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JUNE 1978/$1

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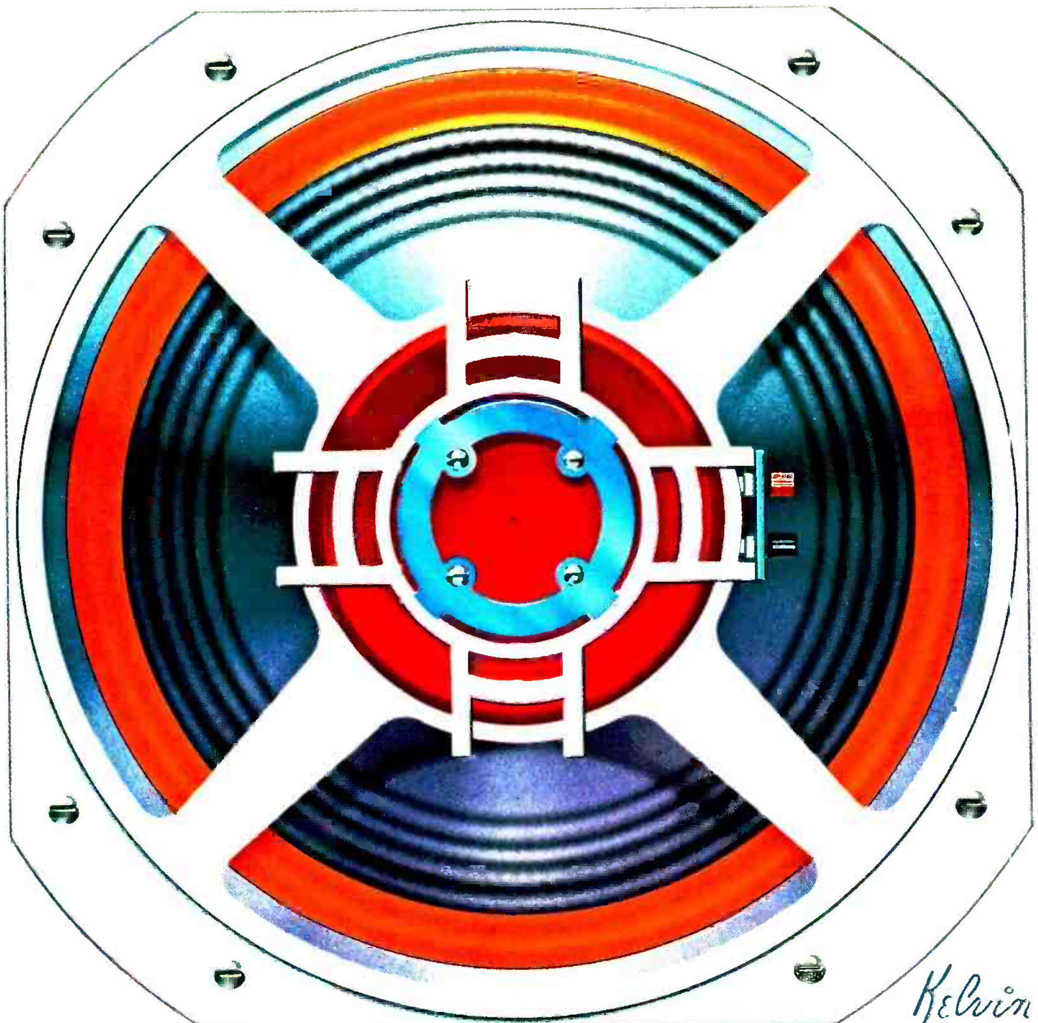

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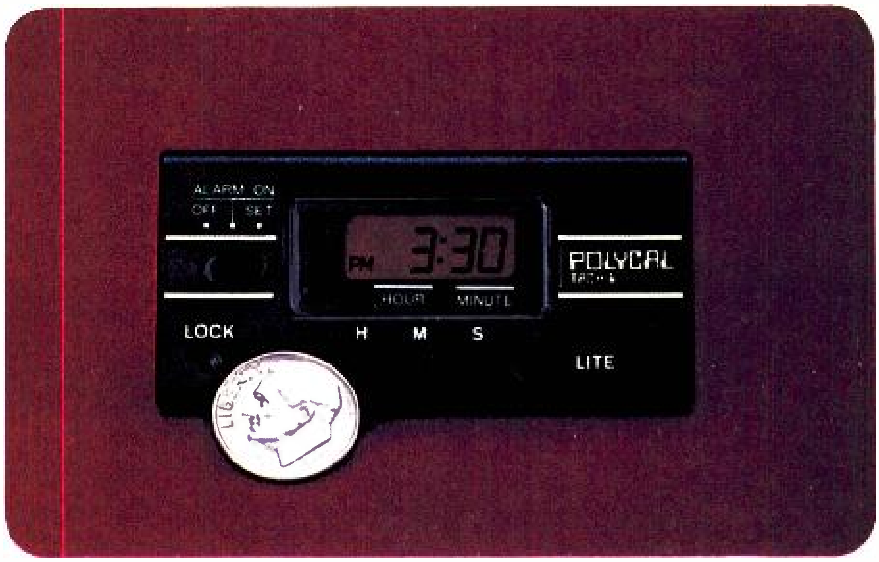

The new JS&A Travel Alarm will fit in your briefcase, pocket or purse and it takes up as much space as four quarters.

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These two items are the best selling new electronic products. Can you figure out why?

New products often surprise us. We never quite know why one product stands out and becomes a big seller.

In our recent catalog, our Security Switch and Mini Travel Alarm were in greater demand than any other item. Both are new innovations using newly developed technology, and both are being sold by the thousands. See if you can understand why:

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The new JS&A Travel Alarm measures only ⅜" x 1¼" x 2½" and has a small easel support on the back. Just set the alarm, and the electronic beep will wake you up. The clock movement is totally solid-state, and a built-in night light lets you view the time in the dark.

But the JS&A Travel Alarm does more. First, it makes a great pocket watch. The small imitation black leatherette carrying case that comes with the unit has a window so you can view the time even when the unit is in its case. Secondly, it tells accurate time – within fifteen seconds accuracy per month. And finally, it's inexpensive – only **$29.95** complete with carrying case and two readily-available hearing aid batteries. It makes a perfect gift for your secretary, business associates, best customers, and friends.

There is also a deluxe version with a built-in timer and dual time zone capability. You can now display one time while keeping the second time in memory.

The Travel Alarm can be ordered by calling our toll-free number below or sending your check for $29.95 for the regular version or $39.95 for the deluxe version. Please add $2.50 postage and handling.

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It's just another very clever application of solid-state technology for the home or office.

You know those security timers that turn your lights on and off while you're away? They are supposed to deter burglars and vandals because they make your home look lived in.

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Now a new space-age device programs your lights to respond to a pre-determined, yet random living pattern. And unlike the devices that fit into an electrical outlet, this device simply slips into your existing wall switch.

A built-in LED digital clock displays the time. When you leave, you turn the switch on. You can choose between five different programs depending on the room you're in. You tell the built-in microprocessor-based computer circuit which room you're in by entering a number. Then the lights controlled by the switch in that room turn on and off just as if the room were being used on a daily basis.

Because it's random, the unit will turn on and off at varying times on different days but always during the approximate times they would normally go on if you were at home.

To install the unit, you simply turn off the fuse for that outlet, remove your present light switch, and replace it with the new one. There's no soldering required – just twist on a few wire nuts and you're finished.

The switch can be overridden and used just like a regular light switch by pressing a button to turn on the light. One of the nice features of the system is its appearance – that of a space-age switching system – sure to be a conversation piece in any room.

The only drawback is that in a power failure, the lights go on and stay on after the power outage. But this could also be considered an advantage as it would warn your neighbors to stop by and check out your home.

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Editorial

THE PERFECT SPEAKER QUEST

Music has an influence on high-fidelity equipment. As an example, an unsung musical revolution of World War II days that spawned much of today's musical style advanced the need for better audio systems. This then-new art form was also my initial motivation for searching out better and better speaker system—a search that has not yet ended.

The music had its start at the Minton Playhouse, nor far from New York's Apollo Theatre. Its pioneer musicians were the cream of orchestral jazz sidemen. The style was the type of progressive jazz known as "Bebop," with a tradition-shattering rhythm-section technique that extends to both jazz and rock today.

When I first heard Bop on records and radio broadcasts, I simply couldn't comprehend it. It sounded discordant, true, but so did Beethoven's music when it was introduced. Worse, though, was the high level of distressing record-surface noise I heard. It wasn't until I heard it performed "live" that its true sound was revealed.

I concluded that my speaker (those were mono days, remember) was the cause of the distressing noise I heard at home, attributing this to unsatisfactory high-frequency reproduction, among other deficiencies. Here's why:

In Bop, the drummer's role became much more important and demanding. While a "swing" drummer such as Chick Webb or Gene Krupa used the bass pedal to keep time, accompanied by cymbal crashes, Bebop drummers—Kenny Clarke, Max Roach, et al—abandoned this style. They used, as do many modern drummers, the top cymbal as their "main" instrument for both 4/4 fundamentals and tonal dynamics. Thus, a continual, shimmering cymbal sound underlined the music. This freed the drummer's left hand and both legs for adding a variety of accents: a top-hat cymbal's "cha-cha" sound, a bass drum's abrupt thump a snare's pistol-like sound, a tom-tom, etc.

So, while most audiophiles of the day were terribly concerned about achieving deeper speaker bass, I also sought better treble and transient response. I needed this improvement to hear the cymbal's persistent sound, without which I couldn't assemble the musical puzzle.

This was no easy task. After all, a cymbal's frequency response extends to 16 kHz, a bass drum goes down to about 30 Hz, with some 25 watts acoustic power in real life. Add the string bass (which no longer simply followed a drum pedal accent) ranging from about 41 Hz to 8 kHz with overtones, and a piano stretching from 27½ Hz to almost 9 MHz with overtones. Top them off with a trumpet and a saxophone, each producing powerful mid-frequency fundamentals and high-frequency harmonics extending to 10 kHz, as spearheaded by Dizzy Gillespie and Charlie Parker, and the complex music elements of a modern jazz group were not easy to reproduce.

Furthermore, to capture the essence of the music, all the instrumental nuances had to be reproduced. This meant good transient response was necessary. Aside from overcoming one-note bass and dull-treble problems, the instrument's true color was at stake. (An instrument's higher overtones, which determine timbre, die out quickly.) Interestingly, one of the reasons for the difficulty in faithfully reproducing piano music is its "attack." Play a piano softly, for example, and many overtones are subdued. But strike piano keys hard and the amplitude of a host of momentary overtones might reach 50% of the fundamentals, imparting a different sound character. If a speaker system distorts these harmonics, then the piano's true sound won't be reproduced.

My quest for better speaker systems led me to a few basic texts, mainly authored by Abraham Cohen, G.A. Briggs, Harry Olson, and James Moir. (Cohen and Briggs, both of whom made important contributions to speaker development and public education on the subject, died this year.) After extensive experimentation with different speaker designs in a variety of listening rooms for almost a dec-

(Continued on page 6)

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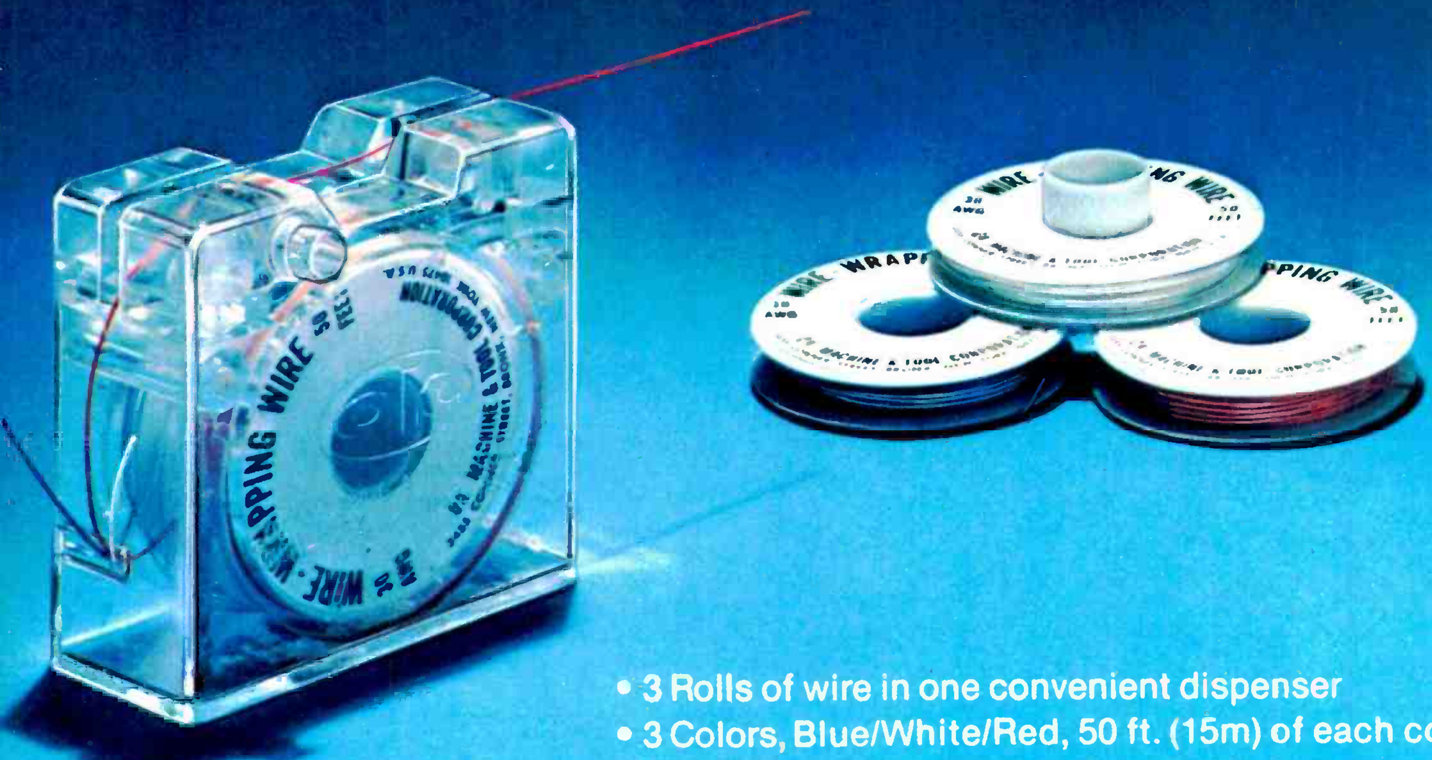

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CIRCLE NO 41 ON FREE INFORMATION CARD

EDITORIAL *(Continued from page 4)*

ade, I gathered a large audience in a small hotel ballroom to participate in speaker listening tests. The speaker systems chosen were the same models evaluated that year by *Consumer Reports*. Check-lists of sound attributes for grading speakers identified only by number were given to participants. The audience consisted of recording engineers, musicians, hi-fi editors, audio dealers, audiophiles and a scattering of men and women who had no special experience in high-fidelity sound. Speakers were hidden behind an acoustically transparent curtain, while a variety of program material specially prepared on master tapes by Capitol Records was alternately played on each system. The results were most interesting: (1) Preference rankings were unlike those listed by *Consumer Reports*. (2) Except for a few systems that exhibited distinct deficiencies, it was not possible to make a logical analysis of listeners' preferences based on their speaker listening experience, audio knowledge or occupation. It was clear then as now that each person has his or her own sense of what sounds best.

Though modern jazz is not a majority art form among listeners, it served me well over the years as an ideal program source for evaluating my audio system. Now, however, much of its complex music roots are evident on more widely favored pop and rock music. So today's sonic challenge to speaker systems and other components is more apparent. Hi-fi equipment buyers, therefore, face many of the same judgement problems I did years ago.

Loss of hearing, for example, is an important determinant in choosing a speaker system. You cannot evaluate what you don't hear! For example, the hearing of a 35-year-old male can be expected to be down about 6 dB at only 4 kHz as compared to a male in his early 20's. At about 60 years, the loss is typically some 30 dB! To a 20-year-old, then, a 4-kHz sound appears eight times as loud as it would to an older chap. A woman, in contrast, experiences less high-frequency hearing loss; perhaps half of a man's as she ages. But she does have a somewhat greater hearing loss at low frequencies. So what you will prefer in terms of extended frequency response depends in part on your sex and your age.

You can fool yourself about your hearing acuity by listening to loudly played test-frequency records or signal generator audio outputs. This will compensate up to a point for the aging effect in hearing (presbycusis). Airtight headphones will perform similarly at lower-than-earthshaking volume by eliminating ambient noise, which in a typical living room is probably about 43 dB or so. I can hear to almost 15 kHz in the foregoing situations. But at low power output levels at about 20 feet from the speaker systems, I don't go much above 13 kHz. With music playing, my HF detection abilities are less keen, of course. I proved this to myself by progressively filtering highs until a change was noticed.

Judging bass-frequency output of speakers can be tricky, too. The human ear can fill in bass that isn't there. Also, you may hear lots of output at a low-bass frequency, but it might consist largely of high-distortion energy. I used an old mono LP, "Hi-fi & Mighty" on an RCA label, for this checkout purpose, especially its "Musetta's Waltz" track. It featured Allen Organ solos, with continual pedal music. I also played Brahms' "Symphony #1" (Otto Klemperer on Angel) for the pounding-drum intro. The liner notes observed that violins came in over the drum beats. In my early speaker models, however, the strings were *under* the drums in sound level. Better speakers later proved that the writer was correct!

I discovered in books and practice years ago that room dimensions, furnishings and speaker placement have a great deal to do with speaker performance quality, too. Few of us enjoy perfect room dimensions for audio (said to be a ratio of 1 x 1.27 x 1.62) or the ideal reverberation time (about 0.5 second for an average-size room and 0.7 second for a larger room, say, 20 feet long). And every new speaker placement sets up different sound vibration modes. A change from mid-wall to corner can add 6 dB to bass energy, for example, but aesthetics don't always permit using such a reduced angle of radiation to achieve a higher SPL.

Searching out the best-sounding speaker systems for one's ears is a delightful pastime, I've always felt. More important, it's worth the effort because it can contribute more than any other audio component toward accurate reproduction of recordings and FM broadcasts. This issue's focus on speaker systems will give you a running start toward this end.

Art Salsberg

WHEN YOU BUILD A SPEAKER TO SOUND GREAT ON EVERY PART OF THE MUSIC, YOU CAN'T CUT CORNERS ON ANY PART OF THE SPEAKER.

A single HPM-100 weighs almost 60 pounds.

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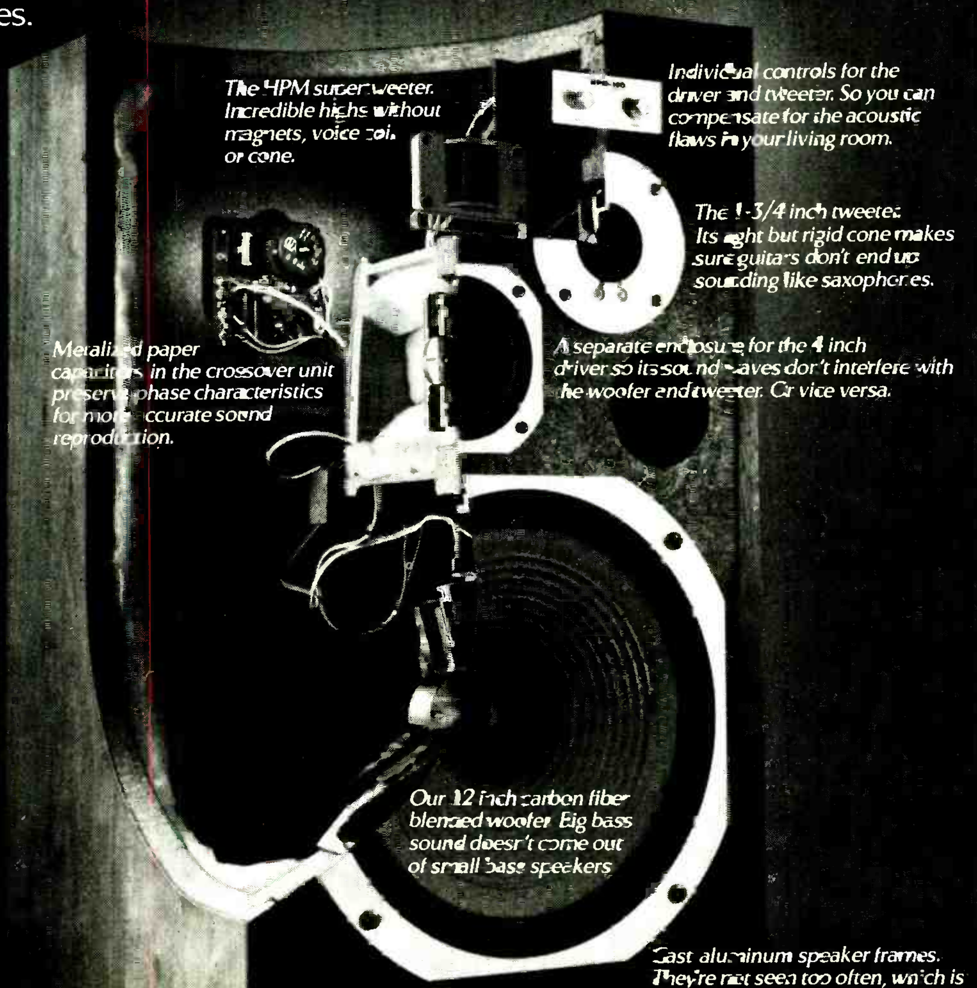
Naturally, we could go on. About our 12-1/2 feet of damping material. Or about the aluminum screws that keep our speakers from falling out. They're ordinarily used to keep airplanes from falling apart.

But we figure at this point you'd rather hear our speakers in person than hear any more about them from us.



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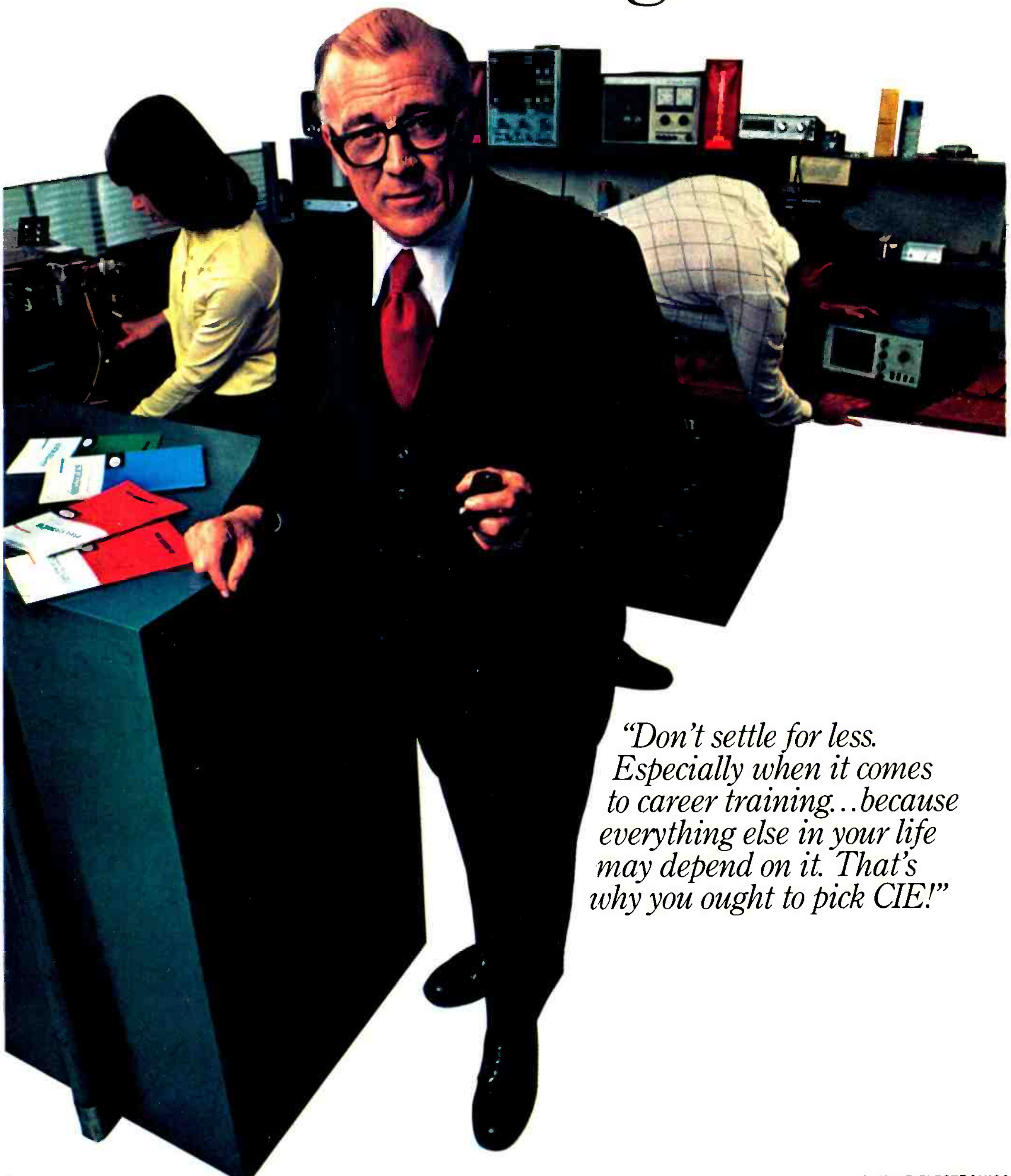

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Letters

POORER BUT BETTER OFF

Thanks to POPULAR ELECTRONICS, I am now $135 poorer. This may sound bad, but it is really good—at least I hope so. I have all of your articles on the Cosmac Elf microcomputer built around the 1802 μP chip from RCA. They have aroused my interest so much that I have gone out and bought my own Elf microcomputer kit. *—Robert J. Kastelic, South Milwaukee, WI.*

THANKS FOR "EXPERIMENTER'S CORNER"

I would like to express my appreciation for the "Experimenter's Corner." This column is always lucid and interesting. I particularly enjoyed the December 1977 and January 1978 columns on read/write memories. Thanks to them, I now understand how data is placed into and retrieved from memory. I would like for author Forrest Mims to devote more space to digital and computer circuits. *—Mark Jennings, Bellevue, WA.*

TRANSMITTER THAT NEVER WAS

As I was leafing through the February 1978 issue of POPULAR ELECTRONICS, I noted that the Amateur Radio column made reference to the Heathkit Model HX-1675 amateur radio transmitter. The information for this article undoubtedly originated from someone here at Heath. Unfortunately, the Model HX-1675 was discontinued at the last minute and never offered for sale. *—V. Virgil Bennett, Heath Co., Benton Harbor, MI.*

UPDATING NBS SERVICES

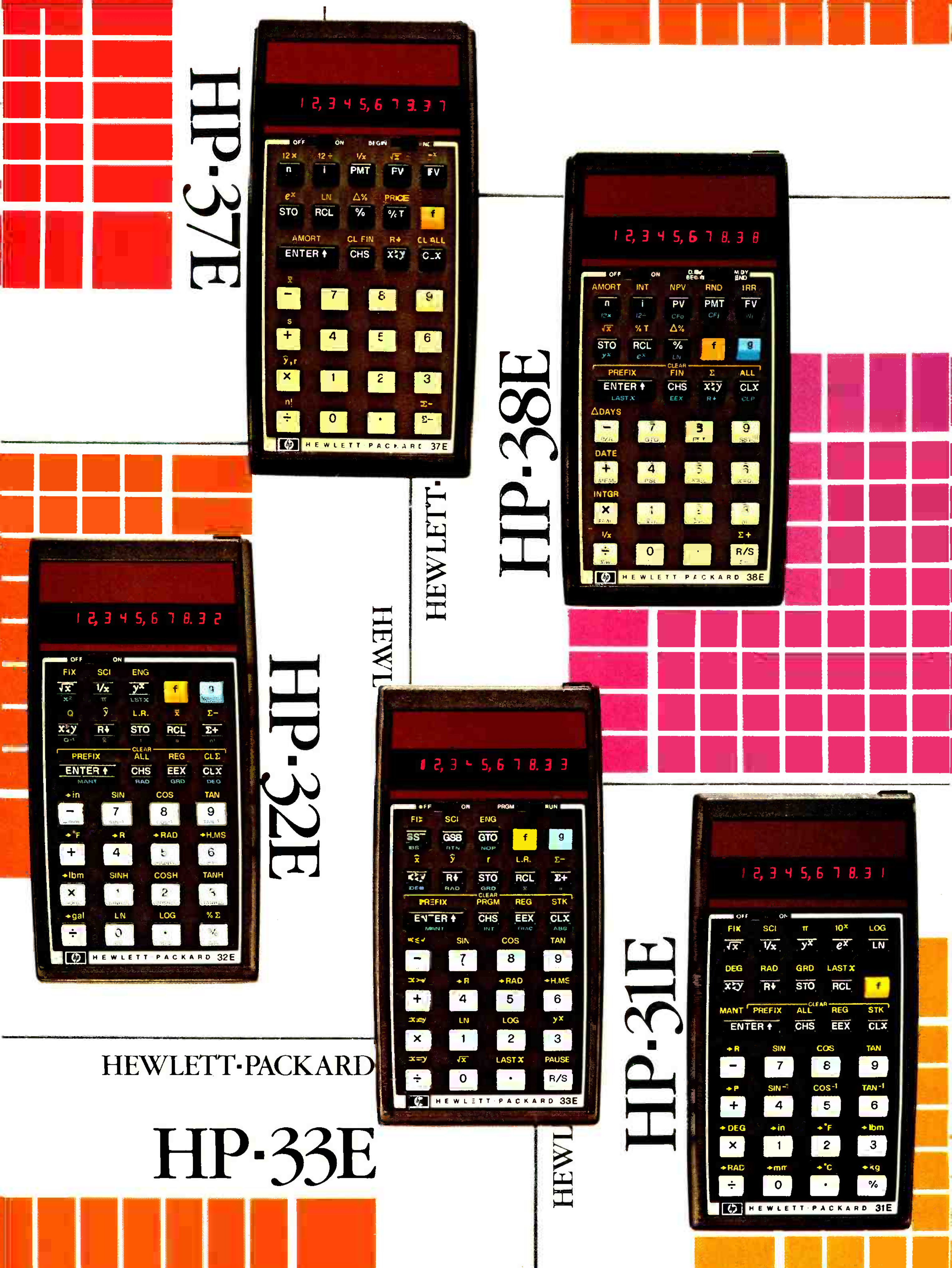
We appreciate your help in keeping your readers abreast of changes in our standard time and frequency services. Here is some late information.

WWVL (which operated near 20 kHz until July 1972) no longer is in operation. WWVB (60 kHz), WWV and WWVH (2.5, 5, 10, and 15 MHz) are still on the air continuously.

Details of station operation, signal formats and other information about WWV, WWVB, and WWVH are included in *National Bureau of Standards Time & Frequency Dissemination Services*, a 60¢ booklet available as NBS Special Publication 432 from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. (SP 432 replaces SP 236.) *—Collier N. Smith, NBS, Boulder, CO 80302.*

Out of Tune

In "Expanding the Elf II" (March 1978), transistors *Q2* and *Q4*, in Fig. 3, should be types 2N5354.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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 Free Information Card or write to the manufacturer at the address given.

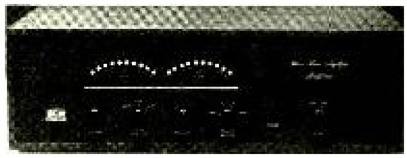
Hand-Held 50-MHz Counter

The Continental Specialties "Mini-Max" is a new hand-held automatic frequency counter that can be battery powered with a standard 9-V battery or, optionally, ac pow-

ered. It has a guaranteed minimum frequency range of from 1090 Hz to 50 MHz, with 100-Hz resolution throughout the entire range. There are no controls, only an on-off switch. The frequency is automatically displayed directly on the counter's 0.1" (2.54-mm) magnified, six-decade display, with leading zeroes blanked out. When the Mini-Max is first turned on, two decimal points (one each for kilo- and megahertz) come on in the display. It has a diode-protected miniature phone-jack input whose impedance is rated at 1 megohm. A built-in crystal-controlled timebase operates at 3.58 MHz and has a claimed frequency stability of 0.2 ppm/°C over a temperature range of from 0° to 50° C. Dimensions are 3" x 6" x 1½". $89.95.

CIRCLE NO. 88 ON FREE INFORMATION CARD

BGW Model 410 Power Amplifier

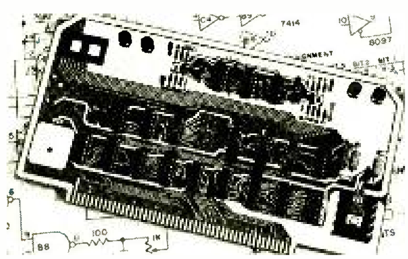


The Model 410 stereo power amplifier from BGW uses a pair of 10 discrete LED "meter" displays in place of the traditional analog mechanical movements to indicate output power. Rated at 200 watts continuous into 8 ohms, the amplifier's frequency response rating is 3 Hz to 100,000 Hz +0/−3 dB. THD and IM distortion are rated at 0.05% and 0.01%, respectively. Residual hum and noise are rated at −110 dB. Input sensitivity is 2 volts for 200 watts output. The LED "meter" display is average responding; it has a three-position sensitivity switch (−20, −10, and 0 dB). A four-position speaker system selector switch with 20-ampere power-handling capability is provided. $699.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Vector Analog Interface Board

A multifunction Analog Interface Board for microcomputers, introduced by Vector Graphic Inc., is for use with potentiometers, joysticks, and voltage sources. An 8-bit digital port with a latch strobe can func-



tion as a keyboard input port. Tone pulse generators can also produce sounds for games or keyboard audio feedback. Additional features include four A/D inputs and MWRITE logic and a power-on jump feature for computers that lack a front panel. $75, kit; $115, assembled.

CIRCLE NO. 87 ON FREE INFORMATION CARD

Sansui Direct-Drive Turntable

The latest direct-drive turntable from Sansui, Model SR-333, is a two-speed manual player with individual pitch-control adjustments for each speed. The motor is a 20-pole, 30-slot brushless type, with wow and flutter rated by the manufacturer at less

than 0.035%. Rumble is rated at −70 dB, signal-to-noise ratio at better than 60 dB. The arm is an S-shaped, counterbalanced type. The SR-333 comes complete with base and dustcover. It measures 18⅛" W x 6 1/16" H x 14 11/16" D. (46 x 15.4 x 37.9 cm), and weighs 17.2 lb (7.8 kg). $200.

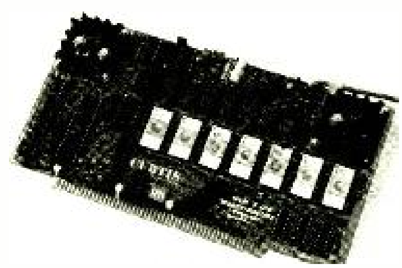
CIRCLE NO. 91 ON FREE INFORMATION CARD

Mobile Antennas for Japanese Cars

A new series of pillar-mount AM/FM/CB antennas, designed specifically to replace existing AM/FM antennas on Datsun, Toyota and Honda automobiles, has been announced by Harada. Five models are available: two each for Datsuns and Hondas, and one for Toyotas. The antennas are top-loaded for CB, with specially designed cables and couplers to accommodate all three reception modes.

CIRCLE NO. 92 ON FREE INFORMATION CARD

Curtis Amateur Radio Computer



A computerized Morse and Baudot code operating system for the ham is available from Curtis Electro Devices, Inc. Called the System 4000, it is designed to receive, decode, and print (via CRT) Morse or five-level Baudot TTY codes at rates of 10 to 100 wpm or 60 to 100 wpm. It also serves as a keyboard or paddle with CRT display of the transmitted text. The Morse keyboard provides a 500-key buffer, eight programmable message memories, and two

(Continued on page 22)

Why you should buy a digital multimeter from the leader in digital multimeters.

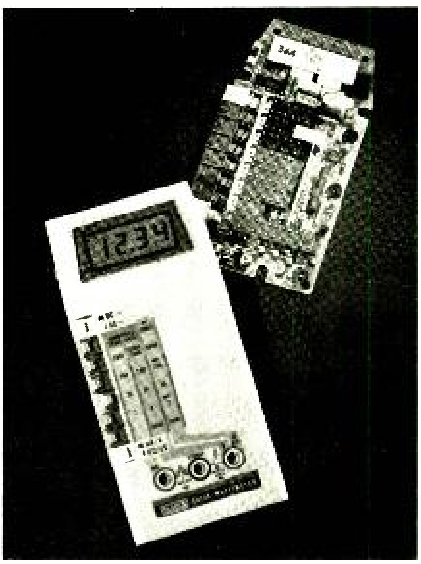
If you're shopping for your first multimeter, or moving up to digital from analog, there are a few things you should know.

First, look at more than price. You'll find, for instance, that the new Fluke 8020A DMM offers features you won't find on other DMMs at *any* price. And it's only $169.*

Second, quality pays. Fluke is recognized as the leading maker of multimeters (among other things) with a 30-year heritage of quality, excellence and value that pays off for you in the 8020A.

Third, don't under-buy. You may think that a precision 3½-digit digital multimeter is too much instrument for you right now. But considering our rapidly changing technology, you're going to need digital *yesterday*.

If you're just beginning, go digital.



Why not analog? Because the 8020A has 0.25% dc accuracy, and that's *ten times better* than most analog meters.

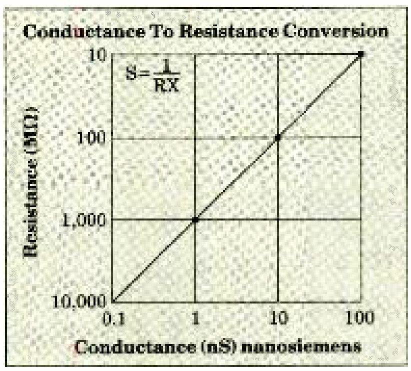
Also, the 8020A's digital performance means things like 26 ranges and seven functions. And the tougher your home projects get, the more you need the 8020A's full-range versatility and accuracy. The 8020A has it; analog meters don't.

If you're a pro.

You already know Fluke. And you probably own a benchtop-model multimeter.

Now consider the 8020A: smaller in size, but just as big in capability. Like 2000-count resolution and high-low power ohms. Autozero and autopolarity. And the 8020A has 3-way protection against overvoltage, overcurrent and transients to 6000V!

Nanosiemens?



Beginner or pro, you'll find the meter you now have can't measure nanosiemens. So what? With the 8020A *conductance* function, you can measure the equivalent of 10,000 megohms in nanosiemens. Like capacitor, circuit board and insulation leakage. And, you can check transistor gain with a simple, homemade adapter. Only with the 8020A, a 13-oz. heavyweight that goes where you go, with confidence.

What price to pay.

$169.*

Of course, you can pay more. Or less. In fact, you could pay almost as much for equally compact but more simplistic meters, and get far less versatility. And, the 8020A gives you the 'plus' of custom CMOS LSI chip design, and a minimum number of parts (47 in all). All parts and service available at more than 100 Fluke service centers, worldwide. Guaranteed, for a full year.

Rugged. Reliable. Inexpensive to own and to operate; a simple 9V battery assures continuous use for up to 200 hours.

Where to buy.

Call (800) 426-0361 toll free. Give us your chargecard number and we'll ship one to you the same day. Or, we'll tell you the location of the closest Fluke office or distributor for a personal hands-on feel for the best DMM value going.

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Fluke 8020A DMM for Home Electronics Experts: $169

FLUKE®

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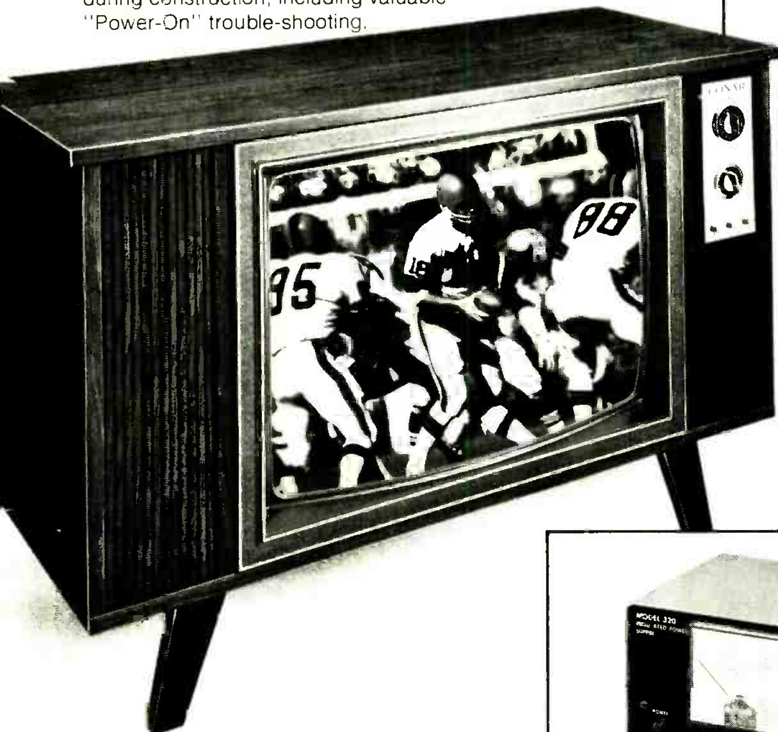
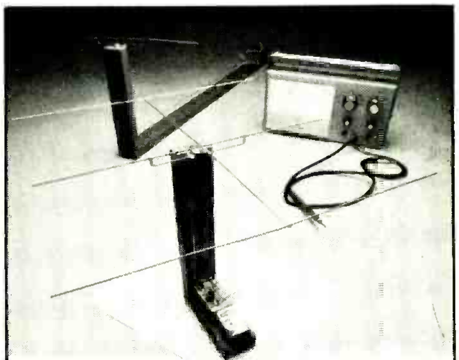
First and only school with a portable CMOS digital frequency counter engineered by NRI to give you experience in the newest types of digital systems coming into expanded use in consumer electronics.

First and only school with designed-for-learning 25" diagonal solid state Color TV complete with cabinet. This solid state set was designed by NRI's own engineers from the chassis up so that students can perform over 25 in-set experiments during construction, including valuable "Power-On" trouble-shooting.



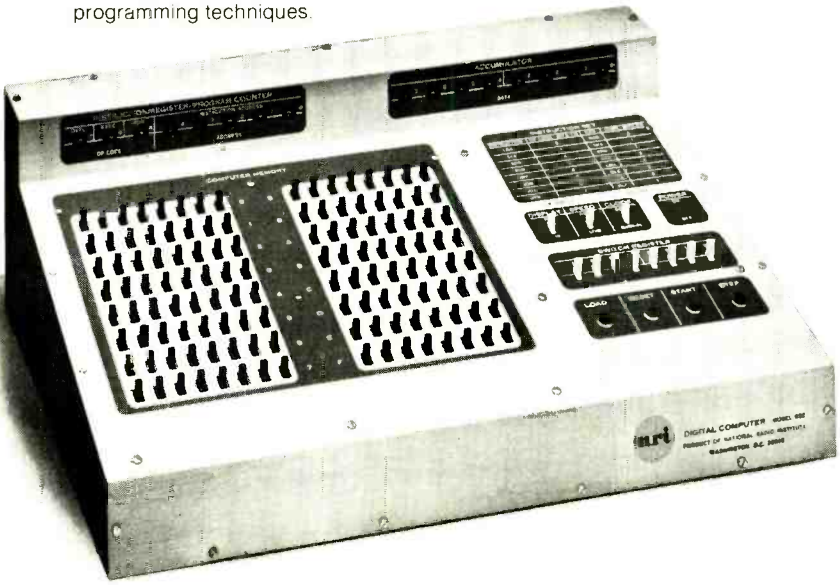


First and only school with an Antenna Applications Lab engineered to give you a thorough understanding of practical communications antenna requirements. You assemble and test several different types of antennas and matching sections, measuring gain and radiation patterns.

First and only school with a solid state regulated power supply engineered by NRI to give you experience with modern power supply designs; to give you a premium power supply for your NRI Transceiver, or to use in trouble-shooting mobile equipment.

First and only school with designed-for-learning, 400-channel, digitally-synthesized VHF Transceiver to give you the only fully-up-to-date 2-meter equipment for complete training in commercial, amateur, and CB communications. The design incorporates circuitry and components representative of the latest state of the art. Circuitry is on five plug-in circuit cards to take full advantage of NRI "Power-On" training.

First and only training with an actual programmable digital computer to give you the only home training in machine-language programming . . . essential to trouble shooting digital computers. Extra Memory Expansion Kit doubles memory size for practice in advanced programming techniques.



If card is missing, write to:

NRI Schools
McGraw Hill Continuing
Education Center
3939 Wisconsin Ave.
Washington, D.C. 20016

(Continued from page 16)
fixed message memories (CQ and ID). The message memories are also available in the paddle keyer mode. Code speeds are adjustable in one wpm increments from 10 to 99 wpm. The System 4000 is designed to be added to the Processor Technology SOL-20 μC, but it can be adapted to any S-100 bus, 8080-based μC by adding additional I/O patches to the video driver and console keyboard. Address: Curtis Electro Devices, Inc., Box 4090, Mountain View, CA 94040.

Bearcat Autoscan Monitor

The Electra Company's Bearcat 250 is a new automatic scanning receiver that monitors 50 channels, requires no crystals, and features auto search and recall. The synthesized scanner includes a nonvolatile memory, five custom-designed chips, and pushbutton programming for any frequency in five bands without the use of crystals. The receiver can monitor low and high vhf bands, the uhf band, the T band, and the 2-meter (146 to 148 MHz) ham band. The 50 channels are arranged in banks of 10. This is said to be the first scanner to automatically search out and activate local public-service frequencies, store them in memory, recall them on demand, and display the active frequencies discovered and stored during the search. It also contains a digital clock that operates while the scanner is performing other functions. A priority channel is built in. $399.95.

CIRCLE NO 93 ON FREE INFORMATION CARD

CCD Video Camera Kit

A charge-coupled device (CCD) video camera kit is available from Solid State Sales. The Model 202 camera can be used for both visible-light and infrared viewing,

and for character recognition with computers equipped with external circuits. It features the Fairchild 202C (100 × 100 bit) self-scanning CCD as the graphic pickup element. Among the advantages claimed for the camera are: all clock voltages at a fixed level to eliminate the need for adjustments; higher video output signal; simplified circuitry for easy assembly; and a two-level TTL output for easy interfacing. All components mount on two parallel boards. The output signal is for display on an X-Y oscilloscope. The camera kit comes with all semiconductors, passive components, boards, data sheets and diagrams, and an 8-mm lens. $349.

CIRCLE NO 9 ON FREE INFORMATION CARD

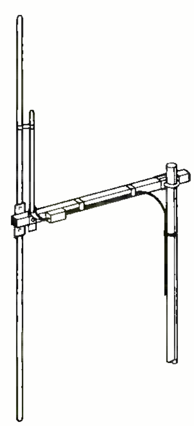
Mobile Entertainment Center With Clock

The Audiovox "Indasher" Model DGC-10 car stereo system contains an AM/stereo FM receiver, cassette player, and full-time clock (hours and minutes/day and date) and timer. Frequencies on AM and FM, time, and elapsed time are indicated by a yellow 7-segment numeric display. A pushbutton switch is provided for adjusting dis-

play intensity for daytime and nighttime driving conditions. The receiver is rated to deliver 10 watts rms and has 4- and 8-ohm outputs. The receiver portion features electronic AM/FM band selection, local/distance switch, and stereo/mono selection. The cassette player has fast-forward/eject/rewind lever and automatic eject mechanism at end of tape play. The time is continuously displayed until a station is tuned. Five seconds after a station is tuned, the display automatically switches back to the time-display mode. $299.95.

CIRCLE NO 95 ON FREE INFORMATION CARD

Finco Monitor Antennas



Two new monitor antennas—one for public-service bands and one for aircraft frequencies—have been announced by Finco. The SMA-1 Scanner Monitor Antenna operates as a ½-wave dipole in the 30-50-MHz lo-vhf band, as a 3/2-wave dipole in the 148-174-MHz hi-vhf band, and as a "J" stub in the 450-512-MHz uhf band. It is also available as SMA-IWK, a window-mounting kit with an 18′ cable. The aircraft-monitor model AMA-3 is a half-wave, omnidirectional groundplane antenna tuned for the 108-138-MHz aircraft band, and is designed to mount on 1¼″ masting or standard 1″ threaded water pipe (not included).

CIRCLE NO 96 ON FREE INFORMATION CARD

Underwater Microphone/Earphone

The Y² Model IO-310 is an underwater microphone rated by its manufacturer for depths of up to 600 feet. It can also be used as an earphone. Specifications are: sensitivity, −85 dB re 1 V/microbar; impedance, 2000 ohms at 1 kHz; electrical leakage resistance greater than 100 megohms; weight, 3/4 oz (23 g); size, 1.2″ dia. × 3/8″ thick (3.0 × 1.0 cm). $16.95. Address: Y-Square Associates, Inc. 2001 So. Eastwood St., Unit "A", Santa Ana, CA 92705.

AM CB Base-Station Transceiver

The Robyn Model AM-500D AM CB base station transceiver is rated to deliver 4 watts of output power with a 100% modulation limit on all 40 CB channels. It features a large LED-type numeric channel indicator, illuminated SWR and S/r-f meters, and separate transmit (TX) and receive (RX) indicators. Pushbutton switches control PA/CB selection, ANL (automatic noise limiter) in/out selection, and choice of internal or external speaker. Separate rotary controls are provided for adjusting VOLUME, SQUELCH, RF GAIN, TONE, MIKE GAIN, and SWR/CAL. The dual conversion receiver is

(Continued on page 24)

Radio Shack's personal computer system? This ad just might make you a believer.

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(Continued from page 22)

rated at: 0.5 µV sensitivity, 60 dB minimum adjacent-channel rejection, 50 dB or more image rejection, and 3.5 watts audio output power. The transceiver can be powered from the ac power line or a 12-volt dc source. Size is 13"W × 11½"D × 5"H (33 × 29.2 × 12.7 cm) and weight is 11 lb (5 kg). $189.95.

CIRCLE NO. 97 ON FREE INFORMATION CARD

IET Digital Multimeter

The IET DM-45 is an auto-ranging, auto-polarity 3½-digit multimeter of pocket size. It measures ac and dc voltages from 1 mV to 999 V, ac and dc current from 1 mA to 2 A, and resistance from 1 to 999,000 ohms. Input impedance is 1000 megohms in the 1-volt range and 10 megohms in other ranges. Basic accuracy is specified as 0.2%, ±1 digit. RANGE HOLD and READING HOLD switch positions enable the user to lock into any range to store any reading on the display. Dimensions are 5.6 x 3 x 1.6 in. (14.2 x 7.6 x 4.1 cm); weight is 10 oz. Includes rechargeable batteries and ac adapter/charger. $159.

CIRCLE NO. 98 ON FREE INFORMATION CARD

KLH Car Speaker

The KLH Model 693DMSC is a 3-way, coaxial speaker designed for automotive use. Its woofer is 6 X 9 in., with a 30-oz magnet. The midrange is a dome type covering the range from 1 to 4 kHz. The tweeter is a samarium-cobalt type which, according to the manufacturer, "functions like an electrostatic unit without electrostatic limitations."

CIRCLE NO. 99 ON FREE INFORMATION CARD

GC Nibbling Tool

A hand-operated nibbling tool for cutting sheet metal and plastic has been introduced by GC Electronics. The tool can cut a hole of virtually any shape in steel up to 18-ga., or in copper, aluminum or plastic up to 1/16" (1.6 mm) thick. A 3/8" (9.5 mm) starting hole is required for inside cuts.

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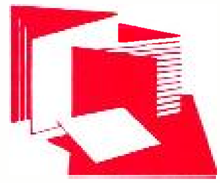

New Literature

SYLVANIA SEMICONDUCTOR GUIDE

GTE Sylvania has announced availability of the 1978 ECG Semiconductor Master Replacement Guide. This catalog ($2.95) lists over 137,000 industry part numbers cross-referenced to the Sylvania ECG semiconductor line. A wide assortment of domestic and imported replacement solid-state devices is presented for entertainment, commercial, and industrial/MRO applications. Also included in this publication are outline drawings, circuit diagrams and technical descriptions of transistors, diodes, rectifiers, SCR's, Triac's, and others. Address: GTE Marketing Services Center, 70 Empire Dr., West Seneca, NY 14224.

H-P CALCULATOR BROCHURE

A new, six-page brochure from the Hewlett-Packard Company describes the HP-19C and the HP-29C keystroke programmable advanced scientific calculators that feature 98 fully merged program steps, continuous memory, full editing and storage functions and 30 data registers. The HP-19C has a built-in thermal printer. Included in the brochure are sections describing the advanced programming features of the two calculators—including branching, subroutines, indirect control functions, and editing—a summary of keyboard features, and physical specifications. Address: Hewlett-Packard Company, 1507 Page Mill Rd., Palo Alto, CA 94304.

EXACT INSTRUMENT CATALOG

Exact Electronics, Inc., has released a 66-page catalog containing specifications for each frequency synthesizer and function/waveform generator in its product line. A comparison chart simplifies instrument selection. Address: Exact Electronics Inc., Box 160, Hillsboro, OR 97123.

B&F SURPLUS ELECTRONICS CATALOG

The 32-page "Clean-Sweep-Sale" catalog available from B&F Enterprises features speaker kits, surplus I/O terminals, a 16-watt stereo amplifier kit, regulated 10-30V 5A power supply kit, plus surplus bargains for the hobbyist and engineer. Photos and diagrams are also included. Address: B&F Enterprises, 119 Foster St., Peabody, MA 01960.

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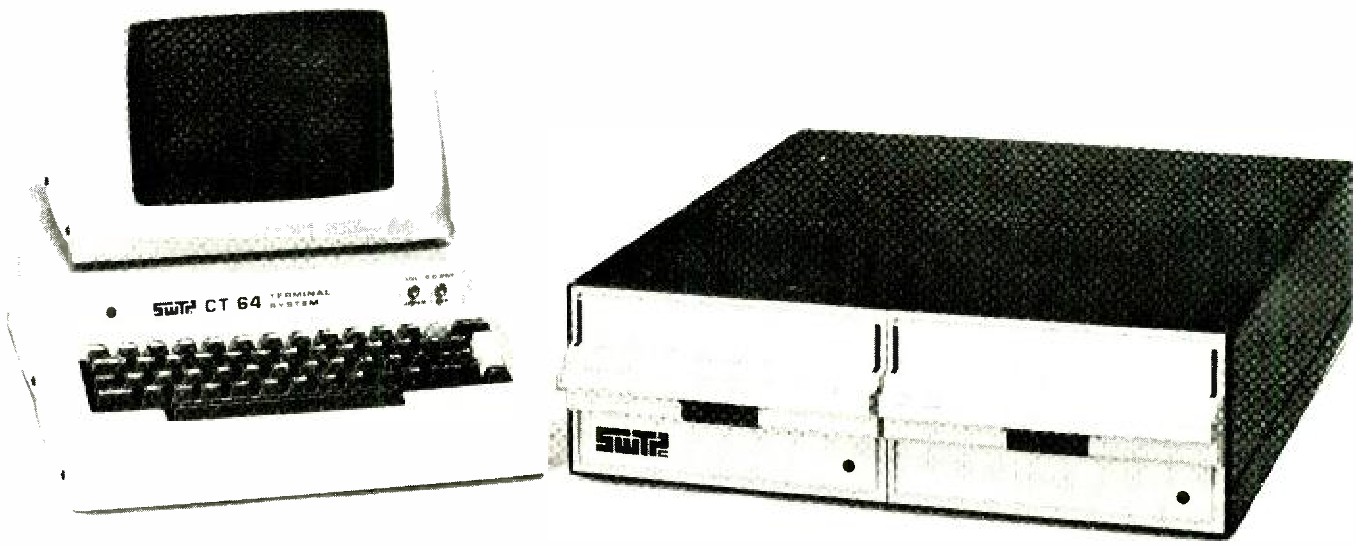

1 MEGABYTE DISK SYSTEM

DMAF1 introduces a new level of capability to small computer systems. This disk system features two standard size floppy disk drives using the new double sided disk and two heads per drive. Usable storage space of over 600 kilobytes per drive, giving a total of over 1.0 megabyte of storage on line at all times. Ideal for small business applications, or for personal "super" systems.

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The controller occupies one main memory slot in an SS-50 bus and uses the Motorola MC-6844 DMA controller. The combination of a DMA type controller and double sided disks give the system speed of data transfer unobtainable with smaller drives.

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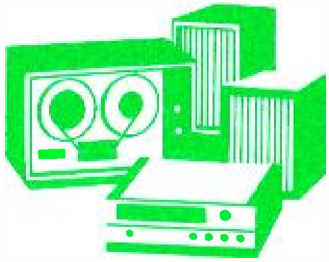

Stereo Scene

By Ralph Hodges

FOR THE RECORD—II

EVERY couple of years the engineering department at Shure Brothers mounts a day-long technical seminar for interested members of the audio press. Invariably these seminars are *events*, not only because they generally herald the unveiling of an important new product, but especially because they bring to light research conducted by the company over the intervening period.

A word about the nature of this research is in order before we go any further. There now exists a considerable body of literature on the subject of record playing, attempting to deal with such matters as tracing distortion, record and stylus wear, mass-compliance considerations in negotiating modulations scribed on a vinyl surface, etc. As a result, the mechanics of record playing have become well enough understood to make it obvious that they are not very well understood at all. Probably what is most lacking is the solid underpinnings of empirical data to support the theoretical conclusions that have been offered. Records differ, one from another, in a surprising number of crucial ways; so do phono cartridges, given the inevitable vagaries of assembling a tiny and complex electromechanical device that can be sold at an affordable price. This raises the problem of accumulating enough experimental evidence to be statistically significant—a problem that Shure has been attacking for some years. The company does not claim to be even close to the ultimate answers, but what it has discovered from playing a great number of records a great number of times with a variety of pickups adds up to a unique body of data.

At the latest seminar, Shure engineers told a somewhat bemused audience of audio writers that: (1) electrostatic charges on record surfaces can have pernicious effects on record-player performance, not the least of them being alterations of tracking force of up to 3/8 gram; (2) that mechanical damping, properly applied, is of benefit when playing the (warped) records available in the real world; that cartridge vertical tracking angle is still a matter of serious concern, although the effects of minor errors (a degree or so) continue to defy objective and subjective analysis; (4) that time-domain distortions such as warp wow are gaining further recognition as major faults in record-player performance; and (5) that record and stylus wear, subjects of profound mysteriousness, can be tied down to a few more generalizations.

Getting Static. Shure finds that your typical phonograph record can accumulate a static charge (negative) of up to 30,000 volts. Above that point the breakdown potential of the surrounding air is reached and static charges are carried off. Surprisingly, the actual business of playing the record does not seem to contribute significantly to the charge. Removing the record from its protective sleeve appears to be the major culprit.

Because vinyl is an effective insulator, these static charges tend to be local, cropping up in distinct patches where (presumably) the record surface has been in intimate sliding contact with the interior of the sleeve. Therefore, although the record will exhibit a measurable and fairly constant "macrofield" from some distance away, the pickup will pass through a series of "microfields" as it negotiates each revolution of the record. The magnetic attraction these fields exert will pull the cartridge to the record, compressing the stylus assembly and giving rise to—of all things—a warp-wow effect. Shure's Roger Anderson demonstrated this by first playing a discharged record with steady test tones (fine) and then after scrubbing a small section of the record with a popular record-cleaning appliance (not so fine). A distinct warble in pitch was heard with every rotation.

The conclusion to be drawn is that the patchy occurrences of static charge on the record can have enough influence on the tonearm/cartridge combination to significantly alter (or wobble) the tracking force. Evidently the effect is quite significant when the tracking force is as low as 1 gram. In fact, Shure's measurements of the variations are in large part based on differences in tracking ability of the cartridge when the static charge (and hence the mutual attraction of disc and pickup) is increased.

No indictment of record-cleaning devices was intended by this demonstration. In fact, Shure generally approves of them. However, discharging or neutralizing the record before it is played is obviously advisable. Its close proximity to the turntable platter (if metallic) will obviously help somewhat, as will the use of anti-static "pistols" available from a number of manufacturers. But a better way is probably afforded by the disc-tracking record cleaners with conductive (and grounded) bristles.

Getting Damped. The application of mechanical damping to the typical record-playing system is likely to be beneficial, Shure has decided, as long as the damping is applied at the proper place and in the proper amount. The proper place is said to be as near the stylus as possible, and the proper amount will of course depend on the characteristics of the cartridge and the effective mass of the tonearm structure, assuming negligible bearing friction. The effects of properly applied damping (with the Shure/SME 3009 tonearm) can be seen in Fig. 1. The damping mechanism being used is an integral part of a new Shure cartridge model (of which more a bit later), and its contribution is said to be a hefty reduction of output at the infrasonic tonearm/cartridge resonance.

What does this reduction mean in a practical sense? There are several interdependent ways of looking at it. According to Shure spokesmen: (1) There is much less infrasonic energy reaching the amplifier and loudspeakers, which

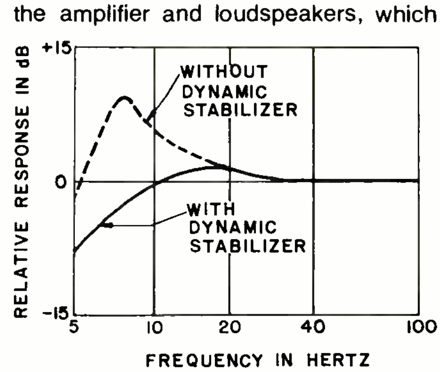

Fig. 1. Curve show effects of use of dynamic stabilizer, as measured by Shure.

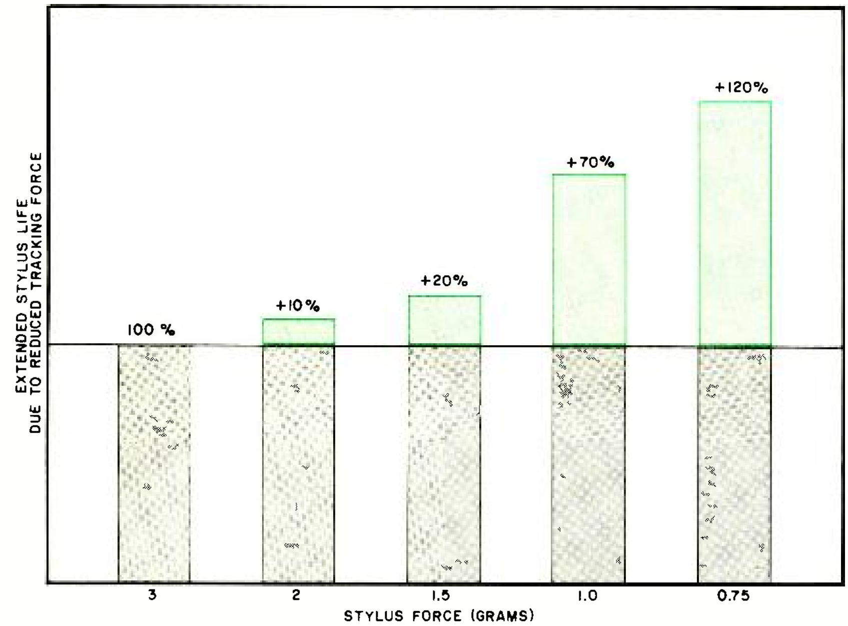

Fig. 2. Shure's studies suggest that stylus forces of 1.5 grams are best for reduced stylus wear.

means much less effort on their part in attempting to reproduce something that is musically inconsequential. (2) There is, by inference, much less stylus motion at these infrasonic frequencies, which means that the musical information on the record won't be frequency-modulated by warps and ripples in the record surface to as great a degree as heretofore. (3) There is an improvement in tracking ability at infrasonic frequencies. According to Shure, tracking ability is directly related to stylus force, and is therefore a commodity that can be used up cumulatively (just as your telephone bill reduces the resources you have to pay your gas and electric bill). Thus an improvement in tracking ability at infrasonic frequencies (present on most records, which are inevitably far from perfectly flat) means more tracking ability left over for the musical information on the disc.

Getting Worn. The perennial questions of consumers as to how long their styli or their records can be expected to last remain unanswered. However, there are some general conclusions that can be drawn at this time. (1) According to Shure, stylus wear is closely related to tracking force, no matter what the configuration of the stylus (conical, elliptical, Shibata, etc.). The bar graph in Fig. 2 illustrates this, and shows why Shure recommends a maximum of 1.5 grams on tracking force. (2) Playing the same record over and over for a given number of hours is likely to result in more stylus wear than playing different records for a comparable length of time. The reason for this seems to be a build-up of abrasive agents in the record groove—in particular, diamond dust from the stylus which has become embedded in the groove during previous plays. (3) A certain amount of wear is inevitable on present-day records when played with present-day cartridges. Even after the first play, sophisticated instruments can detect a shallow trough gouged by the stylus upon the groove walls. To a certain extent this is beneficial; the smoothing of the groove-wall surface improves the signal-to-noise ratio. But after this burnishing of the groove has taken place, any further alteration of its shape is likely to be detrimental.

An interesting sidelight: Shure's experimental results indicate that, on records with simple sine-wave test tones, the wearing process can actually reduce the level of harmonic-distortion products by as much as 66 percent.

Getting a New Cartridge. The new top-of-line Shure phono pickup, the V15 Type IV, is of course an attempt to cope with all the newly documented phenomena discussed above. Like its predecessors it has a flip-down stylus guard that remains as functional as ever. But the stylus guard has grown a little beard of conductive carbon-fiber bristles that draw off static charges from the record surface. It is also supported by a pair of vicous-damped pivots that make it an effective damping mechanism for the arm-cartridge resonance. And finally, the little beard is an effective record cleaner, although that is a secondary function and no substitute for a thorough cleaning of the record before any attempt to play it. (See Hirsch-Houck's test report on the new V15, this issue.)

All in all, the conclusions drawn by Shure's research are highly provocative.

On Another Front. Stanton's remarkable stylus for playing record stampers (Fig. 3) has been fairly well publicized in recent months. It solves—or at least comes as close as possible to solving—a weighty problem on the mind of every record manufacturer: How can I tell whether the molding parts (the stampers) for my record are any good before going to the expense of having them clamped into a press to produce a few test pressings? Because it is a mold, the nickel stamper has ridges instead of grooves, and anything intended to play these ridges must straddle a peak instead of plumbing a depression. The illustration explains much better than words could how the Stanton special-application stylus accomplishes its task, but there's another side to the story as well.

According to Stanton, the stamper-playing stylus has turned out to be a remarkably good tip for the reproduction of 78-rpm records. No explanation has yet been given for this, other than the fact that the stylus's outer dimensions are appropriate for the wider grooves on 78-rpm records (as are, indeed, the dimensions of tips sold especially for 78-rpm reproduction). Pending a thorough examination of exactly what is going on, Stanton may decide to offer the stylus to consumers (it fits the cartridge bodies for the 681 and 680 model series). A consumer price schedule has not yet been created, however. ◇

Fig. 3. Special Stanton stylus plays ridges on metal stampers with a two-point configuration.

Para-Power

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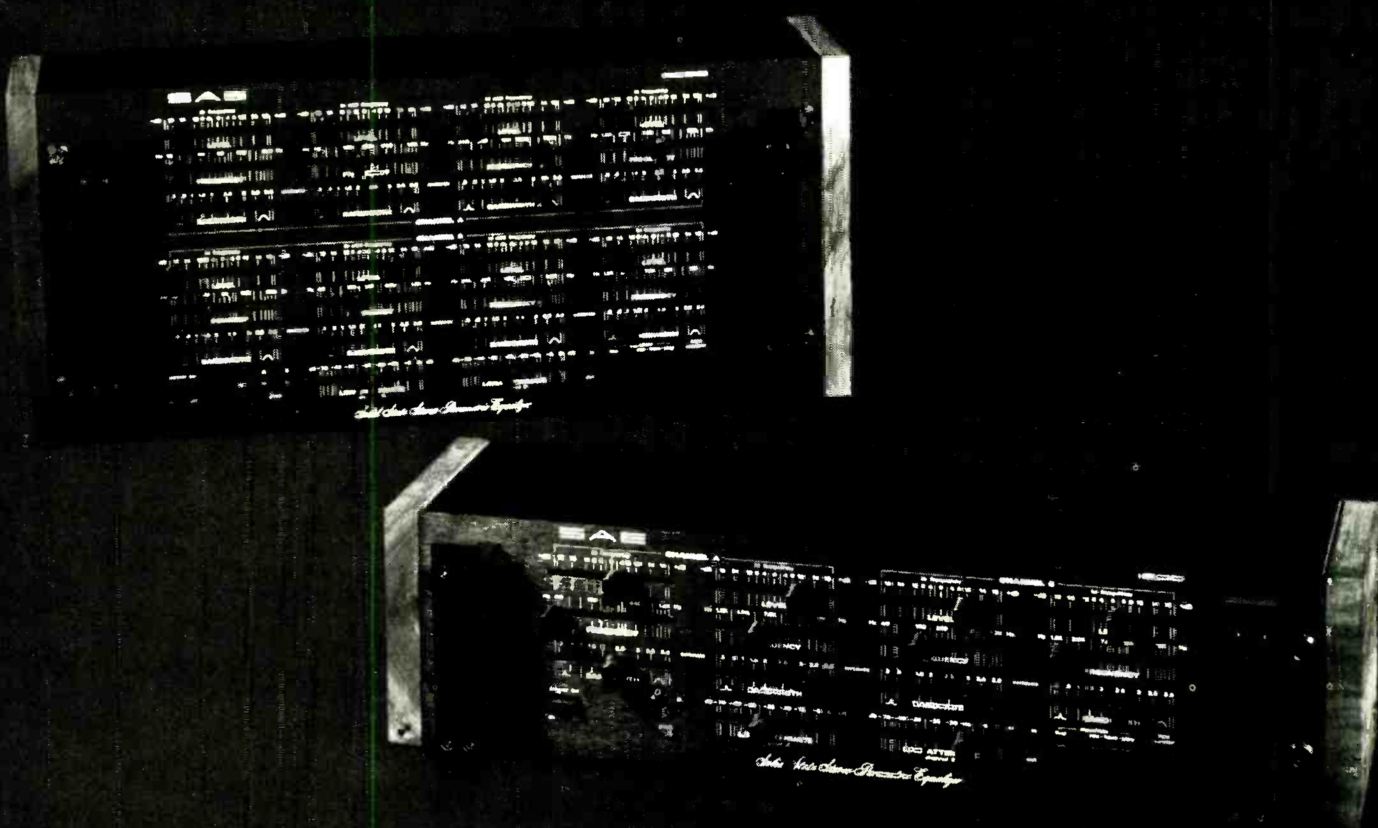

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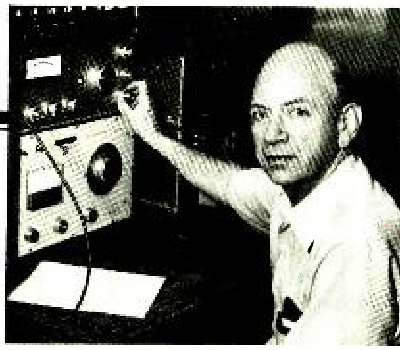
Julian Hirsch Audio Reports



HOW NECESSARY IS SELECTABLE I-F BANDWIDTH IN AN FM TUNER?

ABOUT four years ago, the first consumer-model FM tuner with selectable i-f bandwidths (the Yamaha CT-7000) made its appearance. In a tuner selling for some $1200, one would expect features not found on more mundane products, and the provision for wide and narrow i-f bandwidths seemed to be perfectly reasonable for a pace-setting product. Competition being what it is, other tuners have since joined the "wide/narrow" fraternity. The Nikko Gamma I, reviewed this month, is a good example, and its $300 price brings this feature within the reach of almost every audiophile.

If it were possible to make ideally shaped i-f filters, there would be no need to offer a choice of bandwidths. It is necessary to accept a bandwidth of at least 150 kHz (and undesirable to have it wider than 200 kHz) if a tuner is to receive undistorted programs from any station in an alternate-channel relationship to any other station (a "worst case" example).

Practical filters do not have flat tops or infinitely steep rejection slopes. At least as important as the amplitude response of a filter is its phase response. Group delay distortion can cause different sideband frequencies to pass through the filter in different time relationships, resulting in severe distortion and loss of stereo separation. Generally, it is necessary to compromise filter design to obtain satisfactory phase and amplitude characteristics.

If a tuner has a single i-f bandwidth, it thus represents a compromise between selectivity and distortion (as well as stereo channel separation, to some degree). The fact that some tuners achieve very respectable performance in all categories with a single filter system is a testimonial to the care and expertise that went into their design. However, if one wishes to obtain the best of both worlds (high selectivity and low distortion) from an FM tuner, it is necessary to have two i-f bandwidths available. Sometimes, as in the case of the Yamaha CT-7000, the two are obtained from entirely different i-f amplifiers, each designed for optimum performance. It is also possible to switch filters, using most of the i-f amplifier components in common with both modes of operation.

To illustrate the advantages of a dual bandwidth system, consider some typical selectivity values (alternate channel) for single bandwidth tuners. A fairly good tuner might have an IHF selectivity rating of 60 to 70 dB, combined with a stereo harmonic distortion of perhaps 0.15 to 0.2%. These are certainly very adequate performance figures for most people, especially since they are obtainable in some rather moderate-priced tuners and receivers.

Suppose, however, that one is in the unfortunate position of living near a fairly strong station that broadcasts rock music 24 hours a day, while the nearest classical is 50 miles away and only 400 kHz from the local transmitter (rock enthusiasts can feel free to interchange the programming of the two stations!). Assuming that one's tuner front end does not overload from the local signal, which is another matter entirely, it is likely that you will need all the selectivity you can get. A more expensive tuner might improve the selectivity rating to 80 or even 90 dB without serious compromise in distortion or other factors. To get more than about 90 dB selectivity (100 dB or even more is possible), a tuner with a super-narrow i-f filter is required. The distortion and channel separation of your favorite classical station may be impaired, but probably not enough to be objectionable. The alternative might possibly be not receiving the station at all!

Now suppose your second favorite station is fairly close to your location, quite strong, and transmits very-high-quality programs. Being a purist, you may not wish to settle for "only" 25 to 30 dB of channel separation, though it might be sufficient. It is possible to "eat one's cake and have it, too" with a tuner having switchable i-f bandwidths. For the "easy" listening situation, the wide bandwidth may reduce stereo distortion to well below 0.1% and increase channel separation to 45 dB or even more. The sacrifice is in selectivity, which may be as low as 20 or 25 dB. But, if the station is in the clear, that will pose no problems. I have found no trouble when listening to most stations in the spectrally crowded New York area with a tuner having that order of selectivity.

I have been asked if one can determine just how much selectivity is needed in any given situation so that one can decide whether or not a more selective tuner is required, or if a wider bandwidth will suffice. Unfortunately, no firm answer can be given to that question. There are too many variables involved. About all that can be said with certainty is that, if you experience interference from alternate channel stations (400 kHz spacing) in the form of a program breaking through on to another station, you need more selectivity! Whether a specific degree of selectivity is adequate for your needs is impossible to say. Sometimes the trouble can be cured without involving the tuner. If the two stations concerned are not in the same direction from your location, a good directional antenna can sometimes be used to correct the problem. Such an antenna can reduce the level of the stronger signal by a greater amount than it reduces the level of the weaker one; this alone can sometimes eliminate the interference.

I have this situation in my own home, where one tuner suffers badly from interference by an alternate channel station, yet others (on different antennas) are completely free of the problem. Moving the offending tuner to another part of the house, on a different antenna, corrected the problem. If I were to insist on listening at the original location to those stations, a better tuner would certainly be the answer.

So, to answer the question posed by the title, a choice of i-f bandwidths is a nicety for most people, but a necessity for others. At prices over $1000, most of us can do without it very well. But at $300, it becomes one of the more attractive and useful features to look for when buying a tuner.

NIKKO GAMMA I STEREO FM TUNER

Features wide and narrow i-f bandwidths.

HIRSCH-HOUCK

In spite of its compact dimensions, the Gamma I FM tuner from Nikko has a full complement of operating features and controls. Topping the list is the tuner's selectable i-f bandwidth that allows the user to trade capture ratio and selectivity for greater channel separation and lower distortion. Other features included are: switchable 25/75-μs deemphasis, FM detector output, oscilloscope outputs that provide a multipath display, and both fixed and variable level audio signal outputs.

The tuner has a 19" (48.3-cm) wide front panel, which makes it rack-mountable, although its 2½" (6.4-cm) height does not conform with EIA standards for rack-panel heights. Depth is 9" (23 cm).

Product Focus

The Nikko Gamma I is one of the small, but growing number of FM tuners that offer a choice of wide or narrow i-f bandwidths. This is done by using two separate i-f amplifiers between the mixer output and the limiter output. Both are driven simultaneously from the mixer, through FET stages that isolate them from each other. Their outputs are also joined, but through diodes that can be switched from conducting to nonconducting states by a dc control voltage, through the switch used for WIDE/NARROW bandwidth selection.

The common terminal of the output coupling diodes goes to an IC amplifier/limiter stage that also provides signal-strength and channel-center tuning indications on the meters on the front panel, interstation noise muting, and some of the multipath information to the jacks in the rear of the tuner, for viewing on an external oscilloscope. According to the schematic, the comprehensive i-f IC stage also includes a quadrature detector, which apparently supplies only the tuning signal to the center-channel meter. A separate IC limiter and a ratio detector are actually used to derive the audio signal, presumably because of the lower distortion resulting from a separate optimized detector circuit.

In the selective i-f system, the narrow-band amplifier consists of four pairs of ceramic filters, with gain supplied by three IC stages, in a conventional configuration. The wide-band amplifier consists of two IC stages and two filters. One filter is a relatively large, cased unit identified as a "phase linear filter" (there are no visible clues as to its internal construction), while the other is a ceramic filter that, judging from its size, is rather more complex than the ceramic i-f filters used in most FM tuners (and in the narrow-band amplifier of the Gamma I). The special qualities of these filters presumably lie in their combination of wide bandwidth and linear phase shift, both of which are required for low-distortion stereo FM performance.

PERFORMANCE SPECIFICATIONS

Specification	Rated	Measured
Usable sensitivity (mono)	10.3 dBf, 1.8 µV	14 dBf, 2.7 µV
50-dB quieting sensitivity		
Mono	14 dBf, 2.7 µV	16.5 dBf, 3.7 µV
Stereo	34 dBf, 28 µV	38.6 dBf, 47 µV
S/N at 65 dBf		
Mono	78 dB	68.5 dB
Stereo	75 dB	67.5 dB
Hum (re: 100% modulation)	NA	−65 dB
THD at 65 dBf		
Mono:		
Wide	0.04%	0.057%
Narrow	0.08%	0.155%
Stereo:		
Wide	0.06%	0.044%
Narrow	0.2%	0.47%
Frequency response (30-15,000 Hz)	+0.4/−0.8 dB	+0.9/−0.8 dB
Capture ratio		
Wide	1.0 dB	1.0 dB
Narrow	1.5 dB	2.0 dB
Alternate-channel selectivity		
Wide	35 dB	39.8 dB
Narrow	80 dB	81 dB
Adjacent-channel selectivity		
Wide	NA	4.9 dB
Narrow	NA	9.9 dB
Spurious-response suppression	110 dB	NA
Image-response ratio	110 dB	greater than 106 dB
I-f response ratio	110 dB	NA
AM suppression	60 dB	70 dB
Stereo separation at 1000 Hz		
Wide	55 dB	46.5 dB
Narrow	45 dB	54 dB
Stereo separation (50-10,000 Hz)		
Wide	35 dB	31 dB
Narrow	32 dB	31 dB
Subcarrier product rejection	65 dB	98 dB
Muting threshold	10 dBf, 1.7 µV	19.8 dBf, 5 µV
Output level at 1000 Hz (varies)	1.3 V maximum	1.45 V maximum

It weighs 12.1 lb (5.5 kg). Its nationally advertised value is $350.

General Description. As is the case with some other tuners and receivers we have seen, the Gamma I's stereo/mono selector and muting circuit activator are combined in a single control. Hence, muting can be employed only in the automatic stereo mode. (Of course, mono signals will be heard perfectly well in this mode.) For reception of weak signals where it is necessary to disable the muting, the tuner operates in the mono mode; a stereo signal would not be listenable under these conditions.

The panel dimensions of the tuner allow only a single row of controls to be used, with the dial window occupying about half of the panel width. The calibration marks on the tuning scales are linearly distributed. Actual tuning is by a very smooth flywheel mechanism that is noteworthy considering that the internal height of the tuner does not permit the use of a large-diameter flywheel.

The two meters indicate relative signal strength and center-channel tuning.

In addition to the large TUNING and OUTPUT LEVEL control knobs and a toggle-type POWER switch, there are three pushbutton switches on the front panel of the tuner. The buttons are for selecting WIDE or NARROW IF BAND, switching in and out the HI-BLEND circuit, and for selecting STEREO or MONO MODE of operation. LED's located just above each button come on when the various functions are activated. Another LED inside the dial window comes on when a stereo signal is received.

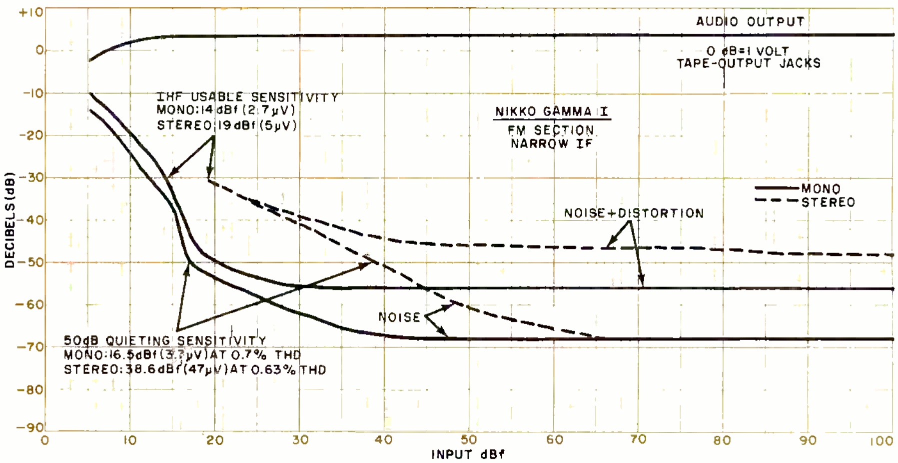
User Comment. The Gamma I can fairly be described as a no-frills "super tuner." We base this description on the fact that the Gamma I has exceptionally high interference rejection and sensitivity, distortion that is lower than the residual levels of the finest signal generators, flat frequency response, and stereo channel separation that is far greater than that of any broadcast station. In fact, only the S/N performance and residual hum (both of which were quite satisfactory but not exceptional) prevent the Gamma I from rivalling the performance of some tuners that cost several times this tuner's price. It should also be noted that although the measured sensitivity of our test tuner fell a couple of decibels short of its published ratings, it still had far more sensitivity than most people will ever need.

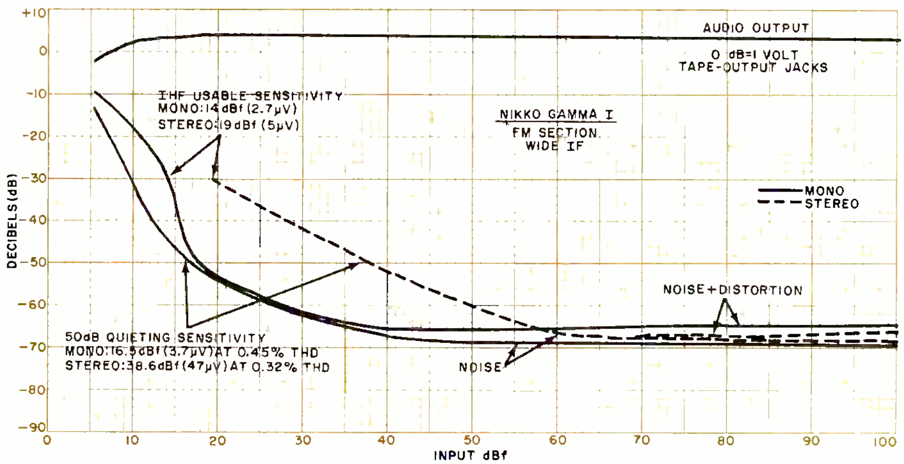
That such a high level of performance

is available for its stated price and in such a compact component is testimony to the state of modern technology and a tribute to Nikko's designers, who appear to have resisted the temptation to dilute their efforts with marginal or purely cosmetic features. Nothing that could contribute to the useful performance of the Gamma I has been omitted.

We preferred to use the tuner in its wide-band mode, which reduces the distortion to well below the rated capabilities of our Sound Technology signal generator. The Gamma I retained enough selectivity in this mode to let it be used without difficulty on the crowded FM band in the New York metropolitan area. Perhaps the most surprising test result was the 19-kHz pilot carrier rejection figure of 98 dB, which was barely within the measurement capabilities of our Hewlett-Packard spectrum analyzer. In spite of this, the tuner's frequency response was almost perfectly flat to 15,000 Hz. This indicates that it has unusually effective low-pass filters in its audio circuits or some form of pilot-carrier cancelling circuitry. (No schematic was furnished with the tuner.) In either case, there should be no problems when it is used with a tape recorder or a Dolby noise-reduction accessory.

The "feel" of the tuning mechanism and general handling ease of the Gamma I were excellent. The muting action was ideal, with no transient noises and a complete silence until the pointer was well into the center of the scale of the tuning meter. Although it was marked only at 0.5-MHz intervals, the dial calibration was very accurate and left no doubt as to what station was being received. In short, the Gamma I proved to be one of the most functional and listenable tuners we have used, in spite of, or perhaps because of, a near-total lack of gimmickry and cosmetic devices.





Noise and sensitivity curves for narrow (top) and wide i-f bandwidths.

CIRCLE NO 101 ON FREE INFORMATION CARD

FISHER MODEL CR-4025 CASSETTE DECK

Wireless control unit has "Pause" for remote on-off recording purposes.

HIRSCH-HOUCK

The Fisher Model CR-4025 cassette deck features a wireless remote control PAUSE function that permits recording and playing back of tapes to be interrupted and resumed from a location some distance from the deck. The front-loading deck also has a single governor-controlled dc motor and two tape heads. It has built-in Dolby B noise-reduction circuitry, tape bias and equalization switching for normal (ferric-oxide) and chromium-dioxide (CrO_2) tapes, and selectable line and microphone inputs.

The deck measures 15 ⅛"W × 11 ⅞"D × 6"H (38.4 × 30.2 × 15.2 cm) and weighs 13 lb 10 oz (6.2 kg). Its nationally advertised value is $249.95

General Description. The recording levels for the two channels are independently adjustable. However, the line and microphone inputs cannot be mixed. Playback level from the deck is fixed.

Illuminated VU meters permit monitoring of both the record and the playback levels over a range of −20 to +5 dB. (The standard Dolby reference mark is at the +3-dB point on the meter scales.) The microphone input and stereo headphone output jacks are located on the front panel of the deck. On the rear apron are the phono-jack LINE inputs and outputs and a control shaft for adjusting the sensitivity of the remote-control system.

The transport controls are operated by mechanical levers located below the hinged door into which the cassette is placed. The levers can be operated in any sequence without having to go through STOP. The transport mechanism has an automatic shutoff and mechanical disengagement system at the end of the tape in the PLAY mode, but it does not operate in the fast-forward and rewind modes.

The STOP/EJECT lever stops tape motion when first operated. Releasing and operating it again causes the cassette door to pop open for easy removal of the tape from the deck.

dB from 40 to 10,000 Hz. (These were the frequency limits of the test tapes.)

For a 0-dB recording level, a LINE input of 67 mV or a MIC input of 0.13 mV was required. The MIC input overloaded at a fairly low level of 23.5 mV. The playback level from a 0-dB recording was 0.80 volt with Maxell UD-XL I tape and 0.71 volt with BASF Professional II tape. The playback distortion (third harmonic) from 1000-Hz recordings at 0 dB were 0.63% and 1.8%, respectively, with these tapes. The reference distortion level of 3% was reached at recording inputs of +7 dB with UD-XL I and +3 dB with the BASF tapes. The S/N, relative to these levels, was 56.5 and 50.5 dB, respectively, in an unweighted measurement. With "A" weighting, they improved to 61.5 and 59.5 dB. Finally, us-

The remote-control transmitter, which is about the size of a 100-mm cigarette package, contains an ultrasonic generator and transducer. A receiving module is located behind the front panel of the deck. When the transmitter is aimed at the deck and a button on its side is pressed, a solenoid in the deck energizes the PAUSE lever and a red LED near the receiver's input grille comes on to indicate that the transport is in the pause mode. A second operation of the transmitter's button releases the solenoid and restores normal operation.

Laboratory Measurements. Since the owner's manual makes no specific recommendations for tapes for which the deck has been matched, we initially ran a series of record/playback curves with tapes we had on hand. With the NORMAL setting of the BIAS switch, there was little difference between the curves we obtained with most tapes, including Scotch Dynarange and Master I, Memorex MRX2, BASF Professional I, and Maxell UD-XL I. The somewhat "hotter" TDK AD tape yielded a slightly rising high-end response, which other tapes did not produce. The flattest response, by a small margin, was obtained with Maxell UD-XL I tape, which we used for our subsequent tests with the NORMAL switch setting.

We made similar measurements with Scotch Master II, Maxell UD-XL II, TDK SA, Sony CrO_2 and BASF Professional II tapes for the CrO_2 setting of the bias switch. (Sony CrO_2 and BASF Professional II were the only true chromium-dioxide tapes in the group.) The three "chrome equivalent" ferric-oxide and the Sony chrome tapes gave nearly identical response curves, but BASF Professional II was clearly the best of the group with our test deck. (Its excellent compatibility was later confirmed by Fisher.)

The frequency response at a −20-dB recording level, with Maxell UD-XL I tape, was within ±1.5 dB from 60 to 14,500 Hz. With the chrome BASF Professional II, the response was nearly the same, except that it was noticeably flatter throughout most of the high-frequency range. At 0 dB, the saturation we observed with the UD-XL I tape was typical of most two-head tape recorders. The response curve gradually fell beyond 6000 Hz and intersected the −20-dB curve at 11,700 Hz. As expected, the chrome tape was considerably better in its high-frequency saturation properties, so that the 0-dB curve dropped off more gradually and never intersected the −20 dB curve.

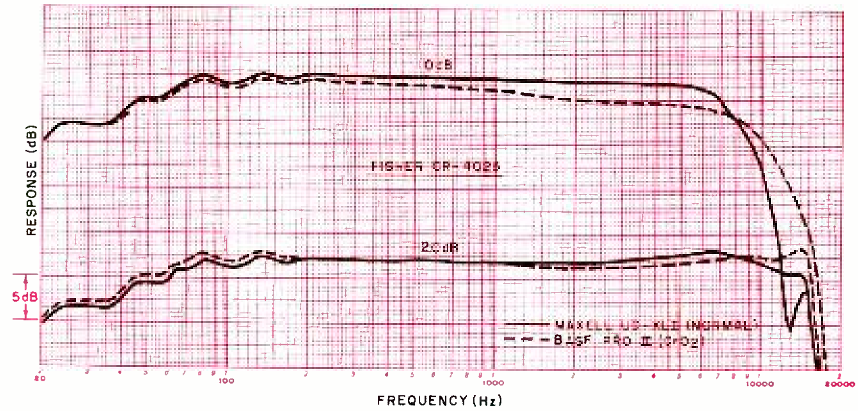
The "tracking" of the Dolby circuits was measured at recording levels of −20, −30, and −40 dB. The net change in frequency response, with the Dolby system in and out of the circuit, was quite noticeable at the two higher levels, amounting to 3 or 4 dB at most frequencies from 2000 or 3000 Hz up to about 13,000 Hz. (The Dolby Laboratories specifications allow a ±2 dB variation.)

The playback equalization was measured with a TDK AC-337 test tape for NORMAL (120-µs) equalization, and with the Teac 116SP tape for CrO_2 (70-µs) equalization. The normal response was within ±0.6 dB from 40 to 12,500 Hz, and the CrO_2 response was within ±1

Product Focus

The most obviously novel feature of the Fisher Model CR-4025 cassette deck is its wireless remote-control PAUSE system. The hand-held transmitter is powered by a pair of AA cells and generates a 40-kHz ultrasonic signal when a button on its side is pressed. This is picked up by a small ceramic microphone element behind a grille on the front panel of the cassette deck and amplified by an IC. A gain control (sensitivity adjustment) follows the IC, and from it, the signal goes to a transistor stage that has a 40-kHz tuned circuit in its collector circuit. After further amplification, the ultrasonic signal is rectified. The dc output from the rectifier is amplified to the point where it can activate a solenoid that moves the PAUSE lever to its ON position. The PAUSE lever latches into place until the next application of a control signal operates the solenoid again and turns it off. The solenoid is operated from a separate power supply rectifier. (Judging from its size, it may well consume more power than the rest of the recorder.)

The basic recorder circuits are conventional and unusually simple. Each channel employs a single IC, three transistors, and a moderate number of discrete components for most of its recording and playback gain and equalization functions. In addition, there is an IC for the Dolby noise-reduction system in each channel and a few discrete components for the audio LINE outputs and metering circuits. (The meter rectifiers are driven from the headphone outputs.) The bias/erase oscillator is packaged as a separate module in a sealed metal can.



Frequency response for two types of tape at 0 and −20 dB.

ing the Dolby system and CCIR/ARM weighting, the S/N was a very respectable 66 dB with either tape. The noise level increased by 18 dB through the MIC inputs at maximum gain, but the increase was correspondingly less at reduced gain.

The weighted rms wow/flutter was 0.095%, and a weighted peak measurement (DIN) gave a ±0.15% reading. The speed of the tape transport was about 1% fast. In fast forward and rewind, a C60 cassette was moved from end to end in 82 and 85 seconds, respectively. The channel separation at 1000 Hz, measured with a TDK AC-352 tape, was 58 dB. The Dolby level calibrations on the meter were accurate to within 0.5 dB. The meters themselves proved to be very accurate and matched standard VU-meter ballistics exactly. They indicated 100% of steady-state on 0.3-second tone bursts. The headphone volume was low with 200-ohm phones, although it might have been adequate with 8-ohm phones.

User Comment. The deck met or surpassed its specified performance ratings, which were typical of cassette decks in its price class. The major concessions to price in its design appear to be in the absence of such niceties as an end-of-play shut-off from high speed

PERFORMANCE SPECIFICATIONS

Specification	Rated	Measured
Wow & flutter	0.09% W rms	0.095% W rms
S/N ratio	50 dB 56 dB with Dolby	50.5 dB (CrO_2) 66 dB with Dolby (CCIR/ARM weighting)
Erase ratio	70 dB	Not measured
Channel separation	35 dB	58 dB
Crosstalk	68 dB	Not measured
Frequency response	±3 dB, 40-14,000 Hz (CrO_2 tape)	±3 dB, 38-14,800 Hz (CrO_2)
THD at 0 VU	1.8%	1.8% (CrO_2)
Tape speed variation	±1.2%	+1.0%
Rewind/FF time	100 seconds	85/82 seconds (C60)
Mic inputs	0.2 mV/600 ohms	0.13 mV

operation, memory rewind, mixing of recording inputs, and playback level adjustment. To compensate for these omissions, it has the remote PAUSE feature, which we found to be quite useful. It always worked well, with enough sensitivity to operate from anywhere in the room. As Fisher suggests, the remote PAUSE is especially convenient for recording off the air or from records, allowing a certain degree of "editing" while recording without requiring the operator to be in two places at the same time.

Playing good recorded tapes, such as the Advent CR/70 series, the deck sounded first rate. Also, when we recorded interstation FM tuner hiss and compared the playback to the original, there was very little discernible difference between the two. When recording from FM broadcasts and records, the sound from the Model CR-4025 gave no hint that the playback was not from the original source.

SHURE MODEL V15 TYPE IV STEREO PHONO CARTRIDGE

Record-cleaning brush damps low-frequency tonearm/cartridge resonance.

HIRSCH-HOUCK

Heading the top of Shure's phono cartridge line is the new Model V15 Type IV. Aside from a damper and static neutralizer (see Product Focus), the basic phono transducer functions of the Type IV have been refined to a new high in performance. The stylus effective mass has been reduced from the Type III's 0.33 mg to 0.29 mg. The cartridge employs a new "hyperelliptical" stylus that is claimed to result in lower tracking distortion at high frequencies. The Type IV also offers a slightly greater output than its predecessor, the Type III. In a departure from Shure's practice for its top-of-the-line cartridges over the past few years, the Type IV is designed to deliver its flattest frequency response when loaded with 200 to 300 pF of capacitance and 47,000 ohms (in contrast, the Type III was designed to operate into a 400-to-500-pF load).

Supplied with a No. VN45HE hyperelliptical stylus, the Model V15 Type IV's nationally advertised value is $150.

General Description. While the Type IV physically resembles the Type III cartridge, the new cartridge's mounting holes have been redesigned to simplify installation in a tonearm headshell. It incorporates a threaded nut plate that fits into the body of the cartridge and eliminates the need for separate nuts to mount the cartridge.

Like the Type III, the Type IV is designed to track at forces in the range of 0.75 to 1.25 grams. However, to compensate for the weight of the brush assembly on the cartridge's stylus guard, the tonearm's tracking force must be set 0.5 gram higher so that the force registered at the stylus itself is in the range of 1.25 to 1.75 grams.

Shure was able to effect reduced mass in the stylus cantilever by using a smaller diameter alloy tube. The tube was strengthened with the aid of a stiffening rod at the pivot end. The damping material at the pivot end of the cantilever is decoupled in a graduated manner to improve trackability at high frequencies.

The frequency response of the new cartridge is rated at ±1 dB up to 8000 Hz and ±2 dB up to 20,000 Hz. The trackability at a 1-gram stylus force has been increased at all frequencies, especially between 5000 and 10,000 Hz and in the warp range between 8 and 15 Hz.

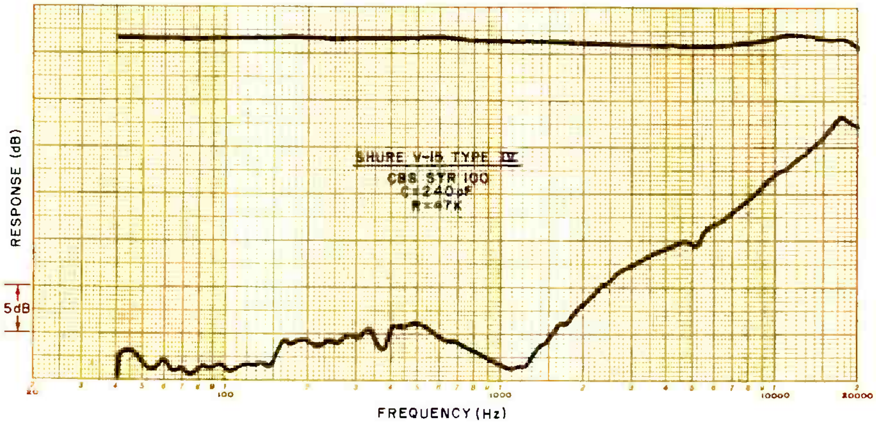
Laboratory Measurements. We installed the cartridge in the tonearm of a Dual Model 701 record player to perform our lab tests. Except where noted otherwise, our tests were performed at a 1-gram tracking force.

At a 1-gram force, the cartridge easily tracked our most severe test records. It could play the 300-Hz tones on the German Hi Fi Institute record to their 70-micron level, which is good hi-fi cartridge performance, at 0.75 gram and to 80 microns at 1 gram. The record's maximum level of 100 microns was playable without distortion at the cartridge's maximum rated tracking force of 1.25 grams. The output of the cartridge at 3.54 cm/s was 3.85 mV, with a channel balance of 0.5 dB (rated 4 mV and 3 dB).

The IM distortion measured with Shure's TTR102 test record was as low as we have ever measured. It was typically about 1% and reached a maximum of only 2% at the record's maximum velocity of 27 cm/s. Similarly, the high-frequency tracking test with the shaped 10,800-Hz tone bursts on the Shure TTR-103 record revealed nearly constant repetition rate distortion between 0.7% and 0.9% over the full 15-to-30-cm/s range of the record. The fact that neither distortion measurement exhibits appreciable variation over a wide range

PERFORMANCE SPECIFICATIONS

Specification	Rated	Measured
Frequency response	10–25,000 Hz (±1 dB to 8 kHz, ±2 dB to 20 kHz)	40–20,000 Hz ±0.8 dB
Output voltage	4.0 mV at 1000 Hz, 5 cm/s	3.85 mV at 1000 Hz, 3.54 cm/s
Channel balance	2 dB	0.5 dB
Channel separation	25 dB at 1000 Hz 15 dB at 10,000 Hz	30 dB at 1000 Hz 18 dB at 10,000 Hz
Tracking force	0.75 to 1.25 g at stylus tip 1.25 to 1.75 g with Dynamic Stabilizer	— —
Load	47 kilohms paralleled with 200 to 300 pF	47 kilohms paralleled with 240 pF



Composite respone and crosstalk using CBS STR100 test record.

of recorded velocities suggests that the measurement is the residual distortion in the records and the associated test instruments, rather than inherent distortion from the cartridge itself.

Our frequency response measurements with the CBS STR100 test record confirmed Shure's rating. The response was flat to within ±0.8 dB from 40 to 20,000 Hz. Channel separation is rated at a minimum of 25 dB at 1000 Hz and 15 dB at 10,000 Hz. Our measured figures were 30 and 18 dB, respectively. The frequency response was not materially affected by rather large changes in load capacitance (150 to 375 pF).

The damper worked with impressive effectiveness. It completely eliminated the usual rise at bass resonance and, in fact, produced a slight rolloff in bass response below about 20 Hz. The difference in bass output with the damper latched up and in its normal position was about 7 dB at 9 Hz and 1 dB at 20 Hz. No measurements were made of the destaticizing properties of the brush, aside from visual observations. The brush did remove visible amounts of dust from the records we played.

User Comment. The sound of the Model V15 Type IV is much like that of the Model V15 Type III, which also has a very flat frequency response. We doubt that the two cartridges could be distinguished by ear when playing most records. The best way to demonstrate the improved performance of the Type IV is to play records that tax the abilities of the Type III, but be prepared to find very few such records.

One test that highlights the difference between the cartridges is on the older Shure TTR110 "Audio Obstacle Course—Era III" test record. Some strain and incipient mistracking can be heard on the highest levels of the sibilance test with the Type III (and almost every other cartridge). At 1 gram, the Type IV was able to handle every part of this record with a complete lack of strain that is rarely encountered even with the finest cartridges. We also tried the completely different material on the new "Era IV" test record but obtained no definitive results. Those obtained with the "Era IV" record were not as easy to interpret as with the "Era III" record, perhaps because the cartridge was able to track it so completely without trouble.

The Type IV appears to be a cartridge that has the "most" of every desirable quality and the "least" of every undesirable quality. It is unsurpassed in the smoothness and flatness of its frequency response, low distortion, high trackability, and neutral sound character. It appears to effectively remove static charges and dust (both from the surface and the grooves) of records.

The cartridge's damping effect at bass resonance is accomplished in a manner that surpasses every other cartridge known to us. Aside from any audible benefits the damper might bestow on record playing, it makes a dramatic improvement in the tracking of warped records. We verified this with a number of warped records that were literally unplayable with other cartridges. Almost all of them were playable with the Type IV, which acted like it was glued to the surfaces of the records. We noted very little tendency for the cartridge to lift from the record surface at the crest of a warp.

About the only shortcoming of the Type IV is its rather high price, although this is certainly not the only phono cartridge in the $150 price range. Most important, with the Type IV, one gets very tangible improvements in performance instead of a cosmetic updating or unnecessary fancy packaging.

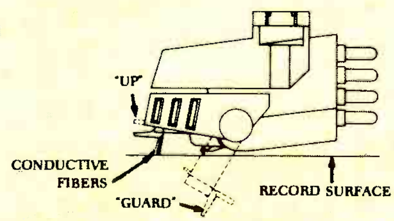
CIRCLE NO 102 ON FREE INFORMATION CARD

Product Focus

Most of the innovative aspects of the Shure Model V15 Type IV phono cartridge are not visible to the eye. Some are not even easy to measure with instruments. However, the cartridge's feature that sets it apart from other cartridges is its hinged stylus guard that is part of its removable stylus assembly.

Close examination reveals that a small brush is built into the lower portion of the stylus guard. It measures about ¼" (6.4-mm) wide and is designed to ride on the surface of the record just ahead of the stylus. There is nothing new about record brushes, even when they are attached to a cartridge, but the brush on the Type IV is rather unique. It consists of some 10,000 tiny graphite fibers, each of which is about 0.3 mil in diameter. In addition to removing dust from the record during play, about 10 of the fibers can fill a record groove to reach in and remove dust from the walls and bottom of the groove.

A more effective record-cleaning brush cannot by itself qualify as a novel cartridge feature. The difference with the brush on the Type IV cartridge is that the graphite fibers are electrically conductive. This plus the fact that the stylus guard is made of metal and is wired through to a ground terminal of the cartridge's signal outputs is what makes the brush unique. As a record is played, electrostatic charges that build up on its surface are drained off to ground. This keeps the net charge relatively low.



There are several advantages to neutralizing the static charge on a record being played. First, the vertical tracking force of the cartridge is not increased by electrostatic attraction, which can otherwise add several tenths of a gram to the net force. Second, the tendency of the vinyl record material to attract dust is greatly reduced. And, third, the crackling and popping sounds generated by electrostatic discharges while playing a record are eliminated or reduced.

The final contribution of the guard assembly is perhaps most important. The pivots of the guard are viscous damped so that the entire assembly acts as a damper for the low-frequency tonearm/cartridge resonance. The rise in the output of the cartridge at some low bass frequency, usually in the range of 8 to 10 Hz, is eliminated by the damping action and the tracking of warped records is greatly improved.

Before you buy a DC integrated amp, find out how much DC you're getting.

Pure DC. From input to output. With each amplifier-stage direct coupled (DC). With no capacitors in between. From the pre-amp to the power amp. That's what makes Technics SU-8080 a true DC integrated amp. But that's just one of the reasons for buying it.

Waveform fidelity is another. With the major source of phase shift, noise and distortion eliminated, Technics engineers were able to increase the frequency response of the SU-8080 to DC ~ 100 kHz −1 dB. And that means the SU-8080 can accurately reproduce waveforms, toneburst signals and square waves. Imagine how accurately it reproduces music.

To the SU-8080's DC pre-amp our engineers added an extremely quiet phono equalizer complete with Technics-developed ultra-low-noise transistors. The result: An increased phono S/N ratio of 100 dB at 10 mV with sharply reduced circuit and transistor noise, especially when compared to conventional designs. They also added some rather unconventional controls. Like a subsonic filter in the phono equalizer and a four-step phono impedance selector.

And to match our DC integrated amp, there's our equally impressive matching ST-8080 tuner.

Two RF stages with low-noise 4-pole dual-gate junction FETs combined with a linear FM variable tuning capacitor boost sensitivity while greatly reducing interference signal levels. At the same time, Technics-developed flat group delay filters in the IF (Intermodulation Frequency) stage increase selectivity without increasing distortion.

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Now that you know what DC does for the SU-8080 integrated amp and the matching ST-8080 tuner, find out what DC does for their specs.

SU-8080 Amp. POWER OUTPUT: *72 watts per channel min. RMS into 8 ohms from 20 Hz to 20 kHz with no more than 0.02% total harmonic distortion.* POWER SECTION S/N (IHF A): 115 dB. PHONO S/N (IHF A): 100 dB (10 mV). INPUT SENSITIVITY: 1 V/47kΩ.

ST-8080 Tuner. 50 dB QUIETING SENSITIVITY: Mono 13.6 dBf. Stereo 34.3 dBf. SELECTIVITY: 85 dB. THD: Mono 0.15%. Stereo 0.3%. CAPTURE RATIO: 1.0 dB.

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CIRCLE NO. 14 ON FREE INFORMATION CARD

CONSTRUCTION

Popular Electronics
JUNE 1978

Protect Your AIR CONDITIONER WITH A "COMPRESSOR GUARD"

Add-on device prevents compressor damage due to sudden loss and reappearance of electric power and low-voltage conditions.

BY RICHARD B. FERMOYLE

POWER BLACKOUTS and brownouts, especially during hot spells when the demand for power is at its peak, can cause damage to air-conditioners, refrigerators, and freezers. You can protect your compressor-type appliances from damage due to fluctuating power with the "Compressor Guard" described in this article. It costs about $15 to build and is easily installed.

Problem Defined. If power to the compressor is suddenly lost and reapplied before system pressures can be equalized, such as during a momentary power outage, damage to the system compressor can result. A low-voltage condition, commonly called "brownout," can also cause damage. In both cases, the damage usually takes place

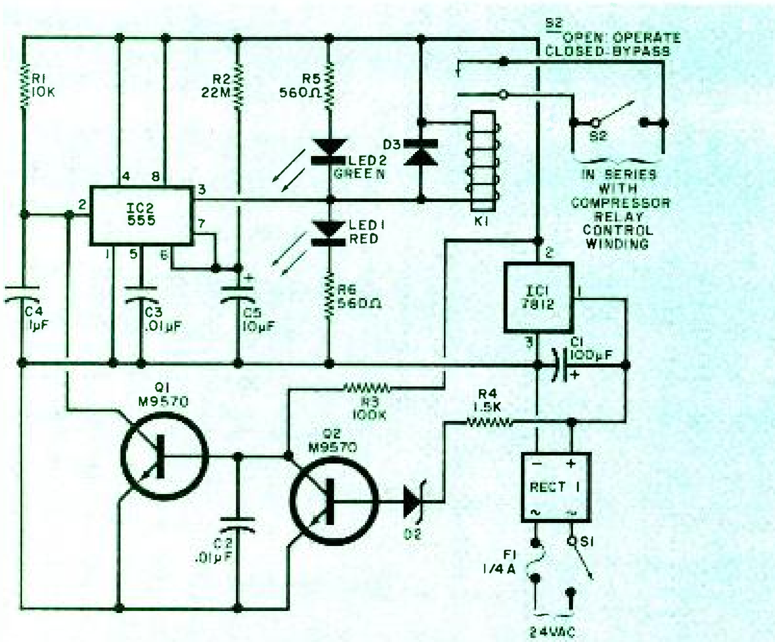


Fig. 1. Circuit provides 4.5 min. delay before power is applied.

PARTS LIST

C1—100-μF, 50-volt electrolytic
C2,C3—0.01-μF disc capacitor
C4—0.1-μF disc capacitor
C5—10-μF Tantalum capacitor
D2—Zener diode (see text)
D3—1N4001 rectifier diode
F1—¼-ampere fast-blow fuse and holder
IC1-7812 voltage regulator
IC2—555 timer
K1—Spst relay with 12-volt coil and 1-ampere contacts (Radio Shack No. 275-003 or similar) or appropriate substitute (see text)
LED1,LED2—Discrete light-emitting diode (one red, one green)
Q1,Q2—M9570 or similar npn transistor
The following resistors are ¼-watt, 10%:
R1—10,000 ohms
R2—22 megohms
R3—100,000 ohms
R4—1500 ohms
R5,R6—560 ohms
RECT1—50 PIV bridge rectifier assembly
S1,S2—Spst switch
Misc.—Socket for IC2; chassis; 4-conductor cable; rubber grommets; machine hardware; hookup wire; solder; etc.

in the compressor's drive motor as a result of overheating due to excessive current drain.

Unfortunately, the compressor and its associated drive motor are generally contained in a single sealed unit in home appliances. This means that the entire unit must be replaced as one expensive component. Although the drive motor for the compressor is usually equipped with a thermal circuit breaker, it takes time for it to sense an overload condition and disable power to the motor. The problem here is that during the time the overload condition exists, before is is sensed and power is cut off, the motor can stall and burn out. Repeated momentary power outages take their toll in weakening the motor, with the result that the motor is ultimately damaged even with the thermal circuit breaker in proper operating condition protecting the circuit.

The Compressor Guard circuit described here can be added to any compressor-type appliance to provide an added degree of protection.

How It Works. As shown in Fig. 1, the Compressor Guard is built around a 555 timer integrated circuit (*IC2*). The power source for the timer circuit is 24 volts ac, which is taken from the appliance itself. In the case of a central air-conditioning system, the 24 volts is supplied by the system's step-down transformer, as shown in Fig. 2. This transformer is part of the air-conditioning control circuitry and supplies power to the compressor's control relay through the contacts of the house thermostat. If the house is too warm, the thermostat closes and energizes the control relay, which in turn supplies power to the compressor unit. (Note: If the compressor system operates at a higher voltage, a separate 24-volt source and a relay with contacts rated for high voltage and current must be used in addition.)

The 24 volts ac is converted to regulated dc by *RECT1*, *C1*, and *IC1* in Fig. 1 to supply power for the timer circuit. Approximately 4.5 minutes after power is applied, pin 3 of *IC2* switches low and energizes relay *K1*. The period is controlled by *R2* and *C5*. With the *K1* contacts closed, a series circuit with the system's thermostat is completed. The compressor can then energize. If a momentary power outage occurs, a minimum of 4.5 minutes must lapse before power can be reapplied to the compressor. This period of time is all that is needed to allow system pressures to equalize and the compressor to be safely started once again.

The low-voltage brownout protection feature of the Compressor Guard is provided by the *Q1* and *Q2* circuits. The breakdown voltage rating of zener diode *D2* is approximately 7% to 10% less than the normal dc output potential of *RECT1*. As long as the output potential from *RECT1* is greater than the breakdown point of *D2*, *Q2* is in a state of conduction and *Q1* is held at cutoff.

If system line voltage drops, a resultant decrease in the output potential from *RECT1* will occur. If the potential drops to less than the breakdown voltage of *D2*, *Q2* goes into cutoff and *Q1* conducts. This grounds pin 2 of *IC2*, caus-

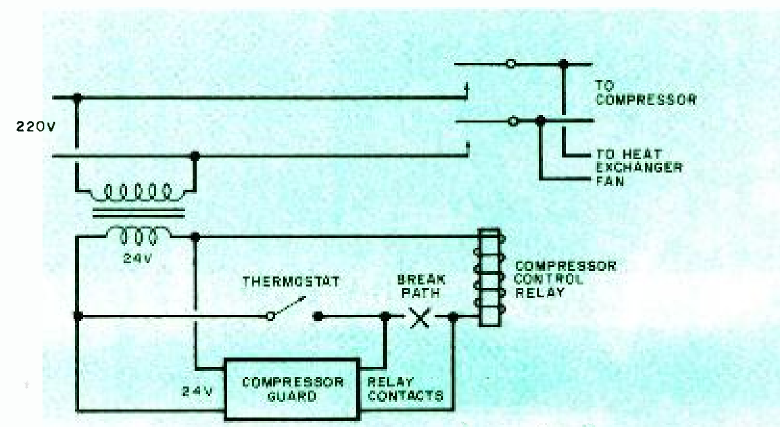


Fig. 2. Circuit showing how to wire Compressor Guard to existing system.

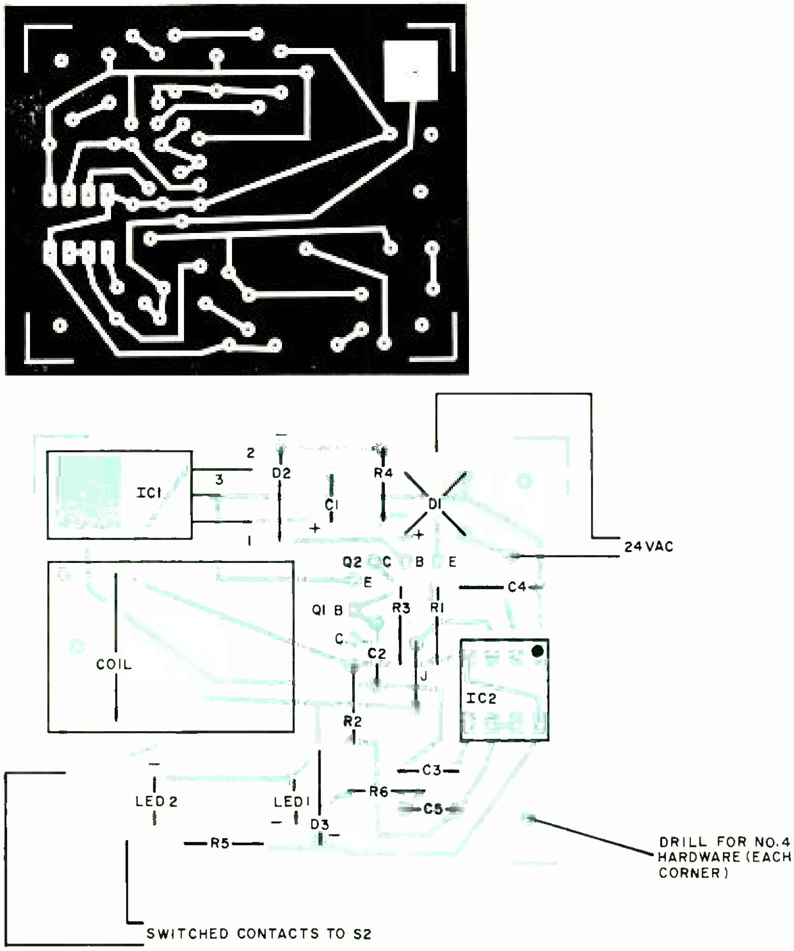


Fig. 3. It is best to assemble the circuit on a printed circuit board. An etching and drilling guide is at top with component placement guide shown below it.

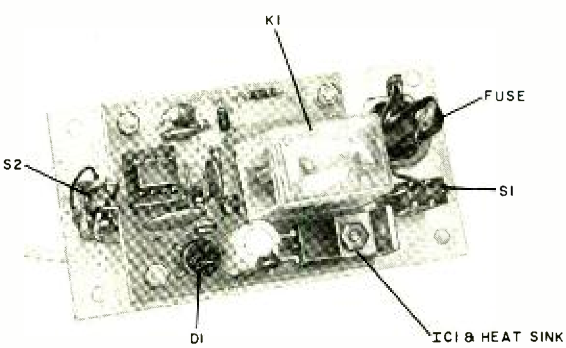


Fig. 4. Photo of prototype printed circuit board removed from enclosure.

ing pin 3 of *IC2* to switch high and deenergizing *K1*. As long as the low-voltage condition exists, *K1* remains deenergized and interrupts power to the compressor. About 4.5 minutes after the brownout condition clears, *K1* energizes to once again supply power to the compressor system.

Status indication of the timer circuit is provided by *LED1* and *LED2*, which are red and green light-emitting diodes, respectively. While the timer is cycling *LED1* is on. Then, when *K1* is energized, *LED1* extinguishes and *LED2* comes on. The LED's and resistors *R5* and *R6* are not essential to the circuit and can be omitted if desired.

The Compressor Guard can be bypassed by closing *S2*. This shorts out the contacts of *K1*. Switch *S2* is included in the circuit to allow system maintenance to be performed.

Construction. Most of the circuit is best assembled on a printed circuit board, the etching-and-drilling guide and component-placement diagram for which are shown in Fig. 3. A small right-angle bracket is used as a heatsink for regulator *IC1*.

Since the pc board assembly mounts behind the front panel of the cabinet in which the circuit is housed, *LED1* and *LED2* (if used) should be mounted on the foil side of the board. Leave enough lead length on the LED's to permit the lenses to fit into small rubber grommets in the front panel when the board is mounted in place with spacers and machine hardware. The fuse holder for *F1*, POWER switch *S1*, and OPERATE/BYPASS switch *S2* should also be mounted on the front panel.

The 24-volt power and relay contact lines can be contained in a four-conductor cable that enters the cabinet through a rubber-grommet-lined hole in the front panel. The assembled printed circuit board is shown in Fig. 4.

To install the Compressor Guard in a system, use the diagram shown in Fig. 2 as a guide. Although Fig. 2 is the representation of the typical scheme used in most central air-conditioning systems, check your system closely to insure compatibility with the Compressor Guard's circuitry. Also, if you are using the Compressor Guard to protect a refrigerator or freezer that does not have the stepped-down 24 volts required, be sure to use a separate 24-volt supply and a heavy-duty relay.

With the Compressor Guard turned on and the compressor running, measure the dc output potential from *RECT1*. Then multiply the figure obtained by 0.93 or 0.90 to obtain the approximate breakdown value of the zener diode required for *D2*. If you cannot obtain a zener diode with the proper breakdown voltage, use two zener diodes that, when connected in series, yield a breakdown characteristic that is as close as possible to the required value

One Last Note. The Compressor Guard presented here has been designed for inside installations. If you plan to use it in an outside air-conditioning installation, be sure to provide adequate weather proofing to protect the circuit from the elements. ◇

Add Fuzz TO YOUR ELECTRIC GUITAR OR BASS

BY JAMES BARBARELLO

Solid-state fuzz box for interesting sound effects.

ELECTRIC guitarists often use special circuits to alter the sounds their instruments produce. One of the oldest but still most popular of these signal modifiers is the "fuzz box." A solid-state circuit, the fuzz box generates a sound like that produced by early, low-cost vacuum-tube power amplifiers. When one of these amps was overdriven, a distorted, but pleasing sound resulted. The fuzz box, when controlled by a foot pedal, allowed the guitarist to introduce some "fuzz" without interrupting his performance to turn up the amp's gain.

Many different fuzz box designs have appeared over the years. The project presented here, is a somewhat different sine-to-square-wave converter. It produces a substantial output signal, even when used with inexpensive instruments. Its "fuzz" effect is as prominent in the bass as in the midrange and treble. In addition to the standard distortion effects, the circuit can produce a raspier, but at the same time mellower, voicing. The circuit's wide range of available output levels allows the user to preset different levels for the rhythm and lead modes. The project is especially useful with electric bass guitars because it can generate many of the effects called for in today's music without sacrificing the bass's characteristic deep tones.

The circuit is simple, uses a small number of readily available components, and can be built for about $10.

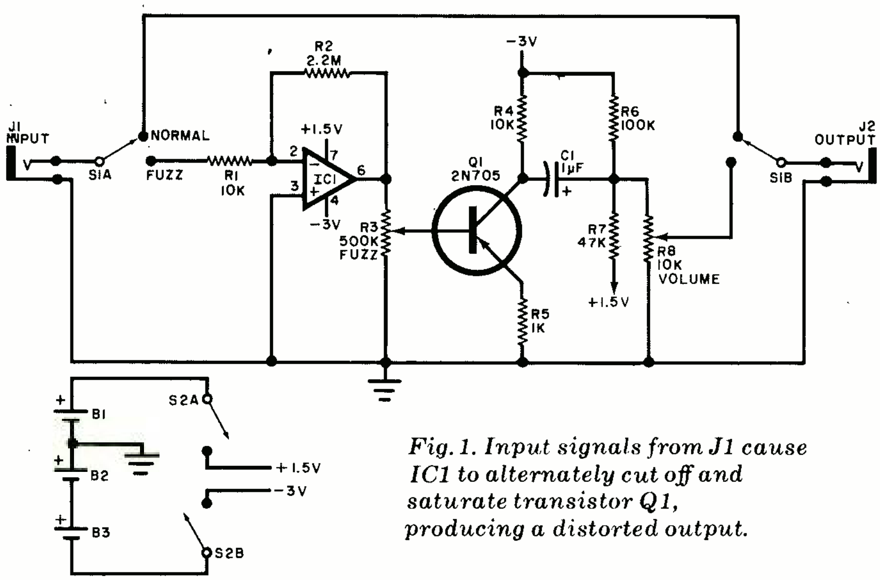


Fig. 1. Input signals from J1 cause IC1 to alternately cut off and saturate transistor Q1, producing a distorted output.

PARTS LIST

B1,B2,B3—1.5-volt AA, A, C or D cells
C1—1-µF, 16-V radial-lead electrolytic
IC1—741CV operational amplifier (Radio Shack 276-007 or equivalent)
J1,J2—¼-inch open-circuit phone jacks
Q1—General-purpose, high-beta pnp switching or audio transistor (2N705, Radio Shack RS-2005 or similar)
The following are ¼-watt, 10% tolerance fixed resistors:
R1,R4—10,000 ohms
R2—2.2 megohms
R5—1000 ohms
R6—100,000 ohms
R7—47,000 ohms
R3—500,000-ohm linear-taper potentiometer
R8—10,000-ohm linear-taper potentiometer
S1—Dpdt switch
S2—Dpst switch
Misc.—Printed circuit board, battery holders, hookup wire, suitable enclosure, knobs, pc board spacers, machine hardware, solder, etc.
Note—The following are available from BNB Kits, RD1, Box 241H, Tennent Rd., Englishtown, NJ 07726: etched and drilled pc board, #F-PC at $3.25; complete kit of parts including etched and drilled pc board, electronic components, jacks and switches, #F-E at $12.50. NJ residents add 5% sales tax.

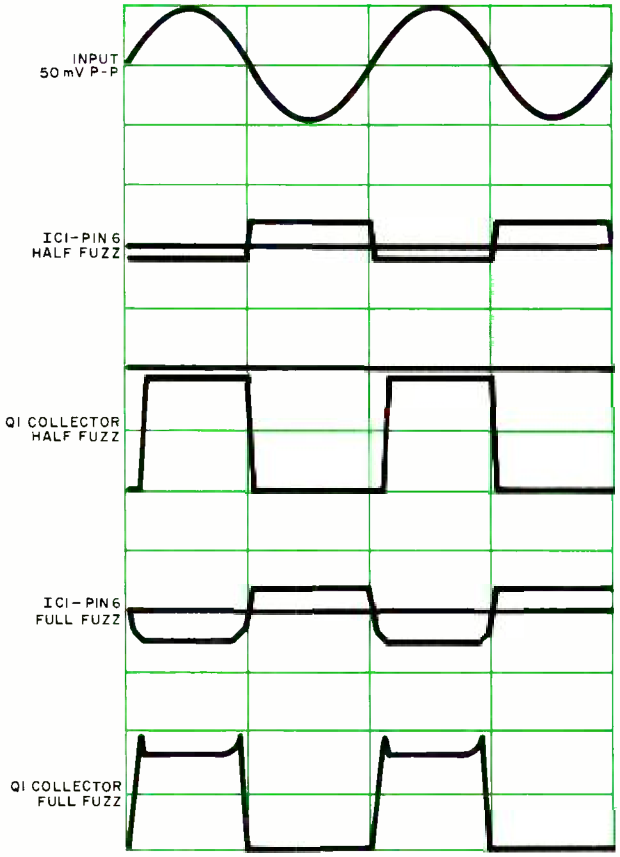


Fig. 2. Waveforms show effect of fuzz control R3. When it is set to pass maximum signal, the output waveform folds over and the sound is raspy.

About the Circuit. As shown in Fig. 1, input signals from the guitar pickup are routed by *S1* to the output jack or to inverting amplifier *IC1*, a standard 741 op amp. You might notice that the power supply voltages, furnished by series-connected AA penlight batteries, are lower than those normally used with this op amp. In this application, *IC1* is used solely to turn *Q1* on and off. The supply voltages employed allow the op amp to saturate at lower than normal input levels to produce the desired base drive for the transistor.

An input signal of about 30 mV produces ± 1 volt at the output of *IC1*, which is applied to the base of *Q1* through *R3*. A positive output from *IC1* causes *Q1* to cut off, and a negative output saturates the transistor. An ac signal will switch *Q1* between saturation and cutoff, thus producing a square-wave output from the circuit.

With *R3* adjusted so as to pass maximum signal to the base of *Q1*, *IC1* forward biases the base-collector junction of the transistor as the op amp's output goes negative. When this happens, *Q1* stops acting like an inverting switch (see Fig. 2) and passes the signal like a simple diode. The voltage at the collector then follows that at the base and, in effect, causes the signal waveform to "fold over" as shown in the bottom trace of Fig. 2. This signal is rich in harmonics and has a raspy, but mellow, sound.

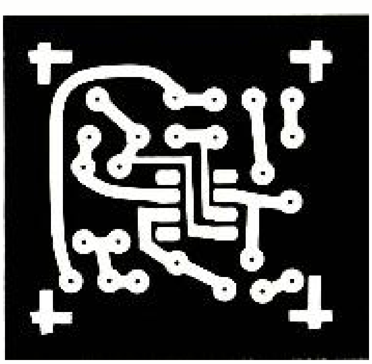
Signals at the collector of *Q1* are ac coupled by *C1* to voltage divider *R6,R7*. Level shifting at this point presents a zero-volt signal to output level control *R8* in the absence of an input signal. This inhibits the generation of "popping" signal transients as the fuzz box is switched in and out of the signal path. The required supply voltages (+3 and −1.5 volts) are provided by three 1.5-volt batteries. Suitable for this application are AA, A, C or D cells.

Construction. Any assembly technique is acceptable, but a printed circuit board is perhaps the easiest and neatest way to reproduce the circuit. (See Parts List for availability of pc board and kit.) Suitable etching and drilling and parts placement guides are shown in Fig. 3. After the project has been wired and is operating, it can be housed in any suitable enclosure, including the electric guitar or bass. If you decide to put it in your musical instrument, keep the batteries accessible for replacement.

Checkout and Use. Connect your guitar or bass to the input jack and your amplifier to the fuzz box's output. Rotate the instrument's output level control for maximum signal and, with *S1* in its NORMAL position, adjust the amplifier's master volume control for a comfortable listening level. Set *R8* (VOLUME) for ⅓ rotation and *R3* (FUZZ) for ¾ rotation. Place *S1* in the FUZZ position and play the instrument, noting the sound produced. Rotate *R3* fully to hear a sound with increased "bite" or raspiness.

Next, adjust *R3* so that the wiper is at the midpoint of its travel and set the instrument's output level control for less signal until the following occurs. When a string is first plucked, a distorted output is heard. As the output level begins to decay, the distortion diminishes to the point where the instrument's sound is relatively unaltered. This is the characteristic distorted "tube" sound that inspired the original fuzz box.

Continue to experiment with different control settings. You'll doubtlessly discover many sounds that will add to your enjoyment of playing and the audience's listening pleasure. ◇



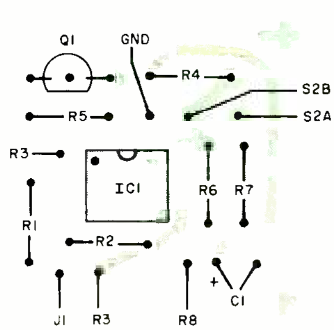
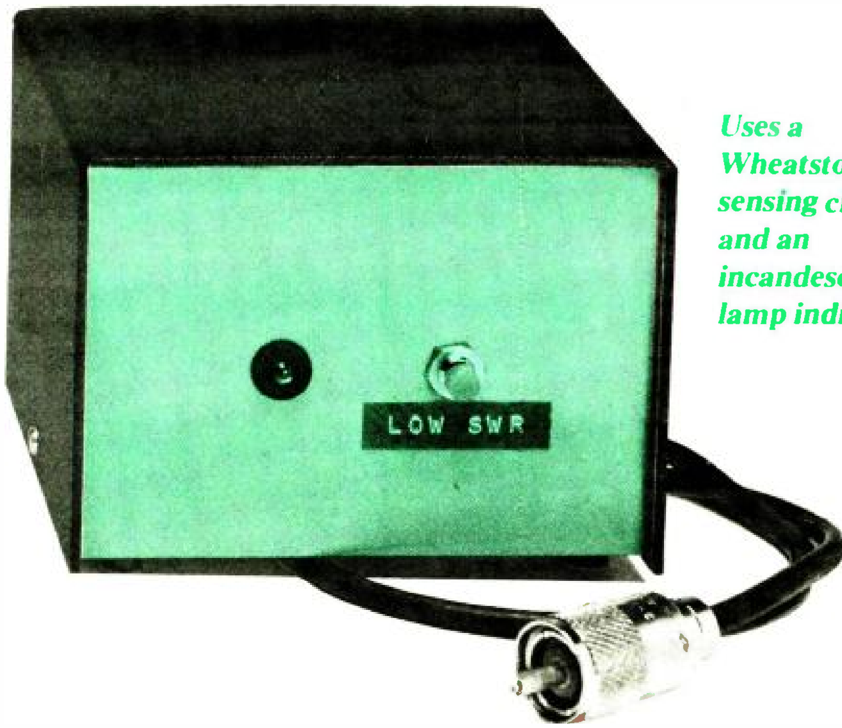


Fig. 3. Full-size etching and drilling guide for pc board is above left; component layout at right.



Uses a Wheatstone bridge sensing circuit and an incandescent lamp indicator.

BY CASS LEWART

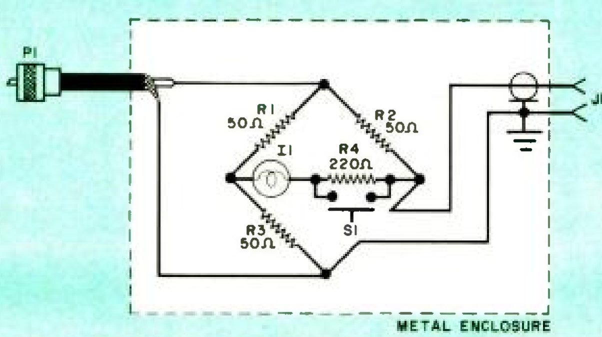
Build a Low-cost SWR TESTER

Initial adjustment of a CB antenna calls for the use of an SWR meter. However, the meter need not be left in the line after the antenna has been tuned, so most CB'ers have not felt the need to purchase one. The project presented here—an inexpensive SWR Tester—allows an operator to make periodic "good/bad" checks of his antenna system. Employing only a handful of resistors, a switch, and a small incandescent lamp, the project can be built for about $3. The SWR Tester will not yield a numerical SWR measurement, but will tell the user whether the antenna/line mismatch is severe enough to warrant further investigation.

About the Circuit. The schematic diagram of the SWR Tester is shown in the diagram. It is a Wheatstone bridge, one of whose arms is formed by the transmission line and antenna. The remaining three arms are 50-ohm carbon resistors. Indicator *I1*, a low-voltage incandescent lamp, current limiting resistor *R4* and pushbutton switch *S1* comprise the bridge's detector.

When an antenna having a 50-ohm resistive feedpoint impedance (the ideal condition for maximum power transfer) is connected to jack *J1* by a length of 50-ohm coax, the impedances of the bridge arms are equal. Therefore, the bridge is balanced and no voltage drop exists across the detector. Lamp *I1* remains dark, indicating an SWR close to unity. If the antenna's feedpoint impedance deviates from the ideal 50 ohms, the bridge becomes unbalanced and a voltage drop exists across the detector.

An antenna/feedline impedance mismatch (that is, an SWR) of about 2.5:1 will produce a voltage drop across the detector sufficient to cause *I1* to glow.

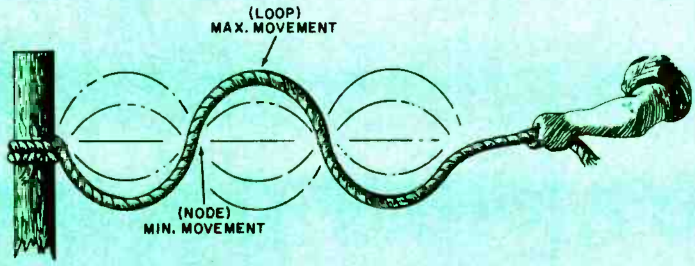


Schematic diagram of tester. The antenna/feedline combination forms the fourth leg of a Wheatstone bridge.

PARTS LIST

J1—SO-239 coaxial connector
I1—1.5-volt, 25-mA miniature incandescent lamp (Radio Shack 272-1139 or equivalent)
P1—PL-259 coaxial connector
R1,R2,R3—47- or 50-ohm, 2-watt 5% carbon composition resistor.
R4—220-ohm, ½-watt, 10% carbon composition resistor
S1—Normally open pushbutton switch
Misc.—Suitable metal utility box, ceramic standoff insulators or multi-lug terminal strip, hook-up wire, RG-58-U coaxial cable, rubber grommets, machine hardware, solder, etc.

WHAT IS SWR?



Tie a rope or string to some solid, stationary object such as a tree or post, as shown in the diagram. Grasp the free end and start waving the rope up and down. You are now generating a train of waves, much in the way that a transmitter sends waves down a transmission line.

When the wave reaches the point where the rope is anchored, there is no place for it to go so it is reflected back down the length of the rope. In this way, a pattern is formed as shown, with the loops being the points of maximum movement and the nodes the points of minimum movement of the rope. The ratio of the maximum to minimum waveform amplitude along the rope (called the Standing Wave Ratio, or SWR) in this case is 1:0, or infinity. This happens because essentially no energy is being absorbed by the wall and all is being reflected back to the driving source. This is analogous to the termination of a transmission line with an impedance that is different from that of the line. If the rope were not tied to the poles and were free to continue to move so that the transmission of the wave could continue, there would be no wave reflection. Each point on the rope would then reach the same maximum amplitude and the SWR would be 1:1, or simply 1.0.

In electrical terms, SWR can be considered as the ratio between the antenna impedance and the CB transmitter output impedance, with the larger value being the dividend and the small value, the divisor. The closer the ratio is to 1:1, the more of the transmitter r-f goes to the antenna. Besides reducing the power output to the antenna, a high SWR can also damage the transmitter output stage by submitting it to either excessive voltage or current. Therefore, keeping the SWR close to 1.0 is very important.

The table shows the relationship between SWR and the power delivered to the antenna, assuming a nominal 4-watt output from the CB transmitter.

SWR	1.0	1.2	1.5	2.0	3.0	5.0
Reflection Loss (dB)	0.00	0.04	0.18	0.51	1.25	2.55
Antenna Power (watts)	4.00	3.97	3.84	3.56	3.00	2.22

The higher the SWR becomes, the brighter *I1* will glow. Closing normally open *S1* increases the bridge detector's sensitivity so that *I1* begins to glow at an SWR of about 1.5:1. Note that this causes *R4* to be bypassed, removing the resistor's protective current limiting action from the detector circuit. If *S1* is closed when a high SWR exists on the line and *I1* is glowing, the lamp might burn out.

The bridge presents a 50-ohm impedance to the transceiver's antenna output when a 50-ohm antenna is connected to coaxial connector *J1*. However, there is a 6-dB power loss associated with inserting the SWR Tester between the rig and the antenna. The project is not designed for continuous monitoring of the SWR during communications, and should be removed from the signal path after tests have been completed. This can be accomplished by either physically disconnecting the SWR Tester or the installation of a ceramic DPDT switch inside the project's enclosure to bypass the bridge circuitry.

Construction. The circuitry of the SWR Tester is very simple, and point-to-point wiring is suitable. Solder lugs mounted on ceramic standoff insulators make ideal circuit tie points, but the standoffs might be hard to find. If you can't procure them, use a multi-lug terminal strip instead.

Mount the standoffs, switch, and coaxial jack in a small metal utility box. Drill holes for the indicator lamp and RG-58-U cable. Insert grommets into these holes, mount the indicator lamp, and pass one end of an 18-to-36-inch (45.7-to-91.4-cm) length of coax through the wall of the enclosure. Form a simple loop knot to act as a strain relief. Then remove 1¼" (3.2 cm) of the outer insulating jacket at the end of the cable inside the utility box. Comb out the braid, expose a short length of the inner conductor, and wire the circuit as per the schematic diagram. Terminate the other end of the cable with *P1*, a PL-259 coaxial connector.

Checkout and Use. Attach *P1* to the transceiver's antenna output jack. Prepare a dummy load by terminating a PL-259 with a 150-ohm, 2-watt carbon composition resistor and attach it to jack *J1*. Tune the transceiver's channel selector to channel 13, or to channel 20 if the radio has 40-channel capability. Place the mode switch in the AM position if you are using an AM/SSB rig. Then key the transceiver's push-to-talk switch.

Lamp *I1* will glow brightly. Note its brightness, and repeat the procedure on the other channels. If the rig's output remains relatively constant across the band, *I1*'s brightness will not vary from one channel to the next. Next, replace the 150-ohm resistive dummy load with a 100-ohm component. Key the transmitter. With *S1* open, *I1* will be dark. Closing *S1* will cause the lamp to glow.

The SWR Tester is now ready for use. Connect the coaxial feedline from the antenna to jack *J1*. If the antenna has been properly tuned and is in good working order, the lamp will remain dark when *S1* is open and the transceiver is keyed. The indicator might glow when *S1* is closed, especially when the channel selector is set to either end of the band and the antenna has been tuned to the center channel. This is normal because it is difficult to maintain a close impedance match over a wide band of frequencies. Short mobile whips with large loading coils are subject to such bandwidth limitations almost as a matter of course.

If the indicator glows when *S1* is open no matter which channel is selected, you should inspect the antenna and feedline for oxidized or corroded connections, clean metal-to-metal contact between the ground plane (vehicle body) and antenna base, etc. If no suspicious conditions are discovered, retune the antenna using an SWR meter and/or a field strength meter.

After you have retuned the antenna or completed your SWR tests, remove the project from the signal path—either physically or by means of a bypass switch. Otherwise, signals passing from the transceiver to the antenna (and vice versa) will be substantially attenuated. ◇

Micro-PROCESSOR MICROCOURSE

BY FORREST M. MIMS

PART 4. PIP-2 AN ULTRA-SIMPLE EDUCATIONAL MICROPROCESSOR.

IN Part 3 of this series (May, 1978), we learned about semiconductor memories and how three-state logic allows data transfer over a bidirectional data bus. We also looked at the basic organization of a microprocessor.

This month we're going to meet PIP-2, a very simple, 4-bit educational microprocessor. Though PIP-2 is not as powerful as the 8080, Z80, 6502 and other real-world microprocessors, it illustrates some of the more important operating features of microprocessors.

Introducing PIP-2. *PIP* is an acronym for Programmable Instruction Processor. PIP-2 is a simplified successor to PIP-1, an educational computer described in detail in *Understanding Digital Computers*, a new book published by Radio Shack.

While PIP-2 is simple, it has many of the elements of a sophisticated microprocessor. For example, PIP-2 contains a built-in program memory—so it really qualifies as a *microcomputer*. Since it also contains a microprogrammable control ROM, this means that its instruction set can be revised, or replaced, by entirely new instructions, as we will see in Part 5 of this series.

PIP-2's Organization. A block diagram of the major components of PIP-2 is shown in Fig. I. As you can see, PIP-2 is a bus-organized microprocessor. All of its sections are connected to a 4-bit bidirectional bus which permits data *and* memory addresses to be transferred from one section to one or more other sections connected to this bus.

Remember from Part 3 that only *one* section can read data onto a bidirectional bus at any one time. PIP-2 meets this operating restriction by employing three-state outputs on all sections designed to read data onto the bus. This isolates the output of those sections from the bus until they are activated (one at a time) by an appropriate enable signal from PIP-2's control section.

Let's now take a look at each of the sections in PIP-2.

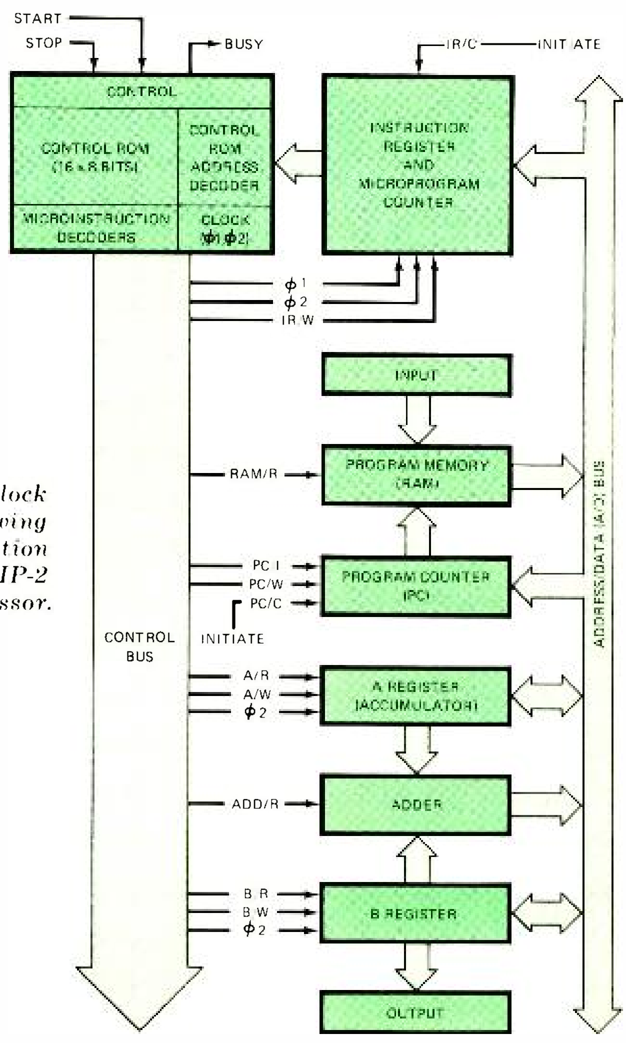


Fig. 1. Block diagram showing organization of the PIP-2 microprocessor.

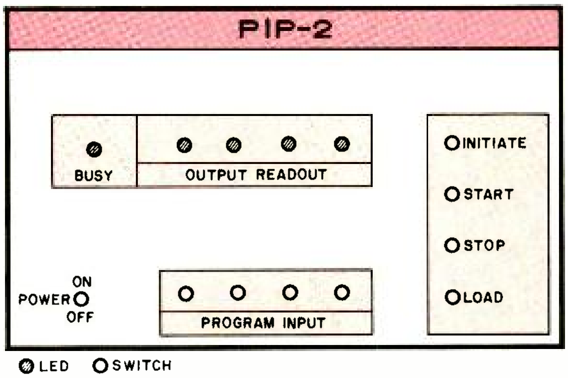


Fig. 2. Front-panel arrangement to facilitate operation of PIP-2.

Input. A row of four toggle switches, a LOAD switch and an INITIATE switch comprise PIP-2's INPUT. All these switches are shown in Fig. 2, a front-panel arrangement that allows PIP-2 to be used like a microcomputer.

Applying power to PIP-2 automatically clears the A and B registers, the program counter and the program memory to all 0's. This permits a program to be loaded into the program memory by simply switching in a binary instruction or data word and pressing the LOAD switch.

Up to sixteen 4-bit instructions and data words can be loaded into PIP-2's program memory. After the program is loaded, the program counter is cleared to 0000 by pressing the INITIATE switch. This returns the program counter to the first memory address in the program memory in preparation for running the program.

Program Memory. This is a 64-bit read/write memory (RAM) organized as sixteen 4-bit words or "nibbles." The RAM has a three-state output to keep its instructions and data isolated from the address data bus until they're needed.

The program memory has a single control input, RAM/R (R = read). When RAM/R is low, the three-state output is enabled, and the RAM reads the word addressed by the program counter onto the address data bus. When RAM/R is high, instructions and data can be loaded into the RAM.

Program Counter. This is a 4-bit binary counter. PIP-1 and many real microprocessors have a special memory address register that saves the contents of the program counter until it's time to advance to the next memory address. In PIP-2, the program counter doubles as a memory address register.

The program counter has three control inputs. A "low" that's supplied to PC/C by pressing the INITIATE switch clears the counter to 0000. The rising edge of a pulse applied to PC/I increments the program counter to the next higher count. A low at PC/W (W = write) writes any data on the address data bus into the program counter. This is a valuable feature since it means the program counter can branch to any address in the program memory.

A and B Registers. These are standard 4-bit data registers with three-state outputs. Each has two control inputs and a clock input ($\phi 2$).

When A/R or B/R is low, data is read from the selected register onto the address/data bus. When A/W or B/W is low, any data on the address/data bus is written into the selected register when the next clock pulse ($\phi 2$) arrives.

Adder. This is a 4-bit combinational logic circuit that continually sums the contents of the A and B registers. The sum is isolated from the address/data bus by a three-state buffer. When ADD/R is low, the buffer is enabled and the sum is placed on the bus.

Output. PIP-2's output consists of four light emitting diodes (LED's) that continually show the contents of the B register. It's possible, of course, to connect external devices in place of the LED's. A 4-line to 16-line decoder, for example, would permit PIP-2 to control any one of up to sixteen external devices.

Control. This is the electronic nerve center of PIP-2. Control fetches instructions from the program memory and executes them one by one under the perfectly synchronized control of timing signals ($\phi 1$ and $\phi 2$) produced by the clock.

Control consists of a 128-bit ROM organized as sixteen 8-bit bytes, an address decoder, several microinstruction decoders and a two-phase clock. PIP-2's instruction register doubles as a microprogram counter and is so closely associated with control that it can be considered part of it.

In the next installment, we'll look at a block diagram of control and study its operation in detail. For now, suffice it to say that control's ROM contains a sequence of from one to five microinstructions for each of the various microroutines necessary to execute PIP-2's six instructions. As you'll recall from Part 3, individual microinstructions implement simple operations such as data transfers from one register to another, etc.

PIP-2's Instruction Set. PIP-2 can process six separate instructions. Each instruction is identified for humans by a type of shorthand called a *mnemonic* (memory aid) and for PIP-2 by a 4-bit nibble called an operation code or in simple terms an *op-code*.

Some of the instructions require only one program memory address, while others are followed by a data word. These latter instructions require two program memory addresses and are called memory reference instructions. For example,

0001 (LDA)
1111 (data)

is the format for a memory reference instruction that loads the A register (LDA) with the data word 1111.

Shown in the box below is a table that summarizes PIP-2's instructions set. These instructions are so simple that they really need no further explanation.

PIP-2's INSTRUCTION SET

Mnemonic	Op-Code	Nibbles	Operation
NOP	1111	1	no operation.
LDA (nibble)	0001 (xxxx)	2	load A with next nibble.
ADD	0101	1	add A+B; store sum in A.
JMP (address)	1000 (xxxx)	2	jump to address in next nibble.
MOV	1011	1	move A into B; save A.
HLT	1110	1	halt the microprocessor.

It will be easier to apply them in actual programs, however, if we know something about how and why they're used. Therefore let's discuss the instructions one by one.

NOP. Pronounced "no-op," this is a do-nothing instruction with several valuable applications. You can use a NOP or two to reserve space in a program for an instruction or two you might want to add later. And you can use NOP's to replace instructions you remove from a program without rewriting the program. Finally, you can use NOP's to add a predictable time delay to a program. This is handy for calibrating a program that loops through a cycle of instructions again and again to act like a timer.

LDA. This memory reference instruction (load A) loads the A register with the data nibble in the next program memory address. It is used to temporarily store a nibble for addition or later transfer to the output or program counter.

ADD. This single-step instruction initiates a string of five microinstructions that *adds* the contents of the A and B registers and place the sum in the A register. It is used for ordinary addition, and to increment the nibble in the A register by some specified number (often 1). Incidentally, ADD uses the A register like the accumulator register found in real microprocessors.

JMP. This (jump) is a very powerful instruction that orders the program counter to branch (or jump) to the address in the program memory specified in the following nibble. JMP is used to set up a *loop*, a program or section of a program that continues to execute again and again until PIP-2 is halted by pressing its STOP button.

MOV. This register-transfer instruction has several applications. As an output instruction, it allows PIP-2's operator to see the contents of the A register on the LED readout (output). It also allows you to accomplish the equivalent of a LDB (load B) instruction by preceeding it with LDA (load A). And, it lets you double a number by following it with an ADD.

HLT. This instruction (halt) is placed at the end of all PIP-2 programs. It disables the clock in the control section, thus preventing PIP-2 from executing any additional instructions.

In the next part of the course, we'll examine the microroutines for each of these instructions in detail. We'll also learn how to add new instructions by changing the microinstructions in control's ROM. Meanwhile, let's learn how to program PIP-2.

How to Program. Let's write a simple program for PIP-2 that continually increments the number in the A register by one and displays the updated count on the LED readout of the output. Here's the program:

Program Memory Address	Mnemonics/Data
0000	LDA
0001	0001
0010	ADD
0011	MOV
0100	JMP
0101	0000
0110	HLT

It's easy to see how this program works. When PIP-2 is started, both the A and B registers are cleared to 0000. This means that the first three instructions load 0001 into A, add A to B and store the sum (0001) in both A and B. JMP loops the program back to line 0000 for another cycle. LDA replaces the contents of A with 0001 first. Register B also contains 0001 so ADD gives 0010. The sum, 0010, is moved into B and displayed on the readout.

Again, JMP loops the program back to line 0000 and the process continues. The result is that the readout flashes a binary count of 0000 to 1111 and continues repeatedly until PIP-2 is halted.

As you can see, this program is nothing more than a software version of an ordinary 4-bit counter. That alone is not very impressive since PIP-2 already contains *two* such counters in its hardware, the program counter and instruction register.

What's significant is that this simple program can be easily modified to implement *any* count increment from 0000 to 1111 by simply changing the data nibble following LDA! While this can be accomplished with some relatively simple hardware, PIP-2 performs the task after only a few seconds of software modification. This nicely illustrates the amazing versatility of using a microprocessor to simulate many different hardware functions with the help of software.

Running the Program. The simple counter program we've been discussing is called a *source program* since it's written using the mnemonics of the various instructions. Before it can be loaded into PIP-2's program memory, it must be converted to an *object program*.

An object program is written using the binary numbers a microprocessor understands. Sometimes it's called a *machine language program*. All that's necessary to generate the object program for our software counter routine is to substitute the appropriate op-codes for the mnemonics in the source program with the help of the table showing PIP-2's instruction set. Here's the machine language result:

Address	Source Program	Object Program
0000	LDA	0001
0001	0001	0001
0010	ADD	0101
0011	MOV	1011
0100	JMP	1000
0101	0000	0000
0110	HLT	1110

After the object program is compiled, it's a simple matter to load it into PIP-2's program memory. First, the power switch is turned on. This automatically clears all of the program memory, registers and counters to all 0's. Then the first object code nibble in the program (0001) is switched in via the front panel switches (a switch is 0 in the down position and 1 in the up position) and the LOAD switch is pressed. This action loads the nibble 0001 into the 0000 address of the program memory and automatically advances the program counter to the next address.

The remaining nibbles are loaded one by one until they are all stored sequentially in the program memory. Then the INITIATE switch is pressed to return the program counter to the 0000 address of the program memory.

Now all that remains is to press START. This causes control to fetch the first instruction from the program memory, load it into the instruction register, decode it and execute it. The program is processed like this a step at a time as the output displays the updated contents of the B register.

Incidentally, if the clock speed is more than about a hundred Hz, the count displayed on the readout will blur into a continuous 1111. Since the clock of most real microprocessors runs at a MHz or more, time delay loops must be added to their programs intended to display data to be viewed by an operator.

Other PIP-2 Programs. Though PIP-2's instruction set is very primitive, it's possible to write a number of different programs with it. Here, for example, is a source program that adds two numbers and displays their sum:

```
LDA
(first number)
MOV
LDA
(second number)
ADD
MOV
HLT
```

Here's a source program that doubles a number:

```
LDA
(number)
MOV
ADD
HLT
```

And here's a program that counts by two's:

```
LDA
0002
ADD
MOV
JMP
0000
HLT
```

Programming Real Microprocessors. Real microprocessors have dozens of instructions in their instruction sets. A typical microprocessor such as the 6800 or 8080 has instructions that can accomplish any of these tasks:

- Move data and addresses between registers.
- Shift and rotate the bits in a data word.
- Perform various arithmetic and logical operations.
- Branch conditionally or unconditionally to any part of a program or to a subroutine.
- Make various logical comparisons.
- Increment or decrement the contents of a register or memory address.

Real microprocessors also have special instructions that may be unique to a particular family of microprocessors. For example, some microprocessors have various instructions for accepting data from outside circuits. Others have built-in decimal arithmetic capability.

Programming real microprocessors can be both tedious and time consuming, but most people can learn to write simple programs with a little practice and some hands-on experience with a microprocessor using a keyboard (best) or toggle switch (OK) input. Of course, many microprocessor programs have been published in books and articles; and as time goes by, the number of available programs will multiply. ◇

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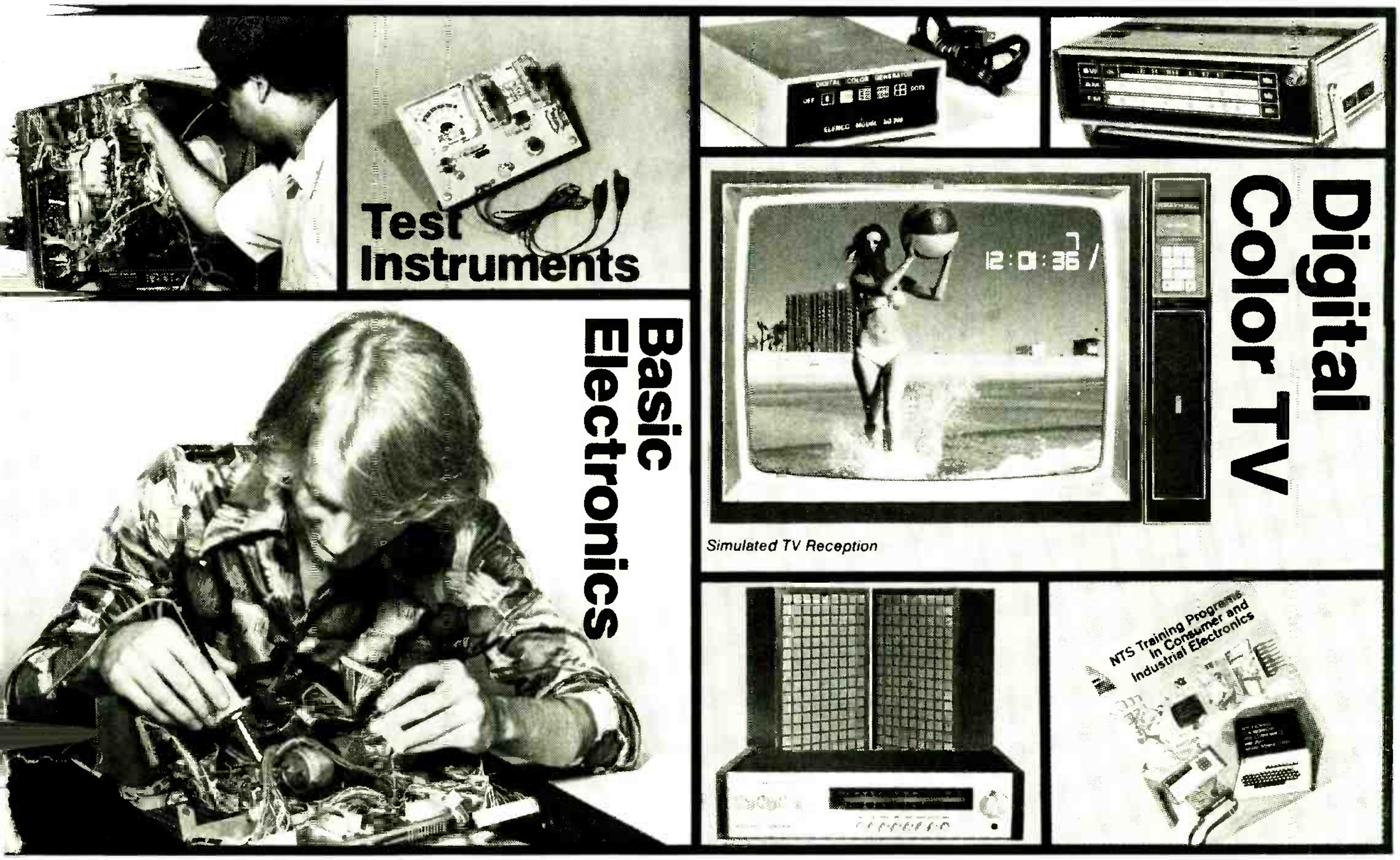

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Focus On Speaker Systems

BY IVAN BERGER, Senior Editor

A buying guide to loudspeaker systems, including model comparisons.

I. UNDERSTANDING THE SPECIFICATIONS

THE SPECIFICATIONS on the following pages cover the vast majority of high-quality speaker systems available in the U.S. and though specs alone can't tell you what a speaker sounds like, they can serve as a preliminary screening guide to help you narrow down your list of speakers to the few most likely to suit your requirements. Since there are probably more manufacturers of speakers than of any other high-fidelity component, that can save you a lot of time.

Nationally Advertised Value. The prices listed in our guide are those that are nationally advertised by the manufacturers. But dealers in your area may offer lower ones—check before buying. The fact that discounts are available on some models means that you needn't restrict your list of possibilities to those whose nominal price is within your budget—models listed at up to one-third more than your budget figure may actually be available in your price range. On the other hand, don't be too surprised if some of the prices listed here have risen by the time you get to an audio dealer. Speaker manufacturers' costs go up, too, and fluctuations in foreign-exchange rates can play havoc with the cost of imports.

When setting your speaker budget, don't stint. Speakers have a greater effect on your system's overall sound than any other component, so it pays to invest substantially in them. But if two speakers sound absolutely *equal* to you (they'll rarely sound absolutely *alike*), feel free to buy the less expensive ones if all else meets your needs.

Enclosure Types. Like most technical specifications, this one is sometimes over-emphasized in sales literature. In most cases today, it's possible to build equally good-sounding—and even similar-sounding—systems with any enclosure type. But every speaker must have some sort of baffle or enclosure to keep the waves that radiate from the back of the speaker from mixing uncontrollably with the front waves. Since the front and rear waves are out of phase, uncontrolled mixing would allow them to neutralize each other, cancelling the sound. In practice, this only occurs at the low frequencies, where the wave lengths are longer than the distance around the baffle. For this reason, enclosure design has most effect on the bass frequencies.

Acoustic-suspension or "air-suspension" enclosures are small, sealed boxes whose trapped air serves as the spring for otherwise floppy speakers. Acoustic-suspension speakers have been most popular for years because they can deliver clean, deep bass from comparatively small enclosures. The drawback of acoustic-suspension systems has been their low efficiency: all else being equal, it takes more power to drive an acoustic-suspension speaker to a given output level than it takes to drive most other systems.

The bass-reflex system, unlike the air-suspension type, has an opening or "port" through which the low-frequency driver's back wave can escape to the front. With careful design, this wave can be made to emerge in-phase with the woofer's front wave, just at the frequencies where the woofer needs help most. You'll find more and more bass-reflex systems among the newer models, since the characteristics of such systems can now be more precisely formulated than a decade ago. This allows designers to eliminate boomy resonances that formerly characterized some reflex systems. And since the back wave is used, not wasted, reflex speakers tend to have higher efficiency than air-suspension types.

Passive radiators (also known as "drone cones" or "auxiliary bass radiators") are sometimes used in place of ordinary open vents. At least one manufacturer therefore calls them "vent substitutes."

Several of the formulas for vented-speaker designs involve the deliberate acceptance of small response irregularities, which can easily be corrected with external equalizers, in exchange for better performance in areas where equalizers cannot help. The equalizer must be carefully matched to the speaker in such cases, and several speakers which come with such external equalizers are listed here. Not all reflex systems offer high efficiency, though. The formulas that now govern reflex system design allow a trade-off between efficiency, deep bass, and enclosure size. Designers may choose to give you more of one in return for less of another.

"Transmission-line" or "acoustic-labyrinth" designs are basically long, padded tubes, folded back and forth to fit into a box of a convenient-size. This is a very clean way to absorb the back wave of the speaker, but its absorption means it cannot contribute to efficiency. Some labyrinths (only the closed type are true transmission lines) therefore are open-ended, tuned so that the back wave emerges in phase at a low frequency where its contribution will be useful.

Horn speakers, today a rarity among woofer enclosures (though horn tweeters are still common) have the highest efficiency of any speaker, and gain low distortion by keeping cone movement small. But their mouths must be immense for good bass output, so the most common type is the "corner horn," which uses the walls of a room corner as part of the horn. Such speakers are, however, expensive—the horn must be folded in upon itself like the labyrinth, making the enclosure complicated to build—and still large. And they can only be used in rooms having suitable corners. (Not all corner speakers are horns, though—and placing any speaker in a corner will reinforce bass response.)

Open baffles also work, but they must be large in order to control bass cancellation. The Transar and many full-range electrostatic and planar speakers use such baffles.

Woofer Size and Type. It's generally believed that the bigger the woofer, the lower the bass. But that's only true if the enclosure is made larger, too. Larger woofers do have lower resonant frequencies when measured in free air. But once mounted in an enclosure, a larger woofer will (all else being equal) exhibit a higher resonant frequency that a smaller one mounted in the same box! The larger cone moves more air for the same degree of cone excursion. Moving more air into a box of a given size raises the air pressure in the box, stiffening the "air spring" the driver is pushing against. Since the resonant frequency depends on both the mass (of cone and air) and the compliance, or springiness, of the air and the driver suspension, the reduction in air compliance raises the system's resonance more than the increased driver mass lowers it.

Within a given enclosure, then, a larger woofer (which moves more air for a given cone excursion) will produce bass more efficiently--but a smaller woofer will produce deeper bass frequencies, though weaker in output. Enlarging the enclosure lets the larger woofer deliver deep bass, too, and more efficiently. But the system then takes up more space and costs more. In short, don't expect woofer size alone to make one system deliver deeper bass than another.

Most woofers are standard cone drivers, regardless of enclosure type. Even here, however, there are some variations. Many makers now use woofers covered or impregnated with plastics (commonly Bextrene) or carbon fibres, to stiffen the woofer and increase its internal damping, both of which reduce cone breakup distortion.

Some manufacturers use very shallow woofers, to minimize the phase differences between woofer and tweeter. Others stagger their drivers, so that the tweeter's mouth is far behind the woofer's. Both techniques put the woofer and tweeter voice coils in the same plane, allowing the output from both drivers to reach the listener at precisely the same time, not a tiny fraction of a second apart (provided the crossover networks dividing the sound between woofer and tweeter do not add time delay problems of their own). Opinions are divided as to whether or not phase-coherent design audibly improves the sound, but there's no question that phase-coherence can't degrade it.

Planar woofers, such as the various electrostatics and the "flat-panel" speakers driven by regular or distributed voice coils, are usually in open baffles. Either the baffles or the speaker driving elements (preferably the latter) must be large to deliver sound power at low frequencies. In practice, this means that such speakers often require additional subwoofers for the very low bass—note the rated frequency-response figures in our chart.

Other Driver Sizes and Types. Most speaker systems use at least two separate drivers—a massive woofer for the lows and a small tweeter for the highs—and many use 3 or more driver sizes. This is because each end of the frequency spectrum imposes opposite requirements on a driver. Bass response requires a large driver that can move a lot of air and handle a great deal of power. Treble response requires as light a driver as possible (which also improves transient response). In addition, it requires a small driver, for broad, even dispersion. (Dispersion is a function of the ratio between driver size and sound wavelength.) Midrange dispersion is rarely a problem, especially in speakers with separate midrange drivers. So high-frequency dispersion—as evidenced by tweeter size—is probably the most important specification in this column.

Dome tweeters have no better (or worse) dispersion than cone types of equal size. However, dome tweeters have larger voice coils, which allows more power-handling capacity—and also increases the size and cost of the magnet that must be used with them.

Electrostatic tweeters tend to have limited excursion, which makes it easier to give them good transient response, but also means they must be larger than cone types, which limits their dispersion. For that reason, most electrostatic tweeters use several tweeter elements, angled apart to cover a wider sound field. (Some nonelectrostatic tweeters do this, too.)

Horn tweeters allow a small, light diaphragm with good transient response to radiate appreciable power efficiently without breaking up. The driving diaphragm is usually a dome or flat diaphragm with a conventional voice coil, but more and more horn tweeters use piezoelectric drivers, solid-state devices that produce sounds by flexing in response to signal voltages. But designing horns for good high-frequency dispersion is hard. The approaches taken include the use of multi-cellular horns, and of "acoustic-lens" louvers at the horn mouth.

Crossover Point. Dividing the frequency range between several different drivers requires that each driver handle only that part of the range that it's designed for. Electrical "crossover networks" ensure that each driver get only its proper range, and that response slopes off at those frequencies that another driver should handle. In practice, the frequency ranges of adjoining drivers overlap, and there is a point—the crossover frequency—where each is contributing half the total radiated sound. The more divisions, the more such frequencies: a two-way (woofer-tweeter) system has just one crossover point, a three-way (woofer-midrange-tweeter) system has two crossovers, and so on.

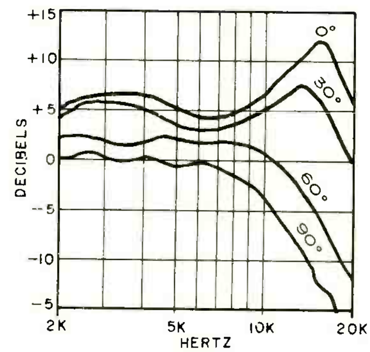
Impedance. A speaker's impedance changes with frequency. Its rated impedance is usually the lowest impedance it will reach at any point within its frequency range (generally, the mid-bass region). Usually given as 4, 8 or 16 ohms, impedance is mainly important when you intend to connect more than one pair of speakers to the same amplifier. Many amplifier circuits can be damaged by the 2-ohm impedance which results from operating two 4-ohm speakers in parallel. Unless you know your amplifier can handle it, buy higher-impedance speaker systems for multiple-speaker installations.

Frequency Response. This specification is useful, but only as a rough guide: measurement standards vary, and a speaker's measured response will vary with the microphone position and the space surrounding the speaker when it's tested. The specified response might be the on-axis response in an anechoic chamber, the on-axis response in a reverberant chamber (which would show more bass—how much more depending on the chamber size and shape), or a total-radiated-power response taken in a reverberant room but including both on-axis and off-axis measurements.

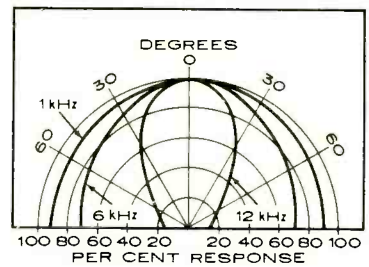
Frequency response figures which specify how many decibels (dB) the sound varies over the indicated range are more meaningful than those which simply state the frequencies spanned. You know that a speaker that is within ±6 dB from 30 to 18,000 Hz has fairly substantial bass response, but a speaker whose response is stated only as an unqualified "30 to 18,000" could be considerably more than 6 dB down at 30 Hz (though it could be less than 6 dB down, too). Without the qualification in dB, you just can't tell.

Sensitivity and Minimum Recommended Power. These useful specifications help determine how much amplifier power you need to drive the speaker system satisfactorily. (Remember that, when driving two speakers, each gets about half the amplifier power, so a "20-watt" minimum means 20 watts per channel.)

Sensitivity (which is a measure of efficiency) is usually stated in terms of sound output from a 1-watt signal measured at a 1-meter distance. For example, a signal that delivers 92 dB SPL (sound pressure level) from a 1-watt signal will require 3 dB less power for a given output than one which delivers 89 dB from the same watt. Thus, the more sensitive (more efficient) speaker can be used with an amplifier half as powerful as the 89-dB speaker would require. The catch, though, is that the rating varies according to the frequency components of the test signal used. Therefore, the manufacturer's minimum power recommendation should be given at least as much weight as the sensitivity figure.



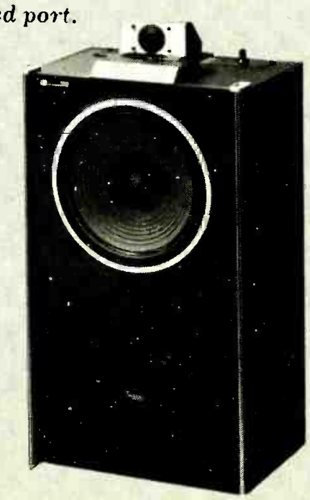
Dispersion can be shown by superimposing frequency-response graphs taken at several angles (above) or as polar plots for several frequencies (below).



E-V Interface: B has matching equalizer, passive radiator.

AR-15 air suspension system with dome tweeter.

Technics SB 6000A has stepped-back drivers for phase correction and ducted port.



Power-handling Capacity. This tells you both how much power the speaker can safely accept. Since this specification is not rigidly defined, you should use it only as a rough guideline.

We've distinguished, where possible, between those power-handling ratings that specify momentary peak input power and those that specify continuous power capacity. However, that still leaves open the question of how long a signal of that power is safe in either case, and what the frequency components of the test signals were. In general, it's safe to use an amplifier whose continuous-power rating is the same as or a little larger than the speaker's, or one-half the speaker's peak power rating. But you can use amplifiers with higher power if you're careful not to drop the tonearm onto the groove with the volume control well up, or to plug and unplug signal sources while the amplifier is on, either of which can create speaker-blowing transients on almost any system. You can also use a high-power amplifier if you don't play your system so loud it goes into audible distortion.

If you combine the maximum power figure with the sensitivity rating, you can tell how loud the speaker can be safely played. Since 20 watts is 13 dB above one watt, a speaker with a power-handling capacity of 30 watts and a sensitivity figure of 93 dB for 1 watt input can play at levels of up to 106 dB (93 + 13 dB) with some presumption of speaker safety. That is probably loud enough for most classical listeners, but not for the truly dedicated rock listener, who would probably prefer a limit of 110-115 dB.

Still, check the speaker at your preferred listening level before buying it. The figures tell you only how loud the speaker can play without damage—not how loud it can play without audible distortion.

Level Controls. The sound of most speakers can be altered somewhat to account for listener preferences as well as the acoustics of the listening room and the speakers' location therein by altering the high-to-low-frequency balance. This usually requires at least a tweeter level control, and may also involve additional controls for the midrange and other drivers. (Woofer controls are almost unheard-of.)

The more such controls there are, and the more continuous their adjustment (as opposed to simple two- or three-position switches), the more precisely the speakers' frequency balance can be adjusted. But the more adjustments there are, the harder you'll have to work to get it just the way you want. Incidentally, tweeter-level settings labelled "flat" or "normal" are just recommendations—alter them if you feel that it makes an improvement.

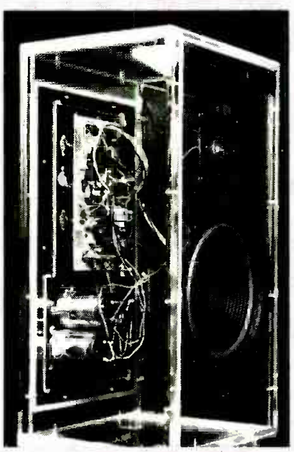
Dimensions and Weight. These have little to do with the sound of a speaker (save that, all else being equal—which rarely occurs—bigger cabinets permit lower bass with fewer trade-offs). But they do help determine how well a speaker will fit into your home. Dimensions are most important, of course, if you plan to locate your speaker systems on bookshelves. And for shelf mounting, weight is important, too. Make sure your shelf can handle any speaker you plan to put on it. ◇

II. UNDERSTANDING WHAT YOU HEAR

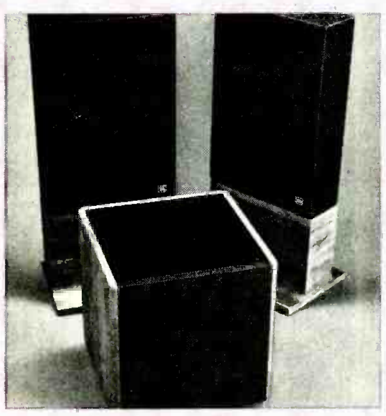
THE SPECIFICATION sheet for a speaker system tells the buyer less about the system's sound than do the similar sheets for other audio components. Thus, the speaker buyer is forced to rely heavily on the judgment of his own ears—superbly sensitive instruments, but not very precisely calibrated ones.

The art of buying a good speaker must therefore begin with training our ears and minds to appreciate and understand what we are hearing. Untrained, it is too easy to fall under the seductive spell of a speaker that

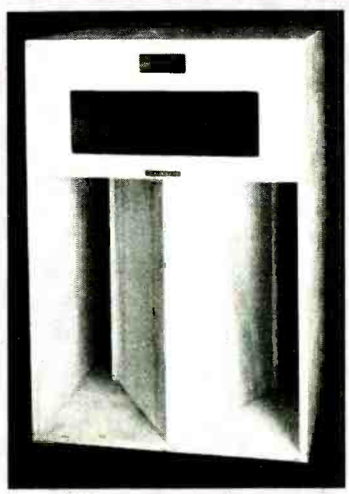
Powered Advent has amplifier inside rear panel.



JBL L212 has mid/high-frequency "satellites" and common bass module.



Klipschorn folded-horn system.



makes one type of program material sound startlingly real only to find its sound inadequate for those types of music you listen to most often. The sound you hear in one acoustic environment is likely to be very different in another listening room, too. There are no perfect speakers. But to the knowledgeable ears, the least inperfect speaker is the one which reproduces recorded sound most realistically, imposing the least possible coloration on that sound.

Assessing realism is, however, difficult. If you attend live concerts of acoustical—not electrical—instruments, you can use them to sharpen your listening judgements. Before shopping for a speaker, attend a concert or two. Close your eyes and analyze the sound you hear, attempting to sum up verbally the differences between this sound and the sound of the same music played at home. The verbal summation is important—words are easier to remember precisely than are subtle differences in sound.

Rock concerts are less useful training for the ear, because rock records rarely attempt to reproduce the concert sound. Instead, rock performances strive to reproduce on stage the sonic experiences that are so easily achieved in the recording studio. Besides, the sound you hear from electrically amplified performances is the sound of the amplifiers and speakers used. Recordings are usually made by direct pickup from the instruments themselves, rather than by microphones aimed at the speakers you'd hear at a concert.

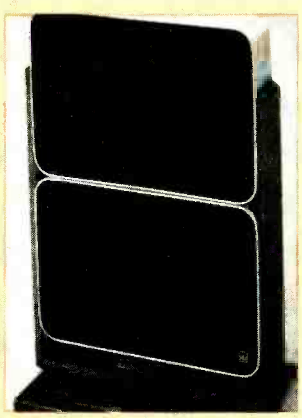
Your Own Tests. In an audio dealer's store, intelligent listening can quickly screen out the most blatantly colored or limited speaker systems. Listen to as many types of program material as you can, but with special emphasis on the kinds of music you will listen to at home. Any speaker which seems to lack highs or lows on all recordings should be rejected. The ear is easily fooled, however, since many colorations sound quite pleasing—on some material. For instance, listen to whether the bass seems rich and full and whether it is rich and full on many different notes. Or does it lend all such notes the same pitch, which is a sign of uncontrolled bass resonance? (Note, too, that below the resonant frequency, speaker output drops off dramatically.) Make sure the musical notes you hear are the ones being played, as well. On a descending passage of bass notes, for example, the fundamental tone should keep descending, not reach a plateau and stop. Some speakers falsify bass by "doubling," delivering a distorted overtone of notes below a real low-frequency limit. In this case, a distorted 60-Hz note, may be heard when a clean 30 Hz is called for. If you could play a sweep-frequency record through such loudspeakers, you would hear the sound fade cleanly as the frequency lowered, then come back at higher volume with higher pitch. A good speaker will simply fade out below its low-frequency cutoff. It's always better to miss a few rarely recorded bass tones that are there than to muddy the sound output with tones that weren't recorded to begin with.

Test reports are a help, of course—even reports on speakers you do not intend to buy. Listen to speakers about which you have read reports, and try to correlate what you hear with what the tester heard and measured. Do this for several speakers. This will help you differentiate various speaker deficiencies and virtues.

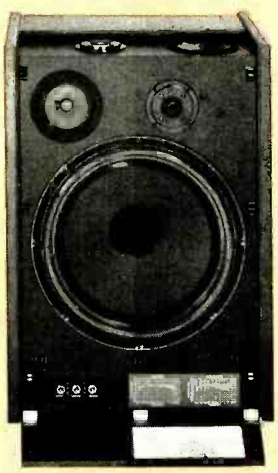
While frequency-response specifications tell you comparatively little about a speaker, frequency-response *graphs*—whether in specification sheets or test reports—tell you a great deal. Minor squiggles can be ignored since all speakers have them (though some speaker specification sheets smooth out curves for public consumption). In your mind, however, shade in the spaces between the response curve and the reference-level chart line. The audibility of response deviations is roughly proportional to this mentally shaded area. Broad, shallow bulges and dips will be plainly audible. So will sharp but high-amplitude resonances. However, resonant peaks and dips that are both sharp *and* short will not greatly affect the speaker's sound.

Observe, too, at what frequency extremes response begins to drop off,

B.E.S. Geostatic's dipole planar drivers radiate from both sides.



H.H. Scott Pro-100 also reflects sound from ceiling.



Heil AMT tweeter squeezes air instead of pushing it.

and how fast it drops. At the bass end, look for a speaker that rolls off smoothly, rather than one which exhibits an exaggerated response hump just above the roll-off point.

Teach yourself also to recognize the effects of room acoustics on speaker demonstrations. Bear in mind that if the room you'll listen in at home has a greater percentage of hard surfaces than the store's listening room, you'll hear more highs at home. If your room is full of soft, absorbent surfaces, highs will be weaker. To some extent, the speaker's tweeter and midrange level controls can help compensate for this when you get it home. But, if the dealer's listening room is more absorbent than your own, and you have to turn the tweeter down to make it sound best in the store, then try another speaker—you may not have enough adjustment range left to compensate for the acoustics in your home.

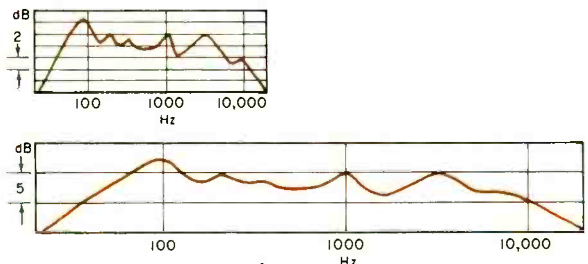
A heavily upholstered room or a turned-down tweeter control can help correct for a speaker whose high-frequency response is exaggerated, but still smooth. It cannot correct, however, for shrillness caused by peaks within the treble region. One can only eliminate these by turning down the treble enough to lose the desired highs as well. Sometimes, though, an equalizer can help here. Similarly, one cannot count on a room that is more "live" compensating fully for a system with deficient treble response.

Note, too, how speaker placement in a room affects bass response. Resting a speaker on a floor accentuates its bass; placing it on the floor in a corner accentuates it further. Raising it above the floor on a stand (or bookshelf) will reduce bass. Conscientious dealers often to try to equalize for these effects by setting up the speakers assymmetrically, so that the speaker nearest the corner on one side of the room will be farthest from it at the other. This gives each pair of speaker systems demonstrated a roughly equal chance.

Long listening sessions lead to listener fatigue, and consequent errors of judgement. So do not assume that you'll be able to pick the perfect speaker (for you) in one visit to a dealer. Take your time; limit your listening experience. You're making a substantial investment to last for many years.

Be sure not to try to compare three or more systems at once. Your sound "memory" won't be good enough. To truly discern the difference between speakers, you must compare two pairs at a time. When you have chosen the better pair, you then may compare them to a third set.

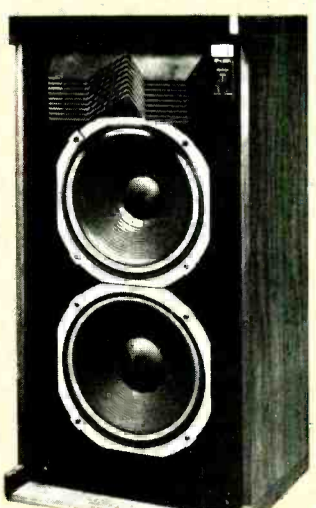
The speakers you're comparing must be *precisely* matched in level. If one speaker is grossly louder than the other, you will hear this mainly as a difference in sound level. But if they differ by only a fraction of a decibel, you are likely to judge the louder one as being clearer, and not attribute the difference to volume at all. Dealers today frequently provide for such level matching in their speaker switchers (the level-match attenuators used should be between the system amplifier and preamp, not between amplifier and speaker). But this match should be rechecked frequently. Of two speakers balanced on, say, pink noise, one might be slightly louder when playing music with a good deal of bass con-



A response curve can be made to look smoother by stretching the horiozontal axis.

Pioneer horn tweeter is segmented for dispersion.

Sansui 3-way system. Note horn tweeter with acoustic lens.



Bose 901 reflects most of its sound from room wall.

tent, and the other slightly louder when playing music strong in treble tones.

As you compare two sets of speakers, spend some time switching quickly between them (preferably in midpassage, not just as the music changes) to hear how each handles essentially the same sounds. Also spend some time listening to each at length.

Listen to as many types of sound as possible. Bring records you're familiar with (fresh copies, if your old ones are worn or dirty), covering as many types of music as possible. Listen also to the noise heard between stations on an FM tuner or receiver.

Why noise, when the emphasis thus far has been on reproducing music naturally? Simply because FM noise contains a balance of all the frequencies over a range of about 50 to 15,000 Hz. Peaks and dips in a speaker's response will often show up quickly on white noise, when you might otherwise have to wait a long time for music to hit a note that would expose them clearly. The sound should be a smooth rushing noise, with both bass and treble clearly present. Grittiness or roughness is one sign of coloration. So is a milky smoothness, usually the sign of insufficient treble. If all you hear is hiss, on the other hand, there's probably too little bass response. The sound should seem high-pitched with no specific pitch attributable to it. Any distinct pitch you can hear is because a resonance overemphasizes a single frequency or narrow frequency band.

Here's an interesting test one can make to check for the nasality or honkiness that afflicts speakers with overemphasized midrange response. With you hands cupped over your mouth, say "Shhhhh"; then listen to the same sound made with your hands removed. White noise should have the same smooth, rushing quality as in the second example. If the speaker sounds as though its hands were over its mouth, it will add nasal coloration to the music.

Noise is also a good test for high-frequency dispersion. Starting from a point on the speaker's axis, walk to either side until the high-frequency sound quality changes noticeably. Then continue walking slowly until the hissiness disappears from the sound. The farther from the speaker's axis you must go to reach these points, the broader and more even the speaker's high frequency dispersion. If, with your eyes closed, you can reliably tell just when you're directly on the speaker's axis, its dispersion is deficient.

While you're tuned to FM, listen to some deep-voiced male announcers. They should sound natural, as if they were in the room with you, not as if they were in a rain-barrel or tub. This boominess or chestiness is a sign of a speaker-response peak at about 100 to 200 Hz. (Check several announcers, though, to be certain that the problem doesn't rest with the broadcast studio or your reception area.)

The ultimate speaker test is on music, of course. That, after all, is what you're buying speakers to hear. Each type of music has different information to impart about the speakers you're auditioning.

Try rock music, where it's easy to listen for bass definition. Transient thumps should be sharp and powerful, not softened into a mushy drone. You should be able to play the speaker as loud as you like, using an amplifier of the wattage you intend to use at home without breakup or distortion from speaker or amplifier. (If the amplifier distorts, then you need a more efficient speaker or you must revise your amplifier selection.)

Rock piano should be clear, transparent, almost bell-like. If it's jangly or annoying, that's usually a sign of high-frequency peakiness or distortion; if too soft, and sweet, the speaker system probably lacks satisfactory treble.

Now listen to massed orchestras or—still better—choruses. You should be able to hear them as groups of individual instruments or voices, not a puree of sound. This is one of the best possible tests for speaker clarity.

String instruments are rich in harmonics and, therefore, a good test of distortion and high-frequency response. Solo and chamber recordings should let you hear the bite of bow on string but without rasping. Cellos should sound full, not thin or ponderous. Massed violins should have a silky sheen, not shrill or dull. Animated passages will reveal more than slow, legato ones.

Organ pedal notes do demonstrate low-bass capability, but they take a long time to build up, so they are not as exacting a test as a good swift thump of bass drum or tympani.

There isn't time in the audio showroom to play every selection on every record you bring as demonstration material. So carefully note what you want to play before you reach the store. If some of your records aren't conveniently divided into bands, you can make a cardboard index that can fit against the spindle as a guide to where to put down the tonearm.

Listen carefully at both the highest levels you're likely to listen to at home and at the lowest. The speaker's sound should not change radically (other than your ears' fading out on bass as it gets lower and a slight loss of treble) as the level diminishes.

Check also for instrument positions. You should be able to differentiate clearly the positions of the various instruments and voices within the stereo fields (easier on some records than others). Be skeptical of speakers with strong, immediate appeal. The speakers that instantly excite you often do so because they sound greatly different from those faithfully reproducing recordings. Perfect speakers, if they existed, would all sound alike. Among high-quality systems a speaker's superiority is likely to be fairly subtle.

Note that every speaker system does not aim all its sound directly forward. Some have drivers facing to the sides, the top, or even to the rear. (And dipoles, of course, project sound equally to both the front and the rear.)

In most cases, this involves midrange and treble drivers whose indirect output, reaching the listener by reflection, may overcome some room acoustic problems, enlarge the apparent sonic space, or simply make the sound richer. Some critics, however, feel that it also diffuses the stereo image or makes solo instruments sound unnaturally large. Here again, the listener should make up his or her own mind. Side-firing woofers, however are there to eliminate an upper-bass dip caused by wall reflections. ◇

SPEAKER SPECIFICATION GUIDE

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz ±dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min input (watts)	Max input (watts) (C=cont, P=peak)	Level controls (number/type C=cont variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
AAL															
Studio 6	430	air susp.	10	–	4	1000	18-25k ±3	94	8	20	200C	2C	38x24x16	90	Fused;
			4x10	horn	1	7000					400P				pedestal base.
			3	piezo	3										
Studio 4	300	air susp.	15	–	1	1000	20-25k ±3	93	8	10	150C	2/C	31x24x16	80	Fused;
			4x10	horn	1	7000					300P				pedestal base.
			3	piezo	3										
Studio 2001	220	reflex	10	–	1	600	25-25k ±3	88	8	10	80C	1/C	37x13x11	50	
			8	–	1	2000					160P				
			3	piezo	1	7000									
			2	–	1										
Studio 3*	200	air susp.	12	–	1	1000	25-25k ±3	93	8	10	100C	2/C	26x15x13	48	Fused.
			4x10	horn	1	7000					200P				
			3	piezo	1										
Studio 2	150	air susp.	10	–	1	4000	27-25k ±3	92	8	10	50C		25x14x11	32	Fused.
			3	piezo	1	7000					100P				
			2	ring	1										
Apollo 2915	140	reflex	15	–	1	1000	20-22k ±3	91	8	5	50C		30x18x11	44	
			5	cone	2	2500					100P				
			2	–	1	5000									
Apollo 8853	130	reflex	8	–	2	1000	25-22k ±3	92	8	5	60C		37x13x11	50	
			5	cone	1	5000					120P				
			2	–	1										
Apollo 2712	95	reflex	12	–	1	1000	25-22k±3	92	8	5	50C		27x16x11	36	
			5	cone	1	5000					100P				
			2	–	1										
Studio 1	90	air susp.	8	–	1	4000	35-20k±3	91	8	5	30C	–	22x11x10	24	
			2	–	1						60P				
Acoustat															
XM	p2600	dipole	2.8 ft²	elect.	3	–	30-20k ±3	–	50k	–	–	2/C	60x37x2	100	Built-in servo amplifier.
X	p1995	dipole	–	elect.	–	–	30-20k ±3	–	50k	–	–	2/C	48x28x19	105	
Acoustical Engineering															
Mach IV	1595	horn	15	–	1	400	16-20k ±5	–	8	10	100	–	41x42x30	175	
			8	–	1	2500									
			–	horn	2										
Saratoga	995	horn	12	–	1	500	20-20k ±5	–	8	10	80	–	30x28x22	150	
			8	–	1	3000									
			–	horn	1										
Model 5A	895	horn	12	–	1	500	20-20k ±5	–	8	10	80	–	30x29x21	125	
			8	–	1	3000									
			–	horn	1										
Mini-Corner Horn	595	horn	8	–	1	800	32-18k ±5	–	8	10	60	–	24x18x12	85	
			4	–	1	5000									
			–	horn	1										
Acoustic Research															
AR9	650	air susp.	12	–	2	200	28-25k –3	87	4	40	400	3/S	53x15x16	138	Side-firing woofers; extension circuitry.
			8	–	1	1200									
			1½	dome	1	7000									
			¾	dome	1										
AR10π	450	air susp.	12	–	1	525	35-25k –3	86	4-8	25	150	3/S	25x14x11	55	Woofer environmental control.
			1½	dome	1	5000									
			¾	dome	1										
AR11	350	air susp.	12	–	1	525	35-25k –3	86	4	25	150	2/S	25x14x11	50	
			1½	dome	1	5000									
			¾	dome	1										
AR12	250	air susp.	10	–	1	700	43-25k –3	86	8	25	150	2/S	25x14x11	38	
			2	–	1	4000									
			¾	dome	1										
AR14	180	air susp.	10	–	1	1300	43-24k –3	86	8	15	100	1/S	25x14x11	35	
			1	dome	1										
AR15	130	air susp.	8	–	1	1700	48-24k –3	85	8	15	100	1/S	22x12x8	24	
			1	dome	1										
AR17	p190	air susp.	8	–	1	2000	48-21k –3	86	8	15	100	1/S	19x10x9	17	Pairs only.
			1¼	press.	1										
AR18	p130	air susp.	8	–	1	2000	58-21k –3	86	8	15	100	1/S	17x10x6	14	Pairs only.
			1¼	press.	1										
Acousti-phase															
Phase III+	300	reflex	12	–	1	900	32-20k ±3	–	4-8	10	100C	1	25x15x14	50	
			5	–	1	5000									
			1	dome	1										
Tower	260	reflex	10	–	1	1000	40-20k ±3	–	8	8	70C	2	37x13x13	59	
			3½	–	1	5000									
			1	dome	1										
Phase II	220	reflex	10	–	1	1200	35-20k ±3	–	4-8	10	70C	1	25x14x13	48	
			5	–	1	1500									
			1	dome	1										
Monitor	180	reflex	12	–	1	1500	35-20k ±4	–	4-8	10	70C	1	25x14x14	48	
			1	dome	1										
Phase I	130	reflex	8	–	1	1600	40-20k ±4	–	8	5	50C	1	22x13x11	29	
			1	dome	1										
Microphase	90	reflex	6½	–	1	1600	48-20k ±4	–	8	3	30C	–	18x11x8	38	
			1	dome	1										

ABOUT PRICES . . . *With repeal of Fair Trade Laws, manufacturers are now providing "Suggested Retail" figures for the guidance of their dealers and customers. Prices stated in the speaker charts are those provided by manufacturers under these conditions. They are, of course, subject to change without notice and some products may be purchased in your trading area at a price that differs from that given here.*

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number/type; C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Acoustique 3a															
SB1200	999	–	11	long coil	4	100	25-0.12k ±3	84-96	20k	–	–	1	14x36x30	170	Subwoofer with feed-back to built-in 150W amp.
Atom 3	n.a.	labyrinth	6	cone	1	600 6000	120-30k ±3	94	8	15	120C	–	10x9x4	50	Satellite for use with above; "time-aligned."
Triphonic	1299														System with 1 SB1200 & 2 Atom 3.
Andante Master Control	829		10	–	1	400	25-40k ±3	94	8/100	5	80C	1	18x12x8	42	120W feedback amp.
			2	dome	1										
			2 1/8x7/8	planar	1										
Arioso Monitor	569	reflex	15	–	1	300	45-20k ±3	94	8	50	120C	2	27x18x15	90	
			5¾	cone	1	5000									
			–	horn	1										
Andante Linear	555		11	–	1	400	30-30k ±3	94	8/100	5	80C	1	18x12x8	40	120W feedback amp.
			2	dome	1	5000									
			¾	dome											
Adagio	435	trans. line	11	–	1	500	35-30k ±3	91	8	25	80C	1	31x12x12	67	Built-in 100-Hz filter.
			2	dome	1	5000									
			¾	dome	1										
Apogee Monitor	359	labyrinth	11	–	1	700	45-30k ±3	92	8	10	70C	–	29x13x13	45	"Time-aligned."
			1 3/8	dome	1	6000									
			¾	dome	1										
Allegreto	319	reflex	10	–	1	200	55-30k ±3	94	8	5	60C	1	25x12x10	35	"Rock speaker."
			4x8	horn	1	10,000									
			–	horn	1										
Apogee	209	reflex	10	–	1	4500	55-30k ±3	94	8	5	50C	–	25x12x10	32	"Time-aligned."
			¾	dome	1										
Alphase	156	labyrinth	8	–	1	5000	55-30k ±3	92	8	5	40C	–	10x10x20	21	"Time-aligned."
			¾	dome	1										
ADS															
910	600	air susp.	10	cone	2	500	18-25k ±5	93	4	15	150C 300P	2/S	34x19x15	100	Swivel stand; bi- and tri-ampable.
			2	dome	1	4000									
			1	dome	1										
810	350	air susp.	8	cone	2	550	20-22k ±5	93	4	20	75C 150P	–	26x14x12	47	
			2	dome	1	4000									
			1	dome	1										
710	265	air susp.	7	cone	2	550	25-22k ±5	93	4	15	65C 130P	–	22x12x11	35	
			2	dome	1	4000									
			1	dome	1										
2002	225	air susp.	4	cone	1	2500	55-22k ±5	–	50k	–	–	1	7x4x5	5	Built-in biamp; 12V dc or opt. 110V ac.
			1	dome	1										
700	180	air susp.	7	cone	2	1500	30-22k ±5	92	4	15	50C 100P	–	22x12x11	33	
			1	dome	1										
500	145	air susp.	8	cone	1	1500	30-22k ±5	91	4	15	40C 80P	–	20x12x10	25	
			1	dome	1										
300	140	air susp.	5	cone	1	2500	68-22k ±5	90	4	10	50C 100P	–	9x6x6	8	Metal cabinet.
			1	dome	1										
400	109	air susp.	7	cone	1	1500	33-22k ±5	91	4	10	50C 100P	–	18x10x9	19	
			1	dome	1										
200	105	air susp.	4	cone	1	2500	55-22k ±5	90	4	5	30C 60P	–	7x4x5	5	Metal cab.; avail. with bracket for car.
			1	dome	1										
Advent															
Powered Advent Loudspeaker	449	air susp.	12	–	1	1500	–	–	–	–	–	2	28x14x13	70	Built-in biamp.
			1 3/8	cone	1										
New Advent Loudspeaker	159	air susp.	12	–	1	1500	–	89	8	15	–	1/S	26x14x12	47	
			1 3/8	cone	1										
Advent/1	120	air susp.	12	–	1	1500	–	89	8	15	–	–	22x13x9	27	
			1 3/8	cone	1										
Advent/2	79	air susp.	10	–	1	1500	–	80	8	10	–	–	19x11x8	19	
			1 5/8	cone	2										
AEI															
Evolution 1	160	–	10	–	1	1500	35-17k ±2	88	4 or 8	15	75C 150P	1/S	25x16x10	43	Switchable impedance.
			1	dome	1										
Evolution 2	110	–	8	–	1	1500	38-17k ±2	88	4 or 8	15	50C 100P	1/S	21x13x9	30	Switchable impedance.
			1	dome	1										
Akai															
SW-177	275	closed	15	–	1	700	25-20k ±3	94	8	100	40C 100P	2	27x17x12	47	
			5¼	–	1	5000									
			1¾	–	2										
SW-157	210	reflex	12	–	1	1200	30-20k ±3	92	8	60	30C 60P	2	27x16x12	36	
			5	–	1	5000									
			1¾	–	1										
SW-137	140	reflex	10	–	1	1200	40-20k ±3	92	8	40	20C 40P	1	23x14x12	26	
			5	–	1	5000									
			1¾	–	1										
SW-127	95	reflex	8	–	1	4000	40-20k ±3	92	8	30	15C 30P	–	20x12x9	16	
			1¾	–	1										
Allison Acoustics															
Allison: One	395	air susp.	10	–	2	350	–	86	8	30	40C 400P	2/S	40x19x11	67	Side-firing woofers.
			3½	–	2	3750									
			1	–	2										
Allison: Two	325	air susp.	8	–	2	350	–	86	8	30	40C 400P	2/S	36x16x9	57	"
			3½	–	2	3750									
			1	–	2										
Allison: Three	275	air susp.	10	–	1	350	–	86	4	30	20C 200P	2/S	40x15x10	45	"
			3½	–	1	3750									
			1	–	1										
Allison: Four	185	air susp.	8	–	1	2000	–	86	8	30	20C 200P	2/C, S	11x19x10	24	"
			1	–	2										
Altec Lansing															
Model 19	749	vented	15	–	1	1200	30-20k	102	8	10	65C 350P	–	39x30x21	143	Radial phase plug; sectoral horn.
			–	horn	1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz, dB)	Sensitivity (SPL in dB at 1 meter, w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number/type: C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Model 17	699	vented	15	–	1	1500	30-20k	100	8	10	65C	–	40x26x18	138	Coax; sectoral horn.
			–	horn	1						350P				
Model 15	479	vented	12	–	1	1700	30-20k	94	8	12	60C	–	27x22x16	84	Radial phase plug.
			–	horn	1						250P				
Stonehenge II	359	vented	12	–	1	500	35-20k	86	8	20	50C	–	38x16x15	76	
			5½	cone	1	5000					250P				
			5	cone	1										
Model 9 Series II	329	vented	12	–	1	800	40-20k	93	8	12	60C	–	27x18x15	64	
			6½	cone	1	7000					250P				
			5	cone	1										
Santana II	279	vented	12	–	1	2500	40-20k	91	8	12	45C	–	26x19x16	67	
			5	cone	1						150P				
Model 7 Series II	259	vented	12	–	1	850	45-20k	90	8	15	50C	–	25x16x14	49	
			6½	cone	1	8000					200P				
			4	cone	1										
Model 5 Series II	189	vented	12	–	1	1500	45-20k	92	8	12	45C	–	26x15x12	38	
			4	cone	2						150P				
Model 3 Series II	149	vented	10	–	1	1500	50-20k	91	8	10	35C	–	24x13x12	33	
			4	cone	1						100P				
Model 1 Series II	129	sealed	8	–	1	3500	50-20k	89	8	10	30C	–	23x12x11	60	
			4	cone	1						75P				
Analogue Systems															
AL-5	430	air susp.	10	cone	2	400	19-21k	–	8	7	125P	2/C	35x14x12	70	Two-piece unit.
		horn	8	cone	1	1500							13x14x13		
		horn	5	cone	1	5500									
		horn	4½	dome	1										
AL-4	300	horn	12	cone	1	1500	20-20k	–	7.5	7	100P	2/C	27x16x13	48	
			5	cone	1	4000									
			4½	dome	1	6500									
			3½	dome	1										
A-550	190	air susp.	10	cone	2	1200	28-20k	–	8	3	70C	C	35x14x12	35	
			4½	cone	1	3500									
			3	cone	1										
AL-3	180	horn	10	cone	1	1500	25-19k	–	7.5	7	90P	2/C	24x14x12	42	
			4½	cone	1	4500									
			3½	dome	1										
A-450	170	air susp.	12	cone	1	1200	35-20k	–	8	3	60C	C	26x16x12	32	
			4½	–	1	3500									
			3	–	1										
A-300	100	air susp.	10	cone	1	1200	35-20k	–	8	3	50C	–	22x12x11	24	
			4½	cone	1	3500									
			3	cone	1										
AL-2	100	reflex	10	cone	1	3500	32-19k	–	8	5	70P	2/C	20x12x11	23	
			3½	dome	1										
Armstrong Audio															
602	275	vented	8	–	1	2300	55-20k ±2	–	8	25	50C	–	24x11x11	25	
			1½	dome	1	7500					100P				
			1	dome	1										
Audioanalyst															
Anthem Array	599	sealed	10	–	2	120	28-25k ±3	86	4-8	15	70C	3/S, C	44x15x15	90	Polymer-treated cone; "time-aligned" staggered mounting.
		open	4½	–	1	500					300P				
		open	1	dome	1	3000									
		open	–	piezo horn	1	12,000									
M8	359	air susp.	12	long throw	1	600	27-25k ±3	86	8	15	80C	2/S	28x16x12	57	Polymer-treated cone.
			4½	cone	–	2000					250P				
			1	dome	1	15,000									
			½	–	–										
M6	269	air susp.	10	long throw	1	700	30-20k ±3	86	8	15	55C	2/S	24x14x12	47	"
			4½	cone	1	2000					150P				
			1	dome	1										
M4	189	air susp.	10	long throw	1	2000	38-20k ±4	88	8	10	40C	–	21x12x11	33	"
			1	dome	1						100P				
A-100X	169	air susp.	10	long throw	1	2000	33-20k ±4	89	8	10	50C	2/S	23x14x12	37	
			4½	cone	1	8000					135P				
			2	–	–										
M2	149	air susp.	5	long throw	1	2000	55-20k ±4	–	4	7	30C	–	10x6x7	7	Polymer-treated cone.
			1	dome	1						60P				
Audionics of Oregon															
LO-2	2500	vented	10	–	4	125	20-26k ±1	90	6	70	100C	C	–	200	Spherical satellites; separate woofers; bi-amp crossover.
			5	–	1	1000					400P				
			1½	dome	1	4000									
			1	dome	1										
T-52	365	vented	10	cone	1	350	32-22k ±2.5	92	4	30	60C	C	48x12x16	90	
			4½	–	1	2500					240P				
			1	dome	1										
Audio Phase															
FW154	390	reflex	15	–	1	800	20-25k ±6	–	8	5	100C	2/C	28x18x16	60	Fused.
			4x10	horn	1	2500					200P				
			3x7	horn	1	6500									
			3	–	1										
FW124	320	reflex	12	–	1	800	20-25k ±6	–	8	5	100C	2/C	26x16x12	45	
			4x10	horn	1	2500					200P				
			3x7	horn	1	6500									
			3	–	1										
SV123	200	reflex	12	–	1	800	30-19k ±6	–	8	5	50C	2/C	26x16x12	40	Fused.
			4x10	horn	1	1500					100P				
			3	–	1										
LV123	170	reflex	12	–	1	800	35-19k ±6	–	8	5	40C	–	26x16x12	35	Fused.
			5	cone	1	1500					80P				
			3	–	1										

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Avid															
300	350	sealed	12	–	1	500	35-20k ±3	88	8	15	250C	2/S	30x17x10	60	Self-resetting
			2	dome	1	6000									protect circuit.
			1	dome	1										
200	225	sealed	10	–	1	475	42-20k ±3	88	8	15	150C	2/S	25x15x10	40	Fused.
			4½	cone	1	4000									
			1	dome	1										
101	175	vented	8	cone	1	2500	30-18k ±3	85	8	15	70C	–	29x13x13	40	
			2	cone	2										
			1¾	cone	1										
102	150	–	10	cone	1	2200	44-18k ±3	85	8	15	100C	1/S	25x15x10	36	Fused.
			1	dome	1										
100	110	air susp.	8	cone	1	2500	48-18k ±3	85	8	15	75C	1/S	23x14x10	28	
			1¾	cone	1										
80	85	air susp.	8	cone	1	3000	66-17k ±3	88	8	8	60C	–	20x12x9	17	
			1¾	cone	1										
Bang & Olufsen															
Beovox M-100	490	vented	12	cone	1	50	35-22k ±4	–	4	25	100C	–	30x16x12	61	Frequency-dependent
			4	Phase-Link	1	2500									circuit breaker;
			2½	dome	1	8000									Phase-Link "linear
			1½	dome	1										phase" system,
			¾	dome	1										with stands.
Beovox M-70	395	air susp.	10	cone	1	500	38-20k ±4	–	4	15	70C	–	26x14x11	37	Phase-Link system
			5	Phase-Link	1	4500					125P				as above; w/stands.
			2½	dome	1										
			1	dome	1										
Beovox S-75	249	air susp.	10	cone	1	700	42-20k ±4	–	4	12	75C	–	23x13x10	24	Phase-Link; opt.
			5	Phase-Link	1	4000					100P				stands or wall brkt.
			2	dome	1										
			1	dome	1										
Beovox P-45	175	air susp.	5	cone	2	2000	55-20k ±4	–	4	10	45C	–	26x14x6	18	Wall mounting;
			3½	Phase-Link	1						75P				Phase-Link.
			1	dome	1										
Beovox S-45-2	149	air susp.	8	cone	1	2000	49-20k ±4	–	4	10	45C	–	19x10x8	15	Phase-Link;
			3½	Phase-Link	1						75P				opt. floor stand or
			1	dome	1										wall brkt.
Beovox P-30	125	air susp.	6½	cone	1	3000	58-20k ±4	–	4	10	30C	–	22x12x4	11	"Linear phase";
			1	dome	1						50P				wall-mounting panel.
Beovox S-35	119	air susp.	8	cone	1	3000	58-20k ±4	–	4	7	35C	–	19x10x8	9	"Linear phase."
			1	dome	1						50P				
Beovox S-25	95	air susp.	6½	cone	1	3000	80-16k ±4	–	4	5	25C	–	16x9x6	9	"Linear phase."
			2	dome	1						40P				
Bedini/Strelioff															
TS-1	p1995	infinite	10	cone	2	500	40-18k ±4	–	8	20	300C	3	57x36x18	–	"Phase-aligned."
			–	dome	4	5000									
			–	dome	4										
BES															
D-120W	599	open	1700 in.²	diaphragm	–	1200	35-20k ±3	89	4	30	110C	–	53x20x4	55	Dual planar dia-
			–	dynamic	3	10,000									phragms; upper has
			–	piezo	1										separate drivers for
					4										midbass, midrange &
															highs.
D-75W	449	open	850 in.²	diaphragm	–	1000	38-20k ±3	91	4	25	60C	–	32x22x4	35	"
			–	dynamic	2	9000									
			–	piezo	1										
D-60W	299	open	850 in.²	diaphragm	–	800	40-20k ±3	88	8	25	150C	–	28x20x4	25	Planar diaphragm with
			–	dynamic	2	10,000									3 drivers for diff.
			–	piezo	1										freq. ranges.
U60	199	open	–	–	2	800	42-18k ±3	88	8	20	–	–	26x18x4	20	As above, with 2 drive
															coils.
U50	139	open	–	–	–	3000	50-20k ±3	88.5	4	15	–	–	22x14x4	15	"
Beta Sound															
1001B	650	horn/vented	15	–	1	400	30-18.5k ±3	100	8	30	100C	1/S	41x22x26	130	
			–	horn	1	4500					200P				
			–	horn	1										
075	500	horn/vented	12	–	1	600	30-18.5k ±3	97	8	15	75C	1/S	38x21x17	100	
			–	horn	1	4500					150P				
			–	horn	1										
050	430	vented	12	–	1	600	30-18.5k ±4	97	8	15	75C	1/S	40x17x18	80	
			–	horn	1	4500					150P				
			–	horn	1										
045	370	vented	12	–	1	6000	35-18.5k ±4	97	8	15	75C	1/S	25x17x15	70	
			–	horn	1	4500					150P				
			–	horn	1										
Harold Beveridge															
System 3	10,000	line source	–	elect.	1	–	25-20k ±2	–	–	–	–	C		200	Vertical line source
															acoustic lens;
															built-in 1500-VA
System 2SW	6000	line source	12	–	2	70	30-18k ±2	–	–	–	–	C	78x24x15	150	As above, w/subwoofer.
			–	elect.	1										
System 2	1800	line source	–	elect.	1	–	50-18k ±2	–	–	–	–		78x24x15	100	As above, w/o subwoofer.
Beveridge Jr.	1500	line source	10	–	2	125	35-18k ±2	80	4	50	100C	C	72x16x16	75	
			–	elect.	1						300P				
B.I.C.															
															Data not available
															for new models.
BML Electronics															
2001 Sound Odyssey	549	planar column	8		3	1500	35-20k ±3	94	6	25	80C		64x24x6	90	
			8	ABR	1	5000					200P				
			1½		2										
1001 Sound Window	349	planar column	8		1	1500	48-20k ±3	92	5.2	20	70C		32x22x5	40	
			8	ABR	1	5000					150P				
			1½		1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont; P=peak)	Level controls (number/type: C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Bolivar Speaker Works															
64	190	vented	10 5 2	– – –	1 1 1	800 3000	–	89	4	10	50C 100P	C	27x14x12	44	
18	145	vented	8 5 2	– – –	1 1 1	1000 3000	–	86	4	10	45C 90P	C	23x13x11	34	
125	115	vented	8 2	– –	1 1	2000	–	86	4	10	35C 70P	–	23x13x11	31	
Bose															
901	765	vented special	4½	cone	9	–	–	–	8	10	–	2	21x13x12	35	1 direct, 8 reflecting drivers; w/ active equalizer.
601	279	vented	8 3	– –	2 4	2000	–	–	8	15	150C	–	25x15x13	36	Top and front radiating.
501	199	air susp.	10 3½	– –	1 –	1500 3000	–	–	4	20	150C	–	24x15x14	42	Tweeters reflect off walls.
301	109	vented	8 3	– –	1 1	1200 3000	–	–	8	10	60C		11x15x10	18	Aimable tweeters reflect off side wall.
Bozak															
Concert Grand	1365	infinite	12 6 2½	– cone cone	4 2 8	400 2500	28-20k	–	8	–	–	–	52x36x19	225	
CS 4000 Symphony	870	infinite	12 6 2½	– cone cone	2 1 8	400 2500	35-20k	–	8	–	–	–	44x27x16 or 30x39x16	190	Avail. in vert. or horiz. cab.
CS-501 Concerto	450	infinite	12 6 2½	– cone cone	1 1 3	400 2500	40-20k	–	8	–	–	S	32x20x16	90	
LS 400	300	infinite	12 6 2½	– cone cone	1 1 2	800 2500	40-20k	–	–	20	–	S	25x18x14	65	
LS 300	250	vented	–	–	–	–	–	–	–	20		–	–	–	
LS 250	190	infinite	12 4 2½	– – –	1 1 1	800 2500	45-20k	–	–	20	–	S	23x15x12	48	
LS 200	115	vented	8 2½	– –	1 1	2000	45-20k	–	–	20	–		20x12x11	34	
Braun															
L-1030	840	infinite	10 2 ¾	– dome dome	1 1 1	500 3000	–	–	4-8	25	100C 140P	–	28x12x10	40	
L-300	400	infinite	5 1 ¾	– dome dome	1 1 1	600 3000	–	–	4	12	40C 50P	–	10x6x7	14	
L-200	270	infinite	5 1	– dome	1 1	1500	–	–	4	12	40C 50P	–	10x6x6	11	
LVP-100	260	infinite	2¾ 1	– dome	1 1	1500	–	–	4	12	35C 50P	–	7x4x4	7	Swivel mtg. brkt.
Output C	230	infinite	2¾ 1	– dome	1 1	1500	–	–	4	12	35C 50P	–	7x4x4	6	
Burhoe Acoustics															
Silver	450	vented	10 1½ 1 1/8	– inv. dome inv. dome	1 1 3	1000 2000 3000	24-26k ±2	97	6	50	100C 200P	1/C	–	58	Angled, side-firing tweeters.
Blue	225	vented	10 1½ 1 1/8	– inv. dome inv. dome	1 1 1	1000 2000	30-16k ±2	96	5	25	75C 175P	2/C	14x24x11	36	
Light Blue	150	vented	10 1½	– inv. dome	1 1	1500	30-16k ±2	98	5	15	60C 175P	1/C	14x24x10	35	
White	140	vented	8 1	– inv. dome	1 1	1800	35-26k ±2	94	5	20	50C 150P	1/C	22x14x10	29	
Green	110	vented	8 1½	– inv. dome	1 1	2000	40-16k ±2	97	5	8	35C 100P	1/S	18x11x10	22	
B&W															
DM6	655	sealed	8 7/8 5 1/8 ¾	cone cone dome	1 1 1	500 5000	50-20k ±3	86	8	25	350C	2	37x16x15		"Linear-phase" staggered cab.; system & tweeter fused.
DM7	545	pass. rad.	– –	cone dome	1 1	–	70-20k ±2	–	8	50	200C	1	36x11x15		"Linear-phase" staggered; fused.
DM4	259	vented	6½ 1 3/8 ¾	cone cone dome	1 1 1	2500 14,00	80-20k ±5	88	8	10	30C	–	21x10x10		Fused.
DM5	159	sealed	5½ ¾	cone dome	1 1	4500	100-20k ±5	87	8	10	25C	–	18x9x10		Fused.
Calibration Standard Instruments															
MDM-4	230	vented	6½ 3½	– –	2 1	1500	70-17k ±3	89	8	10	40C 100P	none	13x19x10	23	For "near-field" monitoring; fused.
Cambridge/Cybervox															
TL 200	599	trans. line	13x8 – – –	– – – –	1 1 1 1	400 3000 10,000	–	–	8	20	50C 90P	–	42x18x13	98	
TL 100	499	trans. line	13x8 – –	– – –	1 1 1	400 3000	–	–	8	20	40C 70P	–	31x13x13	52	
Cannon TLS															
1230-T	399	pass. rad.	12 5½ 2x5 –	– – horn piezo	1 1 1	400 3500	–	–	8	18	185P	3/S, C	14x14x39	61	

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz ±dB)	Sensitivity (SPL in dB at 1 meter w 1W input)	Impedance (ohms)	Min. input (watts)	Max input (watts) (C=cont, P=peak)	Level controls (number type C=cont. variable S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
1230	299	pass. rad.	12	–	1	400	–	–	8	15	170P	3	14x14x25	41	
			5½	–	1	3500									
			2x5	horn	1										
			–	piezo	1										
1030	249	pass. rad.	10	–	1	400	–	–	8	12	150P	3/S, C	14x14x25	39	
			5½	–	1	3500									
			2x5	horn	1										
			–	piezo	1										
1020	179	pass. rad.	10	–	1	3500	–	–	8	10	90P	2/S, C	12x14x22	31	
			2x5	horn	1										
			–	piezo	1										
Canton															
LE-900	758	infinite	11	–	1	700	–	–	4-8	40	90C	–	23x13x11	32	Floor stand opt.
			2	dome	1	2100					130P				
			1	dome	1										
Gamma 800L	558	infinite	8	–	1	750	–	–	4-8	25	80C	–	11x11x11	22	
			1 1/8	dome	1	2200					120P				
			¾	dome	1										
LE-600	558	infinite	7	–	1	680	–	–	4-8	30	70C	–	20x11x10	24	
			1½	dome	1	2700					100P				
			1	dome	1										
LE-400	370	infinite	6	–	1	750	–	–	4-8	20	20C	–	15x9x8	14	
			1½	dome	1	2600					55P				
			1	dome	1										
LX-300	240	infinite	4½	–	1	1600	–	–	4-8	10	30C		10x6x5	6	
			1	dome	1						45P				
HC-100	180	infinite	4	–	1	1700	–	–	4-8	10	15C	–	5x8x6	4	
			1	dome	1						25P				
Celestion Industries															
Ditton 66	530	pass. rad.	12	–	1	500	40-25k ±4	83	8	10	160P	–	40x15x12	66	
			12	pass. rad.	1	5000									
			2	dome	1										
			1	dome	1										
Ditton 25	350	pass. rad.	12	–	1	2000	45-25k ±4	85	8	10	120P	–	32x14x11	42	
			12	pass. rad.	1	9000									
			1¼	dome	2										
			1	dome	1										
Ditton 44	310	air susp.	12	–	1	500	50-25k ±4	84	8	10	100P	–	30x15x10	45	
			6	cone	1	5000									
			1	dome	1										
Ditton 33	260	air susp.	12	–	1	500	50-20k ±4	83.5	8	10	80P	–	24x14x11	34	
			5	cone	1	5000									
			1	dome	1										
UL6	180	pass. rad.	6	–	1	2500	70-20k ±4	79	8	20	80P	–	12x16x9	17	
			6	pass. rad.	1										
			1	dome	1										
Ditton 15	160	pass. rad.	8	–	1	2500	60-20k ±4	84	8	10	60P	–	21x10x9	17	
			8	pass. rad.	1										
			1	dome	1										
Cerwin-Vega															
417R	400	reflex	15	–	1	300	30-19k ±4	103	4-8	0.5	200C	2/C	29x18x18	82	Min. power input is for 100 dB SPL; hi-freq circuit breaker.
			6	–	1	3500									
			–	horn	1										
S1	350	reflex	12	–	1	300	28-20k ±4	98	4-8	2	200C	1/C	25x15x14	55	As above, but with Thermo-Vapor suspension, base equalizer.
			6	–	1	4000									
			–	Dhorm	1										
12TR	350	reflex	12	–	1	250	35-20k ±3	100	4-8	1	100C	3/C	40x14x14	88	As for 417R, but fuse-protected.
			6	–	1	4000									
			–	super Dhorm	1										
			–	horn	1										
312	300	reflex	12	–	1	300	30-17k ±4	100	4-8	1	150C	2/C	26x16x16	63	As for 417R above.
			6	–	1	3500									
			–	horn	1										
R-123	280	reflex	12	–	1	500	38-20k ±4	97	4-8	2	50C	2/C	25x15x12	50	"
			6	–	1	5000									
			–	Dhorm	1										
212	250	reflex	12	–	1	2000	35-17k ±4	100	4-8	1	100C	1/C	26x16x16	58	"
			–	horn	1										
36R	220	reflex	12	–	1	500	38-20k ±4	96	4-8	2	75C	2/C	25x15x12	40	"
			5	–	1	2500									
			2½	dhorm	1										
R12	200	reflex	12	–	1	2000	38-20k ±4	97	4-8	2	50C	1/C	25x15x12	43	"
			–	Dhorm	1										
25	180	reflex	12	–	1	2500	38-20k ±4	94	4-8	4	40C	1/C	25x15x12	39	"
			2½	–	1										
R-10	160	reflex	10	–	1	1200	38-20k ±4	92	4-8	6	40C	1/C	24x13x12	39	"
			1	dome	1										
311R	150	reflex	12	–	1	1500	32-20k ±4	100	4-8	4	40C	1/C	20x16x15	57	"
			5	horn	1	3000									
			1	–	1										
Chartwell															
PM 450 Electronic	3000	reflex	12	cone	1	1800	45-20k ±2	–	20k	–	–	1, amp	30x18x16	70	Adj. sensitivity; switchable impedance; w/amp.
			1	dome	1				600						
PM 450 Passive	2100	reflex	12	cone	1	1800	45-20k ±3	92	8	–	350P	–	30x18x16	70	
			1	dome	1										
PM 400	1650	reflex	12	cone	1	500	45-22k ±3	87	8	–	100C	–	34x15x13	30	
			5	cone	1	3500					250P				
			1	dome	1										
PM 200	400	reflex	8	cone	1	3500	45-22k ±3	86	8	–	50C	–	26x11x14	33	
			1	dome	1						125P				

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PM 100	250	reflex	6½	cone	1	3000	50-20k ±3	84	8	–	40C	–	18x9x8	16	
			1	dome	1						100P				
LS3/5A	225	air susp.	4½	cone	1	3000	80-20k ±3	82	8	15	25P	–	12x8x6	12	
			1	dome	1										
Cizek															
"Woofer"	275	–	10	–	2	200	27-200 ±2	–	4	–	–	–	–	–	Subwoofer w/crossover.
1	198	air susp.	10	–	1	1500	36-17k ±2	–	4 or 8	15	150P	2	25x16x10	49	Switchable impedance.
			1	dome	1										
2	134	air susp.	8	–	1	1500	38-17k ±2	–	4 or 8	15	150P	1	21x13x9	37	Switchable impedance.
			1	dome	1										
3	97	–	8	–	1	1500	42-17k ±2	–	4 or 8	15	100P	1	19x12x8	25	Switchable impedance.
Concept															
CE-M	595	pass. rad.	12	alum. cone	1	1300	25-23k ±3	91	6	25	300P	3/S, C	45x18x16	102	LED power mon.
			12	pass. rad.	1										
			–	Heil AMT	1										
CE 1	445	pass. rad.	10	alum. cone	1	1500	30-23k ±3	91	6	20	280P	2/C	40x16x15	91	As above.
			10	pass. rad.	1										
			–	Heil AMT	1										
CE 2	345	pass. rad.	10	alum. cone	1	1500	35-23k ±3	91	6	20	280P	2/C	25x14x14	54	As above.
			10	pass. rad.	1										
				Heil AMT	1										
CM Labs Div., Audio Int'l.															
CM15B	599	infinite	15	cone	1	450	22-22k ±2	96	4	40	50C	2/C, 1/S	34x17x17	101	Servo woofer control w/adapter incl.
			6	cone	1	5000					150P				
			3	cone	1	12,000									
			3	horn											
CM10a	349	infinite	10	cone	1	500	30-19k ±2.5	86	6	40	50C	none	22x12x12	40	As above.
			4½	cone	1	5000					150P				
			1	dome	1										
Contrara Research															
Vector 5	440	pass. rad.	12	–	1	300	–	91	8	30	250P	3/C	34x18x14	60	"Linear phase."
			12	pass. rad.	1	1500									
			5	–	1	5000									
			1½	–	1										
			1	–	1										
Elan	380	–	8	–	2	1000	–	87	8	35	150P	2/C	40x12x12	65	As above; swivel base.
			1½	–	1	5000									
			1	–	1										
Vector 4	300	pass. rad.	10	–	1	300	–	89	8	15	150P	2/C	28x16x12	45	"Linear phase."
			10	pass. rad.	1	4000									
			5	–	1										
			1	–	1										
Vector Two	260	pass. rad.	10	–	1	1000	–	89	8	15	150P	2/C	25x15x10	45	As above.
			10	pass. rad.	1	5000									
			1½	dome	1										
			1	dome	1										
Pedestal	250		8	–	1	2000	–	91	8	15	100P	–	31x12x12	45	Swivel base.
			1	–	1										
Vector One A	230	pass. rad.	8	–	1	1000	–	89	8	15	150P	2/C	23x14x10	38	"Linear phase."
			8	pass. rad.	1	5000									
			1½	dome	1										
			1	dome	1										
Vector Two B	210	pass. rad.	10	–	1	2000	–	89	8	15	150P	1/S	25x15x10	40	As above.
			10	pass. rad.	1										
			1	dome	1										
Tower	200	–	10	–	1	2000	–	89	8	15	150P	1/S	28x12x12	40	
			1	–	1										
Vector One	180	pass. rad.	8	–	1	2000	–	89	8	15	100P	1/S	23x14x10	35	"Linear phase."
			8	pass. rad.	1										
			1	dome	1										
Piccola 3	145	–	6½	–	1	1500	–	91	8	10	150P	2/C	14x11x6	18	
			1½	–	1	5000									
			1	–	1										
Rectangle	135	pass. rad.	8	–	1	2000	–	89	8	15	25P	–	15x18x9	30	
			1	–	1										
Piccola 2	100	–	6½	–	1	2000	–	90	8	15	100P	–	14x9x6	15	
			1	–	1										
Craig															
5706	170	vented	12	–	1	800	40-20k ±5	94	8	20	50P	2/C	27x19x15	46	
			4½	–	1	5000									
			2	–	1										
5705	120	vented	10	–	1	2500	45-17k ±5	94	8	15	35P	1/C	24x17x14	37	
			2	–	1										
5704	100	air susp.	8	–	2	1200	–	92	8	15	50P	–	22x13x12	25	
			3	–	1										
Dahlquist															
DQ-10	425	–	10	–	1	400	37-27k ±3	–	8	60	200P	1/C	32x31x9	55	"Low-diffraction phased array."
			5	–	1	1000									
			2	dome	1	6000									
			¾	dome	1	12,500									
			–	piezo	1										
DQ-1W	275	air susp.	13	–	1	–	–	–	–	60	200P	–	26x19x15	70	Subwoofer.
Dayton Wright															
XG-8 Mk3 Series 3	2995	dipole	–	elect.	1	16,000	32-25k ±4	86	4	50	250C	1/S	42x39x10	95	
			1½	piezo	1						2000P				
Design Acoustics															
D-8	485	pass. rad.	10	–	2	600	30-17k ±2	92	8	15	40C	3/S	112x42x32	70	Pass. rad. may be driven as second woofer.
			5	cone	1	1500					150P				
			–	cone	3										
			–	dome	1										
			–	piezo	1										

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D-6	318	vented	10	–	1	800	30-15k ±2	92	8	20	30C	2	25x17x14	50	Rear-mouted woofer;
			5	cone	1	2000					100P				spaced, angled
			2½	cone	5										tweeters.
D-4	239	air-susp.	10	–	1	800	40-15k ±3	90.5	8	25	25C	2	38x18x10	60	Dispersion angle
			5	cone	1	2000					75P				180° hor., 90° vert.
			2½	cone	3										
D-2	179	vented	10	–	1	1500	40-18k ±3.5	88	8	20	20C	1	34x13x12	35	Tweeter main axis 30°
			1	dome	1						50P				from vertical.
D-1W	119	vented	8	–	1	1500	50-15k ±3.5	87.5	6	15	15C	–	54x31x20	19	Tweeter fires into
			1½	cone	1						30P				double-reflecting dis-
															persion system.
D-1A	109	vented	8	–	1	1500	50-15k ±3.5	87.5	6	15	15C	–	51x18x20	12	As above.
			1½	cone	1						30P				
Dynaco															
Phase 3 Model 80	399	infinite	13	cone	1	800	–	90	8		100D	2/S	43x15x12	68	"Phase-coherent."
			4¼	cone	1	4000					150P				
			1	dome	1										
Phase 3 Model 60	299	infinite	10	cone	1	1000	–	89	8	–	60D	2/S	36x13x9	44	As above.
			4¼	cone	1	5000					100P				
			1	dome	1										
A-30XL	149	sealed	10	cone	1	1000	–	88	8	–	80P	2/C	23x13x10	38	In-line drivers.
			5	cone	1	5000									
			1	dome	1										
A-25 II	119	vented	10	cone	1	1500	–	88	8		50D	1/C	20x12x10	29	As above.
			1	dome	1						80P				
D-20XL	74	vented	8	cone	1	2000	–	88	8	–	35P		18x11x9	20	
			2	cone	1										
Electro-Voice															
Interface: D	p1500	vented	12	–	1	40	28-18k±3	97	8	1.5	50C	1/S	32x22x16	114	Equalized tweeter
			6½	cone	1	350					500P				protect circ.
			–	horn	1	3000									
Interface: C	p900	vented	10	–	1	42	30-18k ±3	96	6	2.8	20C	1/S	30x22x12	60	As above.
			–	horn	1	2000					200P				
Interface: B II	p675	vented	12	radiator	1	42	30-18k ±3	92	8	3.6	20C	1/S	29x16x11	42	As above.
			8	–	1	1500					200P				
			2½	–	2	8000									
Interface: A II	p500	vented	12	radiator	1	49	35-18k ±3	92	8	3.6	20C	1/S	23x14x8	30	As above.
			8	–	1	1500					200P				
			2½	–	2	8000									
Interface: 3	170	vented	12	radiator	1	57	40-18k ±4	92	8	3.6	20C		27x15x13	33	
			8	–	1	1500					200P				
			2½	–	1										
Interface: 2	140	vented	10	radiator	1	66	47-18k ±4	92	8	3.6	20C		25x14x11	25	
			8	–	1	1500					200P				
			2½	–	1										
Interface: 1	100	vented	8	–	1	76	54-18k ±4	92	8	3.6	20C	–	21x12x11	23	
			2½	–	1	1500					200P				
Ezekiel															
FRL II	425	infinite	10	cone	1	400	27-19k +2, –3	87	7	50	200C	1/C	44x16x10	60	
			4	–	1	3500					300P				
			2½	dome	1										
MTM	225	infinite	8	cone	1	2200	36-19k ±4	89	6	25	90C	1/C	40x15x8	45	
			2½	dome	1						140P				
WRL	149	infinite	8	cone	1	2200	38-19k ±4	89	6	20	90C	1/C	25x15x13	38	
			2½	dome	1						140P				
EPI															
350	400	air susp.	8	–	3	1800	36-20k ±3	87	8	38	125C	1/S	37x15x13	83	
			3	air spring	1										
250	250	air susp.	8	–	2	1800	38-20k ±3	87	8	20	100C	1/S	25x15x15	40	
			1	air spring	2										
2008	225	pass. rad.	12	pass. rad.	1	1800	34-20k ±3	90	8	15	100C	1/S	31x17x11	58	
			8	–	1						150P				
			1	air spring	1										
1208	140	air susp.	10	–	1	1800	38-20k ±3	88	8	25	80C	1/S	25x15x11	46	
			1	air spring	1										
100W	115	air susp.	8	–	1	1800	48-20k ±3	87	8	12	75C	–	21x11x9	25	
			1	air spring	1										
100V	99	air susp.	8	–	1	1800	48-20k ±3	87	8	12	75C	–	21x11x9	25	
			1	air spring	1										
70	75	air susp.	6	–	1	1800	60-20k ±3	86.5	8	10	80C	–	16x11x7	17	
			1	air spring	1										
Epicure															
1000	1000	air susp.	8	–	4	1800	23-30k ±3	87	8	60	150C	1/S	75x18x18	180	
			1	air spring	4						250P				
400+	400	air susp.	6	–	4	1800	27-20k ±3	85	8	30	150C	1/S	38x14x14	90	
			1	air spring	4						250P				
20+	275	air susp.	8	–	2	1800	35-20k ±3	86	8	20	100C	1/S	29x19x12	64	
			1	air spring	2										
14	199	pass. rad.	8	pass. rad.	1	1800	28-20k ±3	84	8	15	80C	1/S	24x14x9	39	
		–	6		1										
			1	air spring	1										
11	149	vented	6	–	1	1800	36-20k ±3	84	8	15	80C	1/S	23x14x10	36	
			1	air spring	1										
10	125	air susp.	8	–	1	1800	43-20k ±3	86	8	12	75C	1/S	22x12x10	33	
			1	air spring	1										
5	80	air susp.	6	–	1	1800	50-20k ±3	84	8	15	80C	–	15x11x8	16	
			1	air spring	1										
ESS															
Transar atd	p3500	infinite	32	Heil AMT (bass drive)	1	1000	30-22k ±3	–	4	–	–	C	40x50x6	–	Inc. current-source woofer amp.
			21.5 in²	Heil AMT	1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number/type C=cont. variable S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
PM 100	250	reflex	6½	cone	1	3000	50-20k ±3	84	8	–	40C	–	18x9x8	16	
			1	dome	1						100P				
LS3/5A	225	air susp.	4½	cone	1	3000	80-20k ±3	82	8	15	25P	–	12x8x6	12	
			1	dome	1										
Cizek															
"Woofer"	275	–	10	–	2	200	27-200 ±2	–	4	–	–	–	–	–	Subwoofer w/crossover.
1	198	air susp.	10	–	1	1500	36-17k ±2	–	4 or 8	15	150P	2	25x16x10	49	Switchable impedance.
			1	dome	1										
2	134	air susp.	8	–	1	1500	38-17k ±2	–	4 or 8	15	150P	1	21x13x9	37	Switchable impedance.
			1	dome	1										
3	97	–	8	–	1	1500	42-17k ±2	–	4 or 8	15	100P	1	19x12x8	25	Switchable impedance.
Concept															
CE-M	595	pass. rad.	12	alum. cone	1	1300	25-23k ±3	91	6	25	300P	3/S, C	45x18x16	102	LED power mon.
			12	pass. rad.	1										
			–	Heil AMT	1										
CE 1	445	pass. rad.	10	alum. cone	1	1500	30-23k ±3	91	6	20	280P	2/C	40x16x15	91	As above.
			10	pass. rad.	1										
			–	Heil AMT	1										
CE 2	345	pass. rad.	10	alum. cone	1	1500	35-23k ±3	91	6	20	280P	2/C	25x14x14	54	As above.
			10	pass. rad.	1										
				Heil AMT	1										
CM Labs Div., Audio Int'l.															
CM15B	599	infinite	15	cone	1	450	22-22k ±2	96	4	40	50C	2/C, 1/S	34x17x17	101	Servo woofer control w/adapter incl.
			6	cone	1	5000					150P				
			3	cone	1	12,000									
			3	horn											
CM10a	349	infinite	10	cone	1	500	30-19k ±2.5	86	6	40	50C	none	22x12x12	40	As above.
			4½	cone	1	5000					150P				
			1	dome	1										
Contrara Research															
Vector 5	440	pass. rad.	12	–	1	300	–	91	8	30	250P	3/C	34x18x14	60	"Linear phase."
			12	pass. rad.	1	1500									
			5	–	1	5000									
			1½	–	1										
			1	–	1										
Elan	380	–	8	–	2	1000	–	87	8	35	150P	2/C	40x12x12	65	As above, swivel base.
			1½	–	1	5000									
			1	–	1										
Vector 4	300	pass. rad.	10	–	1	300	–	89	8	15	150P	2/C	28x16x12	45	"Linear phase."
			10	pass. rad.	1	4000									
			5	–	1										
			1	–	1										
Vector Two	260	pass. rad.	10	–	1	1000	–	89	8	15	150P	2/C	25x15x10	45	As above.
			10	pass. rad.	1	5000									
			1½	dome	1										
			1	dome	1										
Pedestal	250		8	–	1	2000	–	91	8	15	100P	–	31x12x12	45	Swivel base.
			1	–	1										
Vector One A	230	pass. rad.	8	–	1	1000	–	89	8	15	150P	2/C	23x14x10	38	"Linear phase."
			8	pass. rad.	1	5000									
			1½	dome	1										
			1	dome	1										
Vector Two B	210	pass. rad.	10	–	1	2000	–	89	8	15	150P	1/S	25x15x10	40	As above.
			10	pass. rad.	1										
			1	dome	1										
Tower	200	–	10	–	1	2000	–	89	8	15	150P	1/S	28x12x12	40	
			1	–	1										
Vector One	180	pass. rad.	8	–	1	2000	–	89	8	15	100P	1/S	23x14x10	35	"Linear phase."
			8	pass. rad.	1										
			1	dome	1										
Piccola 3	145	–	6½	–	1	1500	–	91	8	10	150P	2/C	14x11x6	18	
			1½	–	1	5000									
			1	–	1										
Rectangle	135	pass. rad.	8	–	1	2000	–	89	8	15	25P	–	15x18x9	30	
			1	–	1										
Piccola 2	100	–	6½	–	1	2000	–	90	8	15	100P	–	14x9x6	15	
			1	–	1										
Craig															
5706	170	vented	12	–	1	800	40-20k ±5	94	8	20	50P	2/C	27x19x15	46	
			4½	–	1	5000									
			2	–	1										
5705	120	vented	10	–	1	2500	45-17k ±5	94	8	15	35P	1/C	24x17x14	37	
			2	–	1										
5704	100	air susp.	8	–	2	1200	–	92	8	15	50P	–	22x13x12	25	
			3	–	1										
Dahlquist															
DQ-10	425	–	10	–	1	400	37-27k ±3	–	8	60	200P	1/C	32x31x9	55	"Low-diffraction phased array."
			5	–	1	1000									
			2	dome	1	6000									
			¾	dome	1	12,500									
			–	piezo	1										
DQ-1W	275	air susp.	13	–	1	–	–	–	–	60	200P	–	26x19x15	70	Subwoofer.
Dayton Wright															
XG-8 Mk3 Series 3	2995	dipole	–	elect.	1	16,000	32-25k ±4	86	4	50	250C	1/S	42x39x10	95	
			1½	piezo	1						2000P				
Design Acoustics															
D-8	485	pass. rad.	10	–	2	600	30-17k ±2	92	8	15	40C	3/S	112x42x32	70	Pass. rad. may be driven as second woofer.
			5	cone	1	1500					150P				
			–	cone	3										
			–	dome	1										
			–	piezo	1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz ±dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number/type, C=cont. variable, S=switched)	Dimensions (H × W × D) (in.)	Weight (pounds)	Remarks
D-6	318	vented	10 5 2½	– cone cone	1 1 5	800 2000	30-15k ±2	92	8	20	30C 100P	2	25x17x14	50	Rear-mouted woofer; spaced, angled tweeters.
D-4	239	air susp.	10 5 2½	– cone cone	1 1 3	800 2000	40-15k ±3	90.5	8	25	25C 75P	2	38x18x10	60	Dispersion angle 180° hor., 90° vert.
D-2	179	vented	10 1	– dome	1 1	1500	40-18k ±3.5	88	8	20	20C 50P	1	34x13x12	35	Tweeter main axis 30° from vertical.
D-1W	119	vented	8 1½	– cone	1 1	1500	50-15k ±3.5	87.5	6	15	15C 30P	–	54x31x20	19	Tweeter fires into double-reflecing dispersion system.
D-1A	109	vented	8 1½	– cone	1 1	1500	50-15k ±3.5	87.5	6	15	15C 30P	–	51x18x20	12	As above.
Dynaco															
Phase 3 Model 80	399	infinite	13 4¼ 1	cone cone dome	1 1 1	800 4000	–	90	8		100D 150P	2/S	43x15x12	68	"Phase-coherent."
Phase 3 Model 60	299	infinite	10 4¼ 1	cone cone dome	1 1 1	1000 5000	–	89	8	–	60D 100P	2/S	36x13x9	44	As above.
A-30XL	149	sealed	10 5 1	cone cone dome	1 1 1	1000 5000	–	88	8	–	80P	2/C	23x13x10	38	In-line drivers.
A-25 II	119	vented	10 1	cone dome	1 1	1500	–	88	8		50D 80P	1/C	20x12x10	29	As above.
D-20XL	74	vented	8 2	cone cone	1 1	2000	–	88	8	–	35P		18x11x9	20	
Electro-Voice															
Interface: D	p1500	vented	12 6½ –	– cone horn	1 1 1	40 350 3000	28-18k±3	97	8	1.5	50C 500P	1/S	32x22x16	114	Equalized tweeter-protect circ.
Interface: C	p900	vented	10 –	– horn	1 1	42 2000	30-18k ±3	96	6	2.8	20C 200P	1/S	30x22x12	60	As above.
Interface: B II	p675	vented	12 8 2½	radiator – –	1 1 2	42 1500 8000	30-18k ±3	92	8	3.6	20C 200P	1/S	29x16x11	42	As above.
Interface: A II	p500	vented	12 8 2½	radiator – –	1 1 2	49 1500 8000	35-18k±3	92	8	3.6	20C 200P	1/S	23x14x8	30	As above.
Interface: 3	170	vented	12 8 2½	radiator – –	1 1 1	57 1500	40-18k ±4	92	8	3.6	20C 200P		27x15x13	33	
Interface: 2	140	vented	10 8 2½	radiator – –	1 1 1	66 1500	47-18k ±4	92	8	3.6	20C 200P		25x14x11	25	
Interface: 1	100	vented	8 2½	– –	1 1	76 1500	54-18k ±4	92	8	3.6	20C 200P	–	21x12x11	23	
Ezekiel															
FRL II	425	infinite	10 4 2½	cone – dome	1 1 1	400 3500	27-19k +2, −3	87	7	50	200C 300P	1/C	44x16x10	60	
MTM	225	infinite	8 2½	cone dome	1 1	2200	36-19k ±4	89	6	25	90C 140P	1/C	40x15x8	45	
WRL	149	infinite	8 2½	cone dome	1 1	2200	38-19k ±4	89	6	20	90C 140P	1/C	25x15x13	38	
EPI															
350	400	air susp.	8 3	– air spring	3 1	1800	36-20k ±3	87	8	38	125C	1/S	37x15x13	83	
250	250	air susp.	8 1	– air spring	2 2	1800	38-20k ±3	87	8	20	100C	1/S	25x15x15	40	
200B	225	pass. rad.	12 8 1	pass. rad. – air spring	1 1 1	1800	34-20k ±3	90	8	15	100C 150P	1/S	31x17x11	58	
120B	140	air susp.	10 1	– air spring	1 1	1800	38-20k ±3	88	8	25	80C	1/S	25x15x11	46	
100W	115	air susp.	8 1	– air spring	1 1	1800	48-20k ±3	87	8	12	75C	–	21x11x9	25	
100V	99	air susp.	8 1	– air spring	1 1	1800	48-20k ±3	87	8	12	75C	–	21x11x9	25	
70	75	air susp.	6 1	– air spring	1 1	1800	60-20k ±3	86.5	8	10	80C	–	16x11x7	17	
Epicure															
1000	1000	air susp.	8 1	– air spring	4 4	1800	23-30k ±3	87	8	60	150C 250P	1/S	75x18x18	180	
400+	400	air susp.	6 1	– air spring	4 4	1800	27-20k ±3	85	8	30	150C 250P	1/S	38x14x14	90	
20+	275	air susp.	8 1	– air spring	2 2	1800	35-20k ±3	86	8	20	100C	1/S	29x19x12	64	
14	199	pass. rad.	8 6 1	pass. rad. – air spring	1 1 1	1800	28-20k ±3	84	8	15	80C	1/S	24x14x9	39	
11	149	vented	6 1	– air spring	1 1	1800	36-20k ±3	84	8	15	80C	1/S	23x14x10	36	
10	125	air susp.	8 1	– air spring	1 1	1800	43-20k ±3	86	8	12	75C	1/S	22x12x10	33	
5	80	air susp.	6 1	– air spring	1 1	1800	50-20k ±3	84	8	15	80C	–	15x11x8	16	
ESS															
Transar atd	p3500	infinite	32 21.5 in²	Heil AMT (bass drive) Heil AMT	1 1	1000	30-22k ±3	–	4	–	–	C	40x50x6	–	Inc. current-source woofer amp.

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz ±dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number/type, C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Seven	470	vented	12	–	1	400	25-25k ±5	99	8	1	50C	2/C	29x19x16	98	
			4	cone	2	4000					75P				
			–	piezo	2										
Mark V	350	vented	12	–	1	500	30-25k ±5	96	8	1	50C	2/C	26x14x12	55	
			4	cone	2	4000					75P				
			–	piezo	1										
Concerto	290	vented	10	–	1	2000	35-25k ±5	93	8	1	30C	1/C	22x16x16	56	End table ht.
			3x7	horn	1	4000					45P				
			–	piezo	1										
Mark IV-A	210	vented	10	–	1	2000	40-16k ±5	93	8	1	30C	1/C	24x14x12	44	
			3x7	horn	1						45P				
Monte Carlo	150	vented	8	–	1	3800	50-25k ±5	95	8	1	30C	–	19x11x12	31	
			3	–	1						45P				
			–	piezo	1										
CAD-1	100	vented	8	–	1	3000	50-15k ±5	96	8	1	15C	–	19x11x11	21	
			3¼	–	1						30P				
Fried Products															
H/II	1900	trans. line	10	cone	2	75	20-20k ±3	87	8	25	70C	–	24x45x24	200	Subwoofer +
	(syst.)		5	cone	1	3500					500P				satellite; kit, $800.
			1	dome	1										
T Subwoofer	1400	trans. line	10	cone	2	75	20-20k ±3	91	8	25	70C	–	24x45x24	170	2-ch. subwoofer
											500P				of above; also avail-
															able as kit.
M/II	850	trans. line	8	cone	1	125	20-20k ±3	90	8	25	70C	–	43x22x12	90	
			5	cone	1	3500					500P				
			1	dome	1										
R/III	400	line tunnel	10	cone	1	350	30-20k ±3	89	8	25	50C	S	28x16x14	60	
			5	cone	1	3000					250P				
			1	dome	1										
W	260	line tunnel	8	cone	1	800	40-20k ±2	89	8	25	35C	S	25x14x10	45	
			3	–	1	3000					250P				
			1	dome	1										
B/2	250	infinite	5	–	1	3200	60-20k ±3	87	8	25	35C	–	12x8x6	14	
			1	dome	1						500P				
A	195	line tunnel	8	–	1	2500	45-20k ±2	88	8	25	35C	S	20x12x10	30	
			1	dome	1						250P				
Q	140	line tunnel	8	–	1	2500	45-18k ±2	88	8	25	35C	S	20x12x10	30	
			1	dome	1						200P				
Gale Electronics															
GS 401A	500	air susp.	7 7/8	–	2	475	35-20k ±5	–	4-8	50	100C	C	13x24x11	48	"Sealed midrange."
			4	–	1	5000					200P				
			¾	dome	1										
GC Electronics															
Audio Trek IV	101	air susp.	12	cone	1	–	35-22k	–	8	10	45C	–	24x15x10	35	
			4½	cone	1										
			1¾	ring	1										
Audio Trek III	72	air susp.	10	cone	1	–	35-22k	–	8	5	35C	–	20x12x10	20	
			3	cone	1										
Genesis Physics															
Genesis 3	299	pass. rad.	10	pass. rad.	1	45	32-20k ±4	87	8	20	40C	2/S	38x15x12	52	
			8	–	1	800					100P				
			4	–	1	3000									
			1	inv. dome	1										
Genesis II+	219	pass. rad.	10	pass. rad.	1	45	32-20k ±4	88.5	8	15	40C	1/S	33x15x11	44	
			8	–	1	1800					80P				
			1	inv. dome	1										
Genesis II	155	pass. rad.	10	pass. rad.	1	45	32-20k ±4	88	8	12	40C	1/S	27x15x12	37	
			8	–	1	1800					80P				
			1	inv. dome	1										
Genesis I	99	air susp.	8	–	1	1800	45-20k ±4	88	8	12	40C	–	21x12x9	24	
			1	inv. dome	1						60P				
Genesis 6	75	air susp.	6½	–	1	1800	60-20k ±5	88	8	12	40C	–	18x10x7	17	
			1	inv. dome	1						60P				
GLI															
Model 4	1700	horn	15	–	2	750	30-20k ±4	103	8	50	260C	–	80x36x30	195	
			15	pass. rad.	2	7000					1100P				
			–	horn	2										
			–	horn	1										
Model 3	898	horn	15	–	2	850	30-20k ±5	101	8	50	200C	–	50x36x30	150	
			20x15	horn	1	7000					900P				
			3	–	7										
Model 2	696	reflex	15	–	2	350	35-20k ±5	98	8	50	200C	–	36x22x21	130	
			5	cone	8	7000					600P				
			3	horn	4										
Model 1	548	reflex	15	–	2	975	35-20k ±5	98	8	25	175C	–	36x22x21	90	
			14x3	horn	1	7000					500P				
			3	horn	3										
Mono	448	pass. rad.	15	–	1	875	35-20k ±5	96	8	25	100C	–	36x22x14	75	
			15	pass. rad.	1	7000					300P				
			–	horn	1										
			–	piezo	2										
FRA-1	388	pass. rad.	15	pass. rad.	1	7000	48-20k ±3.5	93	4	50	100C	–	24x24x10	36	
			5¼	–	8						300P				
			–	piezo	4										
Grafyx Audio Products															
Grafyx SP-Ten	149	vented	10	–	1	2000	35-18k ±3	88	8	10	75C	–	27x15x14	48	
			1	dome	1										
Grafyx SP-Eight	125	vented	8	–	1	2000	39-18k ±3	87	8	10	75C	–	25x14x10	39	
			1	dome	1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont., P=peak)	Level controls (number/type, C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
AMT Monitor	608	pass. rad.	12	–	1	1000	35-23k ±3	90	6	–	375P	C	39x16x16	104	
			12	pass. rad.	1										
			21.5 in.²	Heil AMT	1										
AMT 1B	488	pass. rad.	12	–	1	1000	30-23k ±3	90	6	–	375P	C	35x16x16	85	
			12	pass. rad.	1										
			21.5 in.²	Heil AMT	1										
AMT 1B Bookshelf	416	pass. rad.	12	–	1	1000	40-23k ±3	90	6	–	375P	C	24x14x14	65	
			12	pass. rad.	1										
			21.5 in.²	Heil AMT	1										
Tempest LS-4	348	pass. rad.	10	–	1	2400	35-24k ±3	96	6	–	160P	C	35x13x12	48	
			10	pass. rad.	1										
				Heil AMT	1										
AMT 10B	334	pass. rad.	10	–	1	1400	40-22k ±3	90	6	–	275P	C	24x14x14	55	
			12	pass. rad.	1										
			20.25 in.²	Heil AMT	1										
Performance PS-4	322	pass. rad.	10	–	1	2400	35-24k ±3	96	6	–	160P	–	35x13x12	48	
			10	pass. rad.	1										
			10.4 in.²	Heil AMT	1										
Tempest LS-5	241	pass. rad.	10	–	1	2400	40-20k ±3	95	6	–	140P	–	24x14x14	36	
			10	pass. rad.	1										
			–	Heil AMT	1										
Performance PS-5	234	pass. rad.	10	–	1	2400	40-20k ±3	95	6	–	140P	–	24x14x14	36	
			10	pass. rad.	1										
			10.4 in.²	Heil AMT	1										
Tempest LS-8	179	pass. rad.	8	–	1	2400	50-20k ±3	94	6	–	100P	C	22x13x11	30	
			10	pass. rad.	1										
			–	Heil AMT	1										
Performance PS-8	172	pass. rad.	8	–	1	2400	50-20k ±3	94	6	–	100P	–	22x12x11	30	
			10	pass. rad.	1										
			10.4 in.²	Heil AMT	1										
Fisher															
ST 461	350	reflex	15	–	1	1000	40-20k ±10	92	8	25	130C	2/S	29x18x15	53	Circ. breaker.
			5	cone	2	500									
			3	horn	1										
ST 661A	330	pass. rad.	12	–	1	700	39-22k ±5	94	8	40	125C	2/S	29x18x13	45	Circ. breaker.
			2	dome	1	7000									
			1	dome	1										
ST 451	290	reflex	12	–	1	1000	45-20k ±10	91	8	20	100C	S	27x17x14	44	Circ. breaker.
			5	cone	2	5000									
			3	dome	1										
ST 641A	280	pass. rad.	10	–	1	700	40-20k ±5	92	8	30	90C	2/S	27x17x12	37	Circ. breaker.
			2	dome	1	7000									
			3	dome	2										
XP 95B	250	air susp.	15	–	1	–	–	–	8	75	–	–	28x18x13	44	
			5	–	2										
			3	dome	1										
ST 441	240	reflex	12	–	1	1000	45-18k ±10	90	8	12	75C	1/S	26x16x13	36	Circ. breaker.
			5	cone	1	5000									
			3	dome	1										
ST 430	180	air susp.	10	–	1	1000	50-17k ±10	90	8	6.5	50C	–	26x16x13	34	
			5	cone	1	5000									
			3	cone	1										
XP 335	180	vented	12	–	1	1500	–	–	8	20	70C	–	24x15x11	30	
			5	–	1	5000									
			3	–	1										
XP 330	160	air susp.	12	–	1	1500	–	–	8	17	50C	–	23x15x11	27	
			5	–	1	5000									
			3	–	1										
XP 325	130	air susp.	10	–	1	1500	–	–	8	12	35C	–	22x14x9	19	
			5	–	1	5000									
			3	–	1										
ST 420	120	pass. rad.	8	–	1	5000	50-16k ±10	90	8	3.5	35C	–	22x14x10	19	
			3	cone	1										
MS 135A	100	pass. rad.	8	–	1	6000	70-16k ±10	91	8	5	35C	–	24x15x11	19	
			3	cone	1	8000									
			2	cone	1										
MS 125A	90	pass. rad.	8	–	1	6000	70-14k ±10	91	8	4	30C	–	22x14x9	15	
			2	cone	1										
MS 115A	80	pass. rad.	6½	dual cone	1	8000	80-12k ±10	90	8	3	22C	–	22x14x9	14	
XP 320	80	vented	8	–	1	5000	–	–	8	8.5	25C	–	19x11x9	12	
			3	–	1										
Frankmann Research															
Frankmann	1295	infinite	12	–	8	200	20-22k ±4	98	8	10	200P	2/S	bass: 31x52x24	240	3-pc. syst.; satellites fit stands (incl.) or wall.
			8	–	8	4000							satellites:		
			–	horn	2	10,000							38x10x6		
			–	cone	2										
Mini-Frank	895	air susp.	12	–	4	200	30-22k ±4	92	6	10	125P	2/S	bass: 29x30x20	105	"
			8	–	4	4000							satellites:		
			–	horn	2	10,000							22x10x6		
			–	cone	2										
Frazier															
Frazier Eleven	1300	vented	15	–	1	400	15-25k ±5	103	4	1	100C	2/S	55x30x18	250	
			12	–	1	4000					150P				
			4	cone	4										
			–	piezo	2										
Frazier's Thing	1000	vented	12	–	1	800	20-25k ±5	99	4	1	60C	2/C	48x24x18	146	
			10	–	1	4000					90P				
			3x14	horn	1										
			–	piezo	2										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz ±dB)	Sensitivity (SPL in dB at 1 meter w/ 1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont., P=peak)	Level controls (number/type, C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Grafyx SP-Seven	99	air susp.	8	–	1	2000	43-19k ±3	86	8	10	50C	–	23x13x9	32	
			1	dome	1										
Hartley Products															
Reference	1525	infinite	24	–	1	250	16-25k	93.5	5-8	25	300C	–	50x36x24	300	
			10	cone	1	3000					400P				
			7	cone	1	7000									
			1	dome	1										
Concertmaster	1225	infinte	18	–	1	250	16-25k	93	5-8	25	300C	–	42x29x18	150	
			10	cone	1	3000					400P				
			7	cone	1	7000									
			1	dome	1										
Holton Tower	450	infinite	10	–	2	3000	20-25k	92	4	15	150C	–	50x20x14	105	
			1	dome	1						200P				
Zodiac 300A	250	infinite	10	–	2	2000	30-25k	94	4	5	100C	–	25x14x12	65	
			1	dome	1						150P				
Zodiac '77	175	infinite	10	–	1	2000	35-25k	92.5	8	5	100C	–	30x15x12	50	
			1	dome	1						150P				
Zodiac 1A	135	infinite	10	–	1	2000	40-25k	92.5	8	5	100C	–	22x15x9	35	
			1	dome	1						150P				
Zodiac Jr.	90	infinite	8	–	1	2500	50-18k	90.5	8	5	50C	–	19x12x8	25	
			2	cone	1						75P				
Heath															
AS-1348	290	air susp.	15	–	1	500	28-20k ±3	–	8	8	250C	S	38x24x15	110	Kit; ea. driver
	p540		4½	–	2	3000									fused; rear-
			1	dome	3										mounted woofer.
AS-1373	160		10	–	1	500	40-20k ±3	–	8	11	200C	2	26x15x12	68	"
	p300		4½	–	1	3000									
			1	dome	1										
AS-1344	130		6½	–	2	4000	55-20k ±3	–	4	6	100C	1/S	40x11x11	–	As above; radiates
			1	dome	2										from 2 adj. sides.
AS-1352	100		10	–	1	2800	45-18k ±3	–	8	6	100C	1/S	24x14x11	55	Kit.
	p180		1¾	–	1										
AS-1363	p190		10	–	1	750	45-18k ±3	–	8	5	130C	2/S	25x14x11	–	Kit.
			4½	–	1	4000									
			1	dome	1										
HED															
H-15	250	reflex	15	–	1	2000	32-16k ±4	103	4-8	0.5	100C	1/C	29x18x18	63	
			–	horn	2										
W-12	160	reflex	12	horn	1	2000	38-20k ±4	97	4-8	2	50C	1/C	25x15x12	42	
			–	Dhorm	1										
W-10	150	reflex	10	–	1	2000	38-20k ±4	92	4-8	6	40C	1/C	25x15x12	39	
			–	Dhorm	1										
H-12	130	reflex	12	–	1	2000	38-20k ±4	97	4-8	2	50C	1/C	25x15x12	33	
			–	Dhorm	1										
H-10	120	reflex	10	–	1	2000	38-20k ±4	92	4-8	6	40C	1/C	25x15x12	31	
			–	Dhorm	1										
Hitachi															
HS-530	350	air susp.	10	cone	1	900	30-17k ±5	–	6	–	–	–	25x14x11	38	Metal cones.
			2 1/8	cone	1	3000									
			1	dome	1										
HS-330	250	air susp.	10	cone	1	900	40-18k ±4	–	6	–	–	–	23x12x12	32	"
			2½	cone	1	4000									
			1½	cone	1										
HS-371	200	air susp.	12	–	1	1500	–	–	8	–	–	–	24x15x13	35	
			6	cone	1	6000									
			1	dome	1										
HS-323R	140	air susp.	10	–	1	3000	–	90	8	–	–	–	22x12x12	24	
			1	dome	1										
IMF Electronics															
RSPM Mark IV	1250	trans. line	11¾x8¼	flat	1	350	17-ultrasonic	–	–	50	150C	3	40x20x17	119	
			6	cone	1	3000									
			1¾	–	1	13,000									
			¾	dome	1										
Monitor TSL 80 II	925	trans. line	11¾x8¼	flat	1	350	20-ultrasonic	–	–	40	100C	1	39x18x16	97	
			6	cone	1	3000									
			1¾	–	1	13,000									
			¾	dome	1										
Studio TSL 50 II	550	trans. line	8	cone	1	375	23-ultrasonic	–	4-8	30	70C	1	36x15x14	60	
			4	cone	1	3000									
			–	dome	1	15,000									
			–	dome	1										
Studio ALS 40 II	425	active line	8	cone	1	150	28-20k	–	4-8	25	60C	1	27x14x14	40	Trans. line termin-
			8	cone	1	375									ated by 2nd woofer
			4	cone	1	3000									w. different reso-
			–	dome	1										nant freq.
Super Compact	245	reflex	8	cone	1	375	30-20k	–	4-8	20	50C	–	18x12x11	20	
			4	cone	1	3000									
			–	dome	1										
Compact II	160	reflex	6½	cone	1	4000	35-20k	–	4-8	15	40C	–	15x10x9	13	
			–	dome	1										
Infinity															
Quantum Reference Standard	p6500	dipole	15	cone	1	variable	18-32k ±2	–	4	150 bass	350 bass	3/C, 3/S	80x48x24	300	"Watkins dual-drive woofers";
			–	EMIT	20										el. crossover.
			18	line source	3					100 h-f	350 h-f				
Quantum Line Source	1200	air susp.	12	cone	1	200	18-32k ±2	–	4	100	500C	3/C	66x18x15	190	"Watkins woofer."
			–	dome	6	600									
			–	line source	8	4000									
			–	coupler	1										

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Quantum II	750	air susp.	12	–	1	200	24-32k ±3	–	4	45	350C	3/C	49x13x18	138	"
			–	line source	3	600									
			–	dome	2	4000									
			–	coupler	1										
Quantum III	525	air susp.	12	–	1	200	28-32k ±3	–	4	35	250C	3/C	40x13x18	110	"
			–	line source	2	600									
			–	dome	1	4000									
			–	coupler	1										
Quantum 4	425	air susp.	12	–	1	600	35-32k ±3	–	4	30	250C	2/C	36x15x12	90	"
			1½	dome	1	4000									
			–	EMIT	1										
Column II	329	vented	10	cone	2	750	35-20k ±3½	–	8	15	250C	–	40x14x13	–	
			4½	cone	1	5000									
			–	piezo	2										
Quantum 5	340	air susp.	12	–	1	600	38-32k ±3	–	4	30	250C	2/C	27x15x12	55	"Watkins woofer";
			1½	dome	1	4000									pedastal opt.
			–	EMIT	1										
Quantum Jr.	275	air susp.	12	cone	1	600	40-32k ±3	–	4	25	200C	2/C	25x15x12	50	Pedestal opt.
			1½	dome	1	4000									
			–	EMIT	1										
3000B	210	–	12	cone	1	500	35-20k ±4½	–	8	10	125C	–	25x15x12	–	
			4½	cone	1	5000									
			2½	–	1										
Qb	192	air susp.	10	cone	1	600	42-32k ±3	–	4	15	150C	2/C	25x14x12	43	"
			4	cone	1	4000									
			–	EMIT	1										
Qa	139	air susp.	10	–	1	2500	42-32k ±3	–	4	15	150C	1/C	25x14x12	40	"
			–	EMIT	1										
Qe	105	–	–	cone	1	–	–	–	–	10	100	–	18x12x10	–	Tweeter rotates for
			–	EMIT	1										hor. or vert.
Innotech															
D24	395	trans. line	5½	–	2	3500	30-24k ±3	86	5	35	50C	–	37x11x16	55	
			1½	dome	1	11,000					750P				
			¾	–	1										
Isophon															
Prominent 2002	785	reflex	11 7/8	–	1	–	25-20k ±1.5	–	8	2.2	70C	S	20x16x17	80	Floor-stand;
			8	–	1						100P				controls on
			–	dome	1										top.
			–	dome	1										
TS 8002	361	–	–	–	–	800	35-20k ±1.5	–	8	3.5	60C	C	20x11x9	26	
						3000					80P				
TS 5007A	232	–	–	–	–	800	48-20k ±1.5	–	8	5.6	30C	C	17x9x8	19	
						6000					50P				
DIA 2000	123	–	–	–	–	3000	65-20k ±2.5	–	4	1	50C	C	8x5x4	6	Heat sink.
											70P				
Janis Audio															
Janis W1	650	slot	15	–	1	100	30-100 ±1	87	–	60	150P	–	18x22x22	90	Subwoofer.
Janis W2	450	slot	15	–	1	100	32-100 ±1.5	85	–	60	150P	–	18x22x22	85	"
Janszen															
Z-50	750	trans. line	8x12	–	1	800	25-20k ±3	–	4	20	100C	2/C	55x18x17	125	Carbon fiber woofer,
			64 in.^{2}	elect.	2	4000									dipole mid & high.
Z-40	470	pass. rad.	10	–	1	800	33-20k ±3	–	4	20	100C	2/C	50x13x13	64	Dipole mid & high.
			64 in.^{2}	elect.	2	4000									
Z-30	340	air susp.	10	–	1	800	45-20k ±3	–	4	15	100C	2/C	37x13x13	49	"
			64 in.^{2}	elect.	1										
Z-20	300	air susp.	12	–	1	800	30-20k ±3	–	4	20	100C	1/C	27x15x12	48	
			32 in.^{2}	elect.	1										
Z-20X	275	air susp.	12	–	1	1800	33-20k ±3	–	4	20	100C	1/C	27x15x12	44	
			32 in.^{2}	elect.	1										
Z-10	250	air susp.	10	–	1	800	35-20k ±3	–	4	20	75C	1/C	24x13x11	41	
			32 in.^{2}	elect.	1										
Z-10X	234	air susp.	10	–	1	1800	35-20k ±3	–	4	20	75C	1/C	24x13x11	41	
			32 in.^{2}	elect.	1										
Z-210A	150	air susp.	10	–	1	1800	45-20k	–	4	20	75C	1/C	18x13x11	25	
			32 in.^{2}	elect.	1										
JBL															
D44000 Paragon	3510	horn	15	cone	2	500	–	96	8	10	125C	2/S, C	36x104x24	695	Single-cabinet
			–	horn	2	7000									stereo.
			–	ring	2										
L212	1740	sealed	12	cone	1	70	–	91	8	10	75C	3/C	bass:	225	3-pc. syst.; self-
	(set)		8	cone	1	800							19x19x19		amplified bass.
			5	cone	1	3000							sides:		
			1	dome	1								39x17x13		
L300	960	vented	15	cone	1	800	–	93	8	10	150C	2/C	32x23x23	145	Acoustic lens
			1¾	horn	1	8500									on midr.
			1¾	ring	1										
L65	489	vented	12	cone	1	1000	–	89	8	10	75C	2/C	25x18x13	67	
			5	cone	1	6500									
			1¾	ring	1										
L166	426	vented	12	cone	1	1000	–	89	8	10	75C	2/C	24x14x13	55	
			5	cone	1	6000									
			1	dome	1										
L110	348	vented	10	cone	1	1000	–	89	8	10	75C	2/C	24x14x11	50	
			5	cone	1	4000									
			1	dome	1										
L50	276	vented	10	cone	1	800	–	88	8	10	35C	2/C	25x14x13	47	
			5	cone	1	3000									
			1½	cone	1										
L40	207	vented	10	cone	1	1800	–	88	8	10	35C	1/C	23x15x12	44	
			1	dome	1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz, dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number type. C=cont. variable S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
L19	150	vented	8 1½	cone cone	1 1	2500	–	87	8	10	35C	1/C	21x13x10	29	
Jensen Sound Labs															
550	300	air susp.	15 3½ 1½	– cone dome	1 2 1	1000 4000	45-20k ±3	96	8	10	90C 180P	2/C	31x20x16	70	
LS-6	290	air susp.	15 3½ 1½	– – dome	1 2 1	1000 4000	45-20k ±3	96	8	10	90C 180P	2/C	31x19x16	70	
540	240	air susp.	12 3½ 1½	– – dome	1 2 1	1000 4000	50-20k ±3	95	8	10	75C 150P	2/C	27x16x14	50	
LS-5	220	air susp.	12 3½ 1½	– – dome	1 2 1	1000 4000	50-20k ±3	95	8	10	75C 150P	2/C	26x16x14	50	
530	190	air susp.	10 3½ 1½	– – dome	1 1 1	1000 4000	55-20k ±3	93	8	10	60C 120P	2/C	25x14x12	42	
LS-4	170	air susp.	10 3½ 2	– – –	1 1 1	1000 4000	55-18k ±3	93	8	10	60C 120P	C	25x14x12	40	
520	130	air susp.	10 2	– –	1 1	3500	60-18k ±3	92	8	10	45C 90P	1/C	23x12x11	30	
LS-3	120	air susp.	10 2	– –	1 1	3500	60-18k ±3	92	8	10	45C 90P	1/C	23x13x10	28	
LS-2	80	air susp.	8 2	– –	1 1	4000	65-18k ±3	91	8	10	40C 80P	–	19x11x10	18	
JR Loudspeakers															
JR 149	p475	sealed	5 1/8 ¾	– –	1 1	3000	25-20k ±4	77	15	20	60C 200P	–	15x9 diam.	12	Cylindr. alum. encl.; opt. wall brkt.
JVC															
SK-1000S	260	reflex	12 5 1	– cone dome	1 1 1	1000 10,000	–	93	8	10	85C 170P	2/C	26x16x13	53	
SK-700S	160	reflex	10 5 1	– cone dome	1 1 1	1000 10,000	–	92	8	10	60C 120P	2/C	22x14x12	38	
SK-500S	p200	reflex	10 2½	– cone	1 1	2000	–	91	8	10	35C 70P	–	20x13x11	23	
S-M3	p160	reflex	4 1	– dome	1 1	2500	–	85	8	12	50P		8x5x5	5	Metal cab.
K&H															
092	3000	–	10 5 1	– – –	2 1 1	500 4000	50-16k ±1.5	–	6.8k	–	–	2/S	31x17x12	66	120+60+60W tri amplifier.
OY	1015	–	10 3 –	– – horn	1 1 1	500 8000	100-20k ±2	–	6.8k	–	–	2/S	19x12x9	44	2x30W biamplifier.
KEF Electronics															
Model 105	800	–	12 5 1½	– – dome	1 1 1	400 2500	30-25k ±2	87	8	40	200C	2/S	38x16x18	80	Peak lev. ind.; fused; on-axis ind.; stepped cabinet.
Contata	495	–	13x9 5 1½	– – dome	1 1 1	250 3000	35-20k ±3	87	8	15	150C	2/S	32x13x15	70	Fused.
Model 104aB	350	pass. rad.	8 ¾	– dome	1 1	45 3000	50-20k ±2	85	8	15	100C	1/S	25x13x10	36	"
Calinda	295	pass. rad.	8 ¾	– dome	1 1	45 3500	40-30k ±3	85	8	15	100C	–	27x11x14	42	
Corelli	185	–	8 ¾	– dome	1 1	3500	–	83	8	25	50C	–	19x11x9	20	
Kenwood															
LS-890	350	vented	13 4¾ 1¾	– – –	1 1 1	1300 5000	–	–	8	20	160	2	26x15x13	48	
LS-408B	250	vented	12 4 3/8 1¾	– – –	1 1 1	1500 4000	–	–	8	20	160	2	26x15x13	40	
LS-407B	180	vented	10 4 3/8 1¾	– – –	1 1 1	1500 4000	–	–	8	20	120	2	26x15x13	39	
LS-405B	130	vented	10 1¾	– –	1 1	2500	–	–	8	10	100	–	23x13x11	30	
LS-403B	p180	vented	8 1¾	– –	1 1	2500	–	–	8	10	80	–	18x12x9	21	
KLH															
Baron 355	399	vented	11 1¾ 1	cone dome dome	1 1 1	1200 5000	–	91	8	20	120C	1/C	36x14x13	80	
Magnum CT44	349	–	10 2½ 1	cone cone dome	2 2 1	–	45-22k	92	4	15	100C	–	41x12x12	–	
Classic Five	299	air susp.	12 1¾ 1	cone dome dome	1 1 1	900 3000	–	–	8	20	120C	C	26x14x13	65	
Little Baron 345	299	vented	11 1	cone dome	1 1	1900	–	90.5	8	20	70C	1/C	29x13x12	50	
Baroness 335	249	vented	10 1	cone dome	1 1	–	–	91	8	15	60C	C	23x12x11	–	

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w 1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number/type) C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
319	230	vented	12	cone	1	1200	–	–	8	10	100C	–	25x15x12	40	One rear-fire tweeter.
			5¼	cone	1	3000									
			2½	cone	1										
			1	dome	1										
CL-4	225	vented	10	cone	1	500	30-22k ±3	–	8	25	200C	2/S	27x14x13	59	
			4½	cone	1	5000									
			1	dome	1										
Pistol CT 38	209	–	8¼	cone	2	–	–	–	4	10	75C	–	41x11x11	–	
			2½	–	2										
Classic One	199	air susp.	10	cone	1	1900	–	–	8	15	60C	C	24x12x12	–	
			1	dome	1										
318	190	vented	12	cone	1	–	56-18k	95	8	10	75C	1/C	23x14x11	–	
			2½	cone	1										
CL-3	170	vented	10	cone	1	1500	35-20k ±3.5	–	8	20	100C	–	26x14x12	53	
			2½	cone	1	10,000									
			2	cone	1										
CB-10	135	vented	10	cone	1	–	40-18k ±4	–	8	10	100C	1/S	20x15x7	35	
			2½	cone	1										
317A	130	vented	10	cone	1	–	45-18k	–	8	10	50C	1/C	23x12x10	–	
			2¼	cone	1										
CB-8	115	vented	8	cone	1	–	47-18k ±4	–	8	8	100C	1/C	20x11x7	27	
			2½	cone	1										
331A	99	vented	8¼	cone	1		50-18k	–	8	8	50C	–	21x12x9	–	
			2¼	cone	1										
Klipsch															
Klipschorn	1651	horn	15	–	1	400	35-17k ±5	104	8	–	105C	–	52x31x29	200	
			–	horn	1	6000		at							
			–	horn	1			4 ft							
Belle Klipsch	1374	horn	15	–	1	400	45-17k ±5	104	8	–	105C	–	36x30x19	125	
			–	horn	1	6000		at							
			–	horn	1			4 ft							
Cornwall	746	vented	15	–	1	600	38-17 ±5	98.5	8	–	105C	–	36x26x16	108	
			–	horn	1	6000		at							
			–	horn	1			4 ft							
La Scala	618-671	horn	15	–	1	400	45-17k ±5	104	8	–	105C	–	35x24x25	110	
			–	horn	1	6000		at							
			–	horn	1			4 ft							
Heresy	436	inf. baffle	12	–	1	700	50-17k ±5	96	8	–	105C	–	21x16x13	55	
			–	horn	1	6000		at							
			–	horn	1			4 ft							
Koss															
Model One A	1500	dipole	1845 in.²	elect.	1	250	32-20k –3	83	4	75	300P	–	49x32x10	150	
			461 in.²	elect.	1	1600									
			108 in.²	elect.	1	6500									
			14 in.²	elect.	1										
Model Two	750	dipole	615 in.²	elect.	1	250	37-19k ±3	–	4	75	300P	1/C	41x24x12	82	
			165 in.²	elect.	1	2500									
			1	dynamic	1										
CM/1030A	425	reflex	10	cone	1	400	29-19k –3	96	4	15	200P	3/S	39x17x15	74	
			5	cone	2	2500									
			1	dome	1	6000									
			1	dome	1										
CM/1020A	325	reflex	10	cone	1	450	31-18.5k –3	95	4	15	150P	2/S	33x16x14	60	
			5	cone	1	3000									
			1	dome	1										
CM/1010A	225	reflex	10	pass. rad.	1	2500	35-17.5k –3	92	4	15	100P	1/S	28x16x11	44	Adj. bass with removable woofer mass.
			8	cone	1										
			1	dome	1										
CM/530	150	reflex	8	cone	1	2800	36-17k –3	89	4	15	75P	1/C	24x14x12	35	
			8	pass. rad.	1										
			1	dome	1										
Kustom Acoustics															
Titan Labyrinth	1499	trans. line	12	cone	2	350	24-22k ±2.5	96	4	15	150C 500P	4/C	48x30x18	325	Opt. tilt & straight bases; fused.
			5	cone	2	2500									
			1¼	dome	1	7500									
			1	dome	1										
AEI-Amp Eater	1399	trans. line	12	cone	4	350	28-22k ±3	99	2-8	15	200C 800P	C	48x30x18	340	"
			5	cone	2	2500									
			1¼	dome	2	7500									
			1	dome	2										
TAS-Challenger	799	trans. line	12	cone	2	350	28-22k ±3	96	4	15	150C 500P	C	36x24x16	185	"
			5	cone	1	2500									
			1¼	dome	1	7500									
			1	dome	1										
Labyrinth	749	trans. line	12	cone	1	350	19-22k ±2.5	91	8	15	100C 300P	3/C	48x16x18	130	"
			5	cone	1	2500									
			1¼	dome	1	7500									
			1	dome	1										
Trapezoid	499	trans. line	12	cone	1	350	29-22k ±3	93	8	15	100C 300P	C	40x16x13	100	"
			5	cone	1	2500									
			1¼	dome	1	7500									
			1	dome	1										
Regency	349	trans. line	12	cone	1	350	30-22k ±3	92	8	15	100C 300P	C	26x16x13	76	
			5	cone	1	2500									
			1¼	dome	1										
Signet	259	trans. line	12	cone	1	700	34-22k ±3	95	8	15	100C 300P	C	26x16x13	70	
			5	cone	1	2500									
			1	dome	1										
Impulse	199	trans. line	12	cone	1	700	39-21k ±3	92	8	15	100C 300P	C	24x14x9	48	
			5	cone	1	2500									
			1	dome	1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz ± dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont, P=peak)	Level controls (number/type; C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Lafayette Radio Electronics															
Criterion 3003	300	air susp., pass. rad.	12	cone	1	2000	30-25k ±3	91	6	20	180C	1/C	39x15x15	65	
			12	pass. rad.	1										
			–	Heil AMT	1										
Criterion 3002	240	air susp., pass. rad.	10	cone	1	2000	35-25k ±3	90	6	20	160C	1/C	39x12x14	55	
			10	pass. rad.	1										
			–	Heil AMT	1										
Criterion 3001	200	vented	10	cone	1	2000	40-25k ±3	89	6	15	150C	1/C	25x15x15	45	
			–	Heil AMT	1										
Criterion 2003A	200	reflex	15	cone	1	900	20-20k	95	8	15	120C	2/C	29x18x13	60	
			–	horn	1	5000					200P				
			–	ring	2										
Criterion 2002A	160	reflex	12	cone	1	2000	20-20k	96	8	10	90C	2/C	26x16x14	50	
			–	horn	1	4000					180P				
			–	ring	2										
Criterion 2001A	120	reflex	10	cone	1	2000	30-20k	96	8	10	70C	2/C	25x15x14	42	
			–	horn	1	4000					140P				
			–	ring	1										
Lancer Electronics															
BB-3	550	vented	12	cone	1	100	18-22k ±3	–	8	20	100C	2/C	woofer: 18x21x21 satellites: 12x8x7	118	3-unit system.
			6	cone	2	2500					160P				
			1	dome	1										
PA-20	450	vented	12	cone	1	1000	20-22k ±4.5	–	8	20	75C	2/C	39x18x13	78	"Phase-aligned."
			5	cone	1	4000					120P				
			1	dome	1										
SC-8	360	vented	12	cone	2	500	20-22k	–	8	10	75C	2/C	28x18x13	65	"
			5	dome	1	4500					120P				
			1	dome	1										
SC-7A	280	air susp.	12	cone	1	500	20-20k	–	8	10	75C	2/C	26x15x12	59	
			5	dome	1	4500					120P				
			1	dome	1										
SC-9T	250	air susp.	10	cone	1	500	20-22k	–	8	10	50C	2/C	38x12x12	62	Omnidirectional.
			5	dome	1	4500					90P				
			1	dome	2										
SC-4A	200	air susp.	12	cone	1	500	20-20k	–	8	10	50C	2/C	24x15x13	53	
			5	dome	1	4500					90P				
			1	dome	1										
SC-10A	130	air susp.	10	cone	1	2500	20-20k	–	8	10	50C	1/C	20x13x10	33	
			2¼	dome	1						90P				
9535-2	100	air susp.	12	cone	1	3000	30-20k	–	8	5	35C	–	25x14x12	33	
			2¼	dome	1						50P				
Leak															
3090	870	trans. line	15	cone	1	350	35-26k ±3	88	6	–	100C	2	47x20x15	112	2-pc. encl. w/ swivelling top; casters.
			7	cone	1	2000					160P				
			4	cone	1	7000									
			2x1	–	1										
3080	550	air susp.	10	cone	1	450	38-22k ±3	85	8	12	80C	–	33x14x17	72	"Phase-compensated."
			6¾	cone	1	3500									
			¾	dome	–										
3050	355	air susp.	6¾	cone	2	4000	48-22k ±3	85	8	12	50C	–	25x12x13	42	"
			¾	dome	1										
3030	230	air susp.	5	cone	2	4000	60-22k ±3	85	8	12	35C	–	21x10x11	24	"
			¾	dome	1										
3020	175	reflex	5	cone	1	3000	62-22k ±3	85	8	12	25C	–	17x8x11	16	As above, stepped cab.
			¾	dome	1										
Lentek															
S-4	640	air susp.	6	–	1	2500	60-18k ±3	78	8	25	75C	–	20x10x10	25	
			1	dome	1						100P				
Linn Products															
DMS Isobarik	p1920	Isobarik	12x9	cone	1	375	20-20k ±3	–	4	50	–	–	30x15x16	105	Top-fire midrange & tweeter.
			5	cone	2	3000									
			1	dome	2										
LTC															
TX-5	550	air susp.	10	cone	1	2600	36-24k ±3	94	8	25	100C	1/C	30x28x10	80	Circ. breaker, tweeter prot. circ.; swivel stand.
			1	dome	4						150P				
100	340	air susp.	10	cone	1	2600	36-22k ±3	94	8	25	80C	1/C	39x13x12	61	
			1	dome	4						100P				
50	240	air susp.	10	cone	1	2600	36-20k ±4	94	8	25	80C	1/C	27x15x12	47	
			1	dome	2						100P				
25	180	air susp.	10	cone	1	2600	40-18k ±4	94	8	25	60C	1/C	24x14x12	40	
			1	dome	1						80P				
LTL Electronics															
TP 6953	150		6x9	cone	1	800	30-20k	–	8	5	80C	–	–	14	
			5	cone	1	1500					160P				
			3	cone	1										
CP 693	150	–	6x9	cone	1	2500	30-20k	–	8	5	80C	–	–	11	
			3	–	1						160P				
TP 653	120	–	6	cone	1	800	40-20k	–	8	5	80C	–	–	13	
			5	cone	1	1500					160P				
			3	–	1										
CP 63	120	–	6	cone	1	2500	40-20k	–	8	5	80C	–	–	10	
			3	–	1						160P				
Magnepan															
MG-I	495	dipole	354 in.²	planar	1	2400	50-17k ±4	82	5	35	200P	–	60x22x2	30	Other sizes avail.
			67 in.²	planar	1										
Marantz															
DS-940	400	infinite, vented	12	cone	1	750	30-22k ±3	90	8	15	150C	2/C	15x45x12	80	Choice of inf. baffle or vented operation via removable plug.
			5	cone	1	2300									
			1½	–	1	5000									
			1	–	1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz ±dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max input (watts) (C=cont; P=peak)	Level controls (number/type C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
DS-930	340	infinite, vented	12	cone	1	750	33-22k ±3	90	8	15	125C	2/C	28x15x12	58	"
			5	cone	1	2300									
			1½	–	1	5000									
			1	–	1										
DS-920	340	infinite, vented	12	cone	1	750	33-20k ±3	90	8	15	125C	2/C	38x15x12	65	
			5	cone	1	2500									
			1½	–	1										
HD-880	320	infinite, vented	12	cone	1	750	30-22k ±3	90	8	–	150C	2/C	40x16x12	79	"
			5	cone	1	2300									
			1½	–	1	5000									
			1	–	1										
DS-900	280	infinite, vented	10	cone	1	750	35-20k ±3	88	8	15	100C	2/C	28x15x12	55	"
			5	cone	1	2500									
			1½	–	1										
HD-770	260	infinite, vented	12	cone	1	750	33-22k ±3	90	8	–	125C	2/C	27x15x12	57	"
			5	cone	1	2300									
			1½	–	1	5000									
			1	–	1										
HD-660	200	infinite, vented	10	cone	1	750	33-20k ±3	88	8	–	100C	2/C	24x15x12	45	"
			5	cone	1	2500									
			1½	–	1										
7 MK II	160	infinite	12	cone	1	800	35-20k ±3	88	8	15	200C	2/C	26x14x12	49	
			5	cone	1	2500									
			1¾	–	1										
HD-550	150	infinite, vented	8	cone	1	800	40-20k ±3	88	8	–	75C	2/C	23x13x10	33	As per DS-940.
			5	cone	1	3000									
			1	–	1										
6 MK II	120	vented	10	cone	1	2500	35-20k ±3	88	8	15	125C	1/C	26x15x12	46	
			1¾	–	1										
5MK II	100	infinite	8	cone	1	2500	40-18k ±3	88	8	10	60C	1/C	23x12x10	32	
			1¾	–	1										
HD-440	90	infinite	8	cone	1	2000	40-18k ±3	87	8	–	50C	–	19x11x19	25	
			3½	–	2	8000									
Martin Speakers Div. Eastern Sound															
Sound Tower	449	air susp.	8	cone	4	1000	38-18k ±5	95	8	50	100P	2/C	52x16x10	90	
			5	dome	1	5000									
			–	horn	4										
Magnificat	429	air susp.	12	cone	2	500	26-22k ±5	93	4	50	100P	2/C	38x18x14	90	
			5	dome	1	4000									
			–	dome	2										
Gamma 1500	379	air susp.	15	cone	1	500	26-20k ±4	92	8	25	60P	2/C	71x43x38	59	
			5	cone	1	4400									
			3	–	4										
Gamma 1200M	339	air susp.	12	cone	1	600	25-20k ±3	91	8	25	60P	2/C	71x38x31	53	
			5	cone	1	5000									
			4	–	1										
Gamma 412	269	air susp.	12	cone	1	750	30-18k ±3	92	8	20	55P	2/C	64x36x30	48	
			5	cone	1	4400									
			3	–	2										
Gamma 310	179	air susp.	10	cone	1	1000	35-18k ±3	93	8	15	50P	2/C	54x31x25	33	
			5	cone	1	4500									
			3	–	1										
Gamma 308	119	air susp.	8	cone	1	1000	40-18k ±4	92	8	15	45P	2/C	54x31x18	26	
			5	cone	1	5000									
			4	–	1										
Gamma 208	99	air susp.	8	cone	1	1500	40-18k ±5	92	8	15	40P	1/C	45x26x24	22	
			4	–	1										
Matrecs Industries															
MA-254	255	air susp.	15	–	1	1000	25-24k	–	8	20	65C	–	–	65	
			10	pass. rad.	1	6000					70P				
			4½	cone	2										
			3¼	piezo	1										
			1¾	ring	1										
MA-224	212	air susp.	12	cone	1	1000	30-24k	–	8	10	50C	–	–	50	
			4½	cone	1	6000					55P				
			3¼	piezo	–										
MA-203	166	air susp.	10	cone	1	1000	30-22k	–	8	5	40C	–	26x15x11	32	
			4½	cone	1	6000					45P				
			2¾	–	1										
MA-123	90	air susp.	12	cone	1	1000	35-22k	98	8	8	45C	–	24x15x10	29	
			4½	cone	1	6000					50P				
			1¾	ring	1										
Mc Intosh Laboratory															
XR7	999	air susp.	12	cone	2	250	20-20k*	90	8	30	200P	–	40x20x15	125	*Response with Mc Intosh equalizer; fused.
			8	cone	1	1400									
			2½	dome	4	7000									
			1½	dome	2										
ML-2	799	air susp.	12	cone	2	250	20-20k*	90	8	30	100P	–	29x28x21	144	"
			8	cone	1	1500									
			2¼	dome	1	3000									
			1½	dome	2	7000									
XR6	750	air susp.	12	cone	1	250	20-20k*	89	8	30	200P	–	36x18x13	81	"
			8	cone	1	1400									
			1½	dome	1	7000									
			1	dome	1										
XR5	499	air susp.	12	cone	1	250	20-20k*	89	8	30	200P	–	30x15x12	76	"
			8	cone	1	1400									
			2½	–	2	7000									
			1½	dome	1										

Manufacturer and model	Price ($) (p=pr pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w 1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number/type, C=cont. variable S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
XR3	425	air susp.	10	cone	1	700	20-20k*	89	8	30	200P	–	27x13x12	60	"
			5	cone	1	1400									
			2½	–	2	7000									
			1½	dome	1										
ML-10C	319	air susp.	10	cone	1	1000	20-20k*	89	8	30	100P	–	25x13x13	58	"
			2¼	dome	1	7000									
			1½	dome	1										
Mesa Electronics Sales															
120	259	vented, pass. rad.	12	pass. rad.	1	65	38-19k	93	8	15	120C	2/S	28x16x13	55	Circ. breaker.
			8	cone	1	600					160P				
			5	cone	1	4000									
			3	dome	1										
80	209	vented, pass. rad.	10	pass. rad.	1	65	42-19k	93	8	15	80C	2/S	25x14x12	45	"
			8	cone	1	600					120P				
			5	cone	1	4000									
			3	dome	1										
60	159	vented, pass. rad.	8	pass. rad.	1	80	45-19k	92	8	15	60C	1/S	23x13x11	32	"
			6½	cone	1	2500					100P				
			5	cone	1										
			3	dome	1										
40	109	vented, pass. rad.	6½	cone	1	85	50-19k	95	8	15	90C	1/S	21x12x10	23	"
			6½	pass. rad.	1	3000					75P				
			3	dome	1										
30	109	air susp.	4	foam susp.	1	3500	60-25k	–	4	10	30C	1/C	7x5x4	4	
			1	dome	1						50P				
Micro-Acoustics															
FRM-1A	200	air susp.	10	cone	1	1700	32-18k ±4	–	8	18	100C	2/C	26x15x13	40	Angled tweeter array.
			1¼	dome	4						200P				
			1 1/8	dome	1										
FRM-2A	159	air susp.	10	cone	1	1750	40-16k ±4	–	8	10	75C	1/C	26x15x12	34	
			1¼	dome	3						150P				
FRM-3	124	twin vented	8	cone	1	2500	45-15k ±4	–	8	7	50C	1/C	22x13x10	26	
			1½	dome	1						100P				
Mirsch															
OM3-29	375	air susp.	8½	cone	1	700	35-20k	–	8	20	50C	1/C	32x55x31	37	Side firing ambiance driver.
			4½	cone	1	4000					100P				
			1	dome	1										
OM3-38	330	air susp.	10	cone	1	500	30-20k	–	8	20	70C	–	31x56x32	37	
			2	–	1	4500					150P				
			1	dome	1										
OM3-100	300	air susp.	10	cone	1	700	30-20k	–	8	15	100C	1/C	38x56x26	35	
			2	cone	1	5000									
			1	dome	1										
OM3-28	240	air susp.	8½	cone	1	700	35-20k	–	8	20	50C	–	25x51x32	27	
			4½	cone	1	4000					100P				
			1	dome	1										
OM2-20	120	air susp.	8	cone	1	5000	45-20k	–	8	10	60C	–	27x47x21	15	
			1	dome	1										
OM2-21	120	air susp.	8½	cone	1	3500	40-20k	–	8	10	60C	–	25x46x29	22	
			1	dome	1										
OM3-30	120	air susp.	8½	cone	1	700	35-20k	–	8	15	100C	–	34x50x23	27	
			4½	cone	1	4000									
			1	dome	1										
Mitsubishi															
DS50C5	460	reflex	12	cone	1	600	25-20k	92	6	30	80P	S	35x17x16	77	Front controls.
			5	cone	1	5000									
			1	dome	1										
DS40CS	360	reflex	12	cone	1	1500	30-20k	92	8	25	80P	S	33x16x16	70	"
			2	cone	1										
DS35B	280	air susp.	12	cone	1	800	35-20k	91	6	25	80P	S	26x14x13	46	"
			4	cone	1	5000									
			1 1/8	dome	1										
DS28B	200	air susp.	10	cone	1	800	40-20k	91	6	25	80P	S	23x14x11	33	"
			4	cone	1	5000									
			1¼	dome	1										
DS25B	150	air susp.	10	cone	1	1500	45-20k	90	6	20	60P	S	23x13x12	30	"
			2	cone	1										
Monitor Audio															
MA3 Series II	549	reflex	14x9	–	–	400	40-19k ±2.5	86	8	60	120C	–	28x14x13	60	Fused.
						3500					200P				
MA1 Series II	429	reflex	13x9	–	–	375	45-19k ±3.5	85	8	40	100C	–	30x14x15	60	Fused.
						3000					120P				
MA4	309	reflex	8	–	1	3200	45-18k ±2.5	85	8	15	75C	–	24x13x11	36	
			1	dome	1						100P				
MA5 Series II	288	air susp.	8	cone	1	3300	50-19k ±3	84	8	20	50C	–	22x12x10	26	
			1	dome	1						100P				
MA8	180	air susp.	6	cone	1	3400	45-20k ±3	84	8	15	40C	–	16x9x8	18	
			1	dome	1						80P				
MA7	150	reflex	6	cone	1	3500	55-20k ±4	86	8	10	30C	–	16x9x8	15	
			¾	Mylar	1						10P				
Mordaunt-Short															
Pageant	479	reflex	8	cone	1	350	65-20k ±3	89	8	15	50C	2/C	21x13x9	21	
			1	dome	1						100P				
Festival	339	infinite	8	cone	1	3500	75-20k ±3	89	8	10	45C	–	18x11x7	14	
			¾	dome	1						90P				
Carnival	269	infinite	8	cone	1	3500	85-17k ±3	88	8	10	40C	–	16x10x6	12	
			2¾	cone	1						80P				
Nakamichi Research															
Slimline Reference Monitor	480	reflex	8	cone	1	2000	50-16k ±5	94	16	20	20C	–	37x16x14	62	Fused.
			1	cone	1						60P				

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Norman Laboratories															
Nine	440	air susp.	10	cone	3	1500	35-20k ±3	–	4	–	70C	2/S	40x16x15	75	
			1	dome	3										
Ten	290	air susp.	10	cone	2	1500	40-20k ±3	–	4	–	70C	1/S	38x15x13	60	
			1	dome	2										
Seven	200	air susp.	12	cone	1	1500	40-20k ±3	–	8	–	50C	1/S	24x16x13	40	
			1	dome	2										
Eight	130	air susp.	10	cone	1	1500	45-20k ±4		8	–	35C	–	23x12x10	28	
			1	dome	1										
Normende-Sterling Hi-Fidelity															
804	180		8½	cone	2	1000	30-20k	91	4-8	10	90C	–	26x14x9	29	
			4½	cone	1	10,000									
			1	dome	1										
803	130		8½	cone	1	7500	30-20k	92	4-8	7.5	50C	–	17x11x9	18	
			3½	cone	1	10,000									
			1	dome	1										
802	100		8½	cone	1	7500	40-20k	92	4-8	5	35C	–	17x11x7	15	
			1½	dome	1										
Ohm Acoustics															
OHM F	600	air susp.	12	cone	1	–	37-19k ±4	82	3.7	75	–	–	44x18x18	75	Single omnidirectional Walsh driver.
OHM H	325	vented, pass. rad.	8	cone	1	1700	32-20k ±4	86	4-8	10	–	1/S	27x15x11	54	
			2	ring	1	5000									
			1	dome	1										
OHM C2	250	vented	10	cone	1	1700	37-20k ±4	86	6-8	10	–	1/S	25x14x10	43	
			2	ring	1	5000									
			1	dome	1										
OHM D2	200	vented	10	cone	1	1700	37-19k ±4	86	6-8	10	–	1/S	25x14x10	42	
			2	ring	1										
OHM L	160	vented	8	cone	1	1700	42-20k ±4	87	4-8	8	–	1/S	20x12x10	35	
			2	ring	1	10,000									
			2	dome	1										
OHM E	100	sealed	8	cone	1	1700	65-19k ±4	86	8-6	7	–	1/S	22x12x7	20	
			2	ring	1										
Optonica															
CP-5151	400	–	12	cone	1	500	40-50k	–	8	20	90C	2/C	27x16x14	62	Triampable; 30-kHz filter.
			2	dome	1	6000									
			–	ribbon	1										
CP-2121	170	–	10	cone	1	1200	40-20k	–	8	10	35C	–	29x15x12	33	
			10	pass. rad.	1										
			3	dome	1										
Onkyo USA															
240	250	air susp.	15	cone	1	700	45-20k ±5	93	8	20	100C	2/C	27x17x13	45	Carbon fiber midr. cone.
			4	cone	1	4500									
			1	dome	1										
160	165	air susp.	12	cone	1	2000	50-20k ±5	91	8	15	80C	1/C	22x14x13	30	
			2¾	cone	1										
Panasonic															
SB1800	380	pass. rad.	10	cone	1	3500	–	–	8	5	60P	–	30x18x12	50	
			–	pass. rad.	1										
			–	horn	1										
SB1600	200	pass. rad.	10	cone	1	3000	–	–	8	5	40P	–	25x15x11	30	
			–	pass. rad.	1										
			2¼	–	1										
SB1100	170	pass. rad.	8	cone	1	5000	–	–	8	5	30P	–	22x13x8	25	
			–	pass. rad.	1										
			2¼	–	1										
SB350	100	pass. rad.	5¼	cone	2	5000	–	–	8	5	30P	–	22x13x8	25	
			–	pass. rad.	1										
Parenthian															
3600M	1899 (set)	–	15	cone	1	20-80	–	–	6	–	250C	–	–		3-unit system; 150W bass servo amplifier.
			8	cone	4	500-800									
			2	dome	2	3000-									
			–	planar	4	7000									
2400M	899	infinite	12	cone	2	150	30-22k ±3	–	8	30	150C	2/C	41x13x19	135	
			6	cone	2	150-750									
			–	radiator	2	750-									
			–	diffrator	2	5000									
						5000+									
1200M	400	–	12	cone	1	500	30-20k ±3	–	8	25	60C	2/C	24x16x11	48	
			5	cone	1	500-									
			1	dome	1	3000									
						3000									
DBM100	299	air susp.	10	cone	2	700	17-27k	–	8	10	100C	3/C	44x15x13	84	
			4¾	cone	1	6000									
			–	piezo	1	11,000									
			–	dome	1										
OBM-50	179	air susp.	12	cone	1	800	22-27k	–	8	6	90C	2/C	24x14x12	47	
			4¾	cone	1	6500									
			–	piezo	1										
			–	horn	1										
DB-40	110	air susp.	12	cone	1	1400	28-19.5k	–	8	5	80C	2/C	24x14x12	32	
			4½	cone	1	4500									
			1½	ring	1										

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Phase Linear															
III	1350 (set)	vented dipole	12	cone	2	100	24-22k ±3	80	6	100	350C	3/C	63x24x5	223	4-way, 4-piece—two panels; subwoofer; variable equalizer.
			8	cone	4	600					700P				
			4	cone	4	3000									
			1	cone	8	8000									
			1	dome	2										
	400	vented	12	cone	2	100	24-100 ±3	–	6	100	350C	–	19x22x22	100	Subwoofer.
											700P				
Philips															
RH545	1300	mot. fdback.	12	cone	1	500	20-20k	–	4/8	–	–	4	26x17x13	67	Triamplifier. 50W servo+35W+15W.
			2	dome	1	3000									
			1	dome	1										
RH567	430	mot. fdback.	10	cone	1	500	27-20k	–	4/8	–	–	–	21x13x11	–	Biamplifier: 40W servo+20W.
			2	dome	1	3500									
			1	dome	1										
RH544	380	mot. fdback.	8	cone	1	500	35-20k	–	4/8	–	–	–	15x11x9	26	"
			2	dome	1	4000									
			–	cone	1										
AH477	300	air susp.	12	cone	1	1500	32-20k	–	8	20	80C	2/S	28x15x15	54	
			2	dome	1	5500									
			1	dome	1										
AH476	200	air susp.	10	cone	1	1500	35-20k	–	8	20	60C	–	26x14x11	42	
			2	dome	1	5500									
			1	dome	1										
RH541	200	mot. fdback.	7	cone	1	1400	35-20k	–	4	–	–	–	9x12x7	20	25W servo-amp.
			1	dome	1										
AH475	110	air susp.	8	cone	1	3500	40-20k	–	8	10	40C	–	24x14x11	38	
			1	dome	1										
SJ2931	p200	vented	10	cone	1	2500	45-17.5k	–	8	–	35	–	27x15x13	39	
			4	cone	1	8000									
			2¾	cone	1										
U.S. Pioneer Electronics															
HPM-200	550	air susp.	10	cone	2	100	25-25k	89	6	50	100C	3/S	32x29x19		Polymer film tweeter & super tweeter; carbon fiber cone woofer.
			2½	dome	1	700					200P				
			–	HPM	1	2000									
			–	HPM	1	5000									
HPM-150	500	reflex	15¾	cone	1	750	25-40k	92.5	6.3	50	125C	2/C	39x18x18	82	Polymer film omnidirectional super tweeter, carbon-fiber cone woofer.
			4	cone	1	2600					300P				
			1¾	cone	1	8500									
			–	horn HPM	1										
HPM-100	300	reflex	12	cone	1	1200	30-25k	92.5	8	50	50C	2/C	26x15x16	59	Polymer film super tweeter; carbon fiber cone woofer.
			4	cone	1	4000					200P				
			1¾	cone	1	12,000									
			–	HPM	1										
CS-99A	275	infinite	15	cone	1	800	25-22k	97	8	10	100P	2/S	25x17x11	52	
			5	cone	1	2000									
			4	cone	1	5000									
			–	horn	1	10,000									
			–	HPM	1										
HPM-60	225	reflex	10	cone	1	1200	35-25k	92.5	8	30	30C	2/C	24x14x13	39	As per HPM-100.
			4	cone	1	4000					120P				
			1¾	cone	1	12,000									
			–	HPM	1										
HPM-40	150	reflex	10	cone	1	4000	35-25k	91	8	20	20C	1/C	23x13x13	29	"
			1¾	cone	1	10,000					100P				
			–	HPM	1										
Project 100A	125	reflex	10	cone	1	700	40-20k	91.5	8	10	30C	–	23x13x11	30	
			2	dome	1	6000					60P				
			2	cone	1										
Plasmatronics															
Hill type 1	p5990	–	12	–	1	100	–	–	–	–	–	–	58x25x19	150	Ionized gas discharge (plasma) & Class A tube amp for HF; requires 1 tank helium ea. 300-500 hrs. play; "low tank" light.
			5	–	1	700-									
			–	plasma	1	1000									
Point 3 Systems															
Point 3 System	400 (set)	air susp.	10	cone	2	125	20-20k ±3	90	8	15	100C	–	15x24x14		3-pc system—2 satellites & subwoofer; "time-aligned" midrange & tweeter.
			5	cone	2	5000					200P				
			1	dome	1										
Polk Audio															
Model 10	210	fluid coup.	10	cone	1	60	30-20.5k ±2	96	6	10	100C	–	28x6x12	50	
			6½	cone	2	3000					200P				
			1	dome	1										
Model 7	150	fluid coup.	8	cone	1	60	33-20.5k ±2	94	8	10	60C	–	24x14x9	36	
			6½	cone	1	3000					100P				
			1	dome	1										
Model 5	110	fluid coup.	8	cone	1	60	40-21k ±3	92	8	10	60C	–	22x7x9	29	
			6½	cone	1	3000					100P				
			1	dome	1										
Mini Monitor	100	fluid coup.	4½	cone	2	100	60-20.5k ±2	92	6	5	30C	–	–	20	
			1	dome	1	3000					80P				
Power Research Products															
System III-E	840	ventless duct	12	cone	1	55	26-22k ±4	85	4	60	350C	1/C	45x16x16	110	Bidirectional.
			6	cone	4	275					500P				
			3	–	8	3000									
			1	piezo	1										

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System IV	435	ventless	10	cone	1	75	26-22k±4	83	8	60	120C	–	39x19x12	70	"
		duct	6	cone	1	400					250P				
			3	–	1	4500									
			1	piezo	1										
Rovner 5	310	ventless	10	cone	1	85	32-18k ±4	85	8	40	80C	–	34x14x12	45	"
		duct	5	cone	1	800					150P				
			1¼	dome	1										
Rovner 6	170	ventless	8	cone	1	900	40-16k ±4	84	8	25	40C	–	32x12x9	25	
		duct	1¼	dome	1						80P				
PSB Speakers															
Beta II	495	reflex	8	cone	1	1500	30-20k ±2.5	84	4	50	85C	2/S	23x12x11	35	Motional feedback
			1	dome	1						150P				w/any amp.
Passif II	280	pass. rad.	8	cone	1	2000	70-20k±2	–	8	20	60C	–	30x14x13	40	
			10	pass. rad.	1										
			1	dome	1										
Passif I	200	pass. rad.	7	cone	1	2000	70-20k ±2	–	8	15	50C	–	26x12x10	30	
			8	pass. rad.	1										
			1	dome	1										
Avante II	170	reflex	8	cone	1	1500	70-20k ±3	–	8	12	40C	–	20x11x10	25	
			1	dome	1										
Avantini II	100	reflex	7	cone	1	1500	85-20k ±3	–	8	10	30C	–	15x9x8	15	
			1	dome	1										
Pyramid															
Metronome 2+2W	p3000	air susp.	14	–	1	70	29-90k ±3	88	8	150	–	–	25x28x17	110	1 subwoofer + 1
		air susp.	8	–	1	700	55-22k ±3	88	8	150	–	1/S	18x13x8	27	full-range each
			4½	–	1	2500									channel; cross-
			2	–	1	5000									over freqs. over-
															lap.
Metronome T1	p1000	–	¾	ribbon	1	–	4k-60K ±3	92	4	10	10C	–	5x3x8	15	Tweeter only.
			3¾								40P				
Quadraflex															
ST 21	300	air susp.,	15	–	1	250	28-22.5k ±4	–	8	10	–	2/C	40x13x19	90	Fused.
		trans. line	6	–	1	3000									
			–	dome	1										
ST 19	230	air susp.,	12	–	1	500	32-22.5k ±4	–	8	10	–	2/C	26x13x15	60	Fused.
		trans. line	6½	–	1	3000									
			–	dome	1										
ST 17	170	–	10	–	1	600	38-20k ±4	–	8	10	–	2/C	25x12x14	52	Fused.
			6½	–	1	3000									
			2½	–	1										
ST 15	130	air susp.	10	–	1	1500	45-20k ±4	–	8	10	–	none	23x11x13	30	Fused.
			2½	–	1										
ST 11	99	air susp.	8	–	1	1500	55-20k ±4	–	8	10	–	none	21x10x12	37	Fused.
Qysonic Research															
Qysonic Array	425		8	cone	2	800	28-22k +2, –5	92	6	30	50C	3/C	48x13x10	65	Takes less
			4½	–	1	3000					120P				than 1 ft².
			2	cone	1	8000									
			1	dome	1										
Qysonic Laug	199	–	8	cone	2	90	28-100 +2, –5	–	6	30	100	none	34x12x10	50	Center-channel bass unit for use with TAD or Micro. Separate channel drivers.
Qysonic TAD	179		4	cone	2	2000	40-20k	89	15	–	30C	1/C	25x8x7	23	"
			2	cone	1	8000					100P				
			1	dome	1										
Qysonic Micro	89		3	–	2	3000	80-18k +2, –5	80	6	8	20C	none	11x5x4	15	"
			1	cone	1						60P				
Realistic															
Mach 1	200	air susp.	15	–	1	900	20-25k	88	8	–	100	2/S	28x18x12	50	
			–	4-cell horn	1	5000									
			–	horn	1										
Optimus T-100	150	air susp.	8	–	2	3500	55-18k ±3	90	8	–	75	2/S	35x13x12	38	
			3	cone	1										
Optimus-10	140	pass. rad.	8	–	1	3000	42-20k ±3	88	8	–	75	1/S	25x15x10	–	
			10	pass. rad.	1										
			3¼	dome	1										
Optimus-25	130	air susp.	12	–	1	1300	45-20k	–	8	–	60	2/S	25x14x12	–	
			4	cone	1	6000									
			2½	dome	1										
Optimus-5B	120	air susp.	12	–	1	1500	40-20k	87	8	–	75	2/S	25x14x11	37	
			3	–	2	8000									
			3	–	1										
Nova-7B	120	air susp.	10	–	1	2000	45-20k	87	8	–	55	1/S	22x12x11	30	
			3	–	2										
Optimus-21	100	air susp.	10	–	1	1200	58-18k	88	8	–	70	1/S	22x12x11	23	
RH Labs															
SB-1W	350	air susp.	12	cone	1	–	–	–	–	–	100	–	21x37x21	118	Subwoofer.
Rogersound															
RSL 6600	400	reflex	12	cone	2	800	25-20k	–	4	10	200C	2/C	46x18x11	90	"Twin sub-
			5	cone	2	5000									enclosure",
			–	horn	1										fused.
RSL Max	300	reflex	12	cone	1	800	30-20k	–	8	12	125C	2/C	32x18x12	60	Fused.
			5	cone	1	4000									
			1	dome	1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont., P=peak)	Level controls (number/type; C=cont. variable, S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
RSL 3300	250	reflex	12	cone	1	800	40-20k	–	8	10	100C	2 C	25x15x12	49	Fused
			5	cone	1	5000									
			1	dome	1										
RSL Ranger	200	reflex	10	cone	1	800	42-20k	–	8	15	80C	2 C	25x15x12	39	Fused.
RTR															
DR-1 Dymistatic	1290	see "remarks"	12	cone	1		30-20k ±3	–	–	75	125C	–	–	–	Subwoofer section of 2-piece system "negative environment enclosure."
			10	cone	2	375					250C				
			–	elect.	27	375		–	–	–	–		49x17x17		Circular tweeter array powered by special amp. in woofer cabinet.
HPR-12 Magnum	335	pass. rad.	12	pass. rad.	1	500	30-25k	–	8	15	100	2 C	36x15x13	–	Circuit breaker.
			12	cone	1										
			5	–	1	7500									
			2½	–	2										
			3	piezo	1										
600-D	450		12	cone	2	950	27-35k	–	4	25	120	2 C	48x17x17	–	Circuit breaker.
			1½	dome	2	10,000									
			–	piezo	1										
300-D	320		10	cone	2	1250	28-35k	–	4	25	100	2 C	42x15x13	–	Circuit breaker.
			1½	dome	1	10,000									
			–	piezo	1										
100-D	280		12	cone	1	1250	30-35k	–	6	25	80	2 C	27x15x14	–	Circuit breaker.
			1½	dome	1	10,000									
			–	piezo	1										
EXP-12M	215	–	12	cone	1	1400	32-20k	–	8	20	80	1 C	26x14x12	–	Circuit breaker.
			1¾	–	1	7500									
EXP-12V	150	–	12	cone	1	1400	32-20k	–	8	20	80	1 C	26x14x12	–	Circuit breaker.
			1¾	–	1	7500									
ESR-15	350	–	–	elect.	15	1200	1.2k-30k	–	–	15	100	1 C	20x17x17	–	Add-on tweeter arrays with built-in cross-over, circuit breaker.
RSN-G	220	–	–	elect.	6	1500	1.5k-30k	–	–	15	60	1 C	15x15x12	–	
Sansui															
SP-L800	900	reflex	12	cone	2	1500	30-20k	95	8	–	300P	1 C	36x18x16	94	Casters; bi-amp capability.
			2¾	horn	1										
SP-L700	650	reflex	10	cone	2	2000	30-25k	93	8	–	200P	1/C	33x17x15	82	"
			2¾	horn	1										
SP-X9000	350	reflex	16	cone	1	1000	25-23k	100	8	–	220P	1/S	26x18x11	47	
			8	cone	1	6000									
			2x6	horn	2	10,000									
			1¾	horn	2										
SP-X8000	300	reflex	16	cone	1	1000	25-23k	98	8	–	160P	1/S	27x18x11	45	
			5 1/8	cone	2	6000									
			2x6	horn	1	10,000									
			1¾	horn	2										
SP-X7000	260	reflex	12	cone	1	1500	30-23k	97	8	–	130P	1/S	21x15x11	38	
			5 1/8	cone	1	5000									
			2x6	horn	1	10,000									
			1¾	horn	2										
SP-X6000	210	reflex	10	cone	1	1500	30-23k	95	8	–	100P	1/S	21x15x11	34	
			5 1/8	cone	1	6000									
			2 3/8	horn	1										
H.H. Scott															
Pro-100	440	air susp.	15	cone	1	700	35-20k ±4	–	4	20	125C	3 S	29x19x15	65	Upward- and forward-firing mid-range and tweeter; controls behind hinged panel; fused.
			4½	cone	2	3500					300P				
			1	dome	2										
SST-2	440	air susp.	12	cone	1	–	35-20k ±4	–	6-8	15	125C	2/S	37x15x12	–	
			4¼	cone	1										
			1	dome	1										
Pr-70	330	air susp.	12	cone	1	800	35-20k ±4	–	6-8	15	125C	2/S	17x16x13	50	Controls behind hinged front panel.
			4½	cone	1	4000					300P				
			1	dome	2										
S-197	250	air susp.	15	cone	1	750	40-20k ±4	–	6-8	15	90C	2/S	28x17x13	53	
			4½	cone	1	3500					125P				
			1	dome	1										
S-196	200	air susp.	12	cone	1	800	40-20k ±4	–	6-8	15	75C	2/S	25x13x11	40	Front-panel controls
			4½	cone	1	4000					100P				
			1	dome	1										
SST-1	200	air susp.	10	cone	1	–	40-20k ±4	–	6-8	10	85C	2/S	24x12x11	–	
			4½	cone	1										
			1	dome	1										
S-186	170	air susp.	10	cone	1	800	40-20k ±4	–	6-8	10	60C	2/S	13x13x11	26	Front-panel controls.
			4½	cone	1	4000					80P				
			1	dome	1										
S-177	120	air susp.	8	cone	1	1200	45-18k ±4	–	6-8	7	45C	–	19x11x9	21	
			5	cone	1	3500					65P				
			1¾	–	1										
S-176	90	reflex	8	cone	1	3500	60-18k ±4	–	6-8	5	30C	–	18x11x9	17	
			1¾	–	1						50P				
Shahinian															
Obelisk	350	trans. line	10	pass. rad.	1	2000	–	90	6	30	150C	none	26x14x12	48	
			8	cone	1						350P				
			1	dome	3										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz ±dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number/type: C=cont. variable; S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
Sonab															
OA 2212	840	reflex	6½	cone	2	450	30-15k ±3	–	8	15	100C	yes	30x12x21	72	Multi-directional;
			6½	cone	2	2000									sold in matched
			1 3/8	–	12										pairs only;
															tweeter level
															controlled ±1.5 dB
															by jumper.
OA 116	520	reflex	6½	cone	1	500	28-15k ±3	–	8	15	100C	yes	16x11x18	47	"
			6½	cone	1	1800									
			1 3/8	–	6										
OA 14	315	reflex	6½	cone	1	1800	29-15k ±3	–	8	15	80C	yes	12x9x17	25	"
			1 3/8	–	4										
OA 12	240	reflex	6½	cone	1	1800	42-15k ±3	–	8	15	70C	yes	18x8x13	15	"
			1 3/8	–	2										
OD 11	180	reflex	6½	cone	1	1800	52-15k ±4	–	8	15	60C	yes	10x10x10	12	As above, but for
															floor or bookshelf
															mounting.
Sonic Energy Systems															
TA-12P	400	vented	12	cone	1	600	38-18k ±3	86	8	8	40C	1/C	44x22x12	85	"Time aligned."
			4½	cone	1	6000					400P				
			1	dome	1										
TA-10P	340	vented	10	cone	1	800	43-18k ±3	86	8	8	25C	1/C	40x20x12	75	"
			4½	cone	1	6000					250P				
			1	dome	1										
TA-10F	250	pass. rad.	10	cone	1	600	40-17k ±3	87	8	10	25C	1/C	39x15x12	70	"
			10	pass. rad.	1	1800					250P				
			1½	dome	1										
TA-10	160	vented	10	cone	1	1800	70-17k ±3	87	8	10	25C	1/C	24x13x12	47	"
			1½	dome	1						250P				
Sonic Systems															
Monolith	p2995	reflex	15	–	2	1200	33-18k ±4	97	4	5	300C	C	46x27x24	200	Bi-ampable.
			–	compression	4						600P				
Monitor	p1195	reflex	12	–	1	1200	45-18k ±4	92	8	10	100C	C	31x17x15	70	"
			–	compression	1						250P				
Sony															
SS-G7	1000	reflex	15	cone	1	550	30-20k	94	8		180C	2/C	20x37x18	106	In-line drivers;
			4	cone	1	4500					200P				non-reflecting front
			1½	–	1										panel.
SSU-4000	400	pass. rad.,	10	cone	1	500	30-20k	91	8	20	100C	2/C	47x14x15	71	
		reflex	9	pass. rad.	1	5500									
			3¼	–	1										
			1	dome	1										
SSU-3000	300	vented	10	cone	1	600	35-20k	91	8	10	75C	2/C	34x14x15	60	
			3¼	cone	1	5500									
			1	dome	1										
SSU-2000	150	air susp.	10	cone	1	2500	35-20k	90	8	20	50C	1/C	4x13x14	38	
			2¼	cone	1										
SSU-1250	100	pass. rad.,	8	cone	1	4000	45-20k	90	8	10	30C	–	25x14x12	24	
		reflex	8	pass. rad.	1										
			2¼	cone	1										
Speaker Kit															
Eleven	400	vented	15	cone	1	800	34-15k ±3	103	8	5	50C	2/C	48x25x16	130	Kit; also avail. w/o
			–	horn	1	4000					500P				encl.
Ten	340	vented	12	cone	1	800	37-15k ±3	100	8	5	25C	2/C	48x20x16	117	"
			–	horn	1	4000					250P				
Six	255	air susp.	15	cone	1	200	28-22k ±3	94	8	25	100C	2/C	48x20x16	114	"
			7	cone	1	1600					200P				
			2	dome	1	5500									
			1	dome	1										
Five	170	air susp.	12	cone	1	800	32-22k ±3	93	8	15	80C	2/C	28x16x14	69	"
			2	dome	1	4000					175P				
			1	dome	1										
Four	130	air susp.	12	cone	1	500	35-22k ±3	91	8	15	60C	2/C	24x16x12	50	"
			5	cone	1	4000					150P				
			1	dome	1										
Three	113	air susp.	10	cone	1	500	38-22k ±3	91	8	10	50C	2/C	24x16x10	46	"
			5	cone	1	4000					100P				
			1	dome	1										
Speakerlab															
K	630	horn	15	cone	1	400	–	–	4/8	10	150C	2/C	50x32x28	220	Bass only.
			–	horn	2	5000									
Super Seven	470	air susp.	12	cone	1	1200	–	–	4	15	150C	2/C	29x18x15	86	Kit $307; components
			10	cone	1	6000									$261.
			–	horn	2										
Seven	400	air susp.	12	cone	1	1200	–	–	4	15	150C	2/C	29x18x15	85	Kit $243; comps. $199.
			10	cone	1	6000									
			–	horn	2										
Six	300	air susp.	12	cone	1	1200	–	–	8	15	100C	2/C	28x16x12	65	Kit $191. comps. $167.
			–	horn	2	6000									
Four	270	air susp.	12	cone	1	400	–	–	8	15	100C	2/S	28x16x12	65	Kit $165; comps. $140.
			6	cone	1	4000									
			–	horn	1										
Three	240	air susp.	12	cone	1	400	–	–	8	15	100C	2/S	28x16x12	65	Kit $141; comps. $115.
			6	cone	1	4000									
			1	dome	1										
Two-and-a-Half	185	air susp.	10	cone	1	500	–	–	4	10	50C	2/S	24x15x12	52	Kit $109; comps. $83.
			6	cone	1	3000									
			1	dome	1										
Two	145	air susp.	10	cone	1	1000	–	–	4	10	50C	1/C	24x16x12	49	Kit $84; comps. $58.
			1½	dome	1										

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One	98	air susp.	8	cone	1	3000	–	–	4/8	5	40C	1/C	18x11x10	30	Kit $54; comps; $41.
			1	dome	1										
Point One	89	air susp.	6	cone	1	2500	–	–	4/8	10	40C	1/C	10x7x5	7	Kit $54; comps. $46.
			1	dome	1										
Spendor															
BC3	770	reflex	12	cone	1	700	50-18k ±3	–	8	50	75P	–	32x16x16	75	
			8	cone	1	3000									
			1¼	dome	1	13,000									
			¾	dome	1										
BC-1	320	reflex	8	cone	1	3000	50-18k ±3	–	8	20	50P	–	25x12x12	31	
			1¼	dome	1	13,000									
			¾	dome	1										
SA-1	200	infinite	6	cone	1	3000	65-18k ±3	–	8	20	40P	–	12x9x9	16	
			1	dome	1										
Synergistics															
S72A	600	air susp.	10	cone	2	1000	26-24k	–	4	6	200P	2/C	42x27x11	103	Angled tweeter array; circ. bkr.
			4½	cone	2	7500									
			2½	–	3	12,500									
			–	piezo	1										
S62A	400	air susp.	12	cone	1	1000	26-24k	–	8	8	150P	2/C	36x18x11	67	Circ. bkr.
			4½	cone	1	7500									
			2½	–	3	12,500									
			–	piezo	1										
S52A	325	air susp.	8	cone	2	3200	30-20k	–	4	8	150P	1/C	32x15x13	55	"
			4½	cone	1										
S51A	325	air susp.	12	cone	1	1000	30-24k	–	8	8	150P	2/C	26x14x12	42	"
			4½	cone	1	7500									
			2½	–	1	12,500									
			–	piezo	1										
S42A	230	air susp.	10	cone	1	1500	28-20k	–	8	10	100P	2/C	26x14x12	40	"
			4½	cone	1	7500									
			2½	–	1										
S32A	170	air susp.	10	cone	1	2500	28-20k	–	8	10	80P	–	26x14x12	38	"
			2½	–	1										
S22A	130	air susp.	8	cone	1	3200	33-20k	–	8	6	60P	–	23x12x10	29	
			2½	–	1										
S12A	100	air susp.	8	cone	1	3200	40-20k	–	8	6	60P	–	18x10x9	17	
			2½	–	1										
Tamon															
TS707	380	infinite	15	cone	1	600	30-35k ±3	96	8	15	110C	S	27x17x12	55	
			–	cone	2	2500					200P				
			–	dome	2	15,000									
CR050	360	infinite	12	cone	1	800	32-22k ±3	93	8	15	45C	2/C	25x15x13	39	
			–	cone	1	3000					80P				
			–	dome	2										
TS505	270	infinite	12	cone	1	700	32-35k ±3	93	8	15	80C	2/S	24x15x13	38	
			–	cone	1	2500					150P				
			–	dome	1										
CR040	250	infinite	10	cone	1	–	38-22k ±3	92	8	15	35C	1/C	23x13x13	28	
			–	cone	1						60P				
			–	dome	1										
TS404	230	infinite	10	cone	1	800	38-35k ±3	92	8	10	100P	1 S	22x12x13	28	
			–	cone	1	2500									
			–	dome	1										
CR030	140	infinite	8	cone	1	3000	45-22k ±3	90.5	8	15	25C	–	18x10x11	16	
			–	dome	1						40P				
TS303	140	infinite	8	cone	1	3000	45-22k ±3	92	8	10	40C	–	18x11x10	20	
			–	dome	1						70P				
Tannoy-Ortofon															
Buckingham	2500	reflex	12	–	2	350	20-20k	95	8	10	200C	4 S	46x24x18	250	Coax. midrange tweeter.
			10	–	1	3500					1000P				
			2	horn	1										
Windsor	1450	reflex	12	–	1	350	40-20k ±3	92	8	10	120C	4 S	32x22x16	125	"
			10	–	1	3500					500P				
			2	horn	1										
Arden	588	reflex	15	cone	1	1000	30-20k ±4	–	8	10	85C	2 S	39x26x15	124	Coaxial.
			2	–	1			–							
Berkeley	495	reflex	15	cone	1	1000	30-20k ±4	–	8	10	85C	2 S	33x21x12	90	"
			2	–	1			–							
Cheviot	395	reflex	12	cone	1	1000	40-20k ±4	–	8	10	60C	2 S	33x18x10	66	"
			2	–	1			–							
Devon	348	reflex	12	cone	1	1000	45-20k ±4	–	8	10	60C	2 S	23x16x10	46	"
			2	–	1										
Eaton	295	reflex	10	cone	1	1000	50-20k ±4	–	8	10	50C	2 S	21x14x10	40	"
			2	–	1										
Technics by Panasonic															
SB-7000A	420	vented	13¾	cone	1	700	37-22k	90.5	6	–	150P	2 S	33x19x16	73	"
			4¾	cone	1	6000									
			1½	dome	1										
SB-6000A	320	vented	12	cone	1	1800	39-22k	91	6	–	100P	1 C	33x17x13	55	"
			1½	dome	1										
SB-X50	p460	vented	10	cone	1	700	–	93	6	–	50C	2 C	24x13x11	35	"Linear-phase"; stepped cab.; circ. brks.
			3½	cone	1	4500									
			1½	dome	1										
SB-5000A	170	vented	10	cone	1	1500	40-20k	92	8	–	75P	–	28x14x13	35	"
			2 3 8	cone	1										
SB-X30	p340	vented	8	cone	1	700	–	93	6	–	40C	2 C	21x11x9	23	"
			3½	cone	1	4500									
			1¼	dome	1										

Manufacturer and model	Price ($) (p=per pair)	Enclosure type	Driver size (in.)	Driver type	Number	Crossover frequency (Hz)	Frequency response (Hz-Hz dB)	Sensitivity (SPL in dB at 1 meter w/1W input)	Impedance (ohms)	Min. input (watts)	Max. input (watts) (C=cont. P=peak)	Level controls (number type; C=cont. variable; S=switched)	Dimensions (H x W x D) (in.)	Weight (pounds)	Remarks
SB-4500	p300	vented	10	cone	1	2000	40-20k	92.5	6	–	50C	–	25x14x13	32	"
			2 3/8	cone	1						75P				
SB-X10	p200	vented	8	cone	1	1500	–	90.5	6	–	30C	–	18x10x8	16	"
			1¼	dome	1										
TransAudio															
1012B	160	air susp.	12	cone	1	600	38-18k ±4	–	8	5	–	–	26x10x17	42	
			5½	cone	1	2000									
			2½	–	1										
1011B	105	air susp.	12	cone	1	1800	40-18k ±4	–	8	5	–	–	26x10x16	36	
			2½	–	1										
Videoton															
D-258a	230	air susp.	10	–	1	600	30-20k ±3	–	8	15	60C	2/C	27x15x11	–	
			5	–	1	2000					120P				
			1½	dome	1	7000									
			1	dome	1										
D-402a	200	air susp.	8	–	2	3500	35-20k ±3	–	8	15	50C	–	28x15x11	–	
			4	–	2						100P				
			1	dome	2										
D-257a	150	air susp.	10	–	1	1000	40-20k ±3	–	8	15	25C	1/C	24x12x12	–	
			5	–	1	4000					50P				
			1	dome	1										
D-255	130	air susp.	10	–	1	4500	43-20k	–	8	15	55C	–	24x12x12	33	
			1	dome	1						100P				
DP-202	80	air susp.	8	–	1	3500	40-20k	–	8	10	50C	–	16x10x9	17	
			4	cone	1						100P				
Visonik of America															
SU61/D502	590		12	cone	1	160	16-30k +4, –8	–	6	50	300C	–	24x17x14	79	Subwoofer + 2 D502's (see below).
			4	cone	1	1400									
			¾	dome	1										
D803	250	–	8	cone	1	1100	16-30k +4, –8	–	4	20	120C	–	13x8x8	17	LED overload lite.
			1½	dome	1	4500									
			¾	dome	1										
D702	200		7	cone	1	2100	30-25k +4, –8	–	4	20	90C	–	–	14	"
			1	dome	1										
Euro 5	170	–	8	cone	1	1300	45-17k ±3	–	4	10	60C	–	19x11x10	24	"
			1	dome	1										
D602	160	–	5	cone	1	1400	38-25k +4, –8	–	4	20	80C	–	9x6x6	9	"
			1	dome	1										
D502	127	–	4	cone	1	1400	45-30k +4, –8	–	4	20	70C	–	7x4x4	6	"
			¾	dome	1										
D50BL	110	–	3¾	cone	1	1800	48-25k	–	4	12	50C	–	7x4x4	5	
			¾	dome	1										
D302MO	92	–	4	cone	1	2000	50-22k +4, –8	–	4	10	50C	–	7x4x4	5	
			2	cone	1										
Watson Laboratories															
10	p1800	–	10	cone	2	250	17-22k ±5	93	4	50	–	S	47x24x22	85	
			8	cone	1	800									
			5	cone	2	6000									
			1¼	dome	1										
			1	dome	2										
			–	piezo	1										
7	p1300		10	cone	1	250	20-20k ±5	91	8	50	–	S	33x20x15	62	
			8	cone	1	800									
			5	cone	1	6000									
			1¼	dome	1										
			1	dome	1										
Wharfedale															
E-70	475	reflex	10	cone	1	800	50-18k ±3	94	8	3	100C	2/S	32x14x14	70	
			4	cone	2	7000									
			1	horn	1										
E-50	390	reflex	10	cone	1	800	55-18k ±3	94	8	3	70C	2/S	26x14x14	42	
			4	cone	2	7000									
			1	horn	1										
Dovedale SP2	355	reflex	6¾	cone	2	800	35-26k ±3	88	6	–	60C	–	25x16x12	55	
			4	cone	1	5000					120P				
			2x1	planar	1										
Teesdale SP2	270	reflex	8	cone	1	800	40-26k ±3	87	6	–	40C	–	23x14x11	31	
			4	cone	1	5000					80P				
			2x1	planar	1										
Yamaha															
NS1000	725	air susp.	12	cone	1	500	40-20k	90	8	20	50C	2/C	28x16x15	85	Beryllium-dome tweeters.
			3½	dome	1	6000					100P				
			1 1/8	dome	1										
NS1000M	525	air susp.	12	cone	1	500	40-20k	90	8	20	50C	2/C	27x15x14	68	"
			3½	dome	1	6000					100P				
			1 1/8	dome	1										
NS690 II	310	air susp.	12	cone	1	800	35-20k	90	8	20	80P	2/C	25x14x12	59	
			3	dome	1	6000									
			1 1/8	dome	1										
NS500	260	reflex	10	cone	1	1800	40-20k	91	8	20	30C	1/C	24x13x13	42	Beryllium dome.
			1 1/8	dome	1						60P				
NS325	220	reflex	10	cone	1	600	40-20k	92	8	10	70P	2/C	24x14x12	34	
			4¾	cone	1	5000									
			2	dome	1										
NS225	170	reflex	10	cone	1	800	40-20k	92.5	8	10	60P	1/C	22x13x13	29	
			2	cone	1										
NS5	100	air susp.	10	cone	1	1500	55-20k ±3.5	88	8	10	50P	–	21x12x11	25	
			1	dome	1										

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Experiments with Programmable Logic Arrays

Useful logic circuit has many applications in waveform generation or digital control.

BY KARL LUNT

THE Programmable Logic Array (PLA) is an important, little-understood electronic circuit which many experimenters would use more if they knew more about it. Described here, to help in such an understanding, is a circuit that can be used to generate a wide variety of output waveshapes with frequencies up to 15 MHz, with complete control over the output waveshape.

With some changes in the timing or output circuit, the PLA can also serve as a switch and light controller for model train layouts, a digital controller and sequencer for simple machine or processing operations, a sophisticated timer-controller for use in a lab, darkroom, or kitchen, or even as an electronic "house-sitter" to control several appliances. This PLA can be built for about $15—less if you have a well-stocked "junkbox."

The circuit consists of three elements: a timer and driver that converts a series of clock pulses into BCD information that selects an input line of the PLA matrix, the PLA itself (in this case a diode matrix), and the output circuit that includes the necessary interfaces to relays, lights, other TTL or a digital-to-analog converter.

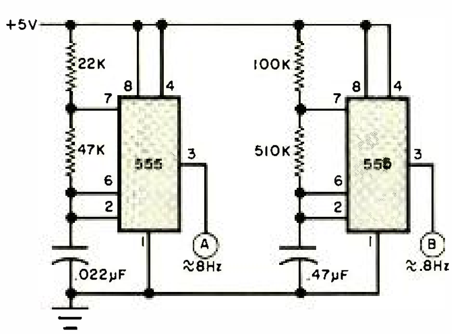


Fig. 1. Frequencies of either 555 can be from 1 MHz to one pulse per minute, depending on selected R and C values.

Circuit Operation. The basic timer can be built around one of two circuits—a pair of conventional 555 timers as shown in Fig. 1 or the 555-7490 circuit shown in Fig. 2. The output frequencies of the 555's are dependent on their resistor-capacitor values and clock rates can be as high as 1 MHz or as low as one pulse per minute.

The selected outputs of the clock oscillators can be used to drive a one-of-two selector like that shown in Fig. 3. The output of this circuit can be either clock-A or clock-B depending on the signal applied to control input C.

The main circuit shown in Fig. 4, accepts the selected clock output from *IC1* and drives one or more decade counters

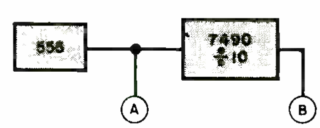


Fig. 2. The 555 drives decade counter in this clock. As many counters as desired can be added for ultra-slow clocks.

(*IC2* is an example of one), and then the final decade counter *IC3* whose outputs are BCD that count from 0 to 9 then automatically repeat.

The BCD outputs are applied to a 1-

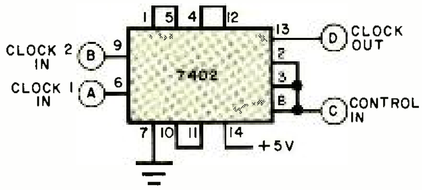


Fig. 3. A one-of-two selector allows PLA to control its own frequency. Output is A or B depending on control input C.

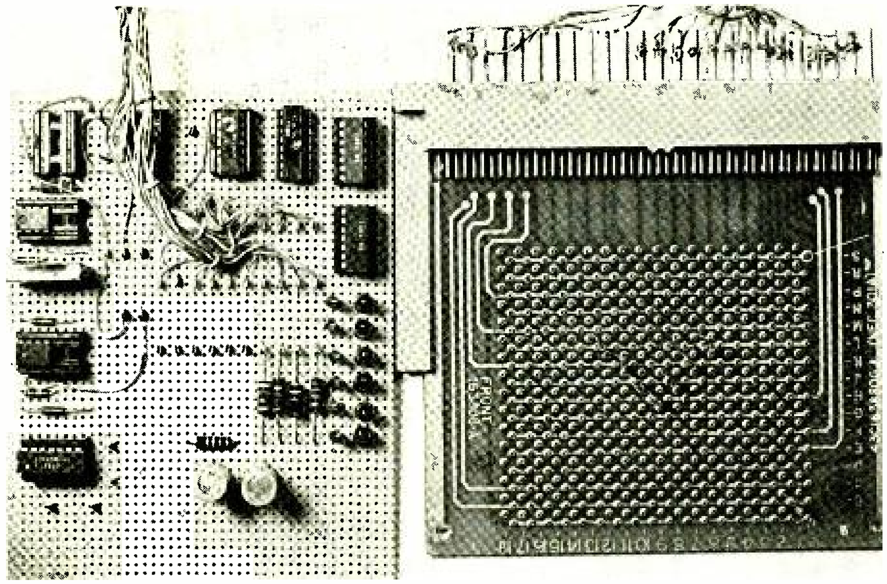


Photo shows the author's prototype of complete PLA project. Diodes are on commercial matrix board at right. IC's and other electronics are on perf board.

of-10 decoder (*IC4*) with each decoded output applied to a corresponding input line of the PLA—in this case, a 10 x N matrix. The 10 x N means that there are 10 inputs and any selected number (N) of outputs. In this matrix, the diode lines are driven low in sequential order by *IC4* and a diode connected between the selected input and output lines will drive that output low. The outputs are fed to the inputs of the hex inverters within *IC5* and *IC6* that provide both inverting and buffering. The outputs of *IC5* and *IC6* can be used to drive other TTL devices, relay drivers, or, in the case shown in Fig. 4, a simple D/A converter that can be used to create various output waveshapes.

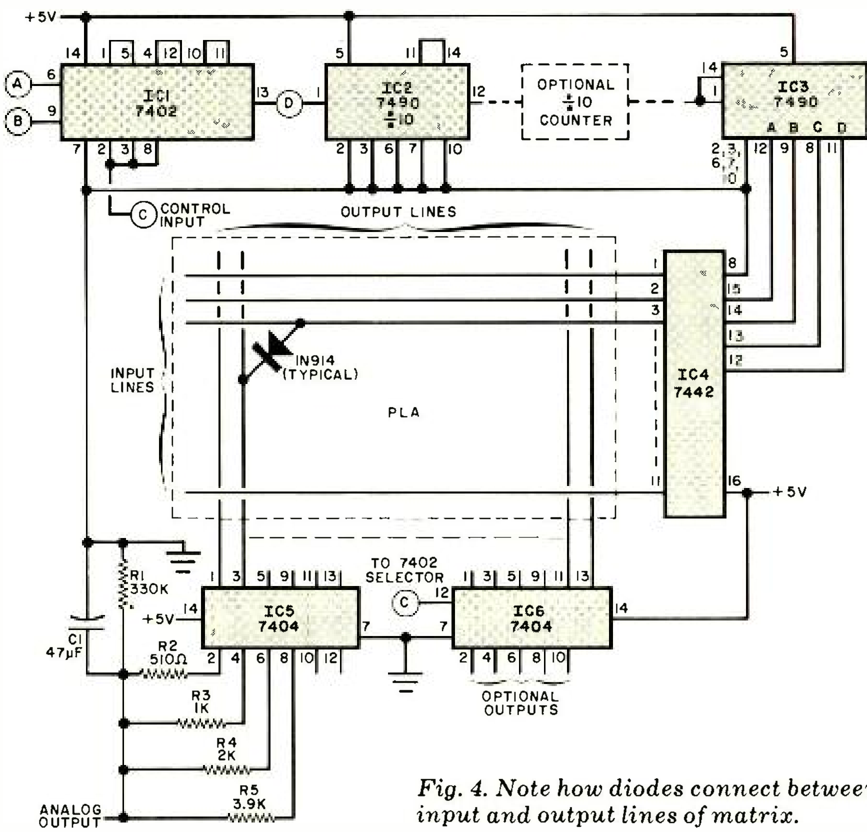


Fig. 4. Note how diodes connect between input and output lines of matrix.

PARTS LIST

- C1—47-μF, 12-V nonpolar capacitor (two 100-μF units connected in parallel)
- IC1—7402 quad 2-input NOR gate
- IC2,IC3—7490 decade counter
- IC4—7442 1-of-10 decoder
- IC5,IC6—7404 hex inverter
- R1—330,000-ohm resistor
- R2—510-ohm resistor
- R3—1000-ohm resistor
- R4—2000-ohm resistor
- R5—3900-ohm resistor
- Misc.—Perforated board, component mounting clips, sockets for IC's, matrix diodes (1N914), 555 timers and passive elements (see text), mounting hardware.

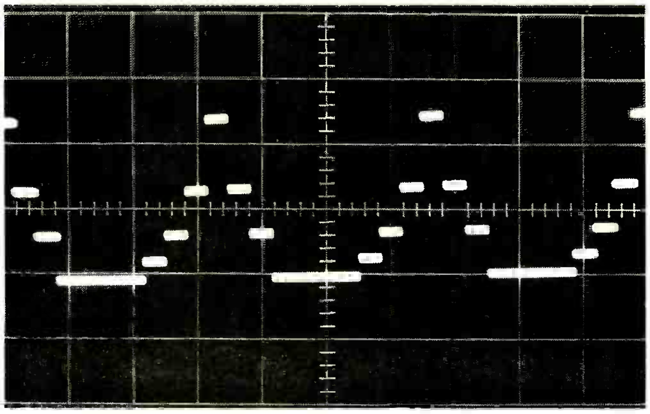
Construction. Layout and lead dress are not critical so any type of construction can be used. Sockets are suggested for mounting the IC's.

The heart of the system is the diode matrix PLA that uses conventional silicon diodes (such as the 1N914) to form the matrix. In the prototype, a commercial pc board with a built-in 18 x 18 matrix of press-in terminals was used, although one can be built of conventional "flea clips" (or similar) with each horizontal (input) row interconnected and wired to its pin on *IC4*. Each vertical (output) column is built in a similar fashion and connected to the *IC5*-*IC6* inputs. The selected diode clips should be capable of accepting the diode leads. The diodes are installed as shown in the matrix of Fig 4.

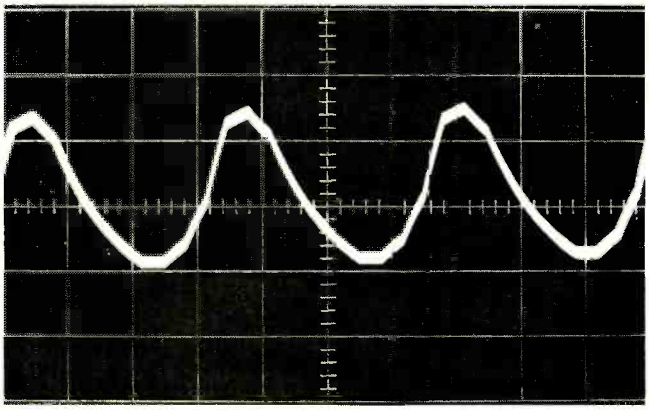
Either of the two oscillators can be selected, with any desired frequency used as the clock input.

The simple D/A converter shown in Fig. 4 consists of four resistors (although more can be added as the matrix is enlarged) that sum across *R1*. The voltage developed across these resistors is dependent on the placement of the diodes in the matrix. The square wave generated across *R1* is smoothed by *C1*. The value of *C1* can be changed as desired, or any other method of filtering can be used.

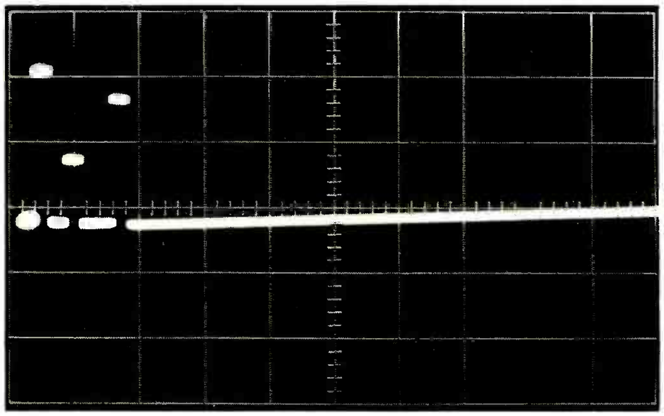
Once the basic circuit has been built, it should be powered and an oscilloscope used to make sure that all perti-



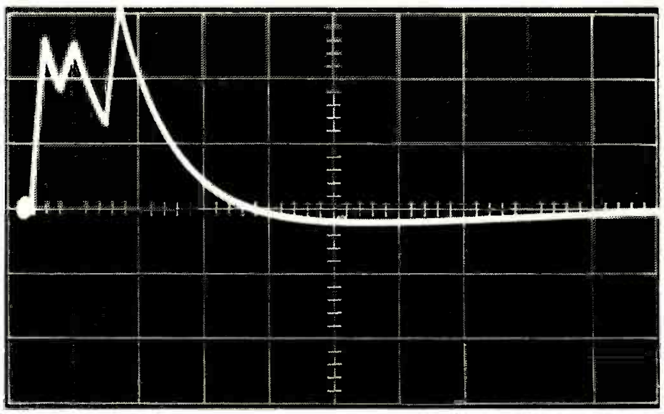
A



B



C



D

Oscilloscope photo (A) shows the output of the digital/analog converter with C1 (Fig. 4) removed at a frequency of 8 Hz. With C1 in, the output would form a sine wave such as that shown at (B). More elaborate filtering will smooth out the sharp edges. Waveform (C) shows how the PLA controls its own clock frequency. The first pulses are about 8 Hz followed by a 2.5-second delay until triggered again. Photo (D) is the PLA controlling its own frequency. The peaks inside the pulse are all 8-Hz rate, while the next pulse will not occur for more than 2 seconds.

nent waveforms are present and have the required fast rise and fall times suitable for TTL.

Use. There are two ways that the diode matrix can be used to control the output frequency. The simplest approach is to tie the "reset-to-zero" inputs (pins 2 and 3) of *IC3* to an unused output line of the matrix and, if a diode is connected to this line, the circuit will recycle back to zero. The obvious disadvantage to this approach is that it becomes impossible to use any diode positions beyond the reset point.

The second method is to change the clock frequency coming from the driver circuits. A simple 1-of-2 decoder such as the 7402 shown can be used to switch either one of two independent clocks (Fig. 1) or one of two frequencies derived from the same clock (Fig. 2). In the case of Fig. 1, the clocks may operate out of sync, therefore the clock in Fig. 2 may be used for more accurate timing. The control input of the 1-of-2 selector (Fig. 3) can be tied to an unused output line of the matrix, and the clock frequency that drives the system can be controlled using a diode on that particular line.

The system shown uses a 7490-7442 combination to produce a 10 x N matrix. If desired, a 7493-74154 combination can be used to produce a 16 x N matrix. The output waveform shape can be changed by varying the value of filter capacitor *C1* and the clock frequency. You can experiment with either of these values and observe the results.

It is possible to trigger the timing cycle with a pushbutton switch coupled to a monostable multivibrator. This allows the PLA to be used as an envelope generator in an electronic music system. It is also possible to generate two independent outputs from *IC5* and *IC6*. Either output can be switch selected.

Although the circuit described is not presented as an actual construction project, it can be easily assembled, and the various parameters altered to create just about any reasonable output signal or waveform the builder can use. ◇

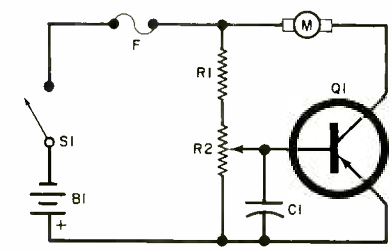
Solid State

By Lou Garner

MOTOR CONTROL CIRCUITS

WITHIN industry, solid-state devices and circuits are used extensively for controlling and driving electric motors and other electromechanical actuators, including solenoids, linear drives and electric valves. Similar techniques can be just as valuable for a variety of hobbyist, experimenter and home projects. Typically, solid-state circuits can be used in constant- and variable-speed motor controls for toys, and household appliances such as mixers, stirrers, grinders and fans, workshop tools, including drills and sanders, and even in more sophisticated applications, such as tape recorders and computer floppy-disk drives. The range of potential applications, in fact, is virtually endless, limited only by the imagination, skill, and resources of the hobbyist.

Small dc motors of the type used in many toys can be controlled easily using a single low-to-medium-power transistor. A typical circuit is given in Fig. 1A. Here, the motor's current, hence its speed, varies as *Q1*'s base bias is adjusted by potentiometer *R2*. Although a pnp transistor is shown, an npn type can be used, if preferred, simply by reversing the battery and motor connections. Bypass capacitor *C1* is optional, as is the fuse. If the transistor is used at or near its maximum ratings, a suitable heatsink should be provided to prevent overheating. In some applications it may be necessary to connect a small bypass capacitor (0.05 to 0.1 μF) across the motor terminals to reduce noise. Actual component values will depend, of course, upon the supply voltage, the transistor's



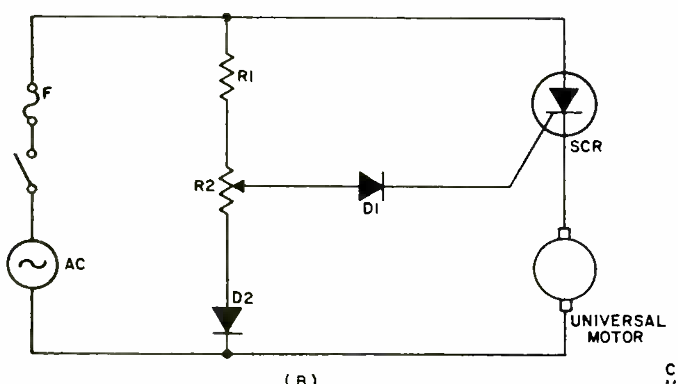


Fig. 1. Two basic motor control circuits. The one at (A) uses a transistor, while (B) is a circuit using an SCR for control.

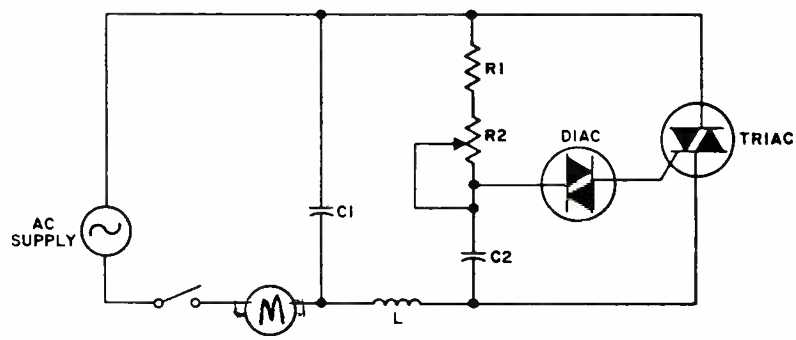
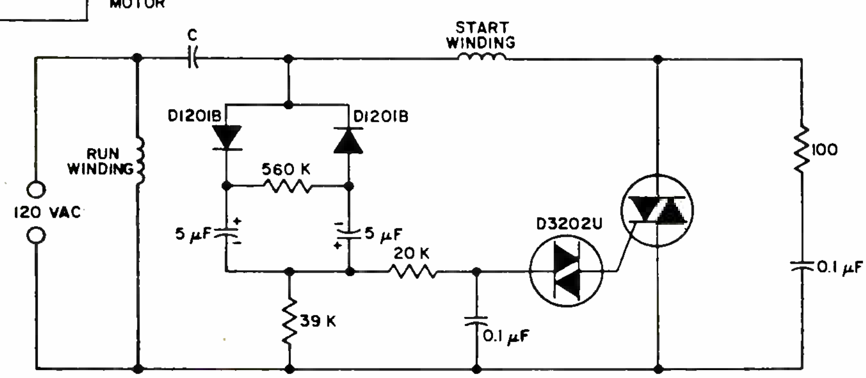


Fig. 2. A typical triac light-dimmer circuit that can also be used for motor control. Component values depend on specific devices used and intended application.

Fig. 3. Here solid-state devices are used in circuit of starting winding for medium and higher-power ac motor.



characteristics, the type of operation required, and the motor's rating. As a general rule, however, the values are not critical. Generally, *R1* is chosen to limit *Q1*'s maximum base bias and thus its maximum collector current and the top motor speed, with *R2*, typically from five to twenty times *R1*'s value. If, for example, a 100-ohm resistor is used for *R1*, *R2* might have a value from 500 to 2000 ohms. Similarly, if *R1*'s value is, say, 10,000 ohms, *R2* might range from 50,000 to as much as 200,000 ohms. Where the motor's *minimum* as well as its maximum speed must be limited, a second fixed resistor can be connected between *R2*'s lower terminal and the power source, thus limiting its bias control range.

Line-operated "universal" (ac/dc) series motors of the type found in many home appliances and small power tools can be controlled effectively using the SCR circuit illustrated in Fig. 1B. Suggested by RCA in *Power Options from the Powerhouse* (publication No. 2M1169), the design uses two general-purpose diodes, an SCR, a fixed resistor (*R1*) and a control potentiometer (*R2*). As in the transistor circuit, the actual component values depend on the specific semiconductor devices used, the motor characteristics, and the mode of operation needed. RCA suggests SCR types S2060, S2061, and S2062 for motors requiring up to 4 amperes, type S2600 for requirements to 7 A, and type S2800 if as much as 10 A is needed. Again, heat sinking may be required.

As long as maximum ratings are observed, most triac light dimmer circuits also can be used as light-duty speed controls for household appliances and small power tools. A typical circuit was described in this column in December, 1977, and another is given in Fig. 2. As before, the component values depend on the specific devices used and the intended application (i.e., motor rating and desired control range). Typical values, however, are 0.1 μF for *C1* and *C2*, 100 μH for *L*, 2.2k to 4.7k for *R1*, and 50k to 250k for *R2*. The diac may be type D3202Y or D3202U, while the triac may be types 2N5757, T2301 and T2302 for loads of up to 2.5 amperes, type T2500B for loads up to 6 A, and types 2N5571, 2N5572, T2800, T2850, T4100 and T4120 for requirements up to 15 A.

Unfortunately, not all ac motors are amenable to solid-state speed control. With synchronous and induction motors, for example, speed is essentially fixed and is determined by design and the power-line frequency. Any variation from the design speed is caused by "slippage" due to loading. Attempts to reduce speed by controlling the line voltage or current may result in a severe loss of torque and power, perhaps even causing a stall and burn-out.

Despite the limitations, solid-state controls can be used effectively for medium and higher power ac motor switching applications. Suggested by RCA, the motor-starting switch illustrated in Fig. 3 is a typical example. Suitable for medium-power motors operating on standard household ac lines, the motor-starting circuit uses a triac as an automatic switch for the motor's start winding and its associated phase-shifting capacitor, *C*. The triacs used may range from types T2800 and T2850 for current requirements of up to 8 amperes to types 2N5567, 2N5569, and T4120 for loads of up to 15 A, or types 2N5441 and T6420 for currents of up to 40 A.

With the increasing popularity of solid-state motor controls, several semiconductor manufacturers have developed special IC's for such uses. The ICH8510/

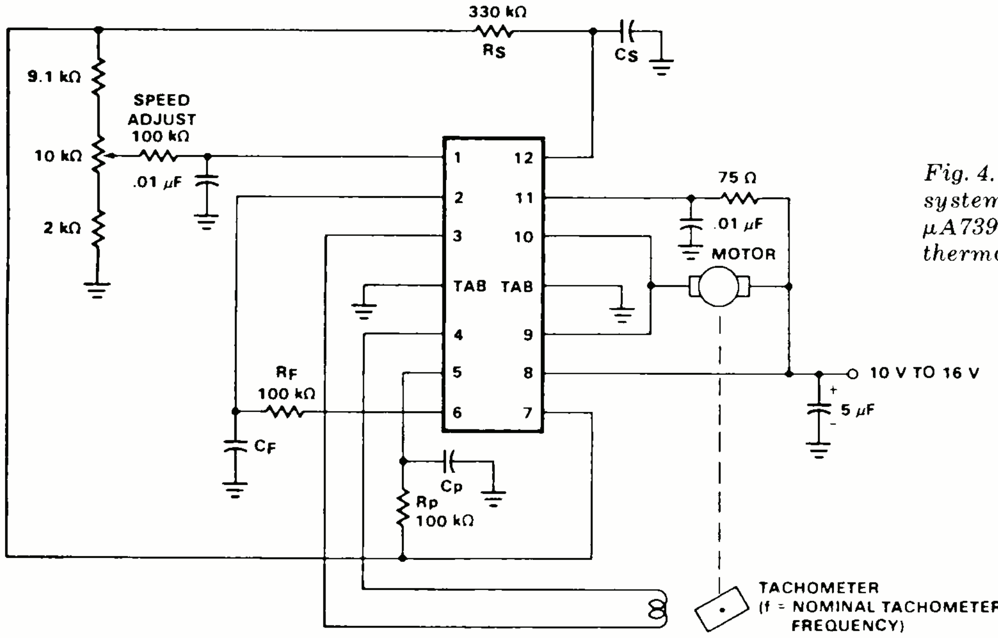


Fig. 4. Typical closed-loop system using the Fairchild µA7391 IC. The circuit includes thermal and overvoltage protection.

8520/8530 family offered by Intersil, Inc. (10710 N. Tantau Ave., Cupertino, CA 95014) is a representative example. Assembled in 8-pin TO-3 style metal cases, the devices are hybrid power amplifiers designed specifically for driving linear and rotary actuators, electric valves, push-pull solenoids, and ac or dc motors. Available for operation on dc supply sources of up to ±30 V, the ICH8510 will supply an output current of up to 1 A, the ICH8520 up to 2 A, and the ICH8530 up to 2.7 A. The devices are protected against inductive kickback by internal power limiting, have integral frequency compensation, offer an equivalent dc gain of better than 100 dB, and require a standby quiescent current of only 20 mA.

Manufactured by the Fairchild Camera and Instrument Corporation (464 Ellis Street, Mountain View, CA 94042), the µA7391 represents another type of motor-control IC. It is designed for precision, closed-loop, systems such as capstan drives in automotive and portable tape players, in floppy-disk drives for computer memories, and in data cartridge drives. Assembled in a 12-pin power package DIP with heavy heatsink tabs, the device will deliver a motor starting surge current of up to 3.5 A and a running current of 2 A. It can be operated on dc source voltages from 6.3 to 16 V. Intended for use with an external motor driven tachometer generator, it will accept tachometer inputs from 100 mV to 1.0 V p-p. The device includes voltage regulator, pulse generator, comparator, thermal sensor, overvoltage sensor, and stall timing threshold and latch circuits as well as driver and power amplifier stages. In operation, the tachometer generator supplies an input signal proportional to motor speed. This signal is converted into fixed amplitude pulses and integrated by a standard R-C network before application to a comparator, where it is compared to a reference voltage representing the desired speed. The result of the comparison controls the duty cycle of the pulse width modulated switching motor drive output stage, thus closing the system's feedback loop and holding the motor speed to the rate established by the reference voltage. The thermal and overvoltage sensor circuits provide shutdown for self protection while the "stall timer" circuit protects the motor itself from burn-out during extended mechanical jams.

A typical application circuit featuring the µA7391 is illustrated in Fig. 4. The circuit component values will vary with the characteristics of the motor and tachometer used.

As a general rule, layout and lead dress are not critical factors when assembling and wiring motor-control circuits, although good wiring practice should be followed, with care taken to observe all dc polarities and to avoid overheating the semiconductor devices during installation. In addition, adequate heatsinks should be provided for the output drivers, whether transistors, SCR's, triacs, or IC's.

Readers' Circuits. Needing a visual indicator for his ac line-operated TRANSMIT/RECEIVE antenna relay, Ted Reiter (1442 Brook Drive, Titusville, FL 32780), replaced his standard spdt unit with a dpdt version, planning to use the extra contacts to control the indicator devices. After rejecting the use of neon lamps and short-lived incandescent types, Ted devised the circuit illustrated in Fig. 5. Permitting standard LED operation on the relay coil (ac line) voltage, Ted's design

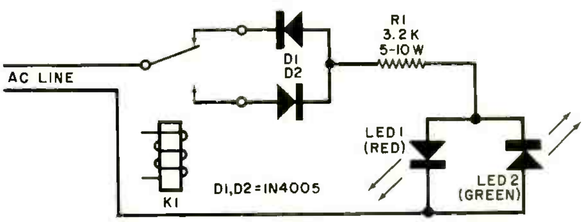


Fig. 5. Reader's circuit provides visual indication of whether relay is open or closed.

avoids the need for a step-down transformer, battery, or conventional dc power supply while retaining the low power and long life advantages offered by these devices.

Ted writes that virtually any LED's will work in his circuit, including low-cost "surplus" types, but warns that the series dropping resistor, *R1*, gets rather warm during operation and should be mounted accordingly.

Edward C. Mauro (12 Pyramid Lane, Rochester, NY 14624) thinks readers may find his digital-logic automatic pump control circuit of interest and value. Used in conjunction with a transistorized relay to operate a water pump, Ed's circuit, Fig. 6, provides automatic level control for a water tank or sump. Ed writes that he uses his model to empty a dehumidifier tank

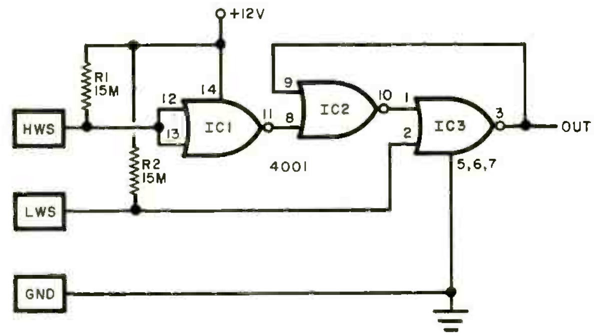


Fig. 6. Digital control circuit for a pump is controlled by level sensors.

automatically in the summer and to control the level in a furnace humidifier overflow holding tank in theTMS* winter.

Using standard CMOS 2-input NOR gates, the circuit's operation is straightforward and easy to follow. HWS and LWS are the high and low water sensors, respectively. When the water level is below both, *IC3*'s output is low. As the water level rises past LWS, *IC3*'s output remains low until HWS is reached. At this point, *IC3*'s output goes high. Sensed by the transistorized relay, the high output switches the pump on. The water level starts dropping down past HWS, but *IC3*'s output remains high due to the feedback loop to *IC2*, and the pump continues to operate. When the water level drops below LWS, however, *IC3*'s output goes low and the pump shuts down completely.

Ed has specified inexpensive, readily available components in his design. The HWS, LWS and GND sensors are one-inch diameter sections of standard pc board (unetched). The LWS and GND sensors are suspended on insulated leads near the bottom of the tank, but above the pump intake level, while the HWS sensor is suspended at the desired pump "turn-on" level. The circuit may be assembled on perf board, a suitably etched pc board, or on a wirewrap breadboard, as preferred. It may be used with virtually any standard transistorized relay circuit compatible with CMOS output levels.

Device/Product News. Three new series of fast turn-off SCR's intended for high-speed switching applications such as power inverters, switching regulators, and high-current pulsing are now available from RCA's Solid State Division (Box 3200, Somerville, NJ 08876). Identified as the S5800, S5801, and S5802 series, the new devices may be used at frequencies of up to 25 kHz. Each series includes five types with voltage ratings ranging from 200 to 600 volts. The turn-off times for an 8-A load is 6 μs for the S5800 series, 10 μs for the S5801 series, and 15 μs for the S5802 series. All the devices are supplied in JEDEC TO-220A/B plastic packages.

Motorola Semiconductor Products Inc. (P. O. Box 20912, Phoenix, AZ 85036) has added four new devices to its popular *Switchmode*® line of power transistors. Suitable for applications as motor controls, inverters, solenoid and relay drivers, and in deflection circuits, the new units include the 10-A types MJ13014 and MJ13015, with V_{ceo} ratings of 350 and 400 volts, respectively, plus two 20-A Darlingtons, types MJ10008 and MJ10009, rated at 450 and 500 volts.

Motorola also has a new FM stereo demodulator IC which is fabricated using the latest in I^2 L, Ion Implant, and Bandgap technologies. Designated type MC1309, the device requires no inductors and very few other external components. A single potentiometer sets initial subcarrier vco frequency in the PLL demodulator, while an external load resistor choice enables the unit to be inserted as a unity gain element in the FM receiver's audio path, and a LED driver output is provided to indicate stereo operation. For operation on 4.5 to 16 volts, the MC1309 is supplied in a standard 16-pin DIP.

National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051) has developed a family of negative three-terminal adjustable voltage regulators. Designated the LM137 series, the monolithic devices complement the LM117 series of positive three-terminal regulators. With outputs adjustable from −1.2 to −37 volts using only two external resistors, the units have integral thermal regulation and a current rating of 1.5 A. Other features of the series are a high ripple rejection of 75 dB and an rms output noise of a mere 0.003% of the output voltage up to 10 kHz. The LM137 devices are in TO-3, TO-5, TO-220 and TO-202 packages. ◇

Experimenter's Corner

By Forrest M. Mims

THE VOLTAGE MULTIPLIER

THIS MONTH, we're going to look at the diode-capacitor voltage multiplier, an extremely simple but very useful power-supply circuit. The diode-capacitor voltage multiplier allows the user to obtain a larger dc voltage than that available from his battery or transformer/rectifier supply. In ac circuits, this voltage multiplication is readily accomplished by transformers, so you can consider the voltage multiplier as a solid-state, dc step-up transformer with very limited current regulation capability.

These networks have found many applications in semiconductor electronics. They are commonly used in digital wristwatches to derive required operating voltages from a single mercury cell. Voltage multipliers are also employed to obtain the relatively high voltages needed for powering neon glow lamps, electrofluorescent displays and semiconductor lasers. Heavily insulated voltage multipliers are frequently found in the high-voltage sections of color television receivers and infrared-to-visible light conversion systems.

Although there are several basic voltage multiplier designs, they are all based on the principle of charging and discharging capacitors with the help of steering diodes. Let's look at a few representative circuits. All inputs are ac.

Typical Voltage Multipliers. Figure 1 is the schematic diagram of the traditional voltage doubler. In operation, an ac voltage is applied across the input terminals. During the negative half-cycle of the input signal (*BP2* positive with respect to *BP1*), *C2* charges to the peak value of the input voltage. During the positive half-cycle, *C1* charges up to the peak value of the input voltage. Since *C1* and *C2* are in series, the output voltage is double the peak input voltage if the output is lightly loaded. Therefore, the capacitors must be rated to withstand the peak value of the input voltage and the diodes twice that value.

Figure 2 shows two other ways to make a voltage doubler. The cascade doubler (A) isn't as efficient or as well-regulated as either the traditional or bridge doubler, but it can easily be expanded to many stages. (Component voltage ratings are given in parentheses.) It's possible to obtain outputs of many thousands of volts from multistage cascade voltage multipliers. Figure 3 shows both a full-wave voltage tripler (A) and quadrupler (B).

You can duplicate any of the circuits in Figs. 1 through 3 using ordinary silicon rectifiers and suitably rated capacitors. Switching diodes (IN914 or IN4148) work fine in low-voltage applications. Rectifiers in the IN4000 series are a good choice for circuits with higher working voltages. Here are the voltage ratings for these rectifiers: IN4001, 50 volts; IN4002, 100 volts; IN4003, 200 volts; IN4004, 400 volts; IN4005, 600 volts; IN4006, 800 volts; IN4007, 1000 volts. Be sure to observe the polarities of diodes and electrolytic capacitors.

A Word of Caution. The sample voltage multiplier circuits that follow produce relatively low voltages. Voltage multipliers, however, can easily produce very high output voltages. If you decide to experiment with high-voltage multipliers, use caution and always make sure the capacitor chain is fully discharged before touching any circuit nodes. The capacitors in an unloaded voltage multiplier chain can retain a dangerous charge for *hours* after the power supply has been turned off.

Op-Amp Voltage Multiplier. It's very easy to generate square waves with an operational amplifier, so an op-amp oscillator makes an ideal input for a voltage multiplier. Figure 4 shows one possible circuit.

Virtually any op amp will work as a square-wave generator, but I've selected the RCA CA3078, a micropower op amp that will operate with power-supply voltages as low as ± 0.75 volt. With the component values shown in Fig. 4, the

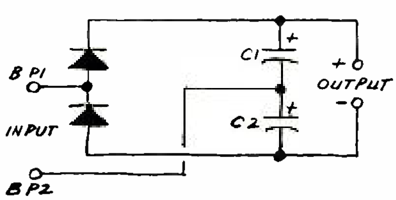


Fig. 1. Traditional diode-capacitor voltage multiplier.

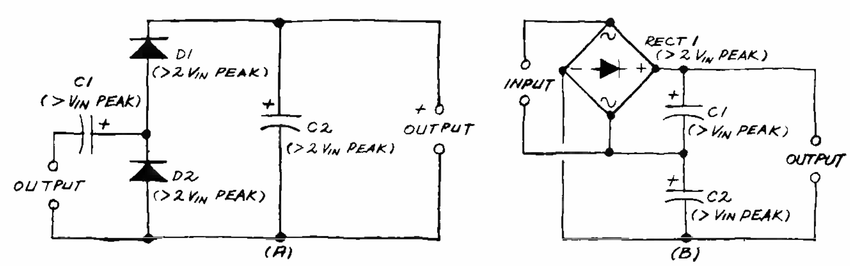


Fig. 2. Two different ways to make a voltage divider.

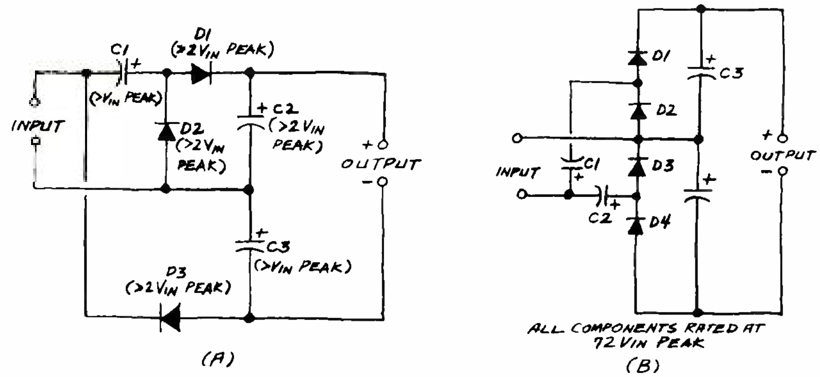


Fig. 3. Full-wave voltage tripler and quadrupler circuits.

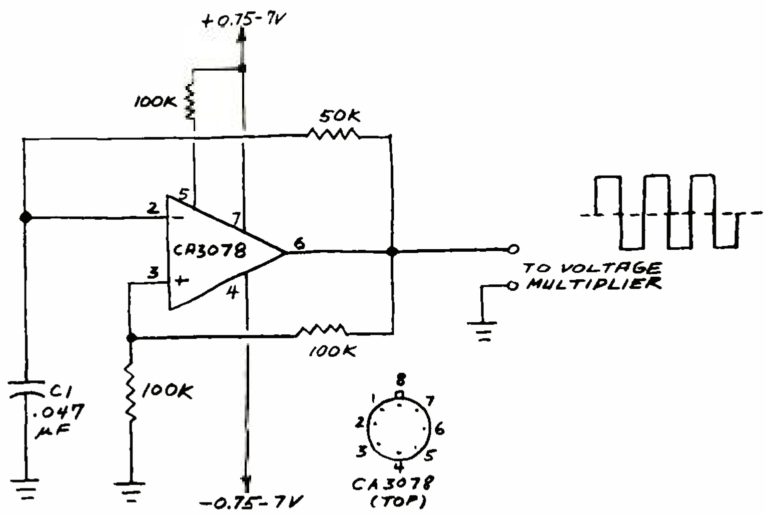


Fig. 4. Micropower op-amp oscillator circuit.

oscillator produces square pulses approximately four milliseconds wide at a frequency of 144 Hz. Increasing the value of *C1* will increase the pulse width and reduce the oscillation frequency.

You can use the basic op-amp square-wave generator as an ac source for any voltage multiplier circuit. Figure 5 shows the results for a ten-stage cascade multiplier. Don't use a supply voltage greater than ±7 volts if you use a CA3078 as the square-wave generator. For higher output voltages, add more multiplier stages or an op amp such as the 741 that will accept a higher supply voltage.

CMOS Voltage Multiplier. It's easy to build CMOS oscillator circuits that provide a square-wave output. Figure 6 shows one way to connect a voltage doubler to a typical CMOS oscillator comprising a clock followed by a 4013 D flip-flop. The clock is an astable multivibrator made from two of the four NAND gates in a 4011 integrated circuit. The flip-flop is operated as a toggle by feeding the not-$\overline{Q}$ output back to the D input.

Note that only half of each IC is used in this circuit. Because unterminated CMOS inputs can bias the gates into the linear operating region, it is essential to connect all unused inputs to either V_{DD} (the positive supply) or V_{SS} (ground). If your circuitry suddenly stops operating and one of the IC's becomes very hot, chances are you've left one or more inputs floating!

The voltage doubler shown in Fig. 6 works quite well. With the capacitor values given and a power supply of 6 volts, the flip-flop toggles at a frequency of 170 Hz and the doubler generates 11.3 volts.

Don't hesitate to experiment with the CMOS multiplier circuit. You can easily produce more than 100 volts by powering the CMOS clock with a 12-volt supply and connecting the flip-flop to a ten-stage voltage multiplier like the one shown in Fig. 5. That's more than enough voltage for a neon glow lamp and a 100,000-ohm series resistor between the positive output terminal of the multiplier and V_{SS} (ground). (Take care—the high voltage can easily zap one or both of the CMOS chips.)

Further Reading. The Motorola "Silicon Rectifier Handbook" (1966) has an excellent chapter on voltage multipliers (Chapter 6). Radio Shack's "Semiconductor Projects, Volume 1" (1975) has a chapter that describes an op-amp pulse generator that powers a ten-stage cascade voltage multiplier. This circuit is capable of producing a 140-volt output when the op amp is powered by a 35-volt supply. ◇

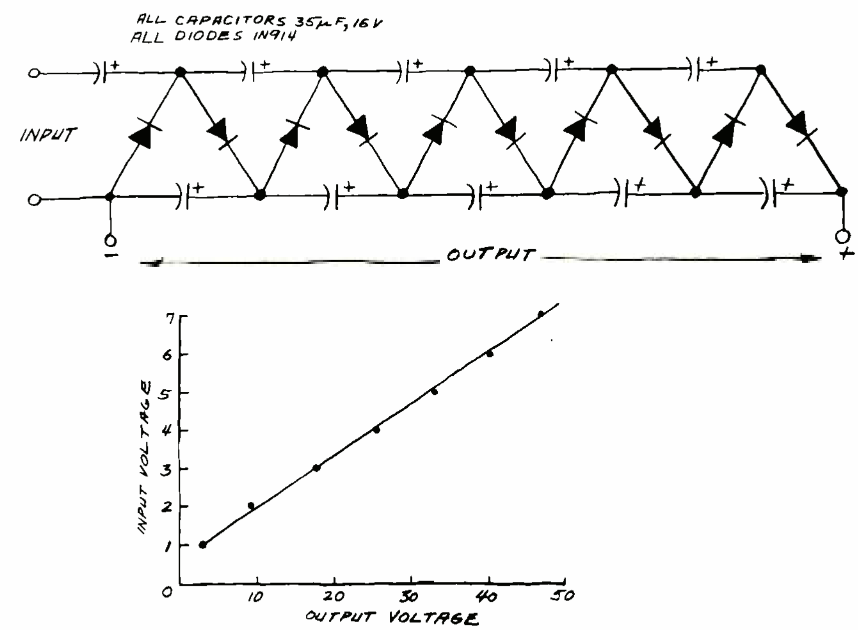


Fig. 5. Performance of op-amp oscillator and ten-stage multiplier.

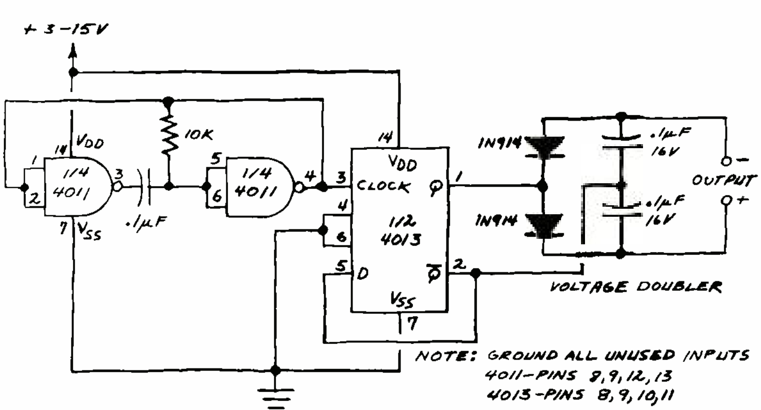


Fig. 6. CMOS oscillator and voltage doubler.

Product Test Reports

TRAM MODEL D62 AM/SSB MOBILE CB TRANSCEIVER

Rig has fine SSB performance and incorporates quick-release bracket.

THE Tram Model D62 CB transceiver is a 40-channel phase-locked loop (PLL) frequency-synthesized AM/SSB mobile rig. A special feature is an Anti-Theft Snap-Brak, an instantaneous quick-release mobile mounting bracket.

Other features include: LED numeric channel display; r-f, audio, and microphone gain controls; switchable automatic noise limiter (anl) and noise blanker(NB) combination; squelch and clarifier controls; SWR indicator; illuminated S/r-f/SWR meter; transmit-on indicator; automatic level or modulation control (alc or amc); PA facility; external-speaker jacks; detachable dynamic microphone; electronic voltage regulation for critical circuits; AM/LSB/USB mode switch; operation from a nominal 13.8-volt negative- or positive-ground dc source; and line filter and reverse-polarity protection.

The transceiver measures 10 ¾"D × 6 15/16" W × 2 ⅜"H (27.3 × 17.6 × 6 cm). Suggested retail price is $450.

Technical Description. The receiver section employs a single-conversion design, with its i-f at 7.8 MHz. AM and SSB selectivity are obtained with a crystal-lattice filter. A dual-gate FET r-f input amplifier provides high sensitivity with very good signal-handling capabilities against overloads.

The local heterodyning signal at the mixer is obtained from the PLL's FET voltage-controlled oscillator (the vco), whose output signal frequency is at the high side of the CB signal (CB signal plus 7.8 MHz). There are actually two individual vco's, one of which is used for AM and USB and the other for LSB. (The frequencies for each channel differ by approximately 3000 Hz so that the signal is in proper relationship to the i-f filter for the related transmission mode.)

Three i-f stages follow the filter, after which either a diode envelope detector and a series-gate anl are provided for AM or a transistorized product detector is used for SSB. The receiver's entire audio system is contained in a single IC. The power-output section of this IC doubles as the transmitter AM modulator.

Built into the receiver section is an amplified squelch setup. The noise blanker is arranged so that it is switched in and out simultaneously with the AM anl. The circuit data for the noise blanker was not given; the only indication that one is included is on the schematic diagram, with a note that it is incorporated into a single IC. The noise-blanker system picks up the noise pulses from the r-f amplifier and processes them for disabling the output of the mixer for the duration of each pulse.

The standard reference signal for the PLL system is derived from a 5120-kHz crystal oscillator. The output signal frequency from the vco is also divided to provide the comparison signal. As usual, both signals go to a phase comparator, where an error voltage is generated for correcting the vco's frequency. Red LED displays for the channel numbers are activated by decoder drivers.

On transmit, the 7802.5-kHz bfo signal goes to the balanced modulator for SSB and then to the filter and a balanced mixer, where the difference-mixture with the output of the vco produces the on-channel signal. The AM carrier is similarly generated at this mixer. The remainder of the transmitter's lineup consists of two r-f amplifiers, a driver stage, and a power amplifier operated in class C for AM and linearly for SSB.

On AM, a speech amplifier is inserted ahead of the IC in the receiver that is used to modulate the transmitter, while on SSB two additional audio preamplifiers feed the balanced modulator. An automatic level control (alc) system is included for both AM and SSB to maintain high modulation without introducing adverse overmodulation.

A multielement output network in the power amplifier stage matches to 50-ohm lines and attenuates spurious responses. This network is also switched in on receive, where it provides improved image rejection and minimizes receiver radiation from the antenna terminals at frequencies above 28 MHz. Radiation from the case in the receiver section is additionally minimized with complete shielding and external-lead bypass capacitors. Antenna switching is performed with a relay, which also initiates other changeover functions.

Laboratory Measurements. On our test bench, the receiver's sensitivity measured 0.5 μV on AM with 30% modulation at 1000 Hz and at least 0.15 μV on SSB for 10 dB (S + N)/N. A slight divergence from these figures occurred on different channels. The squelch threshold range was 0.5 to 2500 μV. The agc held the audio output to within 10 dB with an 80-dB r-f change at 1 to 10,000 μV. The S meter registered S9 with a nominal 50-μV signal, but meter peaking did not exactly coincide with maximum audio output.

The image, i-f, and other unwanted spurious-signal rejection were an unusually good 85, 85, and 75 dB minimum, respectively. On the other hand, a 1-μV internal "tweet" appeared on SSB when the clarifier control was set to one end of its extremes. Adjacent-channel rejection and desensitization was a minimum of 65 dB. The unwanted-sideband rejection at 1000 Hz was 60 dB.

The 6-dB audio response on AM was 325 to 4000 Hz, while on SSB, it was 700 to 4700 Hz. The maximum sine-wave output on receive and PA was 3 watts at the onset of clipping with 1.1% THD at 1000 Hz and 1.7% THD at 400 Hz, both into 8 ohms.

Operating the transceiver from a nominal 13.8-volt dc power source, the output power of the carrier measured 4.25 to 4.5 watts, depending on the temperature. Tone modulation went to 90% at microphone input levels 16 dB greater than required for 50% modulation. The THD at 1000 Hz was 6% (6.5% at 500 Hz). Adjacent-channel splatter under these conditions was 50 dB down at

1000 Hz and 45 to 50 dB at 2500 Hz. With voice operation at maximum microphone gain, the modulation tended to slightly exceed 100% on both negative and positive peaks. Nevertheless, the splatter was 50 to 60 dB down. The overall 6-dB audio response of the transmitter was 700 to 2800 Hz on AM. It peaked at +3 dB at 1350 Hz (600 Hz was down 10 dB).

On SSB, the output power measured 12 watts PEP, with both tone and voice. A tendency toward flattopping was observed at maximum mike levels. However, third-order distortion products were 28 dB below PEP (22 dB below two equal-level tones). Carrier suppression was 45 dB. On LSB, the unwanted-sideband suppression at 1000 Hz was 45 dB, and on USB, it was 50 dB. (While still using a single 1000-Hz tone in the USB mode, a 35-dB down spur appeared at ±3000 Hz. Beyond an 800-to-1200-Hz tone input, these spurs disappeared. In any event, we observed no deterioration in on-the-air signal quality. The overall 6-dB audio response on SSB was nominally 300 to 1350 Hz. The frequency tolerance of the transmitter held to within 0.0015% on all channels at 65° to 85° F (18° to 29° C) ambient temperatures.

User Comment. The Anti-Theft Snap-Brak featured with this transceiver does not in itself prevent theft. What it does is allow the transceiver to be quickly and easily removed from its bracket without having to manipulate the usual holding knobs. This permits convenient removal of the rig for hidden storage elsewhere when the vehicle is left unattended, which is still the best insurance against theft. Removal is also simplified with a quick-disconnect plug at the power cable, although the antenna cable still requires unscrewing the connector.

During bench tests with an impulse-noise generator, the noise blanker/anl system performed well with noise pulses up to 100 dB above 1 μV/MHz bandwidth, except at the 50-dB level, where its effectiveness was reduced. In on-the-road tests, we obtained good NB/anl performance on AM. Here, the audio gain of the receiver diminished to reduce weak signals by 6 to 8 dB. The end result of this was an improved S/N ratio.

The effectiveness in reducing noise pulses was not as noticeable on SSB, which is inherently less noisy than AM.

On AM, the audio receiving quality was full and clear. As can be seen from our SSB response figures, the quality on SSB was somewhat thinner than on AM, apparently due to the high low-frequency cutoff point. However, the resulting crispness produced excellent intelligibility. Adjacent-channel rejection and freedom from overload made reception more interference-free than is usually the case in the presence of properly operated strong signals.

The audio quality on transmit in the AM mode was a bit thinner than usual. On SSB, however, it produced high intelligibility. SSB transmitting quality sounded lower pitched, but still provided excellent readability.

Although occasional overmodulation was experienced on both AM and SSB, no adverse effects were noted during our on-the-air tests.

In sum, this is a fine all-around transceiver. It provides excellent AM performance, while giving the operator all the advantages of SSB communication, a mode of communication to which more and more CB'ers are turning.

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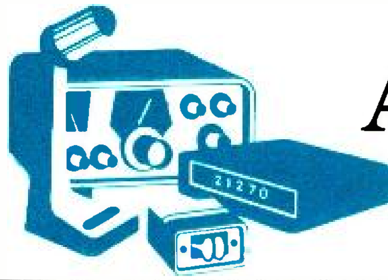


Amateur Radio

By Karl T. Thurber, Jr., W8FX

GETTING IT TOGETHER AS A NOVICE

ONE BRIGHT summer day in 1954, I found in the mailbox a small rectangular envelope from the FCC containing a Novice Class ham license. Station KN2IKZ was now authorized to go on the air. Receiving the license was a particular thrill for me, then a 12-year-old SWL. I had failed the Novice code exam on the first try—in those days, exams were given on FCC premises and a passing score was by no means assured.

Once the thrill of actually holding a valid "ham" license had passed, I, like any newly licensed amateur, had to face the serious challenge of getting on the air and making the first contact. A Philmore 2-tube, 25-watt rig using a 6V6 crystal oscillator and 5Y3 rectifier (remember them?) got KN2IKZ going on 40 meters. Also used were a Hallicrafters S-40B all-wave receiver and a 60-foot "random wire" antenna. Not exactly a dream station, it did the job for several months until I got my General ticket and a then-modern Johnson Viking II and Hallicrafters SX-96 replaced their more humble predecessors.

The thrill is still experienced by today's newly licensed Novices, but the equipment today is different—and better! With the exception of those who tackle a Heath receiver kit, practically no one builds his or her own receiver anymore. The technical sophistication of modern receivers, incorporating such features as frequency synthesis, multiple conversion and i-f filtering, make construction and check-out a very difficult task. Relatively few hams, Novice or otherwise, build their own transmitters, though it certainly can be done by the more enterprising and technically oriented. Transmitter construction, particularly for CW (Morse code) gear, is not as demanding, but is a much greater task than it was in 1954. This is due to the simple fact that unless you're working with a pre-packaged kit, obtaining all the parts needed is now a formidable task. The best bet for most Novices is to buy either ready-made gear or a kit, limiting initial construction projects to various accessories.

In the old days (actually, up to mid-1976, when the FCC raised the Novice power limit and allowed the use of vfo's), most Novices set their sights on a low-power, crystal-controlled ("rock-bound") transmitter such as the

Yaesu's FT-101E runs 180 W CW (260 W PEP SSB) on 160-10 meters.

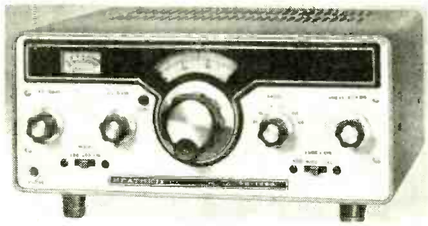
Heathkit DX-series (35,40,60, etc.) and an SWL-type receiver such as one of the old National, Hallicrafters, or Hammarlund models. The relaxation of the Novice operating restrictions has shed an entirely new light on the situation. Now, those who can afford it initially buy equipment suitable for General and higher-class operation. A compromise route is to purchase as good a receiver as possible, and to keep the first transmitter simple. The idea is to hold on to the receiver for some time but to *sell* the transmitter upon attaining the General or Advanced Class license, applying the proceeds toward the purchase of a CW/SSB transmitter or transceiver.

The first-class entry to ham radio, is simply to buy *the* future station transceiver or transmitter/receiver combination at the outset. There is much to be said for this approach—the more sophisticated gear works very well on CW, usually with full or partial break-in, and is capable of running from 180 watts to 1000 watts on CW and SSB. These rigs usually cover 80 through 10 meters, with some covering 160 as well. This avoids the problem of disposing of the "starter" station but assumes that the Novice license *will* be upgraded. The approach represents considerable investment however, and may spur the newcomer to upgrade his license from a financial standpoint, if nothing else!

Transceivers Vs. Separates. Which is better—a transceiver or separate transmitter and receiver? That's not an easy question to answer. Overall price levels are often the same, and no one rig will suit everyone's operating tastes. Amateur transceivers, like their CB counterparts, make efficient use of stages which perform dual receive and transmit-type functions. They tend to be compact and often can be placed in the car for mobile operation, and then taken out for portable use in a motel or vacation retreat. Some of the new solid-state units have built-in 12-volt dc and 117-volt ac power supplies. That means everything is in one package except mike, key, and antenna!

On the negative side, transceivers *do* have their limitations, so the very best-equipped stations do not normally use them. Without an external vfo, one cannot transmit and receive on different frequencies. Although in most QSO's both hams are on the same frequency, some DX stations will not listen for calls on their own frequency. Instead, they ask stations to call them, for example, "10 kHz up" or "10 down" to avoid a pile-up on the DX station's transmitting frequency. The use of an external vfo alleviates this problem, but then we're back to two separate units and added cost. Another problem is that serious CW work is difficult with some transceivers because of exact zero-beating (getting exactly on the other fellow's frequency) problems, lack of full break-in keying, and restricted frequency coverage.

For those willing to put the time and energy into building a transceiver kit, a good bet probably *was* the Heathkit HW-16 transceiver. Unfortunately, it has been discontinued. The Heath Company does sell the HW-8, a 3-watt QRP (flea-power) package that, notwithstanding Heath's reputation for quality and the success some operators have had working at very low power levels, probably will not do the job on today's super-crowded bands, with many Novices running the full 250-watt limit. Successfully

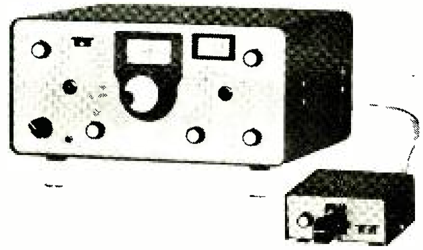


Heath MR-1680 SSB/CW receiver kit covers 80-10 meters.

operating a "QRP station" takes a great deal of skill and clear frequencies. The HW-16 can be found in dealers' used-equipment showrooms and at hamfests. The same is true for its transmitter counterparts such as the DX-35, DX-40, and DX-60. There is now a dearth of new low-to-medium power, CW-only rigs suitable for use by the beginner. (Used amateur gear is, incidentally, usually very well maintained and cared for by its owner and should definitely be considered for purchase.)

On the brighter side, Ten-Tec has introduced its new "Century 21" CW transceiver. The rig is solid-state and runs 70 watts, has vfo control, covers 80 through 10 meters and sports a number of accessories of interest to the Novice or CW buff, including an inexpensive keyer and plug-in crystal calibrator. Price is approximately $300, about the most you would want to invest in a CW-only 'starter' transceiver.

As for receivers, there is frankly little available to the Novice who wants to build a kit, but good, ready-made equipment is available from Drake, Collins, Kenwood and Yaesu. However, the Heath HR-1680 solid-state SSB/CW receiver kit is a good one, and at $200 represents an excellent value. It can provide several years of service before most hams will see the need to upgrade. Even then, it could find a place in the shack as an auxiliary receiver. Heath's instructions, in case you don't know, are usually as foolproof as they can possibly be. The kit features no-instrument alignment, four printed circuit boards, an open chassis layout, and a wiring harness to simplify assembly. If you do go the separate receiver/transmitter route, buy the very *best* receiver you can afford at the outset to avoid having to dispose of a cheaper unit that will probably outgrow its usefulness when a higher-class license is obtained.


Ten-Tec Century/21 Novice rig.

Many of the older (but not ancient) good-quality receivers will also be suitable. Among these are the SX-71, SX-76, HQ-180, NC-183D, NC-303, SX-111, HQ-110, SX-190, HA-350, and the HRO series. Unless you're a technical whiz, stay away from World War II surplus receivers—they just won't make it today. Exceptions to this rule are the Collins war-surplus R-390 and 51-J1.

Rapidly becoming a Novice "standard" is the relatively inexpensive ($340) Heath HW-101 5-band transceiver which runs 170 watts on CW or 180 on SSB. Because phone provisions are built-in, the rig is perfectly suitable for use after your General ticket has arrived. It features semi-break-in keying. The VOX circuitry is keyed by a built-in CW sidetone which also allows you to monitor the transmitted CW signal. About the only accessories needed to get the HW-101 on the air are an antenna key, ac power supply, and (not absolutely necessary but nice) the 400-cycle CW accessory crystal filter to separate closely spaced signals. Very similar to the HW-101 but not a kit, is the Tempo One, an import distributed by Henry Radio. It carries many of the features of higher-priced gear, but costs a shade under $500. Both can be purchased as used equipment.

R.L. Drake's TR-4CW SSB/CW transceiver is also a good bet for the beginner, and won't be obsoleted once the General license is obtained. Designed especially with the Novice/Technician in mind, it covers 80 through 10 meters with up to 300 watts PEP (peak envelope power) SSB input and 200 watts on CW. That's more than enough power to drive a 2-kW PEP linear amplifier should the occasion arise. Some of the features which make it especially attractive to the Novice are the built-in 500-kHz CW filter, 1-kHz dial calibration, 100-kHz crystal calibrator, wide-range agc and shifted-carrier CW operation.

Incidentally, Drake equipment is essentially tube-type. Tube-type rigs are considered "old-fashioned" by many but are somewhat easier to repair by the nontechnical ham. Available as optional accessories are an external vfo for split-frequency work, matching speaker and choice of power supplies (dc or ac).

The Drake Transceiver is in a different price class than the simpler Heath equipment mentioned earlier—the TR-4CW without accessories retails at about $650. That's quite an investment for a beginner! However, older, used Drake equipment, such as the TR-3 and TR-4 would do a good job for the beginner with a more modest investment. Also, if you're lucky enough to find one in good condition, the venerable Johnson Viking "Ranger" or "Navigator" of late 50's vintage make beautiful Novice transmitters, having vfo control and medium power levels (75 watts for the Ranger and 40 for the Navigator). E.F. Johnson long ago gave up on the Amateur market, going heavily into CB, but its equipment is still occasionally seen at hamfests and in the used equipment sections of dealers' showrooms.

Comparable to the Drake line are the Tempo 2020, the Yaesu FT-101E series and the Kenwood TS-520. All offer "custom" features which must be evaluated in terms of the user's interest in the hobby and his needs. The best bet, of course, is to thoroughly investigate the market (including the *used* equipment market) before buying *anything*. Seek advice from local hams and obtain comparative literature from various manufacturers. The period between taking the Novice exam and receiving the license is an excellent time to evaluate specifications, decide on a transceiver vs. receiver/transceiver combination, and actually set up the station in preparation for the big day.

In Closing. No matter what your final decision is as to what equipment will comprise your first ham station, choose carefully and keep the future in mind. A correct first choice can mean the difference between enjoying ham radio and losing interest. Keep in mind that cheap equipment is not necessarily the best value for your dollar. Before plunking down that hard-earned cash, ask a ham who uses the equipment you're considering for his *honest* opinion of his gear. Finally, visit one of the big hamfests or conventions where the major manufacturers exhibit their wares so you can make side-by-side comparisons. ◇

Computer Bits

By Leslie Solomon

COMPUTERS TO AID HANDICAPPED

LAST MARCH, we attended the second annual West Coast Computer Faire and heard eight papers discussing different ways computer enthusiasts can help handicapped people.

This is ample evidence that making home computers to aid the handicapped is an excellent project for computer clubs. It would certainly be more gratifying than Star Trek or creating more computer games. And modestly priced equipment—voice interfaces, modems, controllers, etc.—for this purpose is at hand. If you would like to contribute your talents to this much-needed computer-to-human interfacing, contact Computers for the Handicapped, c/o Warren Dunning, 5939 Woodbine Ave., Philadelphia, PA 19131. You will find it challenging and exciting.

PET Doings. The PET computer, like many of its predecessors is starting to spawn a "cottage industry" of bus plug-in devices.

HUH Electronic Music Productions, BOX 259, Fairfax, CA 94930 (Tel: 415-457-7598), is now making several PET add-ons. Among these is the PET-100, that allows the PET to use conventional S-100 boards. This approach uses a cable-connected board that plugs into an S-100 motherboard (that also has a power supply), with the other end of the cable connected to the PET expansion connector. Two versions are available: mode-1 emulates most S-100 functions except RDY so it has fast memory and no wait states; and mode-2 allows read and write wait states. Kit is $199.95, assembled it is $279.95

Another add-on is PETSQUEAK ($19.95) which automatically "beeps" when a file header is found or written, and when a program is loaded or saved. It may also be used as a beeper under program control. PET-TUNE-YA ($29.95) is an 8-bit D/A converter that can be used as a music generator or as a DAC for graphics or control. The PET Video Buffer ($19.95) is a video combiner that allows the use of conventional large-screen video monitors for classroom display.

S-100 Bus Things. It seems like almost every day something new comes along for the ubiquitous S-100 bus, and here is one more:

Objective Design Inc., POB 20325, Tallahassee, FL 32304 (Tel: 904-224-5545), has released its Programmable Character Generator board for $149.95 kit and $195 assembled/tested. This S-100 plug-in works with any of the

Motorola 9×7 matrix character generators such as used in the VDM-1, SOL, Poly VTI, SSM Video Board, etc. To use this new board, the character generator ROM is removed from the existing system, and plugged into a socket on the PCG. The PCG, in turn, is plugged into the now-empty character generator socket. Under software control, data in the 2K of RAM on the PCG can replace some or all of the characters in the old ROM. Such features as APL characters, special math or scientific symbols, foreign alphabets, italics, or other forms of emphasis, or even music symbols can be created. Programmable characters may be used to create graphics up to 512 × 256. The PCG achieves its high resolution without external memory or DMA activity.

Breadboarding. Probably the best way to try out a new circuit is to breadboard it, preferably using solderless sockets. This way, you can try all sorts of hardware "tricks" without causing any heat damage. In line with this, AP Products Inc., Box 110, 72 Corwin Drive, Painsville, OH 44077 (Tel: 216-354-2102), has released three POWER-ACE Circuit Evaluators said to have twice the component capacity of other solderless breadboards. All three models offer 256 × 5 tie-point terminals, and 16 × 25 tie-point busses, fused power supply, and a ground plane.

POWERACE 101 ($84.95) features a 5-to-15-volt, 600-mA dc supply having excellent characteristics, and a 5%, 0-15-volt meter. POWERACE 102 ($114.95) has a fixed 5-volt, 1-ampere supply, four slide switches with logic-0 or logic-1 outputs, and two debounced momentary switches delivering positive or negative output pulses. In addition, this model also has four LED's, a debounced pushbutton with positive or negative pulse output, and a clock generator from 1 Hz to 100 kHz output. POWERACE 103 ($124.95) is a beefed-up version of the 102, with the addition of a ±15-volt, 250-mA supply, and a 0-15-volt meter.

EPROM Erasure. There have been many articles on programming EPROM's, but erasure has been left up to the user. One way to erase EPROM's is by using the UVS-11E Low-Cost EPROM Erasing Lamp ($59.50) from Ultra-Violet Products Inc., 5100 Walnut Grove Ave., San Gabriel, CA 91778 (Tel: 213-285-3123). It is available from many electronics suppliers and computer stores. The UVS-11E holds up to four chips in a conductive foam base, and supports the chips at 1" from the UV lamp. Up to four chips can be erased in 20 minutes. The holding tray absorbs all UV while transmitting visible light. (The UV lamp will not operate unless seated within the holding tray. When the lamp is lifted from the tray, it goes off.)

Cabinets. Its one thing to build a new keyboard, a TVT, or a complete system, but locating a decent cabinet is something else.

If packaging has been a problem, contact Custom Electronics Industries, 609 Route 109, West Babylon, NY 11704 (Tel: 516-884-2121). This firm makes a variety of high-impact plastic enclosures for a variety of computer items. Prices range from $39.95 for a TVT cabinet and up depending on size. Cabinets are available painted or unpainted.

New I/O Port. According to Vector Graphics Inc., 790 Hampshire Rd., A-B, Westlake Village, CA 91361 (Tel: 805-497-6853), its Bit Streamer I/O S-100 board ($155 kit, $195 assembled), available through most computer stores, combines two parallel, and one serial I/O port with an 8251 programmable UART. One parallel port can also be used as a keyboard input port. Without changes to the pre-jumpered options, the board can also operate as an RS-232 serial port.

Ham/Computer Terminal. Xitex Corp., POB 20887, Dallas, TX 75220 (Tel: 214-620-2993), is marketing its SCT-100 low-cost S-100 plug-in video terminal. Using the Mostek 3870, the board produces 64 characters and 16 lines of 5×8 dot matrix characters and has a 128-character set including upper and lower case, numerics, Greek, common symbols, and special graphic symbols. The board can use either ASCII (110/300 baud) or baudot (45/72 baud). Full cursor control is provided. Both 20- and 60-mA serial loops are provided, as is RS-232. All loops are opto-isolated.

Having both ASCII and baudot, the board can be used for ham FSK as well as computer applications. Three versions are available: SCT-100A is assembled and tested for $185; SCT-100K is a kit for $155; and SCT-100P is a partial kit that includes the 3870, character generator ROM, crystal, pc board, and complete documentation at a price of $85. The documentation package (SCT-100D) is available for $3. ◇

Software Sources

6800 High-Speed Cassette Save/ Load Program. Designed for the SWTPC M68 computer and AC-30 cassette interface, WHIZ can save and load programs at 9X MIKBUG speed, or 3X binary-format speed, using ordinary cassette recorders. The program has a built-in relocator, and allows the user to specify the start, end and program-start addresses for a dump. When loading, WHIZ will produce an "OK" message and display the last address referenced on tape and the PC start address. Other hardware requirements include a terminal with control-character decoding. WHIZ resides in about 1k, and is supplied on KC cassette with origin 1000h, for $15.95, or on Smoke Signal Broadcasting BFD-68-format diskette for $20.95. Write: Shifting Sands Microcomputer Products Corp., Box 441, Fairborn, OH 45324.

Micro "APL" for 8080. 8k EMPL is a micro APL for 8080 based computers, using ASCII-character adaptations of the APL symbols and operators. EMPL has numeric and character vectors (one-dimensional arrays), user-defined functions, 22 primitive functions, 9 system commands, and many other special operators and characters. Typical operators and commands include: logical and arithmetic functions, catenation, string, literal-text, branch, absolute, random, and many others. The program itself resides in the first 5.6k bytes of memory, but requires a minimum of 8k total RAM. Double-precision integer arithmetic, with a range of ±32767 is used. EMPL is available on Tarbell cassette for $10 (NJ residents add 5% tax), including user's manual, from Erik T. Mueller, Britten House, Roosevelt, NJ 08555; and from Tarbell Electronics, 20620 S. Leapwood Ave., Suite P, Carson, CA 90746, for $15 (California residents add 6% tax). Also available for $20 on paper tape, North Star disk, CUTS cassette or MITS cassette from supplier.

6800 Math Package. A math package with 12-digit accuracy up to the value 549,755,813,887, and with 11-digit accuracy for higher values, is available for the SWTPC 6800 computer. Calculations are floating-point, with 5-byte mantissas plus 1-byte exponent, a 25% saving in storage over BASIC, with higher accuracy. The package also supports Fortran-type formatting of floating-point and integer specifications in both read and write. The package includes binary-to-ASCII conversion routines. Updates will be sent to all original purchasers for the cost of postage and disk or tape. If the customer supplies his own disk or tape, the charge will be $1.00. Cost of the math package is $107.50 in Smoke Signal Broadcasting disk, or $103.00 on KC-standard, 300-baud cassette. Write: AAA Chicago Computer Center, 3007½ W. Waveland Ave., Chicago, IL 60618, or participating dealers.

6502 Resident Assembler and Editor. The ASM65 resident assembler and Mini-Editor for 6502 systems are designed to work together, and can produce object paper tapes as well as listings. Both are available in KIM or TIM format; addressing for the ASM65 is 1000-1FA6 (TIM) or 2000-2FBD (KIM); for the mini-editor it's 2600–297F and 3600–3997F for the TIM and KIM versions respectively. The ASM65 on hex dump or paper tape is $13; the manual is $5, and a cross-assembly listing is $28. Prices for the Mini-Editor are $4.00 for the hex dump or binary paper tape, $2.50 for the manual, and $7.50 for the listing. All prices are postpaid, first class. A catalog of other programs is $1.00. Write: The 6502 Program Exchange, 2920 Moana, Reno, NV 89509.

8080 Multitasking Scheduler. MTS/80 is a real-time multitasking scheduler for Intel SBC 80/10 single-board computers. It features relocatable binary libraries, including I/O drivers and system utilities; source code, and manuals. On MDS-800-compatible floppy discs, MTS/80 is $995. If purchased separately, the user's manual is $25, and the System Generation Procedure and I/O Driver Implementation Manuals are $10 each. Write: Resource Control, 2701 152nd Ave. NE, Redmond, WA 98052.

Electronics Library

IC TIMER COOKBOOK

By Walter G. Jung

As cookbooks go, this one has few specific recipes, but a great deal of basic information to help the reader cook up projects of his own. About one-fourth of the book is devoted to RC timer basics, and IC timer types, including precision and programmable varieties. But most of the book is devoted to circuit ideas and building blocks from which the reader can develop a far wider range of projects than a book this size could otherwise contain. Four data-packed appendices include manufacturers' data sheets and a thorough bibliography of IC timer design ideas.

Published by Howard W. Sams & Co., Inc., 4300 West 62nd St., Indianapolis, IN 46268. 287 pages. $9.95 soft cover.

THE POCKET CALCULATOR GAME BOOK #2

by Edwin Schlossberg and John Brockman

Divided into games for one, two, three or more players, this book presents 50 games of mathematics and strategy, many of which will sharpen players' arithmetic abilities. All games are thoroughly explained, with examples of typical game runs that can be used with simple "four-banger" calculators.

Published by William Morrow & Company, Inc., 105 Madison Ave., New York, NY 10016. 203 pages. $6.95 hard cover, $3.95 soft cover.

ELECTRONIC TROUBLESHOOTING, SECOND EDITION

by Clyde N. Herrick

Name a piece of electronic gear in your home, and there's an excellent chance it's covered here. After a brief, but thorough survey of troubleshooting procedures, tools and instruments, the author devotes lengthy chapters to the troubleshooting of specific types of equipment. These include: radio receivers, stereo amplifiers and tuners, tape recorders, black and white and color TV, TV cameras and video tape recorders, ham and CB radios, electronic organs, computers, MATV and CATV, marine electronics, and troubleshooting of test instruments themselves. There are copious sample schematics and illustrations, including color photographs of color bar displays.

Published by Reston Publishing Co., Inc., Reston, VA 22090. 348 pages. $16.95. Hard cover.

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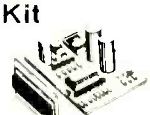

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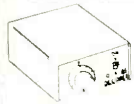

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74LS21	28	74LS109	38	74LS163	85	74LS393	1 45
74LS22	28	74LS112	38	74LS164	1 49	74LS670	2 30
74LS26	32	74LS113	38	74LS168	85	74LS192	95
74LS27	32	74LS114	38	74LS169	85	74LS193	95
74LS30	26	74LS122	49	74LS170	1 69	74LS194	95
74LS32	32	74LS124	99	74LS173	1 10	74LS195	85
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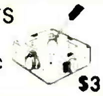

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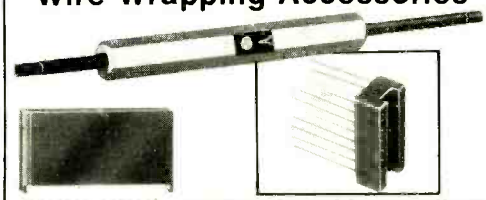

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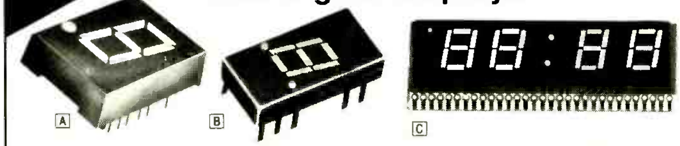

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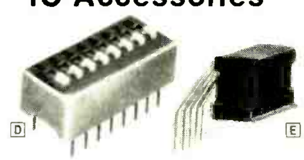

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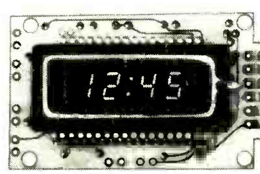

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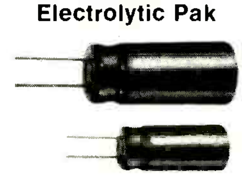

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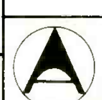

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MC1371	1.85	MC14507CP	1.25
MC1439	2.65	MC14511CP	2.76
MC1458P	.50	MC14512CP	1.70

C MOS

4001AE	.29	4023AE	.29
4002AE	.29	4024AE	1.50
4007AE	.29	4025AE	.35
4010AE	.58	4028AE	1.60
4011AE	.29	4029AE	2.90
4012AE	.29	4030AE	.65
4015AE	1.25	4037AE	4.50
4016AE	.65	4040AE	2.40
4018AE	1.10	4044AE	1.50
4019AE	.65	4049AE	.75
4020AE	1.75	4050AE	.75
4021AE	1.50		

LINEAR

75450BP	.49	LM301H	.35	LM741CH	.45
75451BP	.39	LM307H	.35	LM747	.90
75452BP	.39	LM309K	1.25	LM748H	.45
75453BP	.39	LM311H	.90	LM1458N	.80
75454BP	.39	LM318N	1.50	N5556V	1.50
75491BP	.79	LM339N	1.85	NE5558	1.00
75492BP	.85	LM351AN	.65	NE555V	.60
CA3005	1.60	LM370N	1.25	NE556	1.50
CA3006	3.50	LM380N	1.45	UA702	.80
CA3018	1.10	LM566	2.25	UA703CH	.45
CA3018A	1.60	LM711CH	.60	UA709CH	.30
CA3026	1.50	LM723H	.75	UA749CH	.45
CA3046	.35	LM741CN	.45		

IC's ON THE MOVE

BBD BUCKET BRIGADE DEVICE

MM3001 19.50 MN3002 11.70

MM3003 9.45

HALL IC: DN834 1.25 DN837 1.50

DN835 1.35 DN838(NEW)

ZENER DIODES

½ Watt, ± 10% .... $.30 each to 33 V

1 Watt, ± 10% .... $.40 each to 33 V

Voltages to 200V, and ± 5% Available

1 Megohm Potentiometer - Made by Clarostat. 7/8" diam., split, knurled shaft ½" long.

NT544 $.39 Three for $1.00

5400 SERIES

5400	1.00	5475	1.50
5404	1.25	5486	1.90
5410	1.00	5493	2.00
5426	1.25	54100	1.80
5473	1.50	54LS04	1.00

VOLT.REG

LM340K-5	1.70
LM340K-6	1.70
LM340K-8	1.70
LM340K-15	1.70
LM340K-18	1.70
LM340K-24	1.70
LM340T-5	1.50
LM340T-6	1.50
LM340T-8	1.50
LM340T-12	1.50
LM340T-15	1.50
LM340T-18	1.50
LM340T-24	1.50

RESISTORS

¼ Watt ± 5% Packed 5 of any one value .... $.25

½ Watt ± 5% Packed 5 of any one value .... $.30

STANDARD RESISTANCE VALUES

SEE OUR AD ON JAPANESE TRANSISTORS AND IC's IN THIS ISSUE.

MINIMUM ORDER $5.00

All orders add 1.00 Postage and Handling.

Canada $1.50

N.J. Residents add 5% sales tax

ELECTROLYTIC CAPACITORS

2.2MF50	Axial Leads	.15	30MF25	Axial Leads	.18
3.3MF10	Axial Leads	.15	47MF25	Radial Leads	.19
3.3MF10	No Polarity	.15	47MF50	Radial Leads	.24
10MF25	Axial Leads	.15	100MF16	Radial Leads	.19
10MF50	Axial Leads	.16	100MF25	Radial Leads	.24
10MF150	Axial Leads	.20	500MF50	Axial Leads	.60
25MF35	Axial Leads	.18	1000MF35	Axial Leads	.65

MICROPROCESSOR

C1702A	9.95	2708	34.95	8008	19.95
2101	5.75	C5101-3	4.50	8080A	19.95
2102	1.75	MM5013	3.25	8224	10.45

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NEW FROM NEWTONE

Regulated Power Supply Components Kit - Contains the components needed to build a fixed-voltage regulated supply including: 117/17V- 1 ampere Transformer, Bridge Rectifier, 2000 uF Capacitor, and a 1 ampere LM340 3-terminal IC Regulator. Makes a fine "on board" supply or use it for breadboarding. Components only. Specify 5, 6, 8, 12 or 15 volts. **NT525 $4.99**

Pioneer 6" Speaker - 7½-watt, 3.2-ohm speaker made the way speakers should be made. Has heavy-duty treated paper cone, protected magnet housing, and a ceramic terminal strip marked with polarity. A beautiful speaker at half the price you'd expect. **NT526 $2.39 Three for $6.00**

PC Boards - MIL grade, 1/16" glass-epoxy boards with 2-ounce copper on one side.

NT521 6"x3" $.50, NT522 6"x6" $.90' NT523 6"x8" $1.20

Dry Transfer Patterns for PC Boards - Includes 0.1" spaced IC pads, donuts, angles, and 3-and 4-connector pads. Over 225 patterns on a 2" x 7¼" sheet. **NT520 $1.49**

3PDT - 24 Vold DC Relay - Potter & Bromfield KU14D57. Each contact can handle 10 amperes at voltages to 240 Vac. Coil resistance is 450 ohms. A super buy! Limited quantities. **NT508 $.99**

5" Taut-Band Meter - One milliampere full scale, 3½", scale length. Coil resistance 465 ohms. Made by Modutec for Bose. Meter scale in VUs (-20 to +3). Meter is designed to be mounted coil up. Complete with "smoke" plastic cover. Over-all 5⅛" x 4". Meter face mounts in a 5⅛" x 2⅜" cutout: A beautiful meter. **NT539 $4.89**

Aluminum Knob - Solid machined aluminum knob with fluted sides made for Bose. Black front-face insert, black pointer line. Fits flat ¼" shaft, does not require set screws. .8 high, .7 diam. Easily worth $1.50 **NT540 $.82 2 for $1.50**

We have been informed by the Bose Corporation that the original BOSE 301™ speaker system has not been discontinued as we stated in our previous ad. The BOSE 301 is available through Bose dealers.

We still have a small quantity of speakers originally made for Bose. The Woofers have been tested with the Bose "Tone Standard" as a reference and subjected to the Bose power-handling test which includes both fixed and sweep-frequency testing.

8-Inch Woofer (Bose Part No. 102606) has a free-air resonant frequency of 25-35 Hz., and has a 1.5", 8.5-ounce magnet. The upper tested-frequency is 4000 Hz.

3-Inch Tweeter (Bose Part No. 107376) has a free-air resonant frequency of 1200-1500 Hz., and has an upper tested-frequency of 16.5 kHz. **Supplies are limited.** We urge you to take advantage of these prices and stock up for your future needs.

Sorry, we have no information about the Bose enclosures or the crossover networks, nor do we have more specs. Bose says these data are proprietary information.

8" Woofer NT541 $10.95

3" Tweeter NT542 $ 3.95

RECTIFIERS

	10 For	100 For
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1N4002	.70	6.00
1N4003	.80	7.00
1N4004	.90	8.00
1N4005	1.00	9.00
1N4006	1.10	10.00
1N4007	1.20	11.00

UNIJUNCTIONS

2N2160	.65	MU4892	.50
2N2646	.45	MU4893	.50
2N2647	.55	MU4894	.50
2N4851	.75	2N6027	.55
2N4852	.75	2N6028	.70
2N4870	.50	D5E37	.35
2N4871	.50	MU10	.35
MU4891	.50	MU20	.40

HARDWARE - SOCKETS

Nylon Screws, Nuts and Rivets - 50 piece assortment		$1.99
MK 20 TO-3 Mounting Kit		5 for $.99
NT-505 Mica and bushing. Specify TO-3, TO-66 or TO-220		10 sets for $.99
IC Socket	14-Pin DIL	$.25 each
IC Socket	16-Pin DIL	$.27 each
Wire Wrap	16-Pin DIL	$.32 each

POPULAR JEDEC TYPES

1N34	25	2N1540	.90	2N2712	.18	2N3394	.17	2N3856	20	2N4402	16
1N60	25	2N1544	.80	2N2894	.40	2N3414	.17	2N3566	1 25	2N4403	.20
1N270	25	2N1554	1.25	2N2903	3.30	2N3415	.18	2N3903	16	2N4409	.20
1N914	25	2N1560	2 80	2N2904	.25	2N3416	.19	2N3904	16	2N4410	16
1N4148	.25	2N1605	1.75	2N2904A	.30	2N3417	.20	2N3905	16	2N4416	75
1S1555	.35	2N1613	.50	2N2905	.25	2N3442	1 85	2N3906	16	2N4441	1.00
		2N1711	.50	2N2905A	.30	2N3553	1 50	2N3954A	3.75	2N4442	1.15
2N173	1.75	2N1907	4 10	2N2906	.25	2N3563	20	2N3955	2 45	2N4443	1 35
2N338A	1.05	2N2102	1.70	2N2906A	.30	2N3565	.20	2N3957	1 25	2N4852	55
2N404	.75	2N2160	.65	2N2907	.25	2N3638	20	2N3958	1 20	2N5061	30
2N443	2.50	2N2218	25	2N2907A	.30	2N3642	20	2N4037	60	2N5064	50
2N508A	.45	2N2218A	.30	2N2913	.75	2N3643	.20	2N4093	85	2N5130	20
2N706	.25	2N2219	.25	2N2914	1.20	2N3645	20	2N4124	.16	2N5133	15
2N718	.25	2N2219A	.30	2N3019	1.00	2N3646	.14	2N4126	.16	2N5138	15
2N718A	.30	2N2221	.25	2N3053	.30	2N3731	3 75	2N4141	20	2N5294	50
2N918	.60	2N2221A	.30	2N3054	.70	2N3740	1.00	2N4142	.20	2N5296	50
2N930	.25	2N2222	.25	2N3055	.75	2N3771	1.75	2N4143	.20	2N5306	20
2N956	.30	2N2222A	30	2N3227	1.00	2N3772	1.90	2N4220A	1.00	2N5400	40
2N1302	1.25	2N2270	.40	2N3247	3.40	2N3773	3.00	2N4234	.95	2N5401	50
2N1305	.75	2N2369	.25	2N3250	.50	2N3819	.40	2N4400	.16	2N5457	35
2N1420	.20	2N2484	.32	2N3393	.20	2N3823	70	2N4401	16	2N5458	35

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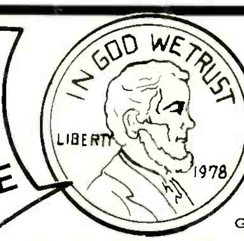

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Type	Each	2 for	Type	Each	2 for	Type	Each	2 for
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☐ SN7403	.19	.20	☐ SN7471	.25	.26	☐ SN74150	.99	1.00
☐ SN7404	.25	.26	☐ SN7472	.25	.26	☐ SN74151	.99	1.00
☐ SN7405	.19	.20	☐ SN7473	.55	.56	☐ SN74153	.99	1.00
☐ SN7406	.19	.20	☐ SN7474	.29	.30	☐ SN74154	1.75	1.76
☐ SN7408	.21	.22	☐ SN7475	.79	.80	☐ SN74155	.79	.80
☐ SN7410	.19	.20	☐ SN7476	.59	.60	☐ SN74156	.69	.70
☐ SN7413	.39	.40	☐ SN7478	.59	.60	☐ SN74157	.99	1.00
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☐ SN7416	.29	.30	☐ SN7482	.39	.40	☐ SN74160	1.25	1.26
☐ SN7420	.19	.20	☐ SN7483	.99	1.00	☐ SN74161	1.25	1.26
☐ SN7423	.29	.30	☐ SN7485	1.49	1.50	☐ SN74163	1.19	1.20
☐ SN7426	.25	.26	☐ SN7486	.39	.40	☐ SN74164	.99	1.00
☐ SN7427	.25	.26	☐ SN7488	1.95	1.96	☐ SN74165	1.25	1.26
☐ SN7430	.29	.30	☐ SN7490	.69	.70	☐ SN74166	1.25	1.26
☐ SN7432	.25	.26	☐ SN7491	.79	.80	☐ SN74173	1.25	1.26
☐ SN7437	.25	.26	☐ SN7492	.45	.46	☐ SN74174	1.49	1.50
☐ SN7438	.29	.30	☐ SN7493	.49	.50	☐ SN74175	.99	1.00
☐ SN7440	.19	.20	☐ SN7494	.69	.70	☐ SN74177	.79	.80
☐ SN7442	.69	.70	☐ SN7495	.69	.70	☐ SN74179	1.49	1.50
☐ SN7443	.69	.70	☐ SN7496	.69	.70	☐ SN74180	.49	.50
☐ SN7444	.65	.66	☐ SN7498	.69	.70	☐ SN74182	.69	.70
☐ SN7445	.99	1.00	☐ SN74100	1.49	1.50	☐ SN74190	1.49	1.50
☐ SN7446	1.35	1.36	☐ SN74107	.39	.40	☐ SN74191	1.75	1.76
☐ SN7447	1.25	1.26	☐ SN74112	.25	.26	☐ SN74192	.85	.86
☐ SN7448	1.35	1.36	☐ SN74113	.19	.20	☐ SN74193	.85	.86
☐ SN7450	.19	.20	☐ SN74114	.25	.26	☐ SN74194	1.25	1.26
☐ SN7451	.19	.20	☐ SN74121	.49	.50	☐ SN74195	.49	.50
☐ SN7453	.19	.20	☐ SN74123	.69	.70	☐ SN74197	.75	.76
☐ SN7454	.19	.20	☐ SN74125	.59	.60	☐ SN74199	1.75	1.76
☐ SN7455	.19	.20	☐ SN74126	.39	.40	☐ SN74200	5.50	5.51
☐ SN7460	.19	.20	☐ SN74132	1.25	1.26	☐ SN74251	1.75	1.76
☐ SN7462	.19	.20	☐ SN74140	.99	1.00	☐ SN74284	4.50	4.51
☐ SN7464	.19	.20	☐ SN74141	1.49	1.50	☐ SN74285	4.25	4.26

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

Type	Each	2 for	Type	Each	2 for	Type	Each	2 for
☐ LM300H	$.49	$.50	☐ LM370N-H	1.29	1.30	☐ LM741V-H	.29	.30
☐ LM301H-V	.45	.46	☐ LM374H	1.79	1.80	☐ LM1304	.79	.80
☐ LM308V-H	.79	.80	☐ LM376V	.29	.30	☐ LM1310	.99	1.00
☐ LM309K	1.29	1.30	☐ LM377N	2.25	2.26	☐ LM1312	1.99	2.00
☐ LM311H-V	.79	.80	☐ LM381N	1.69	1.70	☐ LM1414V	.79	.80
☐ LM318V	1.29	1.30	☐ LM531H	1.49	1.50	☐ LM1458V	.69	.70
☐ LM320H-5, 12, 15	1.29	1.30	☐ LM532H-N	.29	.30	☐ LM1800N	.99	1.00
☐ LM320K-15	1.29	1.30	☐ LM555V	.75	.76	☐ LM3028H	.65	.66
☐ LM320T-6, 5	1.29	1.30	☐ LM558V	.79	.80	☐ LM3900N	.49	.50
☐ LM322N	1.19	1.20	☐ LM561N	1.00	1.01	☐ LM3909V	1.75	1.76
☐ LM324N	1.75	1.76	☐ LM565N	.99	1.00	☐ LM4195	1.95	1.96
☐ LM339N	1.09	1.10	☐ LM703H	.49	.50	☐ LM4250	1.19	1.20
☐ LM340K-5, 6, 8, 12, 15, 18,	1.29	1.30	☐ LM704H	.29	.30	☐ LM75451	.39	.40
☐ LM340T-5, 6, 8, 12, 15, 18, 24	1.29	1.30	☐ LM709N-H	.25	.26	☐ LM75453	.39	.40
☐ LM350N	.59	.60	☐ LM710N	.39	.40	☐ LM75491	.79	.80
			☐ LM733N	.79	.80	☐ LM75492	.79	.80
			☐ LM739N	.89	.90	☐ LM75494	.59	.60

YOU GET 120-DAY MONEY BACK GUARANTEE

HI-POWER STUD RECTIFIERS

Cat. No. 6E3567 - 150 amp

V.		1¢	Sale
☐ 50	$ 2.95	2 for	$ 2.96
☐ 100	3.95	2 for	3.96
☐ 200	4.95	2 for	4.96
☐ 400	7.50	2 for	7.51
☐ 600	9.00	2 for	9.01
☐ 800	10.50	2 for	10.51
☐ 1000	12.50	2 for	12.51

Cat. No. 6E87U685 - 250 amp

V.	Each	1¢	SALE
☐ 50	$ 4.95	2 for	$ 4.96
☐ 100	6.50	2 for	6.51
☐ 200	7.50	2 for	7.51
☐ 400	8.50	2 for	8.51
☐ 600	10.50	2 for	10.51
☐ 800	13.00	2 for	13.01
☐ 1000	14.50	2 for	14.51

Order by Cat. No. & Voltage

10 AMP - POWER TABS! SCRS! TRIACS! QUADRACS!

Order by Cat. No. and voltage!
#6E1448 - TRIACS 6E1730 - SCR
#6E1590 - QUADRACS

PRV	Sale	2 for
☐ 50	$ .55	$ .56
☐ 100	.69	.70
☐ 200	.88	.89
☐ 400	1.19	1.20
☐ 600	1.59	1.60

25 AMP BRIDGE RECTIFIERS

Order by Cat. No. 6E2273 & voltage

V	Each	1¢	SALE
☐ 50	$1.95	2 for	$1.96
☐ 100	1.49	2 for	1.50
☐ 200	1.69	2 for	1.70
☐ 400	1.99	2 for	2.00
☐ 600	2.25	2 for	2.26
☐ 800	2.50	2 for	2.51

25 AMP POWER STUD SCRS, TRIACS

Cat. No. 6E-14A147 (SCRs)
Cat. No. 6E-60B86A (Triacs)

V.	Each	1¢	SALE
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☐ 200	1.95	2 for	1.96
☐ 400	2.50	2 for	2.51
☐ 600	2.95	2 for	2.96

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• Miniature! • 1.5 Amp! Order by Cat. No. and Type No.

Cat. No.	Type No.	PIV	Price	1¢ MORE!
☐ 6E2377	1N4001	50	10 for $.65	20 for .66
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☐ 6E2379	1N4003	200	10 for .85	20 for .86
☐ 6E2380	1N4004	400	10 for .99	20 for 1.00
☐ 6E2381	1N4005	600	10 for 1.29	20 for 1.30
☐ 6E2382	1N4006	800	10 for 1.39	20 for 1.40
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1¢ SALE

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Order by Cat. No. 6E60B84 and voltage

☐ 50V	10 for $.59	20 for $.60
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☐ 400V	10 for .89	20 for .90
☐ 600V	10 for 1.09	20 for 1.10
☐ 800V	10 for 1.19	20 for 1.20

MICRO MINI TOGGLE SWITCHES!

3 Amps, 125 VAC contacts, with chrome handles, complete with mounting hardware.

Cat. No	Type	Sale	2 for
☐ 6E3936	SPDT	$1.29	$1.30
☐ 6E5085	SPDT*	1.39	1.40
☐ 6E4037	DPDT	1.45	1.46
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* Center OFF

LYTIC KLINIC Electrolytic capacitors

Order by Cat. No. 6E3269 and value

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

6 AMP CARTWHEEL RECTIFIERS

Cat. 6E3584

V.	Each	1¢	SALE
☐ 50	$ .36	2 for	$ .37
☐ 100	.45	2 for	.46
☐ 200	.61	2 for	.62
☐ 400	.79	2 for	.80
☐ 600	.90	2 for	.91
☐ 800	1.19	2 for	1.20
☐ 1000	1.39	2 for	1.40

*AXIAL LEADS

BUY 1 AT OUR SALE PRICE — GET 2 FOR 1¢ MORE

LEDS!

YOUR CHOICE 5 for $1.00
1¢ SALE 10 for $1.01

Order by Cat. No.
- ☐ #6E2135 JUMBO RED LEDS
- ☐ #6E2137 MICRO RED LEDS
- ☐ #6E2790 JUMBO RED CLEAR LEDS
- ☐ #6E2792 JUMBO TAPERED AMBER
- ☐ #6E2140 MICRO GREEN LEDS

ZENERS!

Order by Cat. No. 6E5210 & voltage & wattage!

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

5 WATTS	Sale	1¢ SALE
☐ 3.3V	3 for $1.	6 for $1.01
☐ 6. V	3 for 1.	6 for 1.01
☐ 6.2V	3 for 1.	6 for 1.01
☐ 8.2V	3 for 1.	6 for 1.01
☐ 9.1V	3 for 1.	6 for 1.01
☐ 12. V	3 for 1.	6 for 1.01
☐ 15. V	3 for 1.	6 for 1.01
☐ 18. V	3 for 1.	6 for 1.01
☐ 24. V	3 for 1.	6 for 1.01
☐ 30. V	3 for 1.	6 for 1.01

THIS NEW LIST OF "ONE-CENTERS" HELPS FIGHT INFLATION!

Quan. Description (Order by Cat. No. in parenthesis)	Sale	1¢SALE
☐ 1 — WOODGRAIN CABINET, 3½ x 10 x ¼" deep, spkrs, alarms. (#6E5201)	$1.49	2 for $1.50
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☐ 1 — SPST RELAY, norm. open 12-24 VDC, 1250 ohms, dip style (#6E5175)	1.00	2 for 1.01
☐ 1 — VEEDER ROOT COUNTER, 000-999, resettable, panel mt. (#6E5081)	1.49	2 for 1.50
☐ 2 — DUAL GATE MOSFET, sim. to 3N200, 3N187, for RF & Mixer (#6E5101)	1.00	4 for 1.01
☐ 1 — 8-TRACK TAPE HEAD, with plug'n' cord (#6E3468)	2.50	2 for 2.51
☐ 10 CALCULATOR KEYBOARDS, 20 keys and more (6E3524)	$2.00	20 for $2.01
☐ 15 SLIDE VOLUME CONTROLS, asstd values (6E3057)	2.00	30 for 2.01
☐ 10 CRYSTALS, may include CB, Ham & more (6E3250)	2.00	20 for 2.01
☐ 150 MOLEX IC SOCKETS, on a strip, cut to length (6E3144)	2.00	300 for 2.01
☐ 100 TERMINAL STRIPS, from 2 lugs up (6E3136)	2.00	200 for 2.01
☐ 30 NE-2NEON LAMPS, all 100% good (6E2613)	2.00	60 for 2.01
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SN7409N	20	SN7483N	59	SN74170N	1 59
SN7410N	18	SN7485N	79	SN74172N	6 00
SN7411N	25	SN7486N	35	SN74173N	1 25
SN7412N	25	SN7489N	1 75	SN74174N	89
SN7413N	40	SN7490N	45	SN74175N	79
SN7414N	70	SN7491N	59	SN74176N	79
SN7416N	25	SN7492N	43	SN74177N	79
SN7417N	25	SN7493N	43	SN74179N	1 95
SN7420N	20	SN7494N	65	SN74180N	.79
SN7421N	29	SN7495N	65	SN74181N	1 95
SN7422N	39	SN7496N	65	SN74182N	79
SN7423N	25	SN7497N	3 00	SN74184N	1 95
SN7425N	29	SN74100N	89	SN74185N	1 95
SN7426N	29	SN74107N	35	SN74186N	9 95
SN7427N	25	SN74109N	35	SN74188N	3 95
SN7429N	39	SN74116N	1 95	SN74190N	1 25
SN7430N	20	SN74121N	35	SN74191N	1 25
SN7432N	25	SN74122N	39	SN74192N	79
SN7437N	25	SN74123N	49	SN74193N	79
SN7438N	25	SN74125N	.49	SN74194N	89
SN7439N	25	SN74126N	49	SN74195N	69
SN7440N	20	SN74132N	75	SN74196N	89
SN7441N	89	SN74136N	75	SN74197N	89
SN7442N	49	SN74141N	79	SN74198N	1 49
SN7443N	75	SN74142N	2 95	SN74199N	1 49
SN7444N	75	SN74143N	2 95	SN74200N	5 59
SN7445N	75	SN74144N	2 95	SN74251N	1 79
SN7446N	69	SN74145N	79	SN74279N	79
SN7447N	59	SN74147N	1 95	SN74283N	2 25
SN7448N	79	SN74148N	1 29	SN74284N	3 95
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74C00

74C00	39			74C163	3 00
74C02	55			74C164	3 25
74C04	75	74C89	6 49	74C173	2 60
74C08	75	74C90	3 00	74C192	3 49
74C10	65	74C93	2 00	74C193	2 75
74C14	3 00	74C95	2 00	74C195	2 75
74C20	65	74C107	1 25	74C922	9 95
74C30	65	74C151	2 90	74C923	8 95
74C42	2 15	74C154	3 00	74C925	14 95
74C48	4 75	74C157	2 15	74C926	11 95
74C73	1 50	74C160	3 25	80C95	1 50
74C74	1 15	74C161	3 25	80C97	1.50

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78MG	1 75			LM733N	1 00
LM300H	80			LM739N	1 19
LM301H	35			LM741CH	35
LM301CN	35			LM741CN	35
LM302H	75	LM340T-8	1 25	LM741 14N	39
LM304H	1 00	LM340T 12	1 25	LM747H	79
LM305H	60	LM340T-15	1 25	LM747N	79
LM307CN/H	35	LM340T 18	1 25	LM748H	39
LM308H	1 00	LM340T-24	1 25	LM748N	39
LM308CN	1 00	LM350N	1 00	LM1303N	90
LM309H	1 10	LM351CN	65	LM1304N	1 19
LM309K	1 25	LM370N	1 15	LM1305N	1 40
LM310CN	1 15	LM373N	3.25	LM1307N	85
LM311H	90	LM377N	4 00	LM1310N	2 95
LM311N	90	LM380N	1 25	LM1351N	1 65
LM317K	6 50	LM380CN	99	LM1414N	1 75
LM318CN	1 50	LM381N	1 79	LM1458CN/H	59
LM319N	1 30	LM382N	1 79	MC1488	1 95
LM320K-5	1 35	NE501N	8 00	MC1489	1 95
LM320K 5 2	1 35	NE510A	6 00	LM1496N	95
LM320K-12	1 35	NE529A	4.95	LM1556V	1 75
LM320K-15	1 35	NE531H	3 00	MC1741SCP	3 00
LM320K 18	1 35	NE536T	6 00	LM2901N	2 95
LM320K-24	1 35	NE540L	6 00	LM3053	1 50
LM320T-5	1 25	NE550N	1 30	LM3065N	69
LM320T-5 2	1 25	NE555V	39	LM3900N(3401)	49
LM320T-8	1 25	NE556	99	LM3905N	89
LM320T 12	1 25	NE560B	5 00	LM3909	1 25
LM320T-15	1 25	NE561B	5 00	MC5558V	1.00
LM320T 18	1 25	NE562B	5 00	LM7525N	90
LM320T-24	1 25	NE565H	1 75	LM7534N	75
LM323K-5	5 95	NE565N	1.25	8038B	4 95
LM324N	1 80	NE566CN	1 75	LM75450	49
LM339N	99	NE567H	1 25	75451CN	39
LM340K 5	1 35	NE567V	99	75452CN	39
LM340K 6	1 35	NE570	10 50	75453CN	39
LM340K-8	1 35	LM703CN/H	45	75454CN	39
LM340K 12	1 35	LM709H	29	75491CN	79
LM340K 15	1 35	LM709N	29	75492CN	89
LM340K-18	1 35	LM710N	79	75494CN	89
LM340K-24	1 35	LM711N	39	RC4151	5 95
LM340T-5	1 25	LM723H	55	RC4194	5 95
LM340T-6	1 25	LM723N	55	RC4195	4 49

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74LS02	23			74LS157	69
74LS03	23	74LS74	35	74LS160	89
74LS04	29	74LS75	49	74LS161	89
74LS05	29	74LS76	35	74LS162	89
74LS08	23	74LS83	75	74LS163	89
74LS10	23	74LS85	99	74LS164	99
74LS13	49	74LS86	35	74LS175	79
74LS14	99	74LS90	49	74LS181	2 49
74LS20	23	74LS92	59	74LS190	89
74LS26	29	74LS93	59	74LS191	89
74LS27	29	74LS95	79	74LS192	89
74LS28	29	74LS96	89	74LS193	89
74LS30	23	74LS107	35	74LS194	89
74LS32	29	74LS109	35	74LS195	89
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XC22	Yellow	4/$1	XC526	Green	4/$1	XC556	Green	4/$1	INFRA-RED LED		
XC22	Orange	4/$1	XC526	Yellow	4/$1	XC556	Yellow	4/$1	¼" x ¼" x 1.16		
SSL-22	RT	4/$1	XC526	Clear	4/$1	XC556	Orange	4/$1	Flat		5/$1.00
						XC556	Clear	7/$1			

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	270	2 95	MAN 6680	Common Cathode-orange	560	99
MAN 2	5 x 7 Dot Matrix-red	300	4 95	MAN 6710	Common Anode-red-D D	560	99
MAN 3	Common Cathode-red	125	25	MAN 6730	Common Anode-red ±1	560	99
MAN 4	Common Cathode-red	187	1 95	MAN 6740	Common Cathode-red-D D	560	99
MAN 52	Common Anode-green	300	1 25	MAN 6750	Common Cathode-red ±1	560	99
MAN 71	Common Anode-red	300	1 25	MAN 6760	Common Anode-red	560	99
MAN 72	Common Anode-red	300	99	MAN 6780	Common Cathode-red	560	.99
MAN 74	Common Cathode-red	300	1 25	DL701	Common Anode-red ±1	300	99
MAN 81	Common Anode-yellow	300	99	DL702	Common Cathode-red	300	1 25
MAN 82	Common Anode-yellow	300	99	DL704	Common Cathode-red	300	99
MAN 84	Common Cathode-yellow	300	99	DL707	Common Anode-red	300	99
MAN 3620	Common Anode-orange	300	99	DL741	Common Anode-red	600	1 25
MAN 3630	Common Anode-orange ±1	300	99	DL746	Common Anode-red ±1	630	1 49
MAN 3640	Common Cathode-orange	300	99	DL747	Common Anode-red	600	1 49
MAN 4610	Common Anode-orange	300	99	DL749	Common Cathode-red ±1	630	1 49
MAN 4640	Common Cathode-orange	400	99	DL750	Common Cathode-red	600	1 49
MAN 4710	Common Anode-red ±1	400	99	DL338	Common Cathode-red	110	35
MAN 4730	Common Anode-red	400	99	FND70	Common Cathode	250	69
MAN 4740	Common Cathode-red	400	99	FND359	Common Anode	350	75
MAN 4810	Common Anode-yellow	400	99	FND503	Common Cathode (FND500)	500	99
MAN 6610	Common Anode-orange-D D	560	99	FND507	Common Anode (FND510)	500	99
MAN 6630	Common Anode-orange	560	99	5082-7300	4 x 7 Sgl Digit-RHDP	600	19 95
MAN 6640	Common Cathode-orange-D.D	560	99	5082-7302	4 x 7 Sgl Digit-LHDP	600	19 95
MAN 6650	Common Cathode-orange ±1	560	99	5082-7304	Overrange character (±1)	600	15.00
MAN 6660	Common Anode-orange	560	99	5082-7340	4 x 7 Sgl Digit-Hexadecimal	600	22.50

RCA LINEAR

CA3013	2.15	CA3082	2.00
CA2023	2.56	CA3083	1.60
CA3035	2.48	CA3086	.85
CA3039	1.35	CA3089	3.75
CA3046	1.30	CA3130	1.39
CA3059	3.25	CA3140	1.25
CA3060	3.25	CA3160	1.25
CA3080	.85	CA3401	.49
CA3081	2.00	CA3600	3.50

CALCULATOR CHIPS AND DRIVER

FCM3817	$5 00
MM5725	2 95
MM5736	1 95
MM5738	2 95
DM8864	2 00
DM8865	1 00
DM8887	75
DM8889	75
5030	7 95

CLOCK CHIPS

MM5309	$9 95
MM5311	4 95
MM5312	4 95
MM5314	4 95
MM5316	6 95
MM5318	9 95
MM5369	2 95
MM5841	9 95
7001	5 95

9374 - 7-segment LED driver common anode LEDs $ .99

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

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

SOLDERTAIL STANDARD (TIN)

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

SOLDERTAIL STANDARD (GOLD)

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

WIRE WRAP SOCKETS (GOLD) LEVEL #3

8 pin WW	$.40	38	35	22 pin WW	95	85	75
10 pin WW	45	41	37	24 pin WW	1.05	95	85
14 pin WW	39	38	37	28 pin WW	1.40	1.25	1.10
16 pin WW	43	42	41	36 pin WW	1.59	1.45	1.30
18 pin WW	75	68	62	40 pin WW	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea	10 OHM 12 OHM 15 OHM 18 OHM 22 OHM	27 OHM 33 OHM 39 OHM 47 OHM 56 OHM	1/4 WATT 5%	50 PCS
ASST. 2	5 ea	68 OHM 82 OHM 100 OHM 120 OHM 150 OHM	180 OHM 220 OHM 270 OHM 330 OHM 390 OHM	1/4 WATT 5%	50 PCS
ASST. 3	5 ea	470 OHM 560 OHM 680 OHM 820 OHM 1K	1.2K 1.5K 1.8K 2.2K 2.7K	1/4 WATT 5%	50 PCS
ASST. 4	5 ea	3.3K 3.9K 4.7K 5.6K 6.8K	8.2K 10K 12K 15K 18K	1/4 WATT 5%	50 PCS.
ASST. 5	5 ea	22K 27K 33K 39K 47K	56K 68K 82K 100K 120K	1/4 WATT 5%	50 PCS
ASST. 6	5 ea	150K 180K 220K 270K 330K	390K 470K 560K 680K 820K	1/4 WATT 5%	50 PCS
ASST. 7	5 ea	1M 1.2M 1.5M 1.8M 2.2M	2.7M 3.3M 3.9M 4.7M 5.6M	1/4 WATT 5%	50 PCS

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

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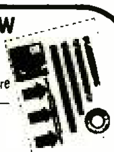
WIRE-WRAP KIT — WK-2-W



WRAP • STRIP • UNWRAP
- Tool for 30 AWG Wire
- Roll of 50 Ft White or Blue 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped wire

$12.95

WIRE WRAP TOOL WSU-30
WRAP • STRIP • UNWRAP - $6.95

WIRE WRAP WIRE — 30 AWG

25 ft min $1.25 50 ft $1.95 100 ft. $2.95 1000 ft. $15.00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

WIRE DISPENSER — WD-30
- 50 ft. roll 30 AWG KYNAR wire wrap wire **$3.95 ea.**
- Cuts wire to desired length
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REPLACEMENT DISPENSER SPOOLS FOR WD 30
Specify blue, yellow, white or red **$1.98/spool**

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Micro-Power version of the popular 555 Timer and directly interchangeable. Dissipates 1/15th the power and operates down to 2.7 volts. Perfect for battery operation and CMOS circuits

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Precision timing circuit for generating timing pulses in minutes, hours and days or up to 1 year by using two. Reduces cost of time delay circuits. Basic 555 Timer with built-in 8-bit Counter.

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XR205	$8 40	XR1489	1 39	XR2556	$3 20
XR210	4 40	XR1800	3 20	XR2567	2 99
XR215	4 40	XR2206	4 40	XR3403	1 25
XR320	1 55	XR2207	3 85	XR4136	1 25
XR555	39	XR2208	5 20	XR4151	2 85
XR556	99	XR2209	1 75	XR4194	1 45
XR567CP	99	XR2211	5 25	XR4202	3 60
XR567CT	1 25	XR2212	4 35	XR4212	2 05
XR1310P	1 30	XR2240	3 45	XR4558	75
XR1468CN	3 85	XR2264	4 25	XR4739	1 15
XR1488	1 39			XR4741	1 4"

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3 3	400m	4/1 00	1N4005	600 PIV	1 AMP	10/1 00
1N751A	5 1	400m	4/1 00	1N4006	800 PIV	1 AMP	10/1 00
1N752	5 6	400m	4/1 00	1N4007	1000 PIV	1 AMP	10/1 00
1N753	6 2	400m	4/1 00	1N3600	50	200m	6/1 00
1N754	6 8	400m	4/1 00	1N4148	75	10m	15/1 00
1N959	8 2	400m	4/1 00	1N4154	35	10m	12/1 00
1N965B	15	400m	4/1 00	1N4305	75	25m	20/1 00
1N5232	5 6	500m	28	1N4734	5 6	1w	28
1N5234	6 2	500m	28	1N4735	6 2	1w	28
1N5235	6 8	500m	28	1N4736	6 8	1w	28
1N5236	7 5	500m	28	1N4738	8 2	1w	28
1N456	25	40m	6/1 00	1N4742	12	1w	28
1N458	150	7m	6/1 00	1N4744	15	1w	28
1N485A	180	10m	5/1 00	1N1183	50 PIV	35 AMP	1 60
1N4001	50 PIV	1 AMP	12/1 00	1N1184	100 PIV	35 AMP	1 70
1N4002	100 PIV	1 AMP	12/1 00	1N1185	150 PIV	35 AMP	1 70
1N4003	200 PIV	1 AMP	12/1 00	1N1186	200 PIV	35 AMP	1 80
1N4004	400 PIV	1 AMP	12/1 00	1N1188	400 PIV	35 AMP	3 00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1 95
C38M	35A @ 600V	SCR	1 95
2N2328	1 6A @ 300V	SCR	50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1 95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1 95

TRANSISTORS

C106B1	50			2N3904	4/1 00
MPSA05	30	2N3055	89	2N3905	4/1 00
MPSA06	5/1 00	MJE3055	1 00	2N3906	4/1 00
TIS97	6/1 00	2N3392	5/1 00	2N4013	3/1 00
TIS98	6/1 00	2N3398	5/1 00	2N4123	6/1 00
TIS133	5/1 00	PN3567	3/1 00	PN4249	4/1 00
TIS135	5/1 00	PN3568	4/1 00	PN4250	4/1 00
40409	1 75	PN3569	4/1 00	2N4400	4/1 00
40410	1 75	MPS3638A	5/1 00	2N4401	4/1 00
40673	1 75	MPS3702	5/1 00	2N4402	4/1 00
2N918	4/1 00	2N3704	5/1 00	2N4403	4/1 00
2N2219A	3/1 00	MPS3704	5/1 00	2N4409	5/1 00
2N2221A	4/1 00	2N3705	5/1 00	2N5086	4/1 00
2N2222A	5/1 00	MPS3705	5/1 00	2N5087	4/1 00
2N2369	5/1 00	2N3706	5/1 00	2N5088	4/1 00
2N2369A	4/1 00	MPS3706	5/1 00	2N5089	4/1 00
MPS2369	5/1 00	2N3707	5/1 00	2N5129	5/1 00
2N2484	4/1 00	2N3711	5/1 00	PN5134	5/1 00
2N2906	4/1 00	2N3724A	65	PN5138	5/1 00
2N2907	5/1 00	2N3725A	1 00	2N5139	5/1 00
2N2925	5/1 00	2N3772	2 25	2N5210	5/1 00
MJE2955	1 25	2N3823	1 00	2N5449	3/1 00
2N3053	2/1 00	2N3903	4/1 00	2N5951	3/1 00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	05	04	03	001µF	05	04	035
22 pf	05	04	03	0047µF	05	04	035
47 pf	05	04	03	01µF	05	04	035
100 pf	05	04	03	022µF	06	05	04
220 pf	05	04	03	047µF	06	05	04
470 pf	05	04	035	1µF	12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

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

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

1/35V	28	23	17	1 5/35V	30	26	21
15/35V	28	23	17	2 2/25V	31	27	22
22/35V	28	23	17	3 3/25V	31	27	22
33/35V	28	23	17	4 7/25V	32	28	23
47/35V	28	23	17	6 8/25V	36	31	25
68/35V	28	23	17	10/25V	40	35	.29
1 0/35V	28	23	17	15/25V	63	50	40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
47/50V	15	13	10	.47/25V	15	13	10
1 0/50V	16	14	11	47/50V	16	14	11
3 3/50V	14	12	09	1 0/16V	15	13	10
4.7/25V	15	13	10	1 0/25V	16	14	11
10/25V	15	13	10	1 0/50V	16	14	11
10/50V	16	14	12	4 7/16V	15	13	10
22/25V	17	15	12	4 7/25V	15	13	10
22/50V	24	20	18	4 7/50V	16	14	11
47/25V	19	17	15	10/16V	14	12	09
47/50V	25	21	19	10/25V	15	13	10
100/25V	.24	20	18	10/50V	16	14	12
100/50V	35	30	28	47/50V	24	21	19
220/25V	.32	28	25	100/16V	19	15	.14
220/50V	45	41	38	100/25V	24	20	18
470/25V	33	29	27	100/50V	35	30	28
1000/16V	55	50	45	220/16V	23	17	16
2200/16V	70	62	.55	470/25V	31	28	.26

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21L02 (450ns) Static Rams 100 @ $1.10 ea.	1702A E—PROM 8 @ $3.75 ea.	6502 Microprocessor 5 @ $11.00 ea.	2708 (450ns) E—PROM 8 @ $11.00 ea.	21L02 (250ns) Static Rams 100 @ $1.36 ea.	Z—80A Microprocessor 5 @ $25.00 ea.	8212 8 Bit I/O Port 25 @ $3.00 ea.	4116 (200ns) 16K Dyn. Ram 16 @ $24.00 ea.
Z-80 Microprocessor 5 @ $20.00 ea.	8224-4 Clk.Gen.&Dvr. 25 @ $8.75 ea.	410D (200ns) Static Ram 100 @ $8.75 ea.	4096 Dynamic Ram 100 @ $3.50 ea.	4200A (200ns) Static Rams 25 @ $10.00 ea.	74LS367 Hex Buffer 100 @ .70¢ ea.	74LS368 Hex Inverter 100 @ .70¢ ea.	2513 (5v) Character Gen. 5 @ $9.00 ea.

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Z80A	28.00
CDP1802CD	19.95
2650	24.95
AM2901	22.95
6502	11.95
6800	18.95
6802	25.00
8008-1	9.95
8035	22.00
8080A	11.95
8085	27.00
TMS9900TL	75.00

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N8T20	3.39
N8T26	2.10
N8T95	1.35
N8T96	1.35
N8T97	1.35
N8T98	1.35
81LS95	2.00
81LS97	2.00
1488	1.75
1489	1.75
D3205	4.00
D3207A	4.55
D3208A	14.20
D3211	10.00
B3222	9.75
B3242	10.15
D3245	5.60
C3404	6.75
P3408A	12.00
P4201A	5.20
MM5320	7.50
MM5369	1.90
TMS5501	24.95
DM8130	2.90
DM8131	2.75
DM8833	2.50
DM8835	2.50
DM8837	1.75
MK50240	20.00
MK50250	15.00

8080A SUPPORT DEVICES

8212	3.50
8214	9.00
8216	3.75
8224	3.50
8224-4	9.95
8226	3.95
8228	7.95
8238	7.50
8251	9.95
8253	21.95
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8257	21.95
8259	21.95
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AY5-3600	13.75

PROM'S

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2704	15.00
2708	12.00
2716	30.00
2716 Intl	38.00
2758	26.60
D3601	4.50
D3604	13.00
5203AQ	5.00
5204AQ	7.50
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6834-1	14.95
82S23B	4.00
82S129B	4.25
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68B10P	6.00
6820P	7.50
6821P	7.50
6828P	11.25
6834P	16.95
6850P	9.75
6852P	11.75
6860P	10.00
6862P	14.50
6871P	28.00
6875P	8.75
6880P	2.50

Z80 SUPPORT DEVICES

3881	12.95
3882	12.95

STATIC RAMS

21L02	1.50	1.24	1.18
21L02 (350)	1.60	1.35	1.25
21L02 (250)	1.75	1.60	1.50
4100	10.75	10.00	9.25
1101A	1.00	.90	.80
2101-1	2.95	2.75	2.60
2102	1.25	1.15	1.00
2111-1	3.95	3.50	3.25
2112-1	2.95	2.80	2.69
2114-3	11.00	10.00	9.25
2125L	11.10	9.00	8.30
2147	37.50		
31L01	2.50	2.35	2.00
3106	3.95	3.70	3.25
3107	3.95	3.70	3.25
TMS-4044	9.95	9.00	8.95
4200A	12.95		
TMS-4045	11.00	10.00	9.25
5101	8.30	7.40	7.25
74C89	3.25	3.05	2.85
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74S201	4.50	4.00	3.75
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P8156	21.00	18.00	
8599	1.88	1.75	1.60
9102BPC	1.65	1.45	1.30

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2513 5v upper	9.75
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566	1.50

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1103	1.00
2104	4.00
2107B	4.25
2107B-4	3.95
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TMS4070-2	32.00
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4116/416D	32.00
MM5270	4.50
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USRT

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AY5-1014A	8.25
TR1602B	5.25
TMS6011	5.95
IM6402	10.80
IM6403	10.80

JADE 8080A KIT

$100.00 KIT
BARE BOARD $30.00

E—PROM BOARDS

MR 8 (8K uses 2708) with 1K RAM	KIT	$99.50
MR 161 (16K uses 2716) with 1K RAM	KIT	$99.50
MM 16 (16K uses 2708)		$99.00
RAM N ROM (16K uses ... E PROM)	KIT	$117.00
JG 8 16 (uses 2708 or 2716)	KIT	$59.95
BARE BOARD		$30.00

TV-1

Convert TV set to Video Monitor
KIT $8.95

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8K

250ns	ASSEMBLED & TESTED	$189.95
450ns	ASSEMBLED & TESTED	$149.75
250ns	KIT	$169.95
450ns	KIT	$125.00
BARE BOARD		25.00

6800 ADAPTER to S-100 System KIT $12.95

16K

250ns	ASSEMBLED & TESTED	$435.00
450ns	ASSEMBLED & TESTED	$380.00
450ns	KIT	$335.00

32K

250ns	ASSEMBLED & TESTED	$850.00
450ns	ASSEMBLED & TESTED	$775.00
450ns	KIT	$675.00

DYNAMIC RAM BOARDS

On board Refresh power is provided with no wait states or cycle stealing required
+8VDC 400MA DC +18VDC 400MA DC and -18VDC 30MA DC

EXPANDABLE 32K

8K (375ns)	KIT	$151.00
16K (375ns)	KIT	$259.00
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EXPANDABLE 64K

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64K (375ns)	KIT	$995.00

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13 slot — w/front panel slot
BARE BOARD $35.00
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ASSEMBLED & TESTED

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WRITE & READ
EPROM
1702A — 2708 — 2716
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- Plugs directly into your ALTAIR IMSAI computer
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MEMORY PLUS

for KIM—1
8K RAM (21L02)
8K EPROM
ASSEMBLED & TESTED
$245.00

JADE Z80 KIT

—with PROVISIONS for ONBOARD 2708 and POWER ON JUMP

$135.00 EA. (2MHZ)
$149.95 EA. (4MHZ)
BARE BOARD $35.00

JADE Z80 "UPGRADE" KIT

Change your JADE 2MHz Z80 to a 4MHz version with this simple kit

only $17.95 with trade
$49.95 purchase.

To trade you must give us your 2MHz Z80 chip and 8224 clock driver

The "UPGRADE KIT" includes

Z80A chip	1.8K resistor
8224 4 clock driver	20 pf capacitor
36MHz crystal	

COMPU TIME CT 100

S100 BUS COMPATIBLE

TIME & CALENDAR

Microprocessors need the power that a real time clock can offer. Date and time becomes instantly available. COMPU/TIME does not have to be initialized every time the system is powered up. It possesses a crystal controlled time base to obtain superior accuracy and has two setable coincidence counters. Time, date, and counters are set via software.

COMPUTATIONAL FUNCTION

Microprocessors need to be complimented by hardware arithmetics to free up memory pages dedicated to floating point routines and mathmatical software. COMPU/TIME provides a 40 function calculator array so that algebraic, trigonometric, basic arthmetic problems can be solved without the need of developing sophisticated software.

Buy It Your Way

COMPU TIME	CT100	$199	KIT	$245	Assembled
COMPU only	C101	$149	KIT	$189	Assembled
TIME only	T101	$165	KIT	$205	Assembled
COMPU TIME	PC Board only	$80			

JADE VIDEO INTERFACE KIT

FEATURES $99.95

S-100 Bus Compatible
32 or 64 Characters per line
16 lines
Graphics (128 x 48 matrix)
Parallel & Compositive video
On board low-power memory

Powerful software included for cursor, home, EOL, Scroll Graphics/Character, etc.
Upper case, lower case & Greek
Black-on-white & white-on-black

full ASCII PROFESSIONAL KEYBOARDS

Full 128 Character ASCII
Tri-Mode MOS Encoding
MOS DTL TTL Compatable Output
Two-key Rollover
Level and Pulse Strobe
Shift and Alpha Lock
Selectable Parity
Positive or Negative Logic

MODEL 756 (56 keys)

PRICING INFORMATION

Model 756 (assembled)	$75.95
Model 756K (kit)	64.95
Model 702 Enclosure	29.95
Model 710 Numeric Pad	9.95
Model 756MF Mtg. Frame	8.95

CONNECTORS

DB — 25P	$3.00
DB — 25S	$4.00
COVER	$1.50
44 Pin — PC & EYE	$1.95
44 Pin — WW	$2.50
86 Pin — (6800) PC	$5.00
86 Pin — (COSMAC ELF) PC	$5.00
100 Pin — (Altair) PC	$4.50
100 Pin — (Imsai) PC	$3.75
100 Pin — (Imsai) WW	$4.25

JADE REAL TIME CLOCK FOR S-100 BUS

1 MHZ Crystal Oscillator
Two independent interrupts
One interrupt uses 16 bit counter in 10 USEC steps
Other interrupt is in decade steps from 100 USEC to 10 sec.
Both software programmable
Board can be selected by 128 device code pairs.
Complete documentation includes software to display time of day.
Double sided solder mask
Silk screen parts layout

JG RT ASSEMBLED & TESTED	$179.95
JG RT KIT	$124.95
BARE BOARD with Manual	$30.00

TARBELL CASSETTE INTERFACE

- Plugs directly into your IMSAI or ALTAIR*
- Fastest transfer rate 187 (standard) to 540 bytes/second
- Extremely Reliable — Phase encoded (self-clocking)
- 4 Extra Status Lines 4 Extra Control Lines
- 37 page manual included
- Device Code Selectable by DIP-switch
- Capable of Generating Kansas City tapes also
- No modification required on audio cassette recorder

JADE KIT* $99.95 ASSEMBLED $175.00
*(6 month warranty from JADE) MANUAL $4.00

JADE PARALLEL/SERIAL INTERFACE KIT

S-100 $124.95 KIT
2 Serial Interfaces with RS232 interfaces or 1 Kansas City cassette interface.
Serial interfaces are crystal controlled.
Selectable baud rates.
Cassette works up to 1200 baud.
1 parallel port.

DATA COMMUNICATIONS ADAPTER

80 103A Serial I/O and FSK modem for professional and hobby communications

- Completely compatible with your IMSAI, ALTAIR* SOL** or other S 100 microcomputers. Trademarks of *MITS, **Processor Technology
- Designed for use on the dial telephone or TWX networks, or 2-wire dedicated lines, meets all FCC regulations when used with a CBT coupler
- All digital modulation and demodulation with on board cyrstal clock and precision filter mean that NO ADJUSTMENTS ARE REQUIRED
  - Bell 103 standard frequencies
  - Automated dial (pulsed) and answer
  - Originate and answer mode
  - 110 or 300 BPS speed select
  - Complete self test capability
  - Character length, stop bit, and parity
  - 90 day warranty and full documentation

PRICES:

BARE BOARD and Manual	$49.95
Assembled (48 hr. burn in)	$279.95
JG DCA KIT	$159.95

NUMBER CRUNCHER

The CT200 is a number oriented microprocessor intended for use in those applications that require fast versatile mathematical solutions.
THIS IS NOT A CALCULATOR CHIP. THERE ARE NO KEY DELAYS.
The CT200 has a unique architecture that is designed to be a TASK processing system within a system. This unique architecture will allow the CT200 to work and run with ANY S100 BUS microprocessor system. It is completely compatible with Z80, 4MHZ version, also, 8080, 6800, 6502 microprocessor. A micro incoded instruction set allows programming in a calculator like language. The instruction set includes a full set of test and branch instructions. All decoding of S100 bus signals (for select or control functions) is performed with strobed latches to eliminate the possibility of glitches.

PRICE: $249.00
Includes Manual. ASSEMBLED & TESTED.

JADE Computer Products

5351 West 144th Street
LAWNDALE, CALIFORNIA 90260
(213) 679-3313

RETAIL STORE HOURS Monday — Friday 9—7
Saturday 9—5

Discounts available at OEM quantities. ADD $1.50 under 10 lbs. for shipping. California residents add 6% sales tax.

NEW CATALOG NOW AVAILABLE

COMPU/TIME CT 100

COMPU/TIME offers A Real Darn Clever Enhancement to users of IMSAI/ALTAIR Microprocessors

S100 BUS COMPATIBLE

TIME & CALENDAR

COMPU/TIME	CT100	$199 Kit	$245 Assembled
COMPU only	C101	$149 Kit	$189 Assembled
TIME only	T102	$165 Kit	$205 Assembled
COMPU/TIME PC Board only			$ 80

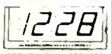
MM16 EPROM

- Utilizing up to 16 2708 EPROMS
- S-100 Bus Computer Systems
- Memory capacity of 8K or 16K bytes by DIP
- 8K boundary addressing by DIP Switch
- 0 to 4 wait cycles by DIP Switch
- Data output address input lines fully buffered
- Hi-grade glass-epoxy with plated-thru holes
- Epoxy solder masked

$99.00

FCS 8000A — 3½ Digit .8 Display

NEW! 25 Pin version with colon & am pm indicator



FRONT VIEW FSC8000

SPECIAL $3.75 ea.

- MAXIMUM FORWARD CURRENT 25 mA
- Connects almost one for one with 3817, 3817A or D 3817 available at $5.00 each
- Typical segment current 8mA except colon 10 hrs b & c and 10 min a & d which are 16 mA
- Forward voltage drop 1.5 volts

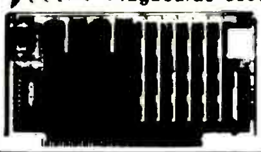
Vector

SLIT-N-WRAP WIRE WRAP TOOL

- Slits and opens insulation exposing bare wire
- No pre-cutting or pre-stripping
- Comes complete with two 100 ft spools #28 AWG wire

Model P180 $24.50

Vector Plugboards 8800V



Universal Microcomputer/Processor plugboard, use with S-100 bus complete with heat sink & hardware 5.3 x 10 x 1/16

$19.95

CHANNEL F

FAIRCHILD VIDEO ENTERTAINMENT SYSTEM

$129.95

- Freeze Action
- Speed Option
- Automatic time and scorekeeping
- Battery-free AC operation
- Dual controls with 8-way action
- Built-in Pro Hockey and Tennis games
- Easy hook-up on any B/W or Color Tv
- Factory warranty

Channel F — additional cartridges — $17.95 ea.

0811 — Tic-Tac-Toe/Shooting Gallery Quadra-doodle Doodle; 0812 — Desert Fox Shooting Gallery; 0813 — Blackjack (1 or 2 players); 0814 — Spitfire (1 or 2 players); 0815 Spacewar (2 players); 0818 Magic Numbers (computer logic); 0819 Drag strip (1 or 2 players); 0820 Maze (2 players); 0822 — Baseball (2 players)

D-SUB CONNECTORS

NO. PINS	PART NO	PRICE	COVER PRICE
9	DE-9P	1.49	1.25
9	DE-9S	2.15	
15	DA-15P	2.11	1.50
15	DA-15S	3.10	
25	DB-25P	3.00	1.50
25	DB-25S	4.00	
37	DE-37P	4.14	2.00
37	DE-37S	6.00	
50	DD-50P	5.40	2.25
50	DD-50S	8.00	

EDGE CONNECTORS

NO. PINS		TYPE		
20	DUAL	10 PIN	GOLD	$ .50
30	DUAL	15 PIN	GOLD	.75
44	DUAL	22 PIN	GOLD	1.95
44	DUAL	22 PIN	GOLD	2.50
80	DUAL	40 PIN	GOLD	4.95
86	DUAL	43 PIN	GOLD(6800)	5.00
100	DUAL	50 PIN	GOLD(IMSAI/ALTAIR)	4.25
100	DUAL	50 PIN	GOLD(IMSAI/ALTAIR)	4.95
100	DUAL	50 PIN	GOLD(NO EARS-IMSAI)	3.50
100	DUAL	50 PIN	TIN (.1 SPACING)	3.25

ALTAIR/IMSAI CARD GUIDES .25¢ EACH

CLOCK CHIPS

MM5309	6 Digit, BCD Outputs, Reset PIN	$9.95
MM5311	6 Digit, BCD Outputs 12 or 24 Hour	4.95
MM5312	4 Digit BCD Outputs 1 PPS Output	4.95
MM5314	6 Digit 12 or 24 Hour 50 or 60 Hz	4.95
MM5316	4 Digit Alarm 1 PPS Output	6.95
MM5318	Video Clock Chip For Use With (MM5841 $9.95)	9.95
CT7001	6 Digit Calendar, Alarm 12 or 24 Hour	5.95

Wire Wrap

	1-24	25-99	100-999	1K
10	39	36	32	26
14	34	33	31	29
16	36	34	32	30
18	70	60	54	40
20	[illegible]	75	67	55
22	95	[illegible]	72	59
24	[illegible]	[illegible]	72	59
28	[illegible]	[illegible]	80	71
36	1.40	1.25	1.00	[illegible]
40	1.56	1.40	1.20	[illegible]

I C SOCKETS

Lo Profile-Solder Tin

	1-24	25-99	100-999	1K & Up
(8)	15	14	13	12
(14)	25	20	16	14
(16)	25	20	18	16
(18)	28	27	26	20
(20)	34	33	30	239
(22)	36	35	34	28
(24)	36	35	34	289
(28)	44	43	42	367
(40)	60	58	57	493

7400 TTL Series

7400	18	7443	1.20	74100	1.25	74162	1.90
7401	20	7445	1.05	74107	40	74163	1.40
7402	20	7446	1.05	74109	45	74164	1.50
7403	20	7447	.85	74110	.80	74165	1.40
7404	20	7448	.95	74116	2.00	74166	1.50
7405	25	7450	20	74120	1.25	74167	3.00
7406	35	7451	20	74121	55	74170	2.00
7407	35	7453	20	74122	45	74172	9.75
7408	.25	7454	20	74123	95	74173	1.50
7409	.25	7460	20	74125	55	74174	1.10
7410	.20	7470	40	74126	.60	74175	1.20
7411	.25	7472	35	74128	65	74176	1.50
7412	40	7473	.40	74132	1.50	74177	90
7413	75	7474	.40	74136	1.80	74180	1.00
7414	70	7475	.70	74141	1.15	74181	2.00
7416	35	7476	.40	74142	4.00	74182	90
7417	40	7479	2.00	74144	4.00	74184	2.00
7420	20	7480	.89	74145	1.10	74185	2.00
7422	75	7482	1.50	74147	2.50	74186	12.00
7425	35	7483	85	74148	1.75	74190	1.40
7426	30	7485	1.10	74150	1.00	74191	1.25
7427	35	7486	40	74151	1.10	74192	1.10
7428	40	7489	2.25	74153	1.10	74193	1.10
7429	.40	7490	55	74154	1.10	74194	1.20
7430	25	7491	1.10	74155	1.10	74195	1.00
7432	30	7492	60	74156	1.10	74196	1.10
7433	40	7493	60	74157	1.20	74197	1.30
7437	30	7494	85	74158	1.75	74198	1.50
7438	35	7495	90	74159	3.60	74199	1.75
7439	36	7496	80	74160	1.30		
7440	20	7497	4.00	74161	1.30		
7441	75						
7442	.50						

CMOS

34001	40	4050	61	4517	8.50	MM74C173N	1.39
4000	25	4051	1.10	4518	1.65	MM74C174N	1.39
4001	25	4052	1.10	4519	90	MM74C175N	1.39
4002	25	4053	1.10	4520	1.65	MM74C192N	1.71
4004	3.50	4060	3.25	4521	3.25	MM74C193N	1.71
4006	1.40	4061	7.00	4522	1.75	MM74C195N	1.61
4007	25	4063	2.50	4527	3.00	MM74C200N	10.45
4008	1.25	4066	85	4528	1.75	MM74C221N	[illegible]
4009	48	4067	6.00	4583	1.45	MM74C901N	84
4010	48	4068	35	4584	75	MM74C902N	84
4011	25	4069	35	MM74C00N	38	MM74C903N	84
4012	25	4070	85	MM74C02N	38	MM74C905N	11.20
4013	60	4071	35	MM74C04N	38	MM74C906N	84
4014	1.25	4072	35	MM74C08N	38	MM74C907N	84
4015	1.25	4073	35	MM74C10N	38	MM74C908N	3.80
4016	59	4075	35	MM74C14N	2.18	MM74C909N	2.52
4017	1.25	4076	1.85	MM74C20N	38	MM74C910N	10.45
4018	1.25	4077	42	MM74C30N	38	MM74C914N	2.18
4019	70	4078	35	MM74C32N	38	MM74C915N	1.71
4020	1.25	4081	35	MM74C42N	1.42	MM74C918N	4.19
4021	1.25	4082	35	MM74C48N	2.13	MM74C922N	5.65
4022	1.25	4085	1.35	MM74C73N	84	MM74C923N	5.75
4023	35	4086	1.45	MM74C74N	87	MM74C925N	12.00
4024	1.00	4089	3.00	MM74C76N	84	MM74C926N	12.00
4025	35	4093	1.75	MM74C83N	2.00	MM74C927N	12.00
4026	2.25	4098	2.50	MM74C85N	2.00	MM74C928N	12.00
4027	60	4160	1.75	MM74C86N	99	MM80C97N	84
4028	1.25	4161	1.75	MM74C89N	6.75	MM80C98N	84
4029	1.50	4162	1.75	MM74C90N	1.32		
4030	60	4163	1.75	MM74C93N	1.32		
4032	1.60	4174	1.75	MM74C95N	1.61		
4033	2.00	4175	1.60	MM74C107N	1.89		
4034	3.50	4194	1.80	MM74C150N	5.67		
4035	1.60	4501	38	MM74C151N	3.80		
4038	1.60	4502	1.75	MM74C154N	5.67		
4040	1.50	4503	1.15	MM74C157N	3.40		
4041	1.45	4506	70	MM74C160N	1.71		
4042	1.25	4507	1.00	MM74C161N	1.71		
4043	1.20	4508	4.00	MM74C162N	2.57		
4044	1.25	4510	1.75	MM74C163N	1.71		
4045	2.50	4511	2.00	MM74C164N	1.61		
4046	1.95	4512	1.50	MM74C165N	1.61		
4047	2.50	4514	4.75				
4048	1.00	4515	4.75				
4049	61	4516	1.75				

74LS00

74LS00	29	74LS60	29	74LS151	1.25	74LS196	1.87
74LS01	29	74LS73	49	74LS153	1.25	74LS197	1.87
74LS02	29	74LS74	49	74LS154	3.65	74LS221	2.00
74LS03	29	74LS75	69	74LS155	1.25	74LS240	3.00
74LS04	29	74LS76	49	74LS156	1.85	74LS241	3.00
74LS05	35	74LS78	65	74LS157	1.50	74LS242	3.00
74LS08	29	74LS83AN	1.75	74LS158	1.55	74LS243	7.60
74LS09	50	74LS85	2.25	74LS160	1.95	74LS244	2.60
74LS10	29	74LS86	69	74LS161	1.95	74LS247	1.68
74LS11	40	74LS90	89	74LS162	1.95	74LS248	1.35
74LS12	50	74LS92	89	74LS163	1.95	74LS251	1.91
74LS13	69	74LS93	89	74LS164	1.95	74LS253	1.75
74LS14	1.70	74LS95	1.50	74LS165	2.00	74LS257	1.75
74LS15	40	74LS96	1.89	74LS166	2.00	74LS258	1.95
74LS20	29	74LS107	55	74LS168	2.00	74LS259	4.25
74LS21	40	74LS109	59	74LS169	2.00	74LS260	50
74LS22	40	74LS112	59	74LS170	4.00	74LS266	68
74LS26	39	74LS113	60	74LS173	2.00	74LS273	7.50
74LS27	39	74LS114	60	74LS174	1.87	74LS279	79
74LS28	39	74LS122	60	74LS175	1.95	74LS283	1.85
74LS30	29	74LS123	1.25	74LS181	3.69	74LS289	6.16
74LS32	39	74LS124	1.80	74LS189	6.16	74LS290	1.56
74LS37	48	74LS125	87	74LS190	2.49	74LS293	1.56
74LS38	48	74LS126	1.07	74LS191	2.49	74LS295	2.00
74LS40	39	74LS132	1.25	74LS192	2.25	74LS298	2.00
74LS42	1.20	74LS136	59	74LS193	2.25	74LS352	1.65
74LS47	1.25	74LS138	1.25	74LS194	1.89	74LS353	1.85
74LS48	1.68	74LS139	1.25	74LS195	1.87	74LS365	87
74LS51	29					74LS366	85
74LS52	29					74LS367	87
74LS54	29					74LS368	87
74LS55	29					74LS386	68
						74LS390	3.00
						74LS395	2.25
						74LS670	3.95

LINEAR

LM300H	1.70	LM702H	79	LM2111N	1.35
LM301AH	35	LM703LN	45	LM2900N	90
LM301AN	35	LM703CH	45	LM2901N	2.95
LM302H	75	LM709CH	40	LM2902N	3.00
LM306H	2.50	LM710CH	60	LM2903N	1.60
LM307H	55	LM710N	75	LM2904N	1.60
LM307N	35	LM711CH	39	LM2917N	2.00
LM308AH	3.75	LM711CN	39	LM3046N	1.25
LM308AN	3.00	LM723CH	55	LM3053N	1.50
LM308H	1.00	LM723CN	55	LM3064N	1.75
LM308N	1.00	LM725CH	2.50	LM3065N	1.00
LM310H	1.15	LM725CN	3.00	LM3067N	2.60
LM310N	2.00	LM733CH	1.00	LM3075N	1.75
LM311D	2.00	LM733CN	1.00	LM3089N	3.00
LM311H	90	LM739N	1.19	LM3146N	2.00
LM311N	80	LM741CH	35	LM3302N	2.00
LM311N	80	LM741CN	35	LM3401N	80
LM312H	2.70	LM741CJ	39	LM3900N	49
LM318H	1.50	LM741CN	39	LM3905N	89
LM318N	1.50	LM747CH	79	LM3909N	90
LM319N	1.25	LM747CN	79	LM3911N	1.25
LM321H	3.00	LM748CH	39	LM4024N	2.75
LM322N	3.00	LM748CN	39	LM4044N	3.00
LM324N	1.65	LM7600N	3.00	LM4250CH	2.00
LM339AN	3.00	LM1303N	90	LM4250CN	2.00
LM339N	99	LM1304N	1.19	LM4558N	75
LM348N	1.85	LM1305N	1.40	LM5556N	1.75
LM350N	1.00	LM1307N	85	LM5558N	1.00
LM358N	1.00	LM1310N	2.25		
LM370H	1.15	LM1358N	1.00		
LM370N	2.75	LM1414N	1.75		
LM373N	2.95	LM1458H	1.30		
LM375N	3.00	LM1458N	59		
LM377N	2.00	LM1468N	2.90		
LM380N	1.05	LM1488N	1.95		
LM380N	1.05	LM1489N	1.95		
LM380N	1.05	LM1496H	95		
LM381N	1.75	LM1496N	95		
LM382N	1.75	LM1556N	1.75		
LM386H	85	LM1596J	2.25		
LM387AN	75	LM1800N	1.90		
LM387N	95	LM1808N	2.00		
LM388N	1.25	LM1810N	2.00		
LM389N	1.25	LM1812N	4.00		
NE531T/V	2.00	LM1820N	1.25		
NE550A	1.30	LM1830N	2.00		
NE555V	39	LM1845N	1.75		
NE556B	1.25				
NE560B	5.00				
NE562B	5.00				
NE565B	1.50				
NE566B	2.00				
NE566T/V	1.75				
NE567V	1.59				

RCA LINEAR SERIES

CA3013	2.15
CA3023	2.56
CA3035	2.48
CA3039	1.35
CA3046	1.30
CA3059	3.25
CA3060	3.25
CA3080	85
CA3081	2.00
CA3082	2.00
CA3083	1.60
CA3086	85
CA3089	3.75
CA3130	1.39
CA3140	1.25
CA3401	49
CA3600	3.50

MICROPROCESSOR CRYSTALS

FREQUENCY	price
1.0 MHz	5.95
1.8432 MHz	9.80
2.0 MHz	5.95
2.097152 MHz	8.50
2.4576 MHz	8.50
2.667 MHz	8.50
3.00 MHz	8.50
3.20 MHz	8.50
3.2768 MHz	8.50
3.579545 MHz	1.25
4.0 MHz	4.95
4.0 MHz	4.95
4.194304 MHz	4.95
4.91520 MHz	4.95

FREQUENCY	price
5.0 MHz	4.95
5.0688 MHz	4.95
5.185 MHz	4.95
5.7143 MHz	4.95
6.00 MHz	4.95
6.144 MHz	4.95
6.40 MHz	4.95
6.5536 MHz	4.95
8.0 MHz	4.95
10.0 MHz	4.95
18.00 MHz	4.95
18.432 MHz	4.95
20.0 MHz	4.95
22.1184 MHz	4.95
27.0 MHz	4.95
36.0 MHz	4.95
48.0 MHz	4.95

FOR PROCESSOR TECH 14.318 $4.95

DIP SWITCHES

4 POSITION	$1.50	7 POSITION	1.80
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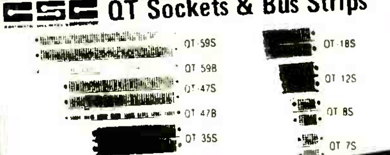

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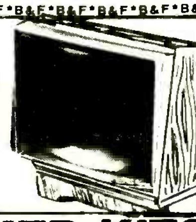
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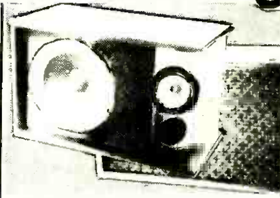
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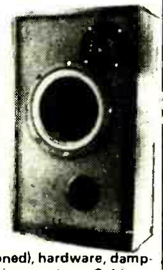
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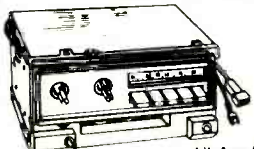

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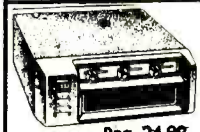

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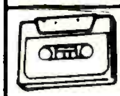

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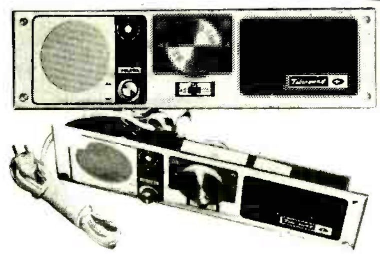

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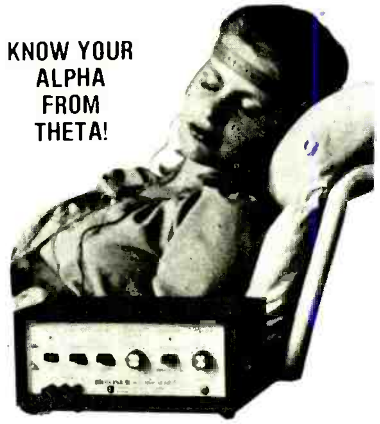

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Chicago Industrial Instrument Co., model 531 tube and battery tester. Schematic diagram. **Atwater Kent** model 44. Schematic, source for tubes and power transformer. Patrick Stallings, Sr., 1307 Suffolk Dr., Austin, TX 78723.

Crescent Industries, Inc., portable wire recorder. Service manual or any repair information. Dr. F.T. Lee, Dept. of Physics, University of Rochester, Rochester, NY 14627.

Lafayette CAB transceiver tester model J 0788. **Sylvania** type 132 oscilloscope. Schematic and manuals. J. Douglas Sanfear, 5 Green Ave., Glen Falls, NY 12801.

Precision Radiation Instruments, Inc., Model 107B professional geiger counter. Schematic and operator/instruction manuals. Harold Timmons, 1819 Hazel St., Gridley, CA 95948.

Dumont 340 serial #4X72 oscilloscope. Need manual schematics or any information. Richard Gorton, Drawer B N-13, Patton, CA 92369.

Westinghouse RA/DA vintage radio. Schematic, parts or any information. J.A. Call, 1876 E. 2990 So., Salt Lake City, UT 84106.

Supreme model 333 tube tester. **Superior** model 450 tube tester. Schematic diagram, service manual or tube chart. M. Aaron, 3012 Center St., Oklahoma City, OK 73120.

Lafayette HE-30 communications receiver. Conversion schematic needed. A. Plamondon, 339 Edinburgh Dr., Ridge, NY 11961.

B&K TV Analyst model 1075. Operation manual and schematic. Ron Patton, Country Ests. Pk-9B, Pratt, KS 67124.

Paco model C-20 register capacitor bridge. Need power transformer or entire inoperative unit for parts. Robert Pilcher, Box 548, Jackson, NJ 08527.

Rheem Califone Corp. duplex booth recorder model LP 901, serial #70703165 reel-to-reel tape recorder. Parts list, schematic and operator's manual. Michael Dulin, Box 38, McAdenville, NC 28101.

Bendix flightphone model PATR-10A. Manual, schematic. Joaquin A. Araujo, Box 11433, Dallas, TX 75223.

Jackson cathode ray oscilloscope. Model CRO-3. Schematic. R. Aggarwal, 1-D Bennet Pkwy., Hornell, NY 14843.

Hycon navy oscilloscope, model OS-8A/U. Schematics. J. Moskowitz, 18 Homer St., Brookline, MA 02146.

Supreme model 561 AF and RF combination signal generator. **Simpson** VTVM of era 1950–1960. Schematic and operating manual. Allen G. Fryou, 3735 Fairmont Dr., New Orleans, LA 70122.

RCA AVQ-50 weather radio. Duplication manual, if original unavailable. Cecil K. Wells, Box 4-2889, Anchorage, AK 99509.

Silvertone 25" console color TV. Mfg. 1963. Schematic. Steve Miller, 131 Thelma Ave., Somerset, MA 02726.

Benrus oscilloscope, model 41-168 serial #2. Alan Ritter, RR1 Box 126, Longdale, OK 73755.

Hallicrafters S40B schematic and manual. James F. Mayer, 24 Charter Oak Dr., Groton, CT 06340.

Motorola model U4GGT-TA236 transceiver. Schematic and instruction manual. Kenton Duncan, 622 N. Elm, Pacific, MO 63069.

Fisher AM/FM chassis, power transformer #T 686-115. Al Brier, 238 Lincoln St., Berkeley Heights, NJ 07922.

Dumont Laboratories Type 224-A oscilloscope. Schematic and operating manual. Leonard Falba, 38 Bryson Mill Rd., New Castle, PA 16101.

Lafayette model Comstat 25A. Schematic and owner's manual. Kenneth Bracken, Route 2, Box 339, Mocksville, NC 27028.

Eico 753 tri-band SSB/AM/CW transceiver. Operation manual and schematic. Tony Renna, Box 391, Ft. Jones, CA 96032.

Multi-Elmac Trans-citer model AF-67 transmitter. Schematic and manual. Gary Cormier, 1411 S. Maple Ave., Green Bay, WI 54304.

British Thompson Houston Co. Ltd. amplifier model M2958, type 307. Need tubes UU9, 6F11, 6P26 and schematic. Allen Weist, c/o Hatchet Bay P.O., Eleuthera, Bahamas.

Wings Goodyear Radio model #778, schematic and service manual for replacement of parts. Jack Stowe, Apt-A-9 Hillcrest Dr., S.E., Mableton, GA 30059.

RCA No. 158 oscilloscope and **Jackson** 640 signal generator. D.E. Burgess, 4901 Mt. Etna Dr., San Diego, CA 92117.

Dura model Mach 10 electronic typewriter. Schematic. Paul Lennard, 3139 East Almond Ave., Orange, CA 92669.

Heathkit extended range 0-6 oscilloscope. Operation manual and schematic. Charles Van Dyke, 11231 Oak St., El Monte, CA 91731.

Harman-Kardon model 3-30 stereo receiver. Schematic and information on power transformer. Mike Welp, 1522 10th Ave. North, Ft. Dodge, IA 50501.

Waterman Products model S-15A pocketscope. Operation manual and any available information. Frank Sokolove, 3015 Graham Rd., Falls Church, VA 22042.

RCA WV-98A VTVM. Schematic. Paul Lombardi, 470 W. Fountain St., Providence, RI 02903.

Metrotec model TA-200 graphic stereo equalizer. Schematic. Duane Anderson, Rt. 2, Box 64, Leeds, ND 58346.

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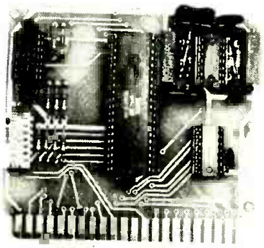

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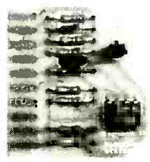

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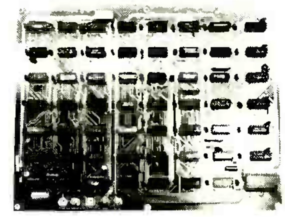

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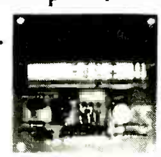

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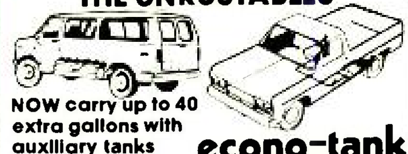

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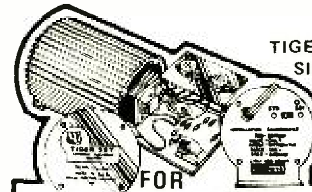

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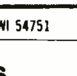

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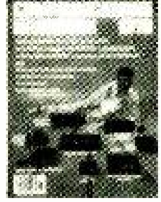

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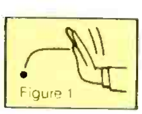

Figure 1

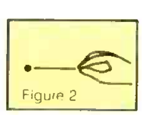

Figure 2

Dr. Oskar Heil's cherry pit illustration

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