, 300 through 30F, and 400 through 40F. Location 200 through 20F should contain 12 ±4, 300 through 30F should contain 24 ±4, and 400 through 40F should contain 36 ±4.

Insert the remaining IC’s in their sockets, load location 195 with 10, and run the test program (Table I). This test uses the signal generator (G1) to create an input for the filters, amplifiers, and zero-crossing detector, and thereby checks the remaining signal paths on the board and calibrates the microphone preamplifier. After running the program, examine locations 200 to 20F to see if it contains 16 to 18. If not, adjust potentiometer R88 and rerun the program until these outputs occur.

**Calibration and Test Program.** The test program (Table I) is a general-purpose calibration, test, and diagnostic program for the Speechlab. It loads at location 100 and requires memory from 100 to 600 for program and data areas. Locations 163-165 should be loaded with a jump to your monitor address so that the program will return control to your monitor after execution. If you do not have a monitor, place a halt at this location.

The program collects four 256-byte buffers of data from four of the eight pos-

Fig. 5. Command latch (IC18) can activate tone generator and switch S1 (IC2). Op amp (1/4IC4) is logarithmic amplifier.
sible inputs to the A/D converter. The first of the four bands is specified by the Test Command word, which also specifies beeper on/off and linear or logarithmic scaling. The next three bands are 1, 2, and 3 greater than specified by the Test Command word. Each band is sampled every five milliseconds until 256 samples have been collected from each of the four bands. Data from the first band is stored in 200 to 2FF, the second band from 300 to 3FF, the third from 400 to 4FF, and the fourth from 500 to 5FF.

For example, if the Test Command word is set to 00, after the test program is run, the four data areas will contain numbers representing the outputs of band-0 (low frequency), band-1 (mid frequency), band-2 (high frequency), and band-3 (zero-crossing detector). Anything that was spoken into the microphone while the program was running, is filtered, converted into a binary number, and stored in the data areas.

If the Test Command word is set to 05, the first three data areas will contain
constant numbers corresponding to the three reference voltage levels to the A/D converter on bands 5, 6, and 7. This is useful for checking the A/D converter operation and isolating problem areas to one side or the other of the 8-to-1 analog switch S1.

If the Test Command word is set to 10, signal generator G1 is enabled which begins to "beep" the microphone and connects the signal-generator output into the microphone preamplifier A1. The four data areas contain data from bands 0, 1, 2, and 3 as when the Test Command word was 00, but the input signal comes from the signal generator rather than from the microphone. This allows calibration of the microphone preamplifier and isolates problems in one of the filter-averager chains.

Adding bit-3 to the command word will cause logarithmic rather than linear data scaling and will isolate problems to the log amplifier or either of the two analog switches comprising S2, the 2-to-1 analog switch.

Various combinations of bits in the Test Command word will allow quick calibration and fault isolation, and also provide a quick way to look at raw data from any input through the microphone.

Software. A simple technique for speech recognition of the digits zero through nine with a recognition rate of 90% or better, is shown in the flowchart of Fig. 10. An 8080 program for this algorithm is shown in Table II. The program starts at memory location 0100 and requires less than 4K bytes of storage including table space.

There are two modes of operation—training and performance. During training, speech examples of the digits are read into the microphone and the parameters of the speech input are extracted and placed in the tables. In the performance mode, an unknown utterance is presented and recognized.

To use the program, enter it into the computer starting at location 0100, and then run the program. The Teletype will respond with "T" (train) or "P" (perform). Type a "T" and the Teletype will respond with "NUMBER?" which can be between 0 and F. Type the digit you desire, and the microphone will emit a "beep" indicating that the speech window is open. When this beep occurs, vocalize the same digit you just typed in. The microphone will beep again to indicate that the speech window is now closed. The machine will then type T or

**TABLE I**

| 0100 | DBS 100H |
| 0100 | START ED0 100H |
| 0101 | LBX H-START1200H |
| 0102 | SLD WH TEMP1 |
| 0103 | SLD TEMP2 |
| 0104 | SLD H-START300H |
| 0105 | SLD TEMP3 |

**‘HANDS ON’ EXPERIENCE WITH A TALKING COMPUTER**

**BY LESLIE SOLOMON, Technical Editor**

While testing the Speechlab, we borrowed an AL Cybernetic Systems (Box 4691, University Park, NM 88003) Model-1000 Speech Synthesizer ($325, assembled) to see if our microcomputer could “talk” as well as "hear." The Model 1000 is designed to fit into one slot of an Altair bus and delivers its output via an audio cable that can be plugged into any audio amplifier system. The output level is 0.6 volt p-p; impedance is 1000 ohms; and frequency range is 150 to 4500 Hz.

This synthesizer is phoneme-oriented. Accordingly, you can program it to say anything, as opposed to speech synthesizers that have only several words fixed in ROM. Essentially, the Model 1000 is a hardwired analog of the human vocal tract and various portions of the circuit emulate the vocal cords, the lungs, and the variable-frequency resonant acoustic cavity of the mouth, tongue, lips, and teeth.
P again. You answer with a T, and the process is continued as long as you want. Do not exceed 16 entries with this sample program.

Once you have some vocalized digits in memory, run the program again. This time, when the Teletype asks T or P, answer with a P (for perform). Now, as you speak the digits into the microphone, the Teletype will respond by typing that digit. When used in a quiet room, with the same vocalization, this algorithm can be

fig. 8. Etching and drilling guides for pc board are shown half size. Guide at left is the component side. Component layout is in fig. 9.

All the information necessary to perform the synthesis functions are located within a ROM that is accessible by the program. Words and sentences are formed by supplying a string of ASCII characters as would be done when outputting to any port, except that these strings also use some non-alphanumeric characters (i.e., the "+" is used to form "th" as in "thaw" or "earth"). Each ASCII character represents a particular phonetic sound or phoneme. If desired, you can create a program that produces simultaneous printout and "voiceout" of the same string.

The device requires very little software to implement: less than 50 bytes of assembly language or a handful of BASIC statements. The manual accompanying the synthesizer covers speech generation in detail, how it is created, and what is involved. It also illustrates how to "mechanize" speech, with several examples shown.

After working with the synthesizer for a couple of weeks, we found that we have a lot to learn about how humans create speech. After many hours of studying, experimenting, and re-doing programs, we made the Model-1000 utter some recognizable sentences. It is not easy, our experience showed, even when one uses the wealth of instructions provided.

Working with a phoneme-oriented speech synthesizer is a little like learning to use a microprocessor. All the logic is there, but programming it properly is another story. Like working with a processor for the first time, one must crawl frustratingly before walking. Slowly, however, the ideas start to percolate. Our computer still talks with a rather heavy "robotic" accent, but we have hopes that someday it will "humanize."

To paraphrase Sam Johnson: "Sir, a computer talking is like a dog walking on its hind legs. It is not done well, but you are surprised to find it done at all. " We have a long road ahead to the "HAL-9000," but the first step has been taken.
The 64 bytes obtained (16 parameters from each of the four bands) are compared with similar parameters which were collected during the training mode. A summation (running total) of the difference between the 64 parameters of the sample and the parameters of the training "templates" is computed. The totals represent a measure of the difference between the sample and each of the previously stored templates. The template with the smallest difference from the sample is then selected as the answer (output).

The above algorithm, while relatively simple, illustrates many of the basic concepts of speech recognition. A manual supplied with the Speechlab kit contains descriptions of other approaches to speech recognition, along with sample programs to demonstrate the techniques of speech recognition.
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54
YOU CAN now copy pc etching and drilling guides directly from the printed page without using a camera or laying out an artwork master. Two pc kits that can accomplish this dream feat for the electronics hobbyist are now on the market. One of these kits is called "Lift-It" from GC Electronics; the other is Datak's No. ER-4 kit.

The two direct-copy pc kits use different approaches to achieve essentially the same end. The Lift-It technique actually lifts the printed pattern from the page with a paint-on transparent film that has an affinity for the printing ink. The ER-4 technique uses a no-camera photographic process to duplicate or reverse a printed image or a positive or negative transparency, depending on how the copy film is exposed. Either copy method will greatly speed up the artwork portion of a construction project in which a pc board is used.

**Kit Lineups.** The Calectro No. J4-828 Lift-It kit from GC contains seven chemicals in bottles and cans, three trays, and pc contact film. The chemical lineup includes the paint-on Lift-It film solution around which the kit is built, board-stripping solution, contact film developer, board developer, paint-on resist lacquer, aerosol resist sensitizer, and premixed ferric-chloride etching solution. Two of the trays supplied are aluminum and are meant for the developing processes, while the third tray is plastic and is for etching only.

The only additional items needed for making printed circuit boards with the Lift-It kit are a yellow "safe" light, any of several light sources for exposing the contact film and board, and copper-clad board blanks. All chemicals in the kit come premixed and ready to use.

Datak's No. ER-4 kit uses a unique direct-photocopy process, called Pos-Neg. The kit contains four chemicals, a printing frame with yellow filter, artwork aids (layout film, drafting tape, and direct-etch dry-transfer pc patterns), photocopy film, and two copper-clad pc blanks. The two types of film developer, film fixer, and ferric-chloride etchant are supplied in powder form (to be mixed when needed), while the board developer and photoresist come ready to use.

The only additional materials needed with the ER-4 kit are a photoflood lamp, three glass or plastic trays, and bottles for the home-mix chemicals.

With both kits, you receive complete, detailed instructions on how to use them. In both cases, materials are supplied for making both positive and negative exposure masks for use with presensitized pc blanks (single-sheet original artwork can measure up to 5" by 5").

**Note:** The two methods are described separately on the following two pages. Methods of transferring from artwork to pc board are given on the final page of this article.
THE "LIFT-IT" METHOD

If you are new to pc techniques and have little or no experience in working with photographic techniques, the GC Lift-It kit may prove to be more convenient to use. There are no photo methods used in making the first film artwork.

Since using the Lift-It method destroys the original published etching and drilling guide, it pays to photocopy both sides of the magazine page on which the artwork appears so that none of the published material is lost. Cut the page from the magazine, trim the artwork to leave about 1/4" (6.35 mm) excess on all sides, and tape the artwork flat on a sheet of waxed paper. Paint the Lift-It emulsion over the entire surface of the artwork and allow to dry for 15 minutes. Repeat painting on the Lift-It emulsion and allowing it to dry until six thin, even coatings have been built up. After applying the final coating, allow the emulsion to dry for at least two hours.

When final drying is complete, soak the artwork in warm, soapy water for an hour or more. Remove the artwork from the soaking bath and carefully remove the softened paper from the Lift-It film by rubbing with the tip of your finger. Be careful to avoid tearing, stretching, or deforming the film. If particles of paper prove to be stubborn, return the artwork to the soaking bath for 15 minutes to a half hour. Finally, when all particles of paper have been removed from the film, allow the latter to completely air dry, after which you can apply a coat of the Lift-It emulsion to the ink side of the film. Make this coat as thin as possible.

You can greatly reduce the time to make the first artwork if, after applying the Lift-It emulsion, you dry it under a heat lamp or in a just-warm oven. Arrange the heating to dry the film in 3 to 5 minutes. (The wet emulsion is milky; as it dries, it becomes clear.) Using heat to speed up the drying, you can put the artwork in the soaking bath after 30 to 45 minutes of final drying. To reduce soaking time, tape the artwork, paper side up, to a clean glass plate and place both in the bath. After 10 minutes or so of soaking, cautiously rub the surface of the paper to break up any glaze. Repeatedly rub the paper gently until it begins to roll off in small bits at first and then in larger pieces. If the paper stubbornly adheres to the film, do not rub harder; allow additional soaking time and then proceed.

The prepared artwork can be used as is to expose presensitized pc blanks treated with positive photoresist, such as GC's No. 22-232 spray-on positive resist (use only GC No. 22-225 resist developer when using this positive photoresist—not the No. J4-630 board developer supplied in the Lift-It kit).

Positive to Negative. Assuming you are using negative photoresist and have a Lift-It positive, the next step is to make a negative of the Lift-It artwork. To do this, you use the contact film supplied in the kit. The procedure is simple. Working under safe-light conditions, you cut the film to size, place it glossy side up in a contact frame (such as GC's No. 22-280 frame), place over the film the Lift-It positive with ink side down, close the frame, and expose it under cool-white fluorescent light. If you do not have a contact frame, two clean sheets of glass will do. Excellent results are obtained with a pair of 20-watt cool-white fluorescent lamps at a distance of 4" (10.2 cm). Exposure time will first have to be established by exposing segments of a thin strip of the film for 1/2, 1, 2, and 4 minutes.

Once you have established the correct exposure time and have exposed the film through the Lift-It positive, switch to safe-light conditions, remove the film from the contact frame, and place it, dull side up, on a clean sheet of glass. Flow onto the film a liberal quanti-

THE "POS-NEG" METHOD

The Pos-Neg method used in the Datak ER-4 kit depends on accurate timing during the exposure of the sensitized film supplied in the kit. Using the Pos-Neg copy mode, you can directly copy the pc etching and drilling guide from the printed page. This results in a film positive that can be used directly to expose positive-resist-sensitized pc blanks.

To use the direct-copy Pos-Neg method, you begin by loading the contact frame (included in the kit) with the printed etching and drilling guide with the artwork facing up, followed by a narrow test strip of the sensitized film with its brown side up, and with the yellow filter on top. The whole is firmly sandwiched together between the contact frame and its top glass.

Next, you expose the test strip in blocks for 30 to 100 seconds at 10-second intervals. After developing and fixing the exposed film strip, you may find only one block satisfactory for your
needs. The "good" block will have almost opaque blacks surrounded by a slight brownish haze in the "clear" areas. It is usually necessary at this point to run off another test strip, this time in 3-second steps that span the exposure time of the "good" test block, to determine the exact required exposure time within 3 seconds.

Since the Pos-Neg technique involves both direct and indirect lighting effects, it is quite critical. An accurate enlarger timer to control the on-time of the photo-flood light will prove helpful. If you do not have an enlarger timer, you can use a clock with a sweep second hand and manually control the lamp.

At all times, the presensitized film must be in intimate contact with the printed etching and drilling guide. Additionally, there can be no "print-through" in the artwork. If printing on the reverse side of the page from the etching and drilling guide is visible, back the artwork with matte black paper.

The simplest of the photo copying procedures with the ER-4 kit is the duplication of a positive from positive or negative film transparency. Here, again, you must determine the proper exposure time. You load the contact frame with the grey side of the sensitized film up, transparency, and yellow filter on top, and expose in blocks for 20 to 90 seconds in 10-second intervals. After developing and fixing the exposed film, the correct exposure time will be that represented by the block with opaque black areas surrounded by water-clear areas.

Positive to Negative. Two separate exposures of the sensitized film are required to make a positive from a film negative or vice-versa. First, you must determine a "clearing" time. To do this, you load the contact frame with the film test strip with its grey side up and place the yellow filter on top. Then, you expose the strip in blocks for 20 to 90 seconds in 10-second intervals. After this, you develop the film in fresh developer at 68° F (20° C) for 2 minutes, place it in the fixer for 5 minutes, wash it under gently running water, and allow it to dry. The test strip should go from fully opaque black to fully water clear, with one or two intermediate shades. If the first fully clear block was exposed for 60 seconds, the clearing time is 70 seconds, for example. Record the clearing time for future reference.

Now, to reverse your film transparency, you first expose the entire test strip through the yellow filter for the recorded clearing time. Then, remove the yellow filter and substitute it with the film transparency and expose again in blocks for 3 to 21 seconds at 3-second intervals. After developing, fixing, and washing the test strip, select the block that has opaque blacks with water-clear whites. You now know the exposure times for both clearing and copying.

The ER-4 Pos-Neg system sounds more complicated than it really is. Once you gain some experience with it, it will be no more difficult to use than were other "photo" methods used in the past.
FROM ARTWORK TO BOARD

With very little practice, you can easily photosensitize copper-clad pc blanks. The blanks must be flat and free of ragged edges. The best way to deal with a ragged edge is to use a fine steel file to remove copper burrs and fine emery cloth to smooth the edges. Next, thoroughly scour the copper with a steel wool soap pad until it has a burnished finish and sheds water. Rinse thoroughly and allow to air dry, either at ambient room temperature or in a just-warm oven. Do not wipe the blank dry with a towel. The blank is now ready to be sensitized with photosensitizer.

Go to safe lighting conditions and place the pc blank with its copper side up on a couple of thicknesses of newspaper, thoroughly shake the can of spray resist, and spray a thin, even coating of the resist over the entire copper surface. Dry the resist for an hour at room temperature or for 15 minutes in a just-warm oven. Then inspect your work under safe lighting. If the coating of resist lacquer appears to be too thin, apply a second thin, even coat and again allow to dry. Before taking on a big job, develop a "feel" for the spray technique, using a piece of scrap pc blank.

**Finishing Steps.** Under safe light, place the sensitized pc blank in the contact printing frame and place the exposure mask on top. Make absolutely certain that the proper side of the mask is in contact with the blank. You can now expose the blank with any of four light sources, detailed in the instructions supplied with the kits. A fluorescent lamp with two 20-watt cool-white tubes at a distance of 4" from the top of the contact frame is suitable. You will have to determine the proper exposure time by trial and error with sensitized scrap pc blank.

Once the blank has been exposed, go to safe lighting and immerse it in the appropriate pc board developing solution and agitate. Remove the blank from the solution promptly when the circuit pattern appears, usually in about a minute or less. At this point, the resist is no longer sensitive to light, and you can switch back to normal lighting. Flush the developed blank under gently running water and allow to air dry at room temperature for an hour or in a just-warm oven for about 20 minutes. At no time before the board is dry should you touch the resist pattern. The pattern will still be soft and easily damaged.

After drying is complete, carefully inspect the pattern for faults and use paint-on resist lacquer or dry-transfer patterns to touch up any breaks. Then etch the blank in pc etching solution. You can speed up the etching time by preheating the etching solution by setting the bottle of solution in hot water until it becomes too hot to handle. Do not pour the etchant into a pot and heat it directly on a stove. Pour the etchant into a glass or plastic tray large enough to accommodate the pc blank. Place the blank, copper side down, in the hot etchant and agitate the bath by gently rocking it back and forth. Periodically check the progress of the etching after 20 minutes. When all unwanted areas of copper have been etched away, remove the pc board from the etchant and thoroughly rinse it under running water. Then remove the resist on the copper with pc board stripping solution.

The final step in making a professional-quality pc board at home is to trim the board to size and drill all component lead and mounting holes. From initial artwork to ready-to-go etched and drilled board, the job should take between five and eight hours, depending on the size and complexity of the board. The boards you make with either of the two kits described here will be indistinguishable from boards made by a professional.

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CIRCLE NO. 10 ON FREE INFORMATION CARD

POPULAR ELECTRONICS
Build a Legal In-Flight AIRLINE RECEIVER

Hear pilot-to-control conversations while in-flight with low-cost Varactor-tuned crystal set.

BY CASS R. LEWART

UNTIL NOW, "armchair pilots" wishing to listen to airplane-to-tower communications have had to confine their activities to ground-based monitoring. But the project described here—essentially a vhf crystal set with a small audio amplifier—will allow reception of such conversations when the user is on board an airliner. It will do so without creating any hazard to the plane's navigation system. The receiver is easily built, using readily available, inexpensive parts.

About the Circuit. Unlike superheterodyne receivers, whose local oscillators generate signals which can interfere with reception in the 108-to-118-MHz radio-navigation band, this project can be used with complete safety. The heart of the project is a 4-transistor audio amplifier with a built-in speaker, shown schematically in Fig. 1. Power switch S1 is ganged with R1, the volume control. The amplifier draws current from a single 9-volt transistor battery, B1.

A few modifications transform this amplifier module into an airline receiver, shown schematically in Fig. 2. The receiver comprises a tuned r-f circuit (L1, C1 and D1), a demodulator (D2) and the modular audio amplifier. The tuned circuit is unusual in one respect—it uses a voltage variable capacitor or Varactor as the variable capacitance. This diode, when reverse biased over a range of 0 to 9 volts, behaves like a variable capacitor of 5 to 15 pF. Because C1 is in series with D1, the effect of the fixed capacitor is negligible. The combination of L1, a small hand-wound coil, and D1 resonate to provide coverage from 118 through 135 MHz. (Construction details for L1 are given on the next page.)

A short piece of insulated, stranded hookup wire serves as an antenna. The wire is terminated with a pin or banana plug (P1), and is connected to the rest of
Fig. 1. Simple four-transistor audio amplifier before modification.

Fig. 2. Schematic of the amplifier with minor additional circuits needed to make airline receiver.

**PARTS LIST**

- A1—Modular Amplifier (Radio Shack 277-1008 or equivalent)
- B1—9-volt transistor battery
- C1—0.01-µF, 50-V disc ceramic capacitor
- D1—5-15-pF voltage-variable capacitance diode (Motorola HEP R2501—do not substitute)
- D2—1N34 germanium diode
- J1—Miniature phone jack (part of A1)
- J2—Pin or banana jack
- L1—Five turns of No. 24 enamelled copper wire on a 3½-inch form, approx. 10 turns per inch
- P1—Pin or banana plug
- R1—Volume/tuning control (part of A1)
- S1—Spst switch (ganged with R1; part of A1)
- Misc. — Dynamic earphone (8 ohms), hookup wire, solder, etc.

The circuit via J2, a pin or banana jack. Signals are thus applied to the tuned circuit, which is resonated by means of R1. This potentiometer, which served as the volume control in the unmodified amplifier, functions as a voltage divider to apply variable reverse bias across D1.

After the vhf signal has been boosted by the parallel LC circuit, it is demodulated by germanium diode D2 and applied to the audio amplifier. The output of the amplifier drives a dynamic earphone plugged into jack J1 (the former input to the amplifier).

**Construction** of the receiver is greatly simplified by modifying a ready-built audio module and adding a few additional components. In the author's prototype, a Radio Shack 277-1008 amplifier was used. However, other units can be used equally well. The additional components fit in place of the module's speaker.

Start by removing the three small Phillips screws which secure the amplifier pc board to the plastic enclosure. Then remove jack J1 and unsolder the leads running to it. Raise the pc board and unsolder the leads connected to the speaker. Remove the speaker by softening the glue holding it to the plastic enclosure. Use acetone or nail-polish remover and pry the speaker away with a sharp knife. Then attach what were the speaker leads (points X and Y) to J1. Polarity is not important.

Refer to Fig. 3A and 3B for the following steps. Open the pc foil running from the volume control (R1) to the amplifier input (point P) and to the input jack (point M) by scraping it off with a sharp blade. Connect the terminal previously running to point M to one side of switch S1 (point S), which is ganged with R1. Solder a wire to the wiper of R1 and connect the other end to one side of C1 and the anode of D1. Then solder a wire to the pc foil that formerly ran to the wiper of R1 (on the other side of the break in the foil), and attach the other end of the wire to the anode of D2.

Next, drill a hole about 1-9/16" (3.97 cm) from the top of the enclosure on the left side (as viewed from the rear) to accommodate J2, the antenna input jack. Mount the jack and secure the pc board to the enclosure with the three small Phillips screws. To form L1, wind five turns of No. 24 enamelled copper wire on a ¾-inch (9.53-mm) form, spaced about 10 turns per inch. Scrape the insulation off the ends of L1 and position the coil in the speaker cutout of the pc board. Connect D1, D2, L1, and C1 as indicated in the schematic, using J2.
for mechanical support. Be sure to observe correct polarity for the diodes or you will damage them. Solder all remaining connections.

**Alignment.** The best way to align the receiver is to couple it to a signal generator producing an output at 125 MHz with internal 400-Hz modulation. Connect a small dynamic earphone to J1 and set the tuning control (R1, the former volume control). Compress or expand the winding of L1 for maximum audio output. If you can't get access to a signal generator with the required output, just go to your local airport. Connect a short (one foot or so) wire terminated with a suitable plug to J2, and listen to transmissions from the airport tower. Adjust L1 for best reception with R1 at center position.

**Operation.** The airline receiver is very simple to use. When you are taking a flight, try to get a seat near the window. Attach the antenna wire to the window with a small piece of masking tape, and plug the earphone into J1. This will allow you to monitor the pilot's conversations without causing a commotion.

You will not usually know the exact frequencies used by a particular airplane. Airport towers generally transmit and receive below 120 MHz. Other communications can be found anywhere between 120 and 135 MHz. Between takeoff and the time when a plane reaches cruising altitude, its pilot will use several frequencies in succession, communicating with the tower, departure control, and possibly to the particular airline controller. Similarly, the pilot will use several frequencies during the descent.

Each conversation will be brief, lasting only a few seconds. Accordingly, an important characteristic of this receiver is its broad selectivity as compared to that of a superheterodyne receiver. The user can therefore leave the tuning control at its center position. The pilot's transmission will still be heard—even if the tuned circuit is not resonant exactly at the operating frequency. The receiver can be quickly retuned for optimum reception if desired. Another possibility is to continuously tune the receiver back and forth, scanning the band until you can hear the pilot's voice.

When using the receiver, you may try to explain to the stewardess what you are doing in case other passengers think you are using a radio that might foul up airline communications. Your radio is similar to a tape recorder which would be permitted on board.
ALTHOUGH the Morse-A-Letter (January 1977) deciphers Morse code signals very effectively, its usefulness is somewhat limited by its single-character LED readout. At higher code speeds, the characters are displayed briefly, straining the operator's ability to copy down the entire text. However, it's easy to interface the Morse-A-Letter to a "TV typewriter." This combination, called "Morse-A-Display," will allow message display in page format—a boon to CW operators and SWL's interested in copying Morse.

Designed with this application in mind, the Morse-A-Letter contains all electronics necessary for converting dits and dahs to TTL-compatible ASCII-6 code. The required interface is simple and straightforward. All features of the original project are retained.

ASCII. Before examining the interface, let's review some basics of ASCII code. This will help us understand how the Morse-A-Letter/TV typewriter team operates. ASCII is a standard 8-bit information code used with most computers and data terminals. It may be used in the parallel (all bits present simultaneously on separate lines) or serial (one bit at a time on a single line) mode. Most systems do not use the eighth bit of the code and it is, therefore, assumed to be a logic one at all times. Some systems, however, use the eighth bit for parity or error testing. The remaining seven bits provide a total of 128 possible characters. Of these, one group of 32 is reserved for the upper case alphabet and a few punctuation marks. Another group of 32 is used for numbers, spacing and additional punctuation symbols. Rarely used punctuation marks and a lower case alphabet are assigned a third group of 32. Finally, the last 32 combinations are assigned as machine or control commands. This group does not actually get printed but is provided to handle hardware operations such as line feed (LF) or carriage return (CR). If only upper case alphanumerics are needed, only the first two groups of 32 codes are required, and only six of the eight bits of the code are used. This diminutive ASCII code is called ASCII-6 and is essentially the code produced by the Morse-A-Letter. No control codes are produced by the Morse-A-Letter, however, so most "housekeeping" operations (line feed, carriage return, etc.) must be performed by the TV terminal. This does not present a real problem, since most TV terminals are programmed to handle...
these operations automatically in the absence of specific commands.

**Interfacing.** Almost any TV terminal capable of receiving TTL-level, 7-bit parallel ASCII code can be used with the Morse-A-Letter. Most terminals will work well with the ASCII-6 code without any changes or additions. However, some terminals require the presence of the seventh bit (B7—not to be confused with edge connector location B7) to produce a question mark (?), due to the method used to check control characters. If the seventh bit is required by your terminal, don’t despair! It can easily be obtained because B7 is merely the complement of B6 for the 41 valid ASCII characters produced by the Morse-A-Letter. This modification requires a small amount of additional wiring on the Morse-A-Letter circuit board. Fortunately, no additional parts are needed since an unused inverter (actually one half of IC5, a 7413 dual NAND Schmitt Trigger) is already “on the board.”

To generate bit 7, connect a wire from B6 of the ASCII output (edge connector location A21) to pin 13 of IC5. Also, connect a wire from pin 8 of IC5 to edge connector location A13. This becomes B7 of the ASCII code. Keep in mind that many TV terminals will function adequately with just the ASCII-6 code, so this addition may be optional.

The TV terminal will normally require a “data ready” signal to tell it when an ASCII character is applied to its input connector. This signal is also sometimes referred to as a “keypressed strobe” or “new character” pulse. It is usually a positive going pulse that appears whenever the ASCII character is ready to be entered. The Morse-A-Letter provides this new character pulse in the form of a positive going pulse at edge connector location A14, which is generated every time a new Morse character is received.

A word of caution is in order. If your terminal does not utilize TTL levels at the ASCII input connector and/or requires a negative-going strobe pulse, an additional interface is needed.

As an example of an interface, the Table lists the wiring requirements for interfacing the Morse-A-Letter to the Southwest Technical Products CT-1024 Terminal, which has a TTL-compatible input and a positive strobe line. All that’s required is connecting a suitable cable from the appropriate points on the Morse-A-Letter connector to the TV terminal connector. Note that no power supplies or additional electronics are necessary. Most other TV terminals will interface in a similar manner.

**Operation.** There are no adjustments required for the Morse-A-Display other than the normal code speed adjustment. It will function in either the code practice or the reception mode. Once a signal is properly tuned in, the television display will read out the incoming characters directly on the television screen. Illegal Morse characters will be displayed as “@.” Noisy signals may generate strings of “E”s or “T”s on the screen, but this is normal. Do not expect to view perfectly edited copy since word spaces are rarely sent in Morse code and the Morse-A-Display is not designed to decode them. This is not a serious handicap, however, and with a little practice you will be able to read complete messages from the screen. To copy high-speed Morse, it might be desirable to reduce the Morse-A-Letter’s C9 from 6.8 microfarads to 2.0 microfarads in the original circuit. This reduces noise immunity slightly, but enables copy at code speeds up to 50 WPM or more.

Remember it is illegal to pass information garnered from ship-to-shore, military, or press transmissions to third parties.
MATCHING hi-fi components of a stereo or four-channel system means that each component must operate compatibly with each other.

For example, your loudspeakers should be efficient enough to deliver satisfactory sound levels—especially in the low bass region—when driven by the amplifier or receiver of your choice. Yet, they should have sufficient power-handling capacity to avoid damage if driven by too much power.

In another sense, compatibility also means that one component should not have substantially better performance than another component in the system. It would be foolish, for example, to have a $300 single-play turntable, $800 receiver, and two speaker systems at $500 each and then add a $19.95 phono cartridge. The latter’s electrical/mechanical performance would be well below that of the other components in the system. As a result, one would not get the full performance capability inherent in the better components. Remember that the final reproduced audio will sound only as good as the weakest component link in the system.

One can often ignore electrical and mechanical considerations at the onset of rounding up his choices, however, by viewing compatibility in terms of each component’s price tag. Thanks to competition among manufacturers, the quality of each type of component varies almost directly in relation to its price (although exceptions can always be found to virtually any generalization).

Most newcomers to component hi-fi (and some experienced audiophiles, too) have little or no idea of how to apportion their dollars to the various components they plan to buy.

Many audio dealers try to simplify this...
problem by “assembling” pre-selected components into a complete system. Such systems usually bear a single price tag and offer significant savings over the prices of the individual components added together. There are both advantages and disadvantages in choosing such a dealer-selected system. Certainly, if the dealer is knowledgeable and reputable, you are at least assured that the components which have been put together in this way will work compatibly with each other—and the savings in making a single purchase from one source are often worthwhile. On the other hand, you may have different ideas about which components you think sound better with which other components. Consequently, your dream system may not be represented by any of the pre-selected groupings offered by the dealer.

In addition, it is common practice for some dealers (but not all) to have loudspeaker systems “custom designed” by local manufacturers who are essentially cabinet makers rather than speaker system designers. Since such speakers are rarely advertised nationally, almost any “suggested retail price” can be assigned
to them. In such instances, the "savings" shown in the final system price tag may actually be the result of reducing these speaker prices to more realistic levels. (This practice is not universal, of course.) What we are suggesting is that each component in such systems be analyzed and evaluated for its own mer-

fast rules; these are simply rough guidelines. In the system shown, any tape equipment would be considered extra and is not included in the initial percentage breakdown.

Suppose you decided to include a cassette deck as part of your initial hi-fi investment, and that you prefer to have a separate tuner and an integrated amplifier (preamplifier-amplifier combination) instead of a receiver. Your system might then look something like that shown in Fig. 2, with the percentages spent for each component given below. Since such a system is necessarily more expensive than the simpler, 4-piece arrangement, let's start with a budget of $1000. You might spend $250 for a turntable and cartridge, $150 or so for a separate FM/AM tuner, $250 for a cassette deck with Dolby, $200 for an integrated amplifier and perhaps $125 for each of your two speaker systems. If the tape deck is eliminated for the moment, percentages could be reassigned as shown in the lower percentage table.

Quadruphonic systems necessarily cost more than stereo systems of equal quality. In Fig. 3 we have represented a typical quadruphonic system centered around a 4-channel receiver. Again, percentages are shown below for each element of the system. If we assume that you are prepared to spend $3000 for such a system (note that it includes both an open-reel tape deck and a stereo cassette unit) your dollars might be apportioned as follows: $600 for the open-reel deck, $300 for the cassette deck and a similar amount for the turntable/cartridge combination (you will need a cartridge designed to play CD-4 records this time), $750 for the 4-channel receiver and $262.50 for each of the four speakers in the system. If you were to omit the tape decks and had only $2000 to spend, the lower percentage table in Fig. 3 suggests that you might spend $800 on the 4-channel receiver, $200 for each of the four speakers needed, and up to $400 for the turntable/cartridge combination.

Specs To Expect. Although specifications are certainly not the only criterion involved in making an intelligent

![Fig. 3. How dollars should be apportioned for a four-channel system with open-reel and cassette decks.](image)

its and performance—for that is the essence of shopping for components for your own high-fidelity system.

Apportioning Hi-Fi Dollars. By far the greatest number of high fidelity stereo component systems consist of an all-in-one receiver, a turntable system (either single-play or multiple-play) and a pair of loudspeaker systems. This basic layout is shown in Fig. 1. Below it is a typical cost breakdown in percentages of available dollars. As an example, if you have $500 to spend on such a basic system, you might consider a turntable (including the phono cartridge, which is usually purchased separately) selling for approximately $125, a $200 receiver and two speakers for about $87.50 each. There are, of course, no hard-and
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...to the first NAND gate, as shown, or the two inputs may be tied together for continuous operation.

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Two of many possible audio circuit applications for VMOS transistors are illustrated in Fig. 4. The first, Fig. 4A, is a simple sound source which may be used in intrusion and fire alarms or similar projects. The design features a NAND gate oscillator similar to the one used in the second lamp dimmer circuit, with the VMOS transistor serving as a power driver for a PM loudspeaker.

The second, Fig. 4B, employs a single VMOS transistor as a Class A linear power amplifier in conjunction with a JFET preamp stage. Suitable for use in radio receivers, TV sets, record players, intercoms, and low-power PA installations, the circuit can deliver 4 watts to a suitably matched loudspeaker load and has a reasonably flat frequency response from 100 Hz to 15 kHz. Overall distortion is kept to within 2% (at 3 W output) by 10 dB of inverse feedback provided by a 1-k resistor between the output and the preamp's source electrode. A 28-volt dc supply is required.

With their fast switching characteristics, VMOS transistors are suitable for many high-frequency projects. A typical linear vhf amplifier circuit is illustrated in Fig. 5. Designed for operation in the 144-to-146-MHz band, the design may be used in both transmitter and receiver applications. As a transmitter power amplifier, the stage has a minimum power gain of 12 dB and can deliver 5 W PEP at 146 MHz. If used as a receiver r-f preamp, the design can furnish 11 dB gain with a low noise factor of only 2.4 dB. All resistors are half-watt types and the coils are hand-wound, with T1 consisting of 8 turns of #24 AWG, 1/8-in. diam., close-wound, and T2 of 5 turns of #24 AWG, 1/8-in. diam., close-wound. In common with most vhf designs, careful layout and proper lead dress during assembly are essential for optimum circuit performance.

A further example of the VMOS transistor's versatility is found in the high-power audio amplifier circuit shown in Fig. 6. Of potential interest to audiophiles and more advanced experimenters, the design is suitable for use in high-quality stereo or quadraphonic systems. Capable of delivering 40 watts to an 8-ohm load, the amplifier has an essentially flat closed-loop frequency response (exclusive of the r-f input filter) from 1 Hz to 1 MHz and a slew rate of better than 100 V/μs. Its total harmonic distortion at 1 kHz, full rated output, is less than 0.05%. Featuring a Class AB quasi-complementary push-pull output stage using three paralleled VMOS transistors in each arm, the circuit is described in detail in Siliconix Design Aid DA76-1, The MOSPOWER™ FET Audio Amplifier. In addition to the schematic diagram and a suggested dc power supply circuit, the 4-page publication includes pc board and chassis layouts, response curves, signal waveforms, construction and adjustment hints, and a detailed parts list.

**Reader's Circuit.** Both early and contemporary design concepts are combined in the interesting AM broadcast band receiver circuit illustrated in Fig. 7. Submitted by William J. Wolf (3543 Dubarry Rd., Indianapolis, IN 46226), the circuit features a reflex front-end, an IC op amp audio amplifier and a Darlington power output stage. Old timers probably will re-
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Fig. 6. 40-watt audio amplifier featuring a VMOS transistor output stage.

member the reflex circuit concept with a touch of nostalgia. Popular in the early to middle 50's, when good quality r-f transistors cost as much as fifty dollars each (pre-inflation dollars, at that!), the reflex circuit permits a single device to amplify two different signals—r-f and audio—simultaneously.

In operation, r-f signals picked up and selected by tuned circuit $L1$-$C1$ are applied to $Q1$, serving, initially, as an r-f amplifier. An amplified signal is developed across r-f collector load $L2$ and coupled through $C3$ to a detector network consisting of $D1$, $R2$, $D2$ and r-f bypass $C2$. The resulting demodulated (audio) signal also is applied to $Q1$, now serving as an audio amplifier and developing an amplified signal across the audio collector load, $T1$'s primary winding. The RFC ($L2$) acts virtually as a short as far as audio signals are concerned. The audio signal is next coupled through gain control $R3$ and dc blocking capacitor $C4$ to op amp $IC1$, which serves to drive the final power output stage, Darlington connected pair $Q2$-$Q3$. A PM loudspeaker, shunted by $R9$, serves as the output load. Inverse feedback is provided across the power output and driver stages through $R8$ to minimize distortion and optimize overall performance. Reflex amplifier ($Q1$) base bias is furnished through $R1$, the op amp's offset biases through $R5$ and $R6$ with, finally, the Darlington receiving its base bias directly from $IC1$ through current limiting resistor $R7$, bypassed by $C6$. Circuit operating power is supplied by $B1$, controlled by $S1$.

Except for the hand-wound loop antenna coil, $L1$, William has specified standard, readily available components in his design. Transistor $Q1$ is a general purpose pnp device similar to Radio Shack's type RS-101, $IC1$ is one section of an inexpensive type LM3900 quad op amp, $Q2$ and $Q3$ are hobby-grade type 2N3055 nnp power transistors, and $D1$ and $D2$ are general-purpose diodes similar to types 1N34 or 1N60. A 2.5-mH RFC is used for $L2$, while $T2$ is a small 10-k to 2-k interstage audio transformer similar to Radio Shack's No. 273-1378. Tuning capacitor $C1$ is a standard 365-pF unit and all other capacitors are low-voltage disc ceramics except for $C4$, which is a 15-volt electrolytic. The fixed resistors are all one-quarter or one-half watt types. Any standard PM loudspeaker with an 8- or 16-ohm voice coil may be used as the output device. The power switch, $S1$, is a spst toggle, slide or

Fig. 7. Broadcast band receiver has reflex front end and IC op amp audio amplifier.

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rotary type, with the power pack, B1, made up of six series-connected size "C" or "D" flashlight cells. William describes L1 as a loop antenna consisting of 16 turns of #22 solid copper insulated hook-up wire tapped at 12 turns and close-wound on a wooden frame measuring 10 in. high by 13 in. long by 3 in. wide.

Although neither layout nor lead dress should be critical when duplicating the circuit, good wiring practice should be followed, with signal carrying leads kept short and direct, heat sinks provided for the power transistors (Q2 and Q3), and all dc polarities observed. The reader suggests that the entire circuit, including the loudspeaker and power pack, can be assembled conveniently within the wooden frame supporting the loop antenna. Depending on Q1's individual characteristics, some experimentation with R1's value may be required for optimum performance. Some hobbyists also may wish to experiment with the number of turns on the loop antenna coil or with C1's value to obtain coverage of other radio bands. If desired, a multiple tapped coil and suitable selector switch can be provided for multi-band operation.

Device/Product News. Suitable for use in instruments, audio systems, controls, and similar analog applications, a new low-cost dual operational amplifier with a unity gain bandwidth over 2.5 MHz has been introduced by Motorola Semiconductor Products, Inc. (P.O. Box 20912, Phoenix, AZ 85036). Designated types MC4558/MC4558C, the new devices are offered in round metal cases as well as in ceramic and plastic 8-pin MiniDIP's. Internally compensated, the new op amps feature a typical large-signal voltage gain of 200 V/mV at 25°C and a CMRR of 90 dB. The two amplifiers within each package are closely matched with respect to both gain and phase, and both are protected against load short circuits.

If your requirements are for a quad rather than dual unit, you should be interested in the RC/RM4156 announced recently by Raytheon Semiconductor (350 Ellis St., Mountain View, CA 94040). Supplied in plastic or ceramic 14-pin DIP's, the op amps are short-circuit protected and feature a minimum unity gain bandwidth of 2.8 MHz.

The Fairchild Camera and Instrument Corp. (LSI Group, 464 Ellis St., Mountain View, CA 94042) is now offering a new dynamic bipolar 4096-bit random access memory (RAM) designed for operation on a single 5-V dc supply. Two versions of the new RAM are in production. Both are organized as 4096 x 1 bits and have a power consumption of 350 mW active, 70 mW standby, and 500 mW in page mode. The standard 93481 has a maximum access time of 120 ns with a 280-ns cycle time, and a page mode access and cycle time of 75 ns. The faster version, type 93481A, has a maximum access time of 100 ns with a 240-ns cycle time, and a page mode access and cycle time of 65 ns. Manufactured using Fairchild's Isoplanar Integrated Injection Logic process, the new RAM's are TTL compatible and are supplied in standard 16-pin ceramic DIP's.

National Semiconductor Corp. (2900 Semiconductor Drive, Santa Clara, CA 95051) has developed a new single-chip IC containing a pair of monolithic npn transistors matched to within 50 µV of each other. Identified as type LM194, the matched pair has a noise figure so low that it is virtually immeasurable and features a minimum current gain of 500, a current-gain match of better than 2%, a CMRR of better than 120 dB, and a low drift of less than 0.1 µV°C. With a maximum collector-emitter voltage rating of 40 V and a maximum power dissipation of 500 mW, the LM194 is supplied in a 8-lead TO-5 style metal case.
USING LED'S AS LIGHT DETECTORS

Light emitting diodes have many applications including status indication, digital readout, signal isolation, and light-beam communication. But did you know LED's can also be used as light detectors?

You can easily demonstrate the photosensitivity of a LED by using the simple circuit in Fig. 1. An infrared emitting LED such as the Texas Instruments TIL32 is connected directly to the terminals of a 0-50 microampere meter. This forms a photovoltaic circuit, and when the LED is placed near a desk lamp or other bright light source, the meter will indicate a photocurrent of at least 10 or 15 microamperes.

Though gallium-arsenide infrared emitting diodes make the best light detectors, visible emitters made from gallium arsenide phosphide, gallium phosphide, and other materials also work. For best results, use LED's with clear encapsulants. Remember that just as LED's emit a narrow spectrum of light, they are sensitive to relatively narrow wavelength bands. Thus a green emitting diode will detect green light better than a red emitter; and infrared emitters will detect infrared far better than visible emitters.

LED's operated as detectors have several very practical applications. For example, an optoisolator can be made by mounting two infrared emitting diodes at either end of a short length of heat shrinkable tubing. The resulting op-...
upper electrode wire. Then insert some clear epoxy, the fiber, and secure the fiber in place until the epoxy has cured. Figure 2 shows how two LED's are coupled together using this method.

Another possible application for a LED in the detector mode is to monitor the light intensity arriving from the sun or artificial sources at the face of a seven-segment LED display. An unused decimal-point LED could be used as the light detector for a circuit which could automatically control the brightness of the display.

The most intriguing application for LED's operated as detectors lies in the field of light-beam communications. One problem with light-beam communicators designed to operate through the atmosphere is optical alignment. (The most perplexing problem, of course, is the atmosphere itself.) Conventional light-beam communicators with separate LED transmitters and photodetector receivers must use two lens systems or complicated optics which allows both to use the same lens or lenses.

LED-LED communicators, however, need only one lens per transceiver. Then when the transmitter of one unit is aligned with the receiver of a second unit, the transmitter of the second unit is automatically aligned with the receiver of the first.

**A Practical LED-LED Transceiver.** The block diagram for a basic amplitude-modulated light beam transceiver using a single infrared LED as both a

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source and a detector is illustrated in Fig. 3. The circuit consists of a preamplifier, amplifier, LED driver and a switching network to switch the LED from the input of the preamplifier (receive mode) to the output of the driver (transmit mode). Several years ago I described a LED-LED communicator patterned upon this basic design in Popular Electronics ("Communicate Over Light Beams with the First Single-LED Transceiver," March 1974, p. 66). While this transceiver worked quite well, it used a relatively large audio amplifier module.

Figure 4 is the circuit diagram for a more up-to-date LED-LED transceiver made with an LM386 audio amplifier IC. Thanks to the LM386, the new circuit is much smaller and somewhat simpler than the original version. Also, the new circuit incorporates a simplified one-transistor modulator, a single 8-ohm speaker which doubles as a microphone, and a 9-volt battery.

I have assembled a working version of the circuit in Fig. 4 and installed it in a miniature bakelite cabinet measuring 3-1/4" x 2-1/8" x 1-1/8" (8.26 x 5.4 x 2.86 cm). There isn't enough room here to include all the construction details, but here are a few assembly tips: Use a perforated board measuring 2" x 1-15/16" (5.08 x 4.92 cm) to leave room for the 9-volt battery. Remove the upper two corners of the board to make room for the cabinet's cover screws. A 2" speaker fits perfectly in the space between battery and the upper end of the cabinet. All the components except the LED can be installed in a circle on the circuit board around the base of the speaker. The 4pdt switch fits between the upper two cover screw receptacles. Because of the limited space, the switch handle will have to emerge from the side of the cabinet opposite the front of the speaker.

Use a miniature phone jack to connect the LED to the circuit. Besides providing an automatic on-off switch, this will allow you to experiment with various kinds of LED's. It will also let you place the LED some distance from the circuit and simplify experimentation with different lenses.

I've used the transceiver in Fig. 4 for communications through the atmosphere and a fiber optic cable. Results with a 10-meter (32.8') length of glass fiber with an attenuation of a few hundred dB per kilometer were excellent. This cable should soon be available from some of the firms which specialize in experimenters' electronics components. Until then, you can try high-loss plastic fibers or stick to the atmosphere.

SUPPRESSING BLOWER HASH
Q. I built the CB converter described in the October issue and have installed it in a 1976 Plymouth Fury. However, the blower fan motor (for air conditioning, heating, and defrosting) creates so much static that it is impossible to operate it and the converter simultaneously. I do not have this problem when I use the AM/FM radio "straight through." Can you suggest a filter that will suppress this interference?—W. B. Grandjean, Baton Rouge, LA.

A. I recommend the installation of 0.25-μF coaxial capacitors across the terminals of each blower motor. The capacitor will act as a short circuit to the r-f hash generated by the sparking at the motor brushes, but will not affect the system from a dc point of view. The capacitors can be obtained from most auto supply houses, and can also be used to silence noisy gauges and sender units. Be sure that the case of the converter and the shield of the antenna lead-in are well grounded.

FM STATION ListaTings
Q. I would like to obtain a listing of FM radio stations. Do you know where I could get one?—Mrs. Don Ginest, Lakin, KS.

A. As I recall, a very comprehensive list of FM broadcasters is offered by the Worldwide TV-FM DX Assoc., Box 163, Deerfield, IL 60015. Also, there's a listing in North American Radio-TV Station Guide, by Vane A. Jones, published by Howard W. Sams & Co.

NIXIE INTERFACE
Q. How can I trigger 170-volt Nixie tubes with the 12- to-14-volt "digit enable" pulse from a 5313 clock chip?—LeRoy Lee, Altus, OK.

A. I think the most inexpensive way to do this is to have the digit enable pulses turn on high-voltage npn switching transistors. These in turn would apply the high voltage to the individual tubes. A suitable transistor is the Motorola HEP S0027. It has a collector-to-emitter breakdown voltage rating of 300 volts, maximum collector current of 500 mA, and a typical cut-off frequency of 50 MHz. However, if you go this route, be sure to include current limiting resistors at the base and collector of each transistor. Of course, some chips provide BCD outputs which can be decoded by suitable IC decoder/drivers. For example, the 7441 is specifically designed for use with Nixies.

TTL VS. CMOS
Q. The circuit for the "Westminster Chime" clock (November 1976) uses CMOS IC's. Is it possible to use TTL IC's in place of them, or a mixture of the two?—Murray Voakes, Essex, Ontario.

A. Although similar CMOS and TTL gates and sequential logic circuits perform the same functions—a CMOS 2-input NAND gate is logically equivalent to a TTL 2-input NAND—there are differences in input and output impedances, drive capabilities, operating voltages, etc. The great advantage of TTL over CMOS is operating speed. However, CMOS has it all over TTL in the areas of power consumption at slow speeds and noise immunity when higher operating voltages are used. In this application, switching speeds are low enough to allow CMOS to run significantly cooler than TTL. This means that a smaller power supply can be used. In fact, CMOS is becoming so popular that several manufacturers are offering MOS devices that have the same pinouts as the 7400 TTL series. This allows one to convert from TTL to CMOS with a minimum of pc board modifications. So I really don't see going TTL or hybrid in this circuit. Surplus CMOS is inexpensive, an all-CMOS design requires no level interfacing, and power supply demands are greatly reduced. As a final note, many CMOS devices are now zener diode "clamped" and won't self-destruct when you touch them!
Logic Probe 1 is a compact, enormously versatile design, test and troubleshooting tool for all types of digital applications. By simply connecting the clip leads to the circuit's power supply, setting a switch to the proper logic family and touching the probe tip to the node under test, you get an instant picture of circuit conditions.

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MAY 1977
KENWOOD MODEL TS-820 TRANSCEIVER

All-band hf transceiver has operating versatility and built-in speech processor.

Although Kenwood's new Model TS-820 160 - through - 10 - Meter SSB/CW amateur transceiver physically resembles its popular Model TS-520, the two are very different in terms of circuit design and built-in features. Also, the TS-820 can accommodate an optional digital frequency readout, whereas the TS-520 cannot. Other new features (discussed later) clearly make the new transceiver Kenwood's "top of the line."

The transceiver is housed in a rugged, gray-finished cabinet that measures 13-3/16" D × 13 1/4" W × 6" H (33.5 × 33.3 × 15.3 cm). A versatile (110- or 220-V, 50- or 60-Hz) ac power supply is built-in, as well as a small loudspeaker. A handle on the right side of the cabinet provides a means for carrying the 35.2-lb (16-kg) transceiver. The basic TS-820 transceiver is priced at $830. The optional DG-1 digital frequency readout, which mounts inside the TS-820's cabinet and can be added at any time, is $170. Other options include the CS-820-20 500-Hz CW crystal filter ($45), the DS-1A dc/dc converter for mobile use ($59), and the VFO-820 external vfo ($139).

General Description. The transceiver circuitry is solid state, except for a 12BY7A driver and two S-2001A (a pin-for-pin 6146B equivalent) final amplifier tubes. The usual complement of transmitter and receiver tuning controls is provided. The multi-function, switch-controlled meter indicates final amplifier plate current or voltage, relative r-f output, alc circuit operation, compression level from the built-in r-f speech processor, and S units.

When the MODE switch is set to TUN or FSK, power input to the finals is automatically reduced so that the tubes' rated plate dissipation is not exceeded. The r-f speech processor is activated by pulling out the COMP LEVEL/PROC control. The amount of the compression (indicated on the meter) is adjusted by rotating this control.

The transmitter pi network and transceiver preselector controls are grouped together. The PLATE tuning control uses a vernier for easy adjustment. The LOAD control is concentric with a FIX CH switch that selects any one of four crystal-controlled channels in the FIX mode (crystals optional).

The center-detented IF SHIFT control is concentrically paired with the receiver incremental tuning (RIT) control, the latter activated by a pushbutton. The CW car level and SSB mic gain controls are also paired, as are the RF GAIN and AF GAIN controls. An RF ATT push-button switch inserts a 20-dB attenuator at the receiver's antenna input to combat overload and desensitization by strong local signals.

The BAND switch has positions for all amateur bands between 1.8 and 29.7 MHz, as well as JY/WWV (reception only) on the 15- to 15.5-MHz band. The 10-Meter band is covered in four 500-kHz segments. (There is also a position on the BAND switch labelled AUX, which apparently can be used for operations outside the regular ham bands, although the manual does not mention it.)

The function switch is normally left in the VFO position to allow the internal vfo to control the transceive frequency. When set to FIX, both frequencies are controlled by internal crystal oscillators, with up to four frequencies selectable by the FIX CH switch. The VFO:R position uses the internal vfo to control the receiver's frequency, while the FIX:R position puts the receiver under crystal control and the transmitter under vfo control. When either the transmitter or the receiver is on vfo control, the FIX and RMT positions are used with the AUX crystal-controlled channels of the remote vfo to zerobeat the vfo to channel frequency.

A separate HEATER switch is provided to shut off the tube heaters when the transceiver is used for reception only. All VOX controls are mounted on the front panel for ready access. Because the VOX circuit controls the changeover relay on CW (semi-break-in) as well as SSB, it is most convenient to have the DELAY control up front for easy adjustment as conditions warrant.

The large tuning knob operates two circular dial scales, one calibrated at 1-kHz intervals (numbered every 10 kHz), and the other calibrated at 50-kHz intervals and numbered from 0 to 500 every 100 kHz. The dial index can be moved to calibrate the scale against the 25-kHz marker oscillator or WWV. The dial setup uses Kenwood's "mono-scale" kilohertz dial system which fits the full 500-kHz tuning range on a single small dial with 1-kHz calibration intervals. The scale is rotated 10 turns for edge-to-edge coverage of each band segment.

When the optional digital frequency display is installed, as it was on our test model, the fluorescent readout appears in a window above the mechanical dial scales. Above the numeric display are four LED's that indicate when the ATT (attenuator) is on and when FIX, VFO, and RIT functions are active.

A button labelled DH (display hold) permits the numeric display to be "frozen" to store a frequency for quick retuning. When the display is frozen, you can tune about using the mechanical dial. To return to the original frequency, you simply note the counter display, release the DH button, and tune until that number again appears in the display.

The single-conversion receiver has an 8830-kHz f-f. A phase-locked-loop (PLL) circuit gives the benefits of both single and multiple conversion with few of the disadvantages of either. The local osci-
The built-in audio input signal is applied to a balanced modulator operating at 455 kHz and is then passed through a filter to remove one sideband. The remaining sideband is compressed—not limited—by an agc amplifier. It is further filtered to remove distortion products beyond the desired modulation passband, down-converted to audio, and finally applied to the main balanced modulator of the transmitter.

Some 10 dB of r-f negative feedback is used in the driver and output stages to reduce odd-order IM products by 6 to 10 dB. This makes the signal unusually clean and free from splatter that could interfere with QSO's on nearby frequencies. Alc is also used to prevent driving the output tubes into nonlinearity.

The optional digital frequency display module counts the frequency to the nearest 10 Hz, then rounds off and displays the operating frequency to the nearest 100 Hz. Accuracy of the display is guaranteed to be 1 ppm/month.

**Transmitter Tests.** On 80 Meters, a two-tone test resulted in 200 W PEP input to the final amplifiers. PEP output into a 50-ohm dummy load was 115 to 120 W. Key-down CW input power measured 165 W, and CW output 100 to 110 W. On SSB, carrier suppression varied from 53 dB (LSB) to 58 dB (USB). The unwanted sideband was 60 dB down when a 1000-Hz modulating signal was applied. Distortion products measured as follows: third order -32 to -34 dB referenced to the two tones, -38 to -40 dB referenced to PEP; fifth order -56 dB referenced to the two tones, -62 dB referenced to PEP. An audio input of 1 mV at 1000 Hz was sufficient to fully modulate the transmitter on the 7-MHz band.

The r-f speech processor produced some interesting results. A sustained "Ahhh" driving the transmitter to full PEP yielded an average power output of 10 W when no compression was applied. With 20 dB of compression (as indicated on the transceiver's meter), the average power output increased to 40 W. Peak power remained at the same level with or without compression. This translates to a 6-dB increase in "talk power," equivalent to an increase of one "ideal" S unit at the receiving end. This increase is nearly equivalent to switching in a 1000- or 1200-W PEP linear.

Of course, the processor (like all processors) introduced some a-f distortion and degraded the unwanted sideband suppression. At a modulating frequency of 1000 Hz, and at 10 dB of compression, the second harmonic of the modulating frequency was 30 dB down-equivalent to 3.2% of distortion. Unwanted sideband suppression measured 50 dB. At 750 Hz, the second harmonic measured -28 dB (4% distortion) when 10 dB of compression was introduced. The third harmonic (2250 Hz) was 20 dB down (10% distortion), and unwanted sideband suppression measured 30 dB. When a 500-Hz tone was used to modulate the transceiver, the unwanted sideband suppression improved to -35 dB. Finally, when a 400-Hz modulating tone was applied, the second harmonic measured -40 dB (1% distortion) at 10 dB of compression. The third harmonic was 10 dB down (32% distortion), and the unwanted sideband suppression measured 25 dB.

Alc action was very good. Flat-topping simply did not appear, even at maximum alc. Audio response measured (at the 6-dB points) 325-2800 Hz (USB) and 240-2700 Hz (LSB). When the speech processor was used, the response was slightly altered. Maximum VOX release time was approximately one second. When the release was shortened to allow semi-break-in CW keying, no shortened first dot or dash occurred. That is the exception, rather than the rule, among today's amateur rigs.

To check the transceiver's frequency stability (rated at better than 100 Hz/hour after a one-hour warmup and less than 1000 Hz of drift in the first hour after a one-minute warmup), the transceiver was attached to a dummy load and placed in the TUNE mode at 7 MHz, yielding an r-f power output of about 15
The frequency of this output signal was measured by coupling a frequency counter to the dummy load. After a brief stabilization period (much less than the allowable hour), the drift averaged about 96 Hz/hour for the next few hours. The final transmitter test we performed was the measurement of r-f harmonics at the antenna output jack. They were consistently 40 dB below the fundamental.

**Receiver Tests.** Results of our measurements of sensitivity, image rejection, i-f signal rejection, and I-f gain in band-to-band gain appear in the Table. Note that sensitivity measurements at these very low signal levels are usually accurate to within ±3 dB. However, even within this margin, the TS-820’s receiver tested extremely “hot.” A 50-µV signal (nominal) was required for an S9 meter reading; a 1-µV signal produced an S2.5 reading. Inserting the r-f attenuator in the input line (by means of the front panel pushbutton) dropped signal levels 20 dB. The receiver incremental tuning varied the receive frequency ±3000 Hz. Unwanted sideband rejection measured 60 dB at 1000 Hz and 50 dB at 500 Hz.

No crossover birds were found when signals below 10,000 µV were applied to the input. Internal spurious signals measured 0.2 µV (equivalent) at 21,200 MHz and less than 0.1 µV (equivalent) at 2 and 21 MHz. Two 320-µV signals (−57 dBm, or 70 dB above the SSB sensitivity) spaced 25 kHz apart created third-order IM (intermodulation) products equivalent to the rated sensitivity (0.1 µV for 10 dB (S+N)/N). An undesired 32,000-µV (−17 dBm) signal 110 dB above a 0.1-µV desired signal desensitized the receiver by depressing the desired signal 1 dB. The receiver section was very resistant to blocking (overload). No loss of output level or increase in distortion was detected when input signals of up to 100,000 µV (−7 dBm) were applied.

When the r-f input signal varied from 0.1 to 1 µV (a 20-dB change), the audio output rose 18 dB. When the input signal was raised from 1 µV to 10 µV, the agc came into play and the audio output rose only 1 dB. A 100-db change in r-f (from 1 to 100,000 µV) caused the audio output to increase only 2 dB. Release time from an S9 signal level to full recovery was approximately 0.75 second when the agc switch was in the FAST position and 4.5 seconds in the SLOW mode.

Nominal overall response—which included the i-f passband and audio responses—measured as follows: 400 to 2150 Hz at −6 dB, 200 to 3525 Hz at −60 dB (USB); 275 to 1850 Hz at −6 dB, 75 to 3300 Hz at −60 dB (LSB); 700 to 1250 Hz at −6 dB, 335 to 1685 Hz at −60 dB (CW). These measurements were made below the agc threshold. The differences between USB and LSB are easily explained by the fact that the frequency of the carrier oscillator feeding the balanced modulator is deliberately shifted for proper generation of USB and LSB signals. It is the change of the relationship between the skirts of the fixed crystal filter and this carrier oscillator that causes different overall responses in the USB and LSB modes. However, in both modes the unwanted sideband suppression was 60 dB at 1000 Hz and 50 dB at 500 Hz.

The transceiver produced 1.5 W of audio output into 8 ohms. A 1000-Hz sine wave was used for this test, and at the start of clipping total harmonic distortion was less than 2%.

In our final receiver test, we applied a pulse train composed of 0.0005-µs-wide pulses at a 60-Hz rate. This pulse train (at 100 dB above 1 µV/MHz bandwidth) completely obliterated a 3-µV input signal. A 10-µV signal was depressed by at least 10 dB due to agc capture by the noise pulses. However, when the TS-820’s noise blanker was activated, normal agc action was restored and undisturbed copy of even 0.1-µV signals became possible! But the blanker had no effect on low-level pulses (less than 50 dB above 1 µV/MHz bandwidth).

**On The Air.** With few exceptions, we confined our on-the-air testing to the 7-MHz band. Operation was equally divided between SSB and CW. During the weeks we operated this transceiver, we never felt the need to use our linear.

It seemed as natural to scan the bands with the digital numeric frequency display as it was to observe the position of a dial scale against an index line. Let us assure anyone who is not ready to make the added investment in the digital display that the mechanical dial is accurate to within about 100 Hz of the digital display.

We were pleased to note that the transceiver can be tuned with its own meter, and modulated within the maximum limits defined by its alc meter scale without compromising performance. The front-panel VOX controls proved to be rock stable. On CW, the delay could be set so that the transmitter would drop out between characters below 20 wpm and between words at higher speeds. This is not really QSK (full break-in keying), but it’s pretty close! Both the keying and modulation received numerous unsolicited compliments from stations contacted. Only rarely useful on SSB, the r-f SHIFT proved to be valuable on CW. It let us move QRM off the skirts of the 500-Hz filter to the point of inaudibility, without changing the pitch of the desired signal.

During our tests, an idling truck blanketed us with ignition noise at S9. Switching in the noise blanker effectively eliminated—not just reduced—the interference! This was a most impressive demonstration, which left us regretting that the blanker could not dispose of types of noise other than impulse noise.

In actual QSO’s, we verified that the r-f speech processor gave a one to two S-unit improvement in signal strength. However, the processor does cause some signal distortion. Thus, the processor should be used (and is intended for use) only under conditions that warrant it. Under strong-signal conditions, all speech processors impair intelligibility to some degree. On the other
hand, when the going gets tough, a good processor like the one in this transceiver can make the difference between contact and no contact.

No sound at all could be heard from the transceiver’s cooling fan. The “silent” fan’s cooling effectiveness was undeniable, however. After almost two hours of either SSB or CW operation, the cabinet was cool to the touch everywhere except directly above the final tubes, where it was faintly warm.

The TS-820 is certainly a full-feature all-band ham transceiver. The only gripe we do have concerns the top-facing speaker, which managed to lose much of its meager output in our acoustically treated ceiling. For fixed-station operation, the owner would do well to connect an external speaker to the rear-panel output jack.

In sum, the TS-820’s versatility and fine performance and the obvious top craftsmanship that has been spent on its design will fill any ham with pride of ownership. If we had to pick the most attractive feature among so many admirable ones, it would be the “digital hold.” With this “memory” function, we’ll never again fail to return exactly to a QSO frequency after a brief listen off-channel.

MURA MODEL PRX-100 “PRM” CB MICROPHONE

Peak-redistribution modulation effectively increases signal power.

The MURA PRM microphone contains a conditioning system that redistributes the asymmetrical sharp-peak portions of speech to make the signal more symmetrical. At the same time, it also holds down the peaks to allow the lower-energy components of the signal to be effectively higher in energy than would be possible with a “straight” microphone. This peak-redistribution modulation (PRM) is accomplished electronically by delaying the large sharp-peak components of the signal for minute amounts of time in relation to the lower-energy signals before passing them on to the transmitter’s modulator. The result can be an effective average modulated signal without adverse distortion.

One of the new PRM microphones for CB use is the push-to-talk Model PRX-100. It has a gain control for setting up the optimum output level for any particular CB transmitter according to the operator’s voice amplitude. (The microphone cannot be used with certain CB transceivers on the market. These are detailed by manufacturer and model on the card on which the microphone is packaged.) Operating impedance is 0 to 2500 ohms. Power for the microphone system is obtained from an internal 9-volt battery. Price is $39.95.

Test Results. We checked the Model PRX-100 with the aid of a dual-trace oscilloscope to observe simultaneously the output of the transducer cartridge and the conditioned output signal from the PRM circuit. Asymmetry at the cartridge was demonstrated with the maximum sharp-peak excursions in the positive direction. The conditioned output still produced some asymmetry, but in the opposite direction and to a lesser degree. However, the peak ratios, compared to the in-between lower-energy components, were reduced sufficiently to permit an overall higher average output level which potentially increased the average power of the modulated signal.

We also made comparisons with other microphones and with different voices. We noted that less improvement was obtained when compared to the output of the poorer-quality microphones than was the case with better units. (Lower-quality, less-expensive microphones usually exhibit their best symmetry, with lower positive/negative-peak ratios.) It should be noted that the advantages gained by using a PRM microphone apply mostly to limited-level amplifying or modulating systems in which operation is below the overload or clipping level. Systems that employ clippers or some form of automatic modulation control (amc) generally tend toward symmetry and higher average signal levels.

MAY 1977
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B&K PRECISION MODEL 1471B OSCILLOSCOPE

Has dual-trace and trigger functions desirable in testing modern circuits.

A GOOD general-purpose oscilloscope for servicing and electronics experimenting should have a linear triggered sweep with a broad selection of sweep rates and triggering sources. It should also have two independent traces to permit observation of both the input and output signals of a circuit under test. Moreover, its vertical amplifiers should have sufficient bandwidth and sensitivity to enable the user to work with high-frequency signals with very low and very high amplitudes. The vertical amplifiers should be dc coupled to permit the scope to double as a voltmeter, and both amplifiers should have identical characteristics to permit the instrument to be used for a vector display. Finally, if the scope is to be used in TV servicing, it should have provisions for frame and line sweeps to serve as a vectorscope for chroma alignment.

All of these characteristics can be found in B&K Precision's Model 1471B dual-trace oscilloscope.

The scope measures 16"D x 9.6"W x 7.7"H (40.4 x 24.5 x 19.6 cm) and weighs 18 lb (8.2 kg). Price is $495.

General Details. Each of the vertical amplifiers in this dual-trace solid-state oscilloscope has a bandwidth that goes from dc to at least 10 MHz, risetime of 35 ns, 3% or less overshoot and ringing with a 100-kHz square-wave input, and 1 megohm paralleled by 22 pF input resistance. The deflection factor of the vertical amplifiers is from 0.01 volt/cm to 20 volts/cm in 11 calibrated ranges, fully variable between range settings.

Either amplifier (trace) can be selected separately, or the scope can be operated in the dual-trace (simultaneous display of both channels) mode. In the dual-trace mode, the traces are chopped at a 200-kHz rate at all sweep rates up to 1 ms/cm, while alternate-trace operation is automatically switched in for all faster sweep rates. Channel separation in the dual-trace mode is better than 60 dB at 1000 Hz.

The sweep circuit shared by both...
channels can be automatically triggered without an input signal to the scope. The sweep range is from 1 μs/cm to 0.5 s/cm, with full variability between ranges. In addition, the sweep can be magnified 5×, yielding a maximum sweep speed of 0.2 s/cm. There is less than 3% (typical) horizontal linearity distortion.

The switch-selectable sweep triggering can be either internal or external and from the channel in use. (Channel A is selected in the dual-trace mode.) At almost all levels, either the positive or the negative slope of the input signal can be selected to initiate the triggering. Alternatively, the triggering can be automatic. The sweep can be triggered from 20 Hz to better than 10 MHz in the internal mode (1-cm deflection on the CRT's graticule) or dc to 10 MHz from an external trigger signal. A built-in sync separator is provided to permit observation with high stability of any portion of a complex TV waveform.

The horizontal amplifier can be accessed through the channel-B connector on the front panel of the scope and is selected by one position on the sweep speed control when the instrument is in the vectorscope mode. The horizontal amplifier then has a deflection factor of from 0.01 volt/cm to 20 volts/cm, which is the same as that of the vertical amplifier, and a frequency response from dc to 1 MHz.

Intensity modulation on the Z axis is available via a TTL-compatible connector on the rear panel of the scope. A logic low increases trace brightness, while a logic high decreases the brightness. The input resistance to the Z axis is 10,000 ohms.

The scope features a 5" (12.7-cm) flat-screen CRT. Over the face of the CRT is an 8 × 10 cm blue-colored engraved graticule. The bezel that holds the graticule in place can be removed easily to allow insertion of the vector overlay needed for color TV alignment. A 1-volt p-p square-wave source permits checking and calibration of the vertical amplifiers without having to use external sources.

User Comment. The Model 1471B oscilloscope is an excellent general-purpose instrument. Calibration was originally performed with a very accurate external voltage source. After operating the scope for six hours a day over a period of two weeks, we again calibrated the scope and found it to be still "on the head."

During our in-service tests, we determined that the scope's sync holds up under even very-low-level and relatively high-frequency signals. The trace was steady, and we experienced no trace break-up in the chop mode. The light blue color of the graticule was very easy on the eyes and permitted relatively long term waveform observation without causing optical fatigue.

All controls on the scope are clearly identified, the knobs are shaped and sized for comfortable user "feel," and the controls have positive, smooth action. The combination tilt stand/carrying handle features a solid locking mechanism in both the carry and tilt positions.

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PERSONAL COMPUTING/167 Corey Road, Brookline, MA 02146, USA
DEBUGGING AIDS

WHAT DO you use your computer's front panel for? Loading programs into memory, monitoring their execution, altering their execution with the sense switches, single-stepping the program to find errors ("bugs"), changing memory locations, and troubleshooting hardware are some examples. Last month, the role of monitor programs such as Motorola's Mikbug in performing routine computer operation tasks was described here. It should have been apparent that the use of a monitor for such functions is far more convenient than using a traditional front panel. But what about non-routine, troubleshooting tasks such as tracing the execution of a new, untried program or locating a hardware malfunction on a new board? Many hobbyists feel that a control panel is indispensable in such situations. Let us examine how monitor software can be used to perform even these "debugging" functions more effectively than a front panel.

**Breakpoints.** Assume that you have just finished writing a relatively complex program of 200 instructions in machine language and are ready to test it. First you load it into memory, hopefully using a monitor and keyboard. After loading by hand, you save the program on tape just in case it wipes itself out in memory as errant programs often do. Then using the monitor's "G" command you execute the program. Chances are it does not execute properly. In fact, it's probably not even close. At this point debugging begins, which can take considerable time without good debugging tools.

If you have an Altair, Imsai or other front-panel oriented computer you will probably single-step your way through the program in an effort to find out where it goes awry. This means simply that the computer is placed in a single-step operating mode where every operation of the "single-step" switch causes exactly one machine cycle to be executed. Generally, as each cycle is executed, you can see in the console lights the memory or input/output address referenced by the cycle and the data transferred. Additional status lights identify the type of cycle out of about a half-dozen possibilities. However there are many things that the panel lights fail to show. For example, when executing an "add register B to register A" instruction in single-step mode, you will only see the memory address of the instruction and the operation code, 200 in octal. You will not see the contents of register A, register B, or the result of the addition. Even the condition flags such as overflow are hidden from view. Obviously the panel is of limited value if you think the root of a particular bug lies in incorrect register contents or if there is an uncertainty as to what a specific instruction does. If this information is critical (as it often is), you must temporarily modify your program to store the necessary data into memory and then halt so that it may be examined.

Another often encountered difficulty is that single-stepping through a loop a dozen times to catch an error that occurs on the thirteenth iteration can take a long time. If the problem occurs on the 387th iteration it would not even be practical to single-step. Again the program must be temporarily modified to make it halt close to the error condition. Such temporary patches are called "breakpoints."

Many monitors have commands or functions that make inserting and keeping track of breakpoints much easier. A command like "3:213B" might insert a breakpoint at location 213 in page 3 (octal notation). What would actually happen is that the monitor would first look at the indicated address and save whatever was there. Next it would store a CALL instruction in the same location which would transfer control to a "breakpoint subroutine" in the monitor. This monitor

```
TEST OF DOUBLE PRECISION SUBTRACT

001:000 006 123
001:002 016 156
001:004 026 356
001:006 036 312
001:010 315 000 003
001:013 311

MVI B,123Q
MVI C,156Q
MVI D,356Q
MVI E,312Q
CALL DSUB
RET

SET DE TO 356:312 = -4405 DECIMAL

DOUBLE PRECISION SUBTRACT REGISTERS B AND C FROM D AND E WITH RESULT PLACED IN D AND E

MOV A,E
SUB C
MOV E,A
MOV A,D
SBB B
MOV D,A
RET

DO THE SUBTRACTION
RETURN TO THE MONITOR

DSUB

MOV A,E
SUB C
MOV E,A
MOV A,D
SBB B
MOV D,A
RET

SUBTRACT LOWER BYTES
MOVE RESULT INTO E
SUBTRACT UPPER BYTES
MOVE RESULT INTO D
RETURN
```
routine prints the contents of all registers and the condition flags.

Now that the breakpoint is set up, the program would be entered with the normal "G" command. When it got to the "CALL BREAKPOINT" instruction that was inserted, the registers and flags would be printed. After the printout, the monitor would be waiting for another command. When the breakpoint is no longer needed, an "E" command might erase the breakpoint and restore the instruction it saved.

A more sophisticated monitor could allow multiple breakpoints. It would automatically keep track of the instruction displaced by each breakpoint and identify the breakpoint when the registers were printed. A really good breakpoint routine might even execute the saved instruction after printing and then automatically return to the program being debugged. In this case, a breakpoint could not be placed on top of a JUMP or CALL instruction.

A breakpoint routine can also take care of the "error on the 387th loop" problem mentioned earlier. Each time the breakpoint routine is entered, a software counter is decremented. If the counter is not zero, the program is re-entered without printing the registers. Only when the counter finally does become zero do the registers get printed—thus saving a lot of time and paper. There would, of course, be a command to set the initial value of the counter.

Some microprocessors make the task of implementing a breakpoint facility in a monitor much easier. In the 8080 a normal CALL instruction is three bytes long. When placed in a breakpoint location, the three bytes that were there have to be saved. These three bytes might represent as many as three separate instructions making the "print registers and continue" function very difficult to implement. The 6800 or 6502, on the other hand, has a one-byte BREAK instruction that seems to be custom designed for just this function.

| $002:232 123 | 3:0,3:6T | (Command to trace between 003:000 and 003:006) |
| $002:232 123 | 1:00   | (Command to start execution at 001:000) |
| $003:000 173 | A=312  B=123  C=156  D=356  E=312  H=113  L=002  SP=017:374  FLG= |
| $003:001 221 | A=130   |
| $003:002 137 | E=130   |
| $003:003 172 | A=356   |
| $003:004 230 | A=203   |
| $003:005 127 | D=203   |
| $002:232 123 (next command) |

Fig. 2. Monitor printout with trace. Underlined portion typed by user.

Software Single-Step. Although breakpoint capability in a monitor greatly simplifies the debugging of machine language programs, it is not real single-stepping. A different class of monitor routines called "trace routines" allows the software equivalent of single-stepping. It is interesting to note that some microprocessors are "dynamic" and cannot be stopped to allow the usual hardware single-step function. With these, a trace routine is the only way to get a single-step operation.

Tracing is really equivalent to putting a breakpoint at every instruction in a program. Then when the program is executed, a printout of the location, instruction, and all registers would be given for each instruction executed. This would be exactly equivalent to manual single-stepping with the bonus of a written record of every aspect of the program execution. In a machine with a lot of registers, time and paper may be saved by only printing the registers that have changed since the last printout. A useful trace feature in a monitor would allow the setting of trace limits so that only the program section of interest would be traced. A fancy trace feature might even allow multiple sets of trace limits with possibly a counter to delay the printing until a specified number of traced instructions has been executed.

How are trace routines actually implemented? One simple method is to use the interrupt feature of the microprocessor itself. With this method, a simple circuit added to the computer is activated to issue an interrupt whenever an instruction is executed. This interrupt would prohibit further interrupts and cause execution of the monitor trace print subroutine. The print routine would not re-enable interrupts until just before it returns to the interrupted program, the one being traced. This prevents the trace print routine from being traced itself. The trace limit feature is implemented by having the trace print routine check if the instruction about to be printed is within the trace limits. If it is not, printing is suppressed and a return to the program is executed. An example is shown in Figs. 1 and 2.

Another method involves interpreting the instructions of the traced program rather than executing them. An interpreter is a program that acts just like the microprocessor itself. It literally looks at the operation codes, addresses, and other components of the instruction and, through software, accomplishes the same result as the real microprocessor would have. The purpose of this is that the interpreter program may also store or print detailed information about the instructions it "executes", something the real microprocessor, of course, would not do. This technique requires much more complex software than breakpoints or trace using interrupts does but it has an important advantage. Since the interpreter routine simulates the machine, it can also simulate hardware features that the real machine may not have, such as memory protect. While debugging, the simulator would trap any instruction that attempts to jump outside of the protected area as well as any instruction that tries to write into protected memory.

Unfortunately the standard, readily available monitors in read-only memory generally do not have these debugging functions. If anything, a simple breakpoint facility is all that is offered. Specialized monitors, designed primarily for debugging rather than routine operations, on the other hand can probably do everything that has been discussed as well as other handy functions. These monitors are often found in the microprocessor manufacturer's development systems, such as Intel's MDS or Motorola's Exorciser (meaning to "exorcize" bugs) and are quite expensive. However the functions described are not difficult to implement and are certainly worth the effort needed to write them. Club meetings provide opportunities to exchange such software with fellow hobbyists.
UNCLE CHARLIE IS SNOWED-IN

They tell us that even the ladies’ room at Gettysberg is stacked high with mailbags. The FCC offices there process all Class D (now the “Citizens Band Radio Service”) license applications and, between January 1st and 26th, had received more than 832,000 new CB license applications. However, reports are that their computer facility has been working so effectively that expected delays in processing those applications which were properly filed are only two to four weeks. To the FCC’s delight, no more than 20% of applications received have included fees, which have to be returned since there is no longer a license charge.

Best estimates are that the FCC will issue more than 990,000 CB licenses in January. That represents an increase of more than 50% above the next greatest month (March 1976). The FCC believes that more than 8,000,000 new CB’ers will go on the air during 1977 and that the total number of licenses issued will exceed 16 million by the end of the year.

Total sales do not appear to account for the flood of license applications received. It appears that many would-be CB’ers are taking advantage of the fee amnesty and are being joined by many others who have been operating without a license. Also, different members of the same family are applying for their own licenses. FCC people tell me that, in many cases, a half dozen or so applications are arriving in the same envelope.

Why Were the Fees Dropped? As most of you know, the FCC handed CB’ers a nice Christmas present by suspending all fees, effective January 1st 1977. That sudden move was not entirely in the spirit of Christmas, however. It was prompted by a court decision ordering the FCC to suspend all fees until fee schedules are restructured, based upon the actual costs for issuance of licenses. In fact, they were ordered to refund all fees collected since January 1975, but don’t hold your breath in anticipation; the FCC’s records on CB licensees do not go back that far in many cases. It is likely that fees will be reestablished again within a few months, and Congress might even pass legislation which permits the Commission to charge fees to support the enforcement effort.

Some New Developments. When the fourth general meeting of PURAC was adjourned on January 27, it marked the halfway point in the advisory group’s two-year Congressional charter. Earlier that morning the meeting was opened with an address by Al Gross, the first licensed CB’er (19W-0001). He recounted all the early efforts to get CB rolling, dating back to World War II. He showed us a pocket-sized walkie-talkie which had been used by the OSS during the war. It was this tiny radio transceiver that convinced the FCC and others that there was a viable future in personal radio communications.

Based on discussions at the meeting, quick FCC action is likely on a proposal by the public safety task group that the four callsign digits, “0911”, be set aside for the exclusive use of state-level public service agencies as an emergency-aid callsign. These special calls, a “K” followed by the State’s two-letter abbreviation and the four digits “0911,” would be issued to any State applying for licensing under the National Emergency Radio Aid (NEAR) program. For example, in Connecticut the NEAR callsign to summon emergency road assistance on channel 9 would be KCT-0911.

The advisory committee was told that the FCC’s Office of Plans and Policy would soon release a radio spectrum inventory report which would study areas of the spectrum for future expansion of Personal Radio Services, including:

- A new FM band somewhere between 218 and 225 MHz.
- Future allocation of a portion of the reserved spectrum near 900 MHz.

A new band of FM frequencies at about 220 MHz (“Class E”) was first proposed nearly ten years ago; it now appears that it will be considered anew, but prospects are dim for its adoption. In contrast, the possibility of using 900 MHz for distant CB expansion is viewed more optimistically by the FCC. In any event, the FCC pronounced that the recently expanded 27-MHz band “... won’t be eliminated ... is here to stay.”

Meanwhile, how many CB’ers have considered moving up to the old Class A band around 465 MHz (now redesignated the General Mobile Radio Service)? Here you can use up to 50 watts of power and antenna heights up to 200 feet. Repeaters and automatic phone patches are permitted. It offers nearly all the features now enjoyed by the hams on the 2-Meter band. However, the equipment is several times the cost of present CB equipment.

From the “Future Needs” Task Group, Cary Hershey, a sociologist at Columbia University, made an interesting observation. In response to a question from the floor regarding the damaging effect of Smokey reports by mobile CB units, he said:

“...we have considered the ‘Smokey Syndrome’ in depth and weighed its negative effects against other factors relating to personal use radio. We have concluded that the sociological advantages to the American public in talking and listening, in direct communication with one another as opposed to all listening only to the media, far outweigh the opportunities offered a minority of criminals using CB to evade the law.”

He continued by pointing out that the more inventive law-enforcement agencies have found that the so-called Smokey Syndrome can actually assist their enforcement efforts.

In the area of “Rules Compliance,” the committees noted that rules infractions have dropped significantly. They rate the most serious violations as those involving the continued use of “liners” to exceed r-f power output limits and deliberate interference with communications. Though FCC members rate the non-use of callsigns high on their list of violations, the non-FCC members of PURAC tend to down-grade the seriousness of this violation and are examining alternate means of transmitter identification. The primary argument against the Automatic Transmitter Identification Signal (ATIS) involves the management of a data base of information on 30-million or more transmitters. This writer, who is also a data-processing consultant, believes that the FCC will eventually have

By Ray Newhall, KW6010

AmericanRadioHistory.Com
to bite the bullet and spend the money to do the job properly. It is an expensive operation.

The FCC is determined to make it very risky to operate overpowered rigs. The reason it is so up-tight about external power amplifiers (linears) is because laboratories operating in both the government and private sectors have now determined that more than 60% of all CB-caused TVI results directly from the use of these illegal devices. This is particularly true with the “cheapie” import varieties that are being sold illegally in the United States. They cause all sorts of havoc on frequencies outside of the CB band, and are illegal to manufacture, sell, or even own in this country. In spite of this, someone managed to slip a packet of sales material onto the FCC reception table at the PURAC meeting! TVI complaints, mostly CB-related, have increased more than ten-fold over the past two or three years.

It has now also been determined through extensive field tests that modern TV receivers are less susceptible than was originally thought to fundamental signals. Most TVI occurs under conditions of severe front-end overloading of the receiver, whether caused by an antenna preamplifier or by an extremely powerful CB signal. In a recent field test by the FCC’s Field Operations Bureau, where 32 randomly selected CB-related TVI complaints were examined in depth, 63% were the direct result of external power amplifiers used to boost the CB signal well above the legal limit.

Rules Simplification. I have just completed a review of the reorganized version of Part 95, as reported earlier in this column, and I find it a great improvement over the older versions. These should be readily available through the GPO by the time this column is published. The three classes of personal use radio services have been renamed under the overall designation of “Personal Radio Services” as shown in the Table listing. The 27 MHz CB service (Class D) has been designated the “Citizens Band (CB) Radio Service.” All of Part 95 required to be read and understood by a CB operator is contained in Sub-part D. This sub-part will be available as a separate publication.

The PURAC efforts to simplify Part 95 are still not complete. Work is already underway to simplify the language as well as the structure. It is expected that this work will be completed and available to the public by late summer 1977.

Legal Problems For CB’ers. As more and more CB’ers go on the air, their legal problems appear to be growing by leaps and bounds. Throughout the country, individual communities are attempting to outlaw CB by the use of local zoning or nuisance ordinances. In Connecticut, for example, there is a statute which was enacted long before CB was authorized making it illegal to operate a radiotelephone in a moving vehicle. Taxis, amateur radio operators, business radio users and commercial radiotelephone are exempted from the law, which appears to leave only CB’ers who can and have been arrested by the State Police. However, there are State Representatives who have pledged to work for the repeal of this law during the current legislative session.

But the number of legal actions which have reached the courts, involving either CB’ers or hams, has increased ten-fold within the past ten years, and a considerable amount of legal precedent is being accumulated. The Personal Communications Foundation is a new non-profit legal organization which was formed recently for the purpose of collecting and redistributing all the legal data available on such cases. Its services are free except for the actual cost of reproducing and mailing materials to those attorneys who request it in defense of a personal radio user. If you should have a legal problem, your lawyer may contact them in Lancaster, CA 93534 (805-942-0144).

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CIRCLE NO. 64 ON FREE INFORMATION CARD
Secret Shortwave Stations. If you scan the non-broadcast bands with a good, sensitive receiver for evidence of broadcast programming, you should discover, as we did last fall, a number of tropical-band harmonics in the 18–25 MHz range. Some of them are listed below. As the sunspot count picks up, so should harmonic reception, even up to 31 MHz. Whether you hear the stations listed depends on skip conditions, but there is likely to be less interference on weekends. F2 propagation peaks around noon, but sporadic E (short skip) can extend into the evening.

In regular out-of-broadcast-band tuning, you'll also find broadcast programs transmitted on SSB. Most feed the remote retransmission sites. Guyana Broadcasting Service is seldom armchair copy on 3.290 or 5.950 MHz, but when they activate 16.454 MHz, listening is easy. Radio Monte Carlo feeds Arabic programs of pop music to its MW relay on Cyprus, via 15.575 or 17.555 MHz frequently heard during the morning in North America. Chilean stations such as Radio Colo-Colo and Radio Cooperativa can be heard on 12.250, 6.6845 or 4.885 MHz at irregular hours.

<table>
<thead>
<tr>
<th>MHz</th>
<th>Harmonic</th>
<th>Fundamental (MHz)</th>
<th>Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.3298</td>
<td>4</td>
<td>6.08245</td>
<td>R. Nacional, Peru</td>
</tr>
<tr>
<td>24.024</td>
<td>4</td>
<td>6.006</td>
<td>R. Reloj, Costa Rica</td>
</tr>
<tr>
<td>24.020</td>
<td>4</td>
<td>6.005</td>
<td>BBC, Ascension</td>
</tr>
<tr>
<td>23.850</td>
<td>2</td>
<td>11.925</td>
<td>Rdf. Portuguesa</td>
</tr>
<tr>
<td>23.630</td>
<td>2</td>
<td>11.815</td>
<td>BBC, Ascension</td>
</tr>
<tr>
<td>23.610</td>
<td>2</td>
<td>11.805</td>
<td>WYFR, Massachusetts</td>
</tr>
<tr>
<td>23.540</td>
<td>2</td>
<td>11.770</td>
<td>BBC, Ascension</td>
</tr>
<tr>
<td>19.860</td>
<td>4</td>
<td>9.495</td>
<td>R. Santa Fe, Colombia</td>
</tr>
<tr>
<td>19.480</td>
<td>2</td>
<td>9.740</td>
<td>Rdf. Portuguesa</td>
</tr>
<tr>
<td>19.328</td>
<td>4</td>
<td>9.632</td>
<td>R. Reloj, Costa Rica</td>
</tr>
<tr>
<td>19.210</td>
<td>2</td>
<td>9.605</td>
<td>Deutsche Welle, Antigua</td>
</tr>
<tr>
<td>19.100</td>
<td>2</td>
<td>9.550</td>
<td>R. Habana Cuba</td>
</tr>
<tr>
<td>19.050</td>
<td>2</td>
<td>9.525</td>
<td>R. Habana Cuba</td>
</tr>
<tr>
<td>18.5688</td>
<td>3</td>
<td>6.1896</td>
<td>La Voz de los Centauros, Colombia</td>
</tr>
<tr>
<td>18.3456</td>
<td>3</td>
<td>6.1152</td>
<td>La Voz del Llano, Colombia</td>
</tr>
<tr>
<td>18.315</td>
<td>3</td>
<td>6.105</td>
<td>La Pantera, Mexico</td>
</tr>
<tr>
<td>18.2262</td>
<td>3</td>
<td>6.0754</td>
<td>La Voz del Junco, Honduras</td>
</tr>
<tr>
<td>14.835</td>
<td>3</td>
<td>4.945</td>
<td>R. Colosal, Colombia</td>
</tr>
<tr>
<td>12.320</td>
<td>2</td>
<td>6.160</td>
<td>Em. Nueva Granada, Colombia</td>
</tr>
</tbody>
</table>

The World Station. Matching its image as the "number one" SW service in English, the BBC also publishes the best program guide, "London Calling." New subscribers to the illustrated free monthly had been turned down due to rising costs. But in April BBC began accepting subscriptions from anyone paying the new charge of $10 per year (630 Fifth Ave., New York, NY 10020). Alternatively, you can consult our fortnightly column, Short Waves, in the Roundup section of the Sunday Denver Post.


DX Programs. Radio Nederland is broadcasting a "Communications System Course" covering radio, TV, radar, navigation and radio astronomy, written by Jim Vastenhoud. Besides broadcasting each lesson two weeks in a row, printed lessons and illustrations are available free. You can still enroll in this course, which began April 7 on the Thursday "DX Juke Box" programs, and continues through the summer. R. Nederland is also celebrating 50 years of SWBC with a special QSL card, and yours truly is celebrating his 10th anniversary as a DX correspondent on the April 21 program. You can also hear our DX report in Spanish, the second Friday of each month on "Espacio DX-ista."

DX listeners are invited to participate in or monitor a ham net discussing all phases of DX'ing and SWL'ing, Wednesdays at 2130 GMT on 7.275 ±0.005 MHz (perhaps an hour earlier by GMT during daylight time). NCS is Charles, W9NWF. Medium-wave DXer's exchange tips Monday mornings at 0700 (0600 GMT, starting in May) on 3.900 MHz; listen for Skip, K0SBV, or Ross, W6BG.

The hams also operate a well-organized "intruder watch" designed to expunge non-ham stations from their bands, and qualified SWL's are invited to help. Contact the ARRL Intruder Watch, E. H. Conklin, K6KA, 402 Oliveto Pl., Box 1, La Cañada, CA 91011.

Mark Your Calendar. The International Committee of the Red Cross broadcasts only 4 hours a day, 3 days a week, 6 weeks a year, making its QSL more of a prize than others from Switzerland. Here's the schedule, via SBC on 7.210 MHz, for the rest of 1977: May 23/25/27; July 25/27/29; Sept. 26/28/30; Nov. 21/23/25, at 0600-0700, 1130-1230, 1700-1800, 2200-2300 GMT. The last, and possibly the first, have a chance of being heard in North America this time of year. Mondays are in English; Wednesdays, French/German; and Fridays, Spanish/Arabic.

If you make a point of listening to certain stations on important dates, you may hear extended or special programming. For a starter, try 5.047 MHz on April 27, Togo's National Day. Deutsche Welle is 24 years old on May 3. Liberation Day in Czechoslovakia is May 9, and R. Prague itself marks 54 years on May 18. Cameroun stations on 4.9725 and 5.010 MHz may observe National Day on May 20. Guyana Independence Day is May 26, a good time to check.

DX Listening
By Glenn Hauser
MAY-AUGUST ENGLISH-LANGUAGE SW B'CASTS by Richard E. Wood

<table>
<thead>
<tr>
<th>TIME-EDT</th>
<th>TIME GMT</th>
<th>STATION</th>
<th>QUAL* FREQUENCIES, MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:28 a.m.-8:00 p.m.</td>
<td>1026-2400</td>
<td>*Montreal, Canada (Northern Service)</td>
<td>G 9.625, 11.172 (includes French, etc.)</td>
</tr>
<tr>
<td>7:00-7:25 a.m.</td>
<td>1100-1125</td>
<td>Tirana, Albania</td>
<td>F 9.50, 11.885</td>
</tr>
<tr>
<td>7:08-8:30 a.m.</td>
<td>1100-1330</td>
<td>Melbourne, Australia</td>
<td>G 9.58</td>
</tr>
<tr>
<td>7:08-9:30 a.m.</td>
<td>1100-1330</td>
<td>London, England</td>
<td>G 6.09 (via Sackville), 6.195 (via Antigua), 11.79 (via Antigua, tentative by midsummer) 15 07</td>
</tr>
<tr>
<td>7:00-11:00 p.m.</td>
<td>1100-1400</td>
<td>*VOA, Washington, USA</td>
<td>G 5.955, 9.73</td>
</tr>
<tr>
<td>7:30-8:25 a.m.</td>
<td>1105-1225</td>
<td>Trans-World Radio, Bonnere, N.A.</td>
<td>G 11.815</td>
</tr>
<tr>
<td>7:45-8:05 a.m.</td>
<td>1145-1205</td>
<td>*Montreal, Canada</td>
<td>G 9.56, 11.72</td>
</tr>
<tr>
<td>8:00-8:30 a.m.</td>
<td>1200-1230</td>
<td>Jerusalem, Israel</td>
<td>F 11.655, 15.10, 16.485, 17.085</td>
</tr>
<tr>
<td>8:08-8:55 a.m.</td>
<td>1200-1255</td>
<td>Peking, China</td>
<td>F 11.085</td>
</tr>
<tr>
<td>8:10-8:30 a.m.</td>
<td>1210-1230</td>
<td>Santiago, Chile</td>
<td>F 9.660, 11.81, 15.15</td>
</tr>
<tr>
<td>8:15-9:00 a.m.</td>
<td>1215-1300</td>
<td>Athens, Greece</td>
<td>F 15.345, 17.83</td>
</tr>
<tr>
<td>8:30-9:00 a.m.</td>
<td>1230-1300</td>
<td>HCJB, Quico, Ecuador</td>
<td>G 11.745</td>
</tr>
<tr>
<td>8:30-10:00 a.m.</td>
<td>1230-1300</td>
<td>Trans-World Radio, Bonnere, N.A.</td>
<td>G 15.305</td>
</tr>
<tr>
<td>8:30-11:30 a.m.</td>
<td>1230-1630</td>
<td>HCJB, Quico, Ecuador</td>
<td>G 15.255 (Sat., Sun.)</td>
</tr>
<tr>
<td>9:15-9:45 a.m.</td>
<td>1315-1345</td>
<td>Berne, Switzerland</td>
<td>P 11.775, 15.345, 17.83</td>
</tr>
<tr>
<td>9:30-10:00 a.m.</td>
<td>1330-1400</td>
<td>Helsinki, Finland</td>
<td>G 9.58 (via Sackville), 15.305</td>
</tr>
<tr>
<td>9:30-11:00 a.m.</td>
<td>1330-1600</td>
<td>*London, England</td>
<td>G 17.84 (via Ascension), 9.58 (via Sackville Sat., Sun.)</td>
</tr>
<tr>
<td>10:00-10:15 a.m.</td>
<td>1400-1415</td>
<td>*Montreal, Canada</td>
<td>G 11.775, 15.345, 17.83</td>
</tr>
<tr>
<td>10:00-10:30 a.m.</td>
<td>1400-1430</td>
<td>Oslo, Norway</td>
<td>G 9.58 (via Sackville), 15.07</td>
</tr>
<tr>
<td>11:30-11:45 a.m.</td>
<td>1430-1500</td>
<td>Helsinki, Finland</td>
<td>G 17.84 (via Ascension)</td>
</tr>
<tr>
<td>11:45-12:00 a.m.</td>
<td>1500-1600</td>
<td>London, England</td>
<td>G 15.175 (Sun.)</td>
</tr>
<tr>
<td>11:15-11:30 a.m.</td>
<td>1515-1530</td>
<td>Athens, Greece</td>
<td>G 15.175 (Sun.)</td>
</tr>
<tr>
<td>12 noon-12:15 p.m.</td>
<td>1600-1615</td>
<td>London, England</td>
<td>G 15.175 (Sun.)</td>
</tr>
<tr>
<td>12:00 noon-12:30 p.m.</td>
<td>1600-1630</td>
<td>Oslo, Norway</td>
<td>G 17.80, 17.12, 21.21</td>
</tr>
<tr>
<td>12:04-12:56 p.m.</td>
<td>1604-1656</td>
<td>*Paris, France</td>
<td>G 9.58 (via Sackville), 15.07</td>
</tr>
<tr>
<td>1:00-4:00 p.m.</td>
<td>1700-2000</td>
<td>*Kuwait, Kuwait</td>
<td>F 13.855, 15.325, 17.82</td>
</tr>
<tr>
<td>2:00-3:30 p.m.</td>
<td>1800-1830</td>
<td>*Kenya, Uganda</td>
<td>F 15.325 (Tues., Thurs., Sat., Sun.)</td>
</tr>
<tr>
<td>2:30-3:00 p.m.</td>
<td>1830-1900</td>
<td>*Montreal, Canada</td>
<td>F 16.855, 15.325, 17.82</td>
</tr>
<tr>
<td>2:50-4:00 p.m.</td>
<td>1850-2000</td>
<td>*Abidjan, Ivory Coast</td>
<td>F 11.92 (Sun.)</td>
</tr>
<tr>
<td>3:00-3:30 p.m.</td>
<td>1900-1930</td>
<td>*Montreal, Canada</td>
<td>F 11.955, 15.325, 17.82</td>
</tr>
<tr>
<td>3:00-4:00 p.m.</td>
<td>1900-2000</td>
<td>*Algiers, Algeria</td>
<td>F 11.91, 15.42 (variable)</td>
</tr>
<tr>
<td>3:00-6:00 p.m.</td>
<td>1900-2200</td>
<td>*Jeddah, Saudi Arabia</td>
<td>F 11.955</td>
</tr>
<tr>
<td>3:30-4:30 p.m.</td>
<td>1930-2030</td>
<td>*Montreal, Canada</td>
<td>F 11.955, 15.42, 17.82</td>
</tr>
<tr>
<td>4:00-4:30 p.m.</td>
<td>2000-2030</td>
<td>*Tehran, Iran</td>
<td>F 15.29, 15.325, 17.82</td>
</tr>
<tr>
<td>4:05-5:00 p.m.</td>
<td>2000-2100</td>
<td>Jerusalem, Israel</td>
<td>F 9.027, (11.17 alternate)</td>
</tr>
<tr>
<td>4:05-5:00 p.m.</td>
<td>2000-2100</td>
<td>Accra, Ghana</td>
<td>G 9.009, 9.425, 9.615, 11.655, 15.10</td>
</tr>
<tr>
<td>4:05-2:05 p.m.</td>
<td>2000-2120</td>
<td>*Hilversum, Holland</td>
<td>F 11.85 (urg.)</td>
</tr>
<tr>
<td>4:50-5:50 p.m.</td>
<td>2050-2150</td>
<td>*Haifa, Cuba</td>
<td>G 11.805, 17.75</td>
</tr>
<tr>
<td>5:00-5:50 p.m.</td>
<td>2100-2130</td>
<td>*Brasilia, Brazil</td>
<td>G 15.19</td>
</tr>
<tr>
<td>5:05-5:55 p.m.</td>
<td>2100-2150</td>
<td>*Johannessen, S. Africa</td>
<td>F 5.98, 9.585</td>
</tr>
<tr>
<td>5:00-6:00 p.m.</td>
<td>2100-2200</td>
<td>Brasilia, Brazil</td>
<td>F 15.24 (11.17, 15.24 alternate)</td>
</tr>
<tr>
<td>5:15-6:45 p.m.</td>
<td>2115-2245</td>
<td>London, England</td>
<td>G 9.58, 11.75</td>
</tr>
<tr>
<td>5:30-6:55 p.m.</td>
<td>2130-2250</td>
<td>Hilversum, Holland</td>
<td>G 9.715, 11.73 (exc. Sun.)</td>
</tr>
<tr>
<td>6:06-6:15 p.m.</td>
<td>2200-2215</td>
<td>*Belgrade, Yugoslavia</td>
<td>F 6.10, 7.24, 8.67</td>
</tr>
<tr>
<td>6:06-6:30 p.m.</td>
<td>2200-2230</td>
<td>*Montreal, Canada</td>
<td>G 15.175 (Sun.)</td>
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<tr>
<td>6:30-7:15 p.m.</td>
<td>2200-2315</td>
<td>Oslo, Norway</td>
<td>F 15.40 (even, Mon.-Fri.)</td>
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<tr>
<td>6:30-7:30 p.m.</td>
<td>2200-0030</td>
<td>Ankara, Turkey</td>
<td>G 9.085</td>
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<tr>
<td>6:30-7:00 p.m.</td>
<td>2230-2300</td>
<td>Jerusalem, Israel</td>
<td>G 9.515, 11.88</td>
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<tr>
<td>6:07-7:00 p.m.</td>
<td>2230-2300</td>
<td>Moscow, U.S.S.R.</td>
<td>G 9.705, 11.75, 7.355, 7.40, 9.685</td>
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<tr>
<td>6:30-7:20 p.m.</td>
<td>2230-2320</td>
<td>Johannesburg, S. Africa</td>
<td>F 5.96, 9.585, 11.80</td>
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<tr>
<td>6:35-7:00 p.m.</td>
<td>2245-2300</td>
<td>London, England</td>
<td>G 5.975, 7.325, 9.58, 11.75</td>
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