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Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE SEPTEMBER 1977/$1.25

HOW TO CUSTOM DESIGN CASES FOR PROJECTS

UPGRADE YOUR OLD STEREO FM TUNER

An easy-to-add phase-locked-loop IC does the trick

FIELD REPORT: CALIFORNIA HOBBYIST COMPUTER SHOW

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TEST REPORTS:

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Speakerlab Model 7 Speaker System Kit
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Aries "System 300" Electronic Music Synthesizer Kit

BUILD A ½-OCTAVE "REAL TIME" AUDIO ANALYZER

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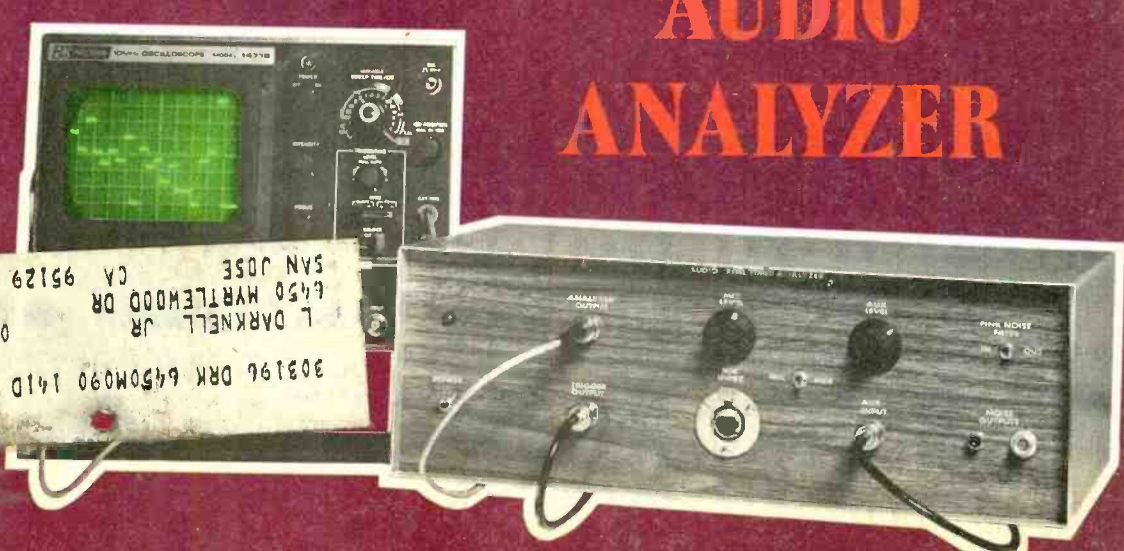

Introducing the mobile that can move you out of the world of the ordinary and into the world of the serious CB'er. The Cobra 138XLR Single Sideband. Sidebanding puts you in your own private world. A world where there's less congestion. More privacy. More time to talk.

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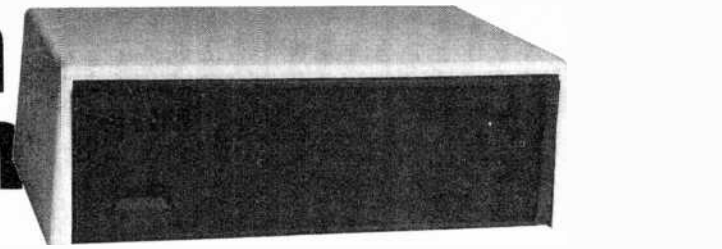
UPWARD MOBILITY.

Burglar Alarm Breakthrough



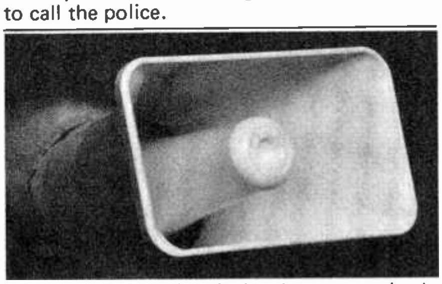
A new computerized burglar alarm requires no installation and protects your home or business like a thousand dollar professional system.

The Midex security computer looks like a handsome stereo system component and measures only 4" x 10½" x 7".

It's a security system computer. You can now protect everything—windows, doors, walls, ceilings and floors with a near fail-safe system so advanced that it doesn't require installation.

The Midex 55 is a new motion-sensing computer. Switch it on and you place a harmless invisible energy beam through more than 5,000 cubic feet in your home. Whenever this beam detects motion it sends a signal to the computer which interprets the cause of the motion and triggers an extremely loud alarm.

The system's alarm is so loud that it can cause pain—loud enough to drive an intruder out of your home before anything is stolen or destroyed and loud enough to alert neighbors to call the police.



The powerful optional blast horns can also be placed outside your home or office to warn your neighbors.

Unlike the complex and expensive commercial alarms that require sensors wired into every door or window, the Midex requires no sensors nor any other additional equipment other than your stereo speakers or an optional pair of blast horns. Its beam actually penetrates walls to set up an electronic barrier against intrusion.

NO MORE FALSE ALARMS

The Midex is not triggered by noise or sound, temperature or humidity—just motion, and since a computer interprets the nature of the motion, the chances of a false alarm are very remote.

An experienced burglar can disarm an expensive security system or break into a home or office through a wall. Using a Midex system there is no way a burglar can penetrate the protection beam without triggering the loud alarm. Even if the burglar cuts off your power, the four-hour rechargeable battery pack will keep your unit triggered, ready to sense motion and sound an alarm.

DEFENSE AGAINST PEEPING TOMS

By pointing your unit towards the outdoors from your bedroom and installing an outside speaker, light, or alarm, your unit can sense a peeping tom, and frighten him off. Pets are no problem for the Midex. Simply put them in one section of the house and concentrate the beam in another.

When the Midex senses an intruder, it remains silent for 20 seconds. It then sounds the alarm until the burglar leaves. One minute after the burglar leaves, the alarm shuts off and resets, once again ready to do its job. This shut-off feature, not found on many expensive systems, means that your alarm won't go wailing all night long while you're away. When your neighbors hear it, they'll know positively that there's trouble.

PROFESSIONAL SYSTEM

Midex is portable so it can be placed anywhere in your home. You simply connect it to your stereo speakers or attach the two optional blast horns.

Operating the Midex is as easy as its installation. To arm the unit, you remove a specially coded key. You now have 30 seconds to leave your premises. When you return, you enter and insert your key to disarm the unit. You have 20 seconds to do that. Each key is registered with Midex and that number is kept in their vault should you ever need a duplicate. Three keys are supplied with each unit.

As an extra security measure, you can leave your unit on at night and place an optional panic button by your bed. But with all its optional features, the Midex system is complete, designed to protect you, your home and property just as it arrives in its well-protected carton.

The Midex 55 system is the latest electronic breakthrough by the Midex Corporation—a company that specializes in sophisticated professional security systems for banks and high security areas. JS&A first became acquainted with Midex after we were burglarized. At the time we owned an excellent security system but the burglars went through a wall that could not have been protected by sensors. We then installed over $5,000 worth of the Midex commercial equipment in our warehouse. When Midex announced their intentions to market their units to consumers, we immediately offered our services.

COMPARED AGAINST OTHERS

In a recent issue of Consumers Report, a leading consumer publication, there was a complete article written on the tests given security devices which were purchased in New York. The Midex 55 is not available in New York stores but had it been compared it would have been rated tops in space protection and protection against false alarms—two of the top criteria used to evaluate these systems. Don't be confused. There is no system under $1,000 that provides you with the same protection as the Midex 55.

YOU JUDGE THE QUALITY

Will the Midex system ever fail? No product is perfect but judge for yourself. All components used in the Midex system are of aerospace quality and of such high reliability that they pass the military standard 883 for thermal shock and burn-in. In short, they go through the same rugged tests and controls used on components in manned space ships.

Each component is first tested at extreme tolerances and then retested after assembly. The entire system is then put under full electrical loads at 150 degrees fahrenheit for a full week. If there is a defect, these tests will cause it to surface.

PEOPLE LIKE THE SYSTEM

Wally Schirra, a former astronaut and scientist, says this about the Midex 55, "I know of no system that is as easy to use and provides such solid protection to the home owner as the Midex. I would strongly recommend it to anyone. I am more than pleased with my unit."

Many more people can attest to the quality of this system but the true test is how it performs in your home or office. That is why we provide a one month trial period. We give you the opportunity to personally see how fail-safe and easy the Midex system is to operate and how thoroughly it protects you and your loved ones.

Use the Midex for protection while you sleep, to protect your home while you're away or on vacation. Then after 30 days, if you're not convinced that the Midex is nearly fail-safe, easy to use, and can provide you with a security system that you can trust, return your unit and we'll be happy to send you a prompt and courteous refund. There is absolutely no obligation. JS&A has been serving the consumer for over a decade—further assurance that your investment is well protected.

To order your system, simply send your check in the amount of $199.95 (Illinois residents add 5% sales tax) to the address shown below. Credit card buyers may call our toll-free number below. There are no postage and handling charges. By return mail you will receive your system complete with all connections, easy to understand instructions and one year limited warranty. If you do not have stereo speakers, you may order the optional blast horns at $39.95 each and we recommend the purchase of two.

With the Midex 55, JS&A brings you: 1) A system built with such high quality that it complies with the same strict government standards used in the space program, 2) A system so advanced that it uses a computer to determine unauthorized entry, and 3) A way to buy the system, in complete confidence, without even being penalized for postage and handling charges if it's not exactly what you want. We couldn't provide you with a better opportunity to own a security system than right now.

Space-age technology has produced the ultimate personal security system. Order your Midex 55 security computer at no obligation, today.

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SEPTEMBER 1977 VOLUME 12, NUMBER 3

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Editorial

TV ELECTRONIC GAMES GROW UP

The sale of home TV electronic games peaked during the Christmas season of 1976, followed by a severe decline in 1977. Was the estimated 3-million video games sold in '76 just a passing fancy of the American public? Obviously not, since manufacturers are now producing with the expectation that 1977 sales will easily be twice those of 1976. And nonvideo electronic games will certainly make their mark this year, too.

Home TV games did not move as well as anticipated during the first half of '77 for a variety of reasons: (1) Christmas doesn't last all year (though the interest in games should be year-round); (2) reduced selling prices on games disheartened many retailers, who placed them on the back shelves; (3) programmable games are just around the corner. Concerning the latter, there are two companies already marketing them—Fairchild, who can't seem to keep up with consumer demands at $170 a game plus "cartridges," and RCA, just really entering the market with a $150 programmable model.

Dramatic decreases in prices for the older, dedicated video games are anticipated, with prognosticators saying that they will simulate the price dip exhibited by calculators and digital watches. But with the new dedicated games, such as Atari's Tank™ (with sound effects and joy-stick controls) at a suggested retail price of $65, don't expect $9.95 paddleball/hockey sellers to be around just yet.

The future of home video games is extraordinarily bright. And speaking of brightness, I find it amusing that one major TV receiver manufacturer, who also produces a TV electronic game, indicates that its receiver CRT warranty will be voided if electronic games are displayed on it. I've been personally assured by a top executive in the company that they have not seen a single defective CRT with burn spots caused by video electronic games—even with "duds."

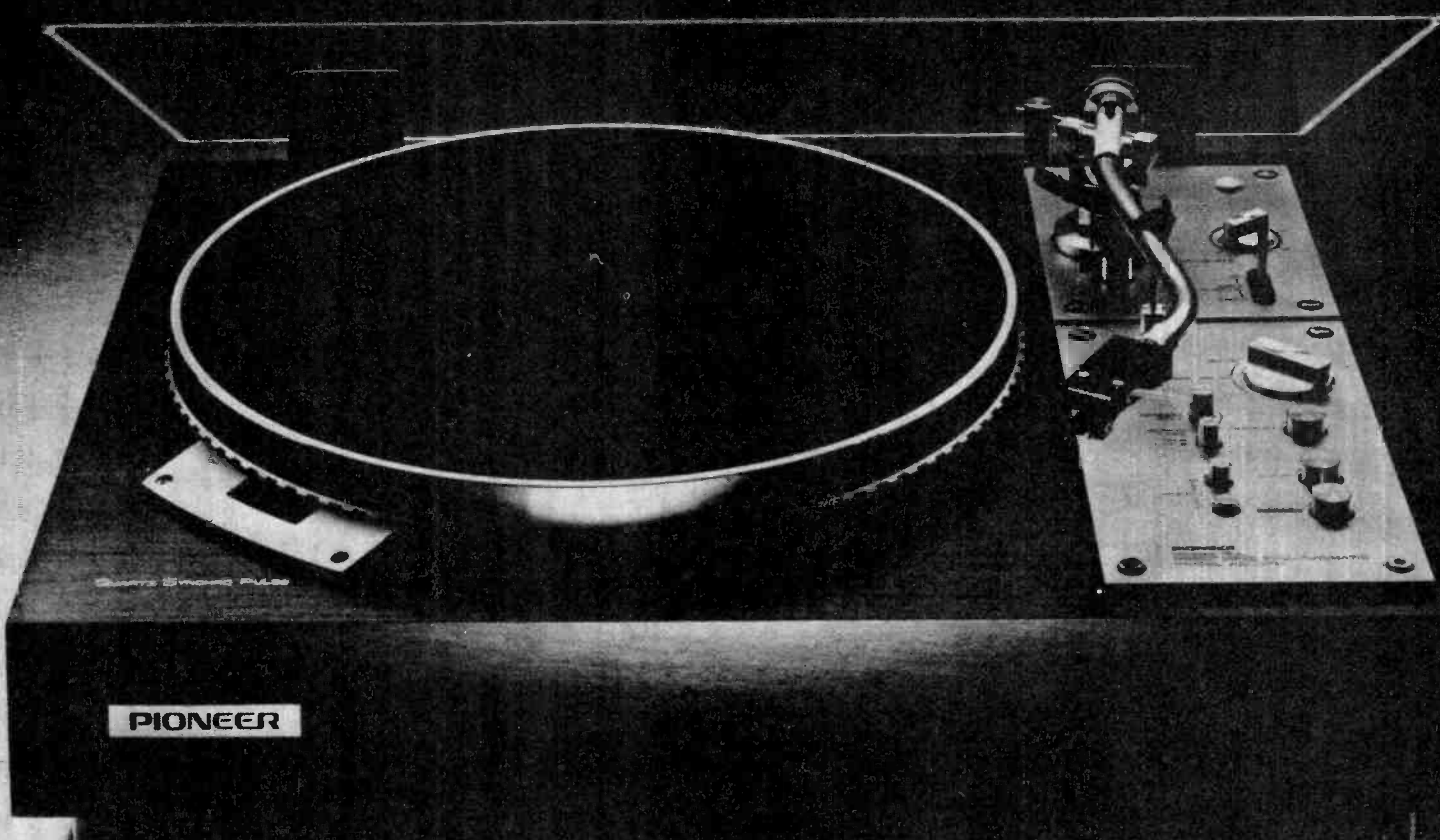
The burn-spot question arose last year because some coin-operated units in arcades did display such CRT marring after a considerable period of video-game use. Users of home video games, however, do not play them sufficiently, without shutoff, to cause CRT damage.

It's projected that programmable video games will account for some 20% of unit sales in 1977, rising to 33⅓% by 1980. The omnipresent microprocessor will also be utilized for nonvideo electronic games. Parker Brothers (of "Monopoly" fame) will soon market a nonvideo electronic game based on the old "Battleship" game, as an example. Another toy maker, Mattel, will offer hand-held missile, auto race and football games with LED score readouts . . . Fidelity Electronics will be presenting an electronic chess game that the user plays against . . . Tryom Inc. will enable you to pit your wits against a microprocessor in the game of backgammon . . . Unisonic has a four-function calculator that can also permit one to play blackjack, even changing the deal when 38 cards are played, a la Vegas rules.

Although the programmable microprocessor games are destined to take over the electronic game market, at least in dollars, the input medium used will not necessarily be the ROM-type cartridges now prevalent. Among other possibilities that may evolve are matchbook-size tape cartridges and magnetic cards. Regarding the latter, kilobyte cards can be produced much as record discs can and, therefore, offer the potential for very low costs. The four-stripe plastic cards now available provide 1024 bytes, enough for most game programs, unless you want a Star-Trek game. Then you'll need a full blown microcomputer system.

Clearly, microprocessors are changing the face of consumer electronic products for increased efficiency and, in the case of games, to add another leisure activity to our lives.

Art Salsberg


PIONEER

Letters

CUTTING DOWN THREE BYTES

In "Debugging Aids" (Computer Bits, May 1977), Hal Chamberlain has mistakenly assumed that to insert a breakpoint in an 8080 program, a three-byte CALL instruction must be used. This gives the impression that a breakpoint feature on an 8080 is clumsy at best. We recommend that 8080 users initiate one of the RESTART (RST) instructions to implement a breakpoint feature in their software. The RESTART instructions are essentially one-byte CALL instructions and require only one memory location within the user's program for storage. In fact, the RST instruction is very similar to the BRK instruction of the 6502 microprocessor.

One nice feature of both the RST and BRK instructions is that both cause the incremented program counter (PC) to be saved on the stack. This makes the "print registers and continue" function very easy to implement on either of the microprocessors.—*Christopher A. Titus, Blacksburg, VA.*

A QUESTION OF LEGALITY

Your May 1977 article titled "Build a Legal In-Flight Airline Receiver" was cause for inquiries from persons concerned with the requirements of the Federal Aviation Regulations (FAR) and the legality of using the receiver while on board an airliner. From the description of the receiver, it would be considered a "portable electronic device" and, therefore, comes under the requirements of FAR 91.19, titled "Portable Electronic Devices." This regulation places the responsibility for determining that the receiver will not cause interference to the aircraft navigation and communication systems with the air carriers, who should approve its operation while on board their aircraft.—*John W. Flavin, Chief Avionics Staff, Flight Standards Service, FAA, Washington, DC.*

HI-FI FEEDBACK

I commend Ralph Hodges for the honesty of his observations and opinions expressed in the June 1977 Stereo Scene. I concur with his skepticisms on the validity of the "phase coherence' technique in speaker systems. While in theory it may produce better patterns on the CRT of an oscilloscope, its improvement of the sound as interpreted by the human ear-brain combination is questionable. The human brain is a remarkable decoding device of audio signals and is able to perceive "true" sound even through the phase distorting motion of turning one's head a fraction of an inch. The phase-coherent speaker system can be valid only for a controlled and stationary listening device. Otherwise it becomes no better than a conventional speaker system.—*Michael P. Liben, New York, N.Y.*

I found "Instruments I Have Miked" (Stereo Scene, July 1977) totally engrossing. The article delivered a tantalizing amount of tips to use in professional recording that whetted my appetite to pursue a career in professional recording engineering. I would like to see a great deal more material published on this topic.—*H. Douglas Black, Raleigh, NC.*

APPRECIATES "ELF"

I would like to express my appreciation for the best project I have ever built from the pages of POPULAR ELECTRONICS—the "Cosmac Elf" microcomputer (August 1976). Now I would like to see you publish plans for a cassette interface and other peripherals, plus appropriate programming, for the Elf. Keep up the good work.—*Louis Choiniere, Barton, VT.*

HERB BRIER

Herbert S. Brier, W9AD, ex-W9EGQ, died May 21, 1977 at age 63. Herb was crippled by rheumatoid arthritis at the age of 12 and was unable to attend school past grade 7. In spite of this, he taught himself advanced mathematics, electronics, Spanish, and Braille. For 17 years he was POPULAR ELECTRONICS' Amateur Radio editor, and for years wrote the Novice column in *CQ* magazine. He wrote one book on amateur radio, and co-authored the *VHF Handbook* with William Orr, W6SAI. He held an Extra Class amateur license. During World War II, he ran the Gary (Indiana) emergency radio station, for which he received a citation. In later years, he maintained industrial electronic equipment in Gary and Chesterton, Indiana, and tutored local residents in electronics and amateur radio.

Out of Tune

In "Digital Capacitance Meter" (April 1977), one end of *C3*, in Fig. 2, should be connected to pin 9 of *IC1*, not pin 13 as shown. The normally open contact of *S1* should be connected to pin 13 of *IC1*, not pin 9 as shown. Also, at the center of Fig. 3, the 1.5-k resistor should be 1.5 ohms. The second lowest range measures capacitances from 0.01 to 0.99 µF. When the switch is placed in this position, it automatically inserts a decimal point in the proper location and the display gives the capacitance directly in microfarads.

In "RC Circuit Quiz" (July 1977), the differentiator should be circuit H, and the integrator circuit J. The answers, as given, were reversed.

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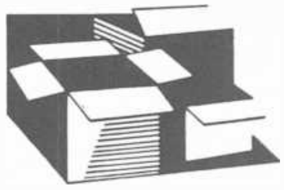


New Products

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

SONY THREE-WAY SPEAKER SYSTEM

Sony's Model SU-3000 speaker system features a "carbocon" cone material that is claimed to provide reproduction that virtually mirrors the original sound. The three-way bass-reflex system is rated to be driven by 20 watts of amplifier power and to handle up to 150 watts over a frequency range of 35 to 20,000 Hz. Crossovers are at 600 and 5500 Hz, while woofer rolloff and tweeter turn-on are at a 12-dB/octave rate. The midrange driver and tweeter are fronted by radial diffusion elements which are said tc smooth the frequency response and provide improved dispersion and imaging. Dual-slope level control network and adjustable midrange and tweeter controls permit adjustment to suit the listening room. Size is 34¼"H × 14¼"D × 13½"W (87 × 36.2 × 34.3 cm) and weight is 59 lb 9 oz (27 kg). $300.

CIRCLE NO. 89 ON FREE INFORMATION CARD

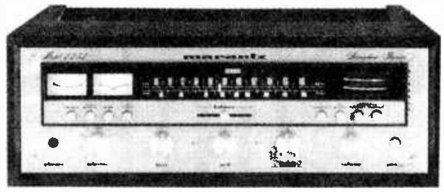
BEARCAT PROGRAMMABLE SCANNER

Communications Electronics' new Bearcat 210 five-band programmable "super" synthesized scanning receiver needs no crystals. It gives the user push-button access to more than 16,000 different frequencies in the 32-to-50-, 146-to-174-, and 416-to-512-MHz ranges, which include frequencies on 2 meters and the entire 0.75-meter amateur band. The synthesizer permits one to enter or change any 10 frequencies in seconds. The receiver scans entered frequencies at a rate of 20 channels per second. A digital input and display allows the operator to see the frequencies selected as well as those being received. Automatic search scanning and lockout are included. Sensitivity is rated at 0.6μV for 12 dB SINAD on the low and high bands. $319.95.

CIRCLE NO. 91 ON FREE INFORMATION CARD

MARANTZ STEREO RECEIVERS

Marantz has added three popularly priced AM/FM receivers to its line. Featuring dual-gate MOSFET front ends, the receivers are equipped with zone-detented tone controls for convenient variation of bass, midrange, and treble frequencies. Other features include Dolby FM de-emphasis (25-μs), full complementary symmetry direct-coupled amplifier section, phase-locked-loop multiplex demodulator, and quadradial-ready jack so that a 4-channel decoder can be connected should a standardized 4-channel FM broadcast system be approved by the FCC. The three new models are 2226 (26 watts), 2238 (38 watts), and 2252 (52 watts), all into 8-ohm loads. The 2226 is rated at no more than 0.2% THD with an 8-ohm load; the other two models, 0.1%. All models include separate FM-tuning and signal-strength meters.



CIRCLE NO. 92 ON FREE INFORMATION CARD

McKAY DYMEK COMMUNICATIONS RECEIVER

McKay Dymek has introduced an all-wave, fully synthesized communications receiver covering the frequency range of 50 kHz to 29.7 MHz. The DR-22 is equipped with switch-selectable 4- or 8-kHz bandwidth ceramic filters. Preceding the ceramic filters are crystal filters at 30 MHz and 10.7 MHz. All AM broadcast, international shortwave, ham radio contacts, and CB channels are tuned in by means of a digital phase-locked-loop tuning system. A large five-digit LED readout indicates the frequency being received, which is selected by four rotary switches and a fine-tuning control with a ±5-kHz tuning range. Standard features include high-impedance audio output for recording, 455-kHz i-f output jack, mute control for use with transmitters, front-panel headphone jack, internal speaker and control switch, and external speaker connections. The receiver is housed in a textured black enamel case with teak wood sides and brushed aluminum face. Measures 17.5"W × 16"D × 5.1"H (44.5 × 40.7 × 13.0 cm). $2,900.

CIRCLE NO. 93 ON FREE INFORMATION CARD

CONTINENTAL SPECIALTIES SOCKETS

Continental Specialties has two new "Experimentor" 300 and 600 solderless breadboarding sockets, which provide 94 five-point terminals, plus two 40-point bus strips for a total of 550 solderless tie-points. The 600, priced at $10.95, has a 6/10" center channel, making it suitable for microprocessors, clock chips, RAM's, ROM's, and other larger DIP packages. The 300 has a 3/10" center channel that is right for smaller DIP's. Both sockets also accept transistors, LED's, resistors, capacitors, pots and virtually all types of discrete components.

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HEATH AUDIO OSCILLATOR

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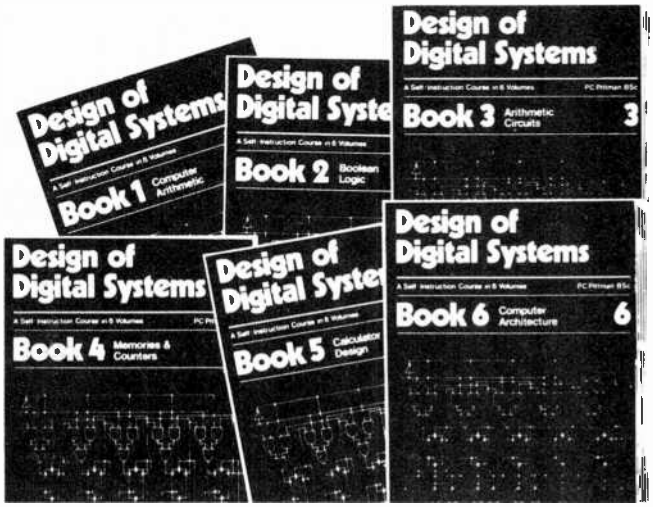

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Book 5 Structure of calculators; keyboard encoding; decoding display data; register systems; control unit; program ROM; address decoding; instruction sets; instruction decoding; control program structure.
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New Literature

CB INTERFERENCE CURES

Electronic Specialists offers a flyer describing cures for common FM, TV and audio interference caused by CB radios. Featured are solutions to problems such as interference picked up by stereo speaker leads and hi-fi phono inputs, and interference conducted over ac power lines. Address: Electronic Specialists Inc., Box 122, Natick, MA 01760.

RCA REPLACEMENT GUIDE

RCA offers its 1977 Solid State Replacement Guide, SPG-202T. The new 195-page guide cross references more than 123,000 solid-state devices, transistors, rectifiers, thyristors and IC's that can be replaced with RCA SK-Series types. Features of the publication are an index of SK-Series semiconductors and accessories, application information, line drawings of dimensional outlines and terminal arrangements, and a listing of mounting hardware. Cost, $1.50. Address: RCA Distributor and Special Products Div., PO Box 85, Rûnnemede, NJ 08078.

SILTRONIX ANALOG SWITCH HANDBOOKS

Two new publications from Siltronix facilitate analog switch system design. The first, titled "Analog Switches and Their Applications," is a 352-page handbook covering the theory and practical application of analog switches. It begins with an explanation of FET switch characteristics and driver circuits and moves on to multiplex systems, signal conversion, and n-path filters. Cost $4.00. The second, "High Speed CMOS Analog Switches," is a 20-page catalog of Siltronix's DG3000 series CMOS analog switches. Available free. Address: Marketing Services Dept., Siltronix, Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054.

MARINE RADIOTELEPHONE CATALOG

A new booklet from Motorola describes its line of Triton marine radiotelephones. Featured are the Triton 55/75, a fully synthesized unit with simplified channel identification, and the Triton SSB marine radiotelephone, which has FM reliability at distances greater than 30-40 miles. Other models described are bridge-to-bridge marine radio telephones, vhf-FM limited Coast Guard Station models, and FM portables. Accessories are also listed. Address: Motorola Communications Group, Literature Distribution center, 1301 E. Algonquin Rd., Schaumburg, IL 60196.

MEMOREX VIDEO TAPE NEWSLETTER

Understanding the video picture is the topic of Vol. 3, No. 1 of SCAN, a 4-page newsletter for video-tape users offered by Memorex. The issue discusses how a video picture is created within a monitor/receiver and gives tips on troubleshooting the video playback system. Address: SCAN, Memorex Corp., PO Box 420, Santa Clara, CA 95052.

NEDA 1977 BATTERY INDEX

The National Electronic Distributors Association (NEDA) offers the 1977 Battery Index. A replacement guide for over 182 battery types, the index uses number suffixes to list batteries according to their group; rechargeable NiCd batteries and various groups of nonrechargeable types. Major manufacturers included are Bright Star Industries, Eveready, Mallory, Burgess, Inc., and Ray-O-Vac. Price 50 cents. Address: National Electronic Distributors Association (NEDA), 3525 W. Peterson Ave., Suite 601, Chicago, IL 60659.

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INTERSIL

Stereo Scene

By Ralph Hodges

RECORDS AND THE VERTICAL ANGLE

WHAT THE world still lacks, surprisingly enough, is a really adequate conceptual model for a record player. To be sure, the overall principles have always been obvious: the groove undulates, thereby wiggling the stylus, which is connected to an electrical generator, etc. But the intimate geometry of the way a record is played, taking place as it does on what is really a submicroscopic scale, remains somewhat obscure. Vinyl indentation affects stylus tracing in ways that are not wholly understood; frictional drag and other forces on the stylus assembly alter the geometry of the tracing and transduction situations in complex ways: the rate of stylus and record wear—and the form in which it manifests itself—is not completely predictable. Periodically there are technical papers written to expand or refute existing theories of stylus-groove interaction, but the ultimately authoritative paper has yet to appear.

Fortunately, we don't have to fully understand the record player to use it. In fact, the system seems to be surprisingly tolerant of human error. A cartridge can be installed in a tonearm in five minutes, using the crudest "eyeballing" techniques for alignment, and almost no one will object to the audible results achieved thereby. Considering that the stylus inhabits a world in which the miniscule wavelengths of visible light are beginning to become significant dimensions, its apparently obliging response to very slapdash alignment is a little unexpected.

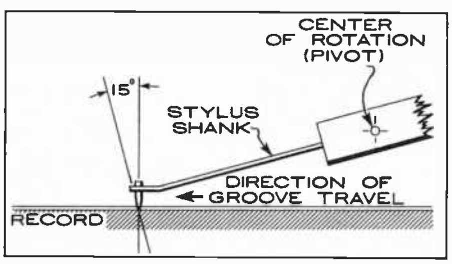

Diagram shows vertical tracking angle and stylus pivot point.

In the back of many a well-furbished mind there has always been the nagging idea that this can't be right; that closer attention to record-player alignment *must* result in superior reproduction. The trouble is, no one's been able to demonstrate this to the satisfaction of the record-playing world at large.

The Shreve-Rabco Arm. About a year ago (November 1976) I wrote in this space of a modification to the Rabco SL-8 and SL-8E tonearms performed by Dr. David Shreve (Department of Mathematics, University of Wisconsin). At that time I referred only obliquely to several interesting claims made by Dr. Shreve, among them being that the vertical angle (the "rake angle," as it is often called) at which the stylus impinges on the record surface as viewed from the side is critical to within a very small fraction of a degree.

Dr. Shreve referred to his findings as being totally empirical, and he has never shown any inclination to "dignify" his claims with any nice, neat explanatory theory (although there are some very attractive ones free for the taking). His attitude has always been: "I can demonstrate the phenomenon, and if you can hear it (and apparently everyone has so far) you're free to make of it what you will.'

I have been "making what I will" of all this ever since, and my conclusion—supported by the informed opinions of others who have looked into the matter—is that we have at hand a very basic and nontrivial demonstration of how disc-playing systems can be significantly improved.

The Scanning Aperture. Shortly after my first meeting with Shreve, I brought his work to the attention of Mitchell Cotter, founder and chief executive of Verion Audio and a researcher with a long and varied background in many areas of practical and theoretical audio. As it happened, Cotter was already convinced of these effects' existence, although he had not fared notably better than others in demonstrating their audibility. He was, however, somewhat surprised by Shreve's reports on the criticalness of the vertical angle. True, theory seemed to predict this, but theory had not quite been batting 1000 in corresponding to the perceived and/or measurable world of record playing.

What exactly *does* theory seem to predict? I couldn't begin to deal with the complexities here, even if they could be pursued profitably in a nonmathematical presentation. But some of the individual effects can be mentioned. Imagine viewing the stylus (a Shibata or other type of "line-contact" CD-4 stylus) from the side as it traces a record groove. If the rake angle is correct, the stylus' contact line will be parallel with the modulation angle of the groove. If it is not, the upper part of the stylus will either lead or lag the lower part in tracing the groove.

So far the situation seems analogous to tape-head alignment. When the azimuth of a playback head is disturbed, the "scanning aperture" corresponding to its gap becomes effectively wider, and high-frequency response begins to fall off in the same way as it would if the gap were physically wider. However, while the "effective" edge of the stylus is also a scanning aperture, a simple loss of high-frequency response is not the only predictable result of incorrect rake angle. Whether azimuth is right or not, a tape head is always scanning the flat plane of the tape surface. The stylus "sees" a flat plane from a modulated groove only when its rake angle is absolutely on the button. Otherwise it traces—or tries to trace—a curvature that can become rather complex, with the skewed contact line of the stylus doing its best to strike a rough average between the various groove contours it is encountering. Also, groove curvature is a definite factor in stylus indentation of the record material, so that a further ambiguity in tracing is introduced.

At this point, let's consider the several dimensions in which a stylus moves. Ideally, all its excursions take place within a curved plane—a section of the shell of a sphere that has its center at the sty-

(continued on page 20)

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lus's pivot point. Also ideally, the shell is almost infinitely thin. However, especially in the case of a line-contact stylus, an error in rake angle "thickens" the shell, with resulting phase-time ambiguities. Such errors are inevitable; even vertical stylus excursions produce them. But at what point, if any, do they become audibly detrimental? And what is their effect when they combine with other errors in tracing geometry?

The Listening Approach. Since the means (the Shreve/Rabco arm) seemed to be at hand, we decided to let theory rest for the time being and work toward empirical findings with listening tests. The Rabco SL-8/SL-8E arm, as you may be aware, is (or was; it is no longer made) a radial-tracking mechanism. The arm carriage transits on an aluminum track that has vertical screws at either end to facilitate height and levelling adjustments. Thus the stylus rake angle can be varied minutely and repeatably even while a record is playing, without doing any great violence to other parameters of cartridge alignment (we invariably found ourselves working with a range of rake angles spanning considerably less than a degree of difference). This, plus its other refinements, made the arm a viable experimental tool in our judgment.

Once we (Dr. Shreve, Mitchell Cotter, and I, for the most part) had confirmed that we could hear these seemingly small differences and could agree on what the "right" sound was, we evolved individually for the most part, but with close agreement later on) a number of working hypotheses.

(1) The optimum vertical adjustment should not be the same for every record. Variables such as different record-cutter geometries, different cutting practices, and even different record thicknesses would logically prevent this.

(2) A warped record should make the optimum vertical adjustment less easy to achieve, if it could be achieved at all.

(3) Adjusting the carriage track of the arm so that it is not quite parallel with the record surface should result in a change of vertical angle over the record side, and therefore a change in the "sound." (It would also result in slight changes of other alignment parameters; the big questions concerned which changes, if any, would be most audible.)

(4) A true line-contact CD-4 stylus should be quite critical to adjust; and once properly adjusted, it might conceivably yield performance superior to that of a "conventional" stylus.

(5) A change in stylus force should change the rake angle, and hence the "sound."

After about a year of listening, our general observations are as follows.

(1) The optimum vertical angle is not the same for every record. With the records we have sampled we've encountered a range of "optima" spanning a mere 25 minutes (!) of arc. However, some records audibly perform quite badly when used with a different record's optimum setting, although they may sound very good when individually compensated for.

(2) Warped records are not as difficult to adjust for as anticipated. An attempt at explaining this must await further work. It is true that we've not been extraordinarily successful in obtaining warped and unwarped copies of the same record. It almost appears that a given release is either unwarped or warped, although the warps are usually not the same. We have not attempted to deliberately warp any records.

(3) Making the carriage track nonparallel to the record surface alters the sound over a record side in an identifiable way. Deliberately misaligning the effective length of the radial arm to create a similar change in lateral tracking-angle error over the record side does not seem to alter the sound as recognizably. But this test lacks a certain amount of rigor.

(4) CD-4 styli are typically easier to set at optimum vertical angle; the "optimum" is much less ambiguous. When so set, they consistently (audibly) outperform comparable cartridge models fitted with spherical or "conventional" biradial stylus tips.

(5) Altering the vertical stylus force seems to produce the expected change in "sound." In fact, in some cases small changes in stylus force have seemed to be as effective as small changes in vertical angle in achieving the most listenable results. (In all cases the stylus-force changes have been very small, and always well within the recommended tracking-force range of the cartridge's manufacturer. Measurement of the force, with one exceptional instance, has always been consistently repeatable with the Shreve arm and a tracking-force gauge of high reliability and resolution [within 1/10 gram].)

And What Is the Sound? While we agree when the verticle adjustment is correct to our ears, we do not always use the same language to describe what we hear when it is not to our liking. High frequencies are affected most profoundly, to the point where sharp sibilance on voice recordings can be reduced to almost no sibilance. There is a noticeable change in the quality of whatever noise is present on the record, so that it becomes subjectively smoother, less obtrusive, and less troubled by what subjectively seems to be a periodic modulation effect. Whatever stereo perspective is present on the record seems dramatically enhanced, with sharper and stabler positioning of sound sources both left to right and forward to back (although we think we have occasionally discovered "faults" in the stereo perspective of some recordings as a result of optimum adjustment).

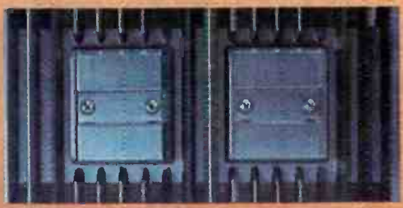
The Unanswered Questions. The vertical cutting angle adopted in making a record is established at the discretion of the mastering engineer. A fairly common practice is to use a special test record as a vertical reference while the cutting head is set up. However, we have heard of instances in which the cutter's vertical angle has been slightly modified to achieve a smoother or quieter cut.

The variations in vertical angle from record to record we have found are probably small enough to be accounted for by differences in test records, or even differences in set-up procedures when the same test record is used. However, the precise roles that these and other factors play in the vertical-angle situation are far from clear to us at present.

Several other questions remain. One concerns the matter of deformations in the ideally flat surface of the record, and what part they could or should play in properly defining the correct vertical angle. Another question asks whether there is (as would seem logical) an optimum relationship between rake angle, vertical tracking angle, and stylus force, since the first two would certainly change with an alteration of the third, but not necessarily in the same direction with respect to an optimum adjustment.

Perhaps the ultimate question is whether a significant number of commercially available arms and record players (as opposed to the custom-built and carefully adjusted equipment in our hands) can reveal the effects of these minute variations in alignment. Thanks to Mr. Cotter's efforts, the first tentative answer to this question seems to be moving toward a qualified "yes." And thus it appears certain that you'll have heard far from the last of this matter when you lay down this magazine. ◇

THE INTEGRATED DC AMPLIFIER HAS ARRIVED.



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Julian Hirsch Audio Reports

HIRSCH/HOUCK LABORATORIES

PROS AND CONS OF MULTI-WAY SPEAKER SYSTEMS

IT HAS long been recognized that a single loudspeaker cone cannot properly reproduce the full audible frequency range. Nevertheless, a single speaker is still widely used, as in TV receivers, automobile radios, and low-priced home radios and record players for that impossible task. Here, a degree of effectiveness is made possible only by a reduction in quality standards, which would not be acceptable in a high-fidelity system.

The examples mentioned above cannot be called "hi-fi" by any stretch of the imagination, although sometimes, against all reason, that claim is made for them. Even a minimum quality component speaker system uses at least two drivers to cover the audio range, and more expensive ones divide the audible spectrum into three or even four bands. It is thus quite natural to assume that more separate frequency bands in a speaker system result in better quality.

The foregoing assumption may be natural, but it is not necessarily correct. In fact, in the absence of other information, there is no reason to conclude that a three-way system is better than a two-way system or even as good. To see why this is so, let us consider the reasons for dividing up the reproduction task among several drivers.

To generate appreciable amounts of acoustic power at low frequencies, a large volume of air must be moved by the speaker cone. This can be done by using a large cone area with a relatively small excursion, or a smaller cone with a large excursion. Both methods are capable of good results, but the popular acoustic suspension speakers are based on the latter approach. To get a reasonably flat, smooth bass response, it is not sufficient simply to use the largest possible speaker diameter, or to increase the size of the enclosure. These two factors, together with a host of other speaker parameters, are interrelated. Once a certain performance standard has been decided upon, neither can be changed without a corresponding change in the other. The value of a proper bass speaker design is demonstrated by the many small speakers, with woofers only 6 to 8 inches in diameter, whose bass response extends to 40 Hz or even lower.

A larger cone diameter gives the designer several possible options for improved performance. The lower limit of the speaker's response could be extended (perhaps together with reduced distortion), or its efficiency could be increased. Since nothing in this world is truly free, what disadvantages might result from such a change?

A woofer cone can deliver its calculated flat response only in the limited frequency range within which it moves as a piston. At higher frequencies, where the speaker diameter becomes an appreciable fraction of the acoustic wavelength, the response becomes irregular, as well as increasingly directional. The massive cone, which is advantageous for a woofer, becomes a liability at higher frequencies. Here, low moving mass is necessary to allow the cone to reverse direction hundreds or even thousands of times each second. Therefore, whatever the size of the woofer, above some selected frequency the signal energy must be diverted from it to another speaker more suitable for that range. The choice of a "crossover" frequency is not entirely arbitrary since it must take into account the high-frequency aberrations in the woofer's response, and the low-frequency limitations of the smaller speaker. A "tweeter," as the high-frequency driver is usually called, is much smaller in diameter than the woofer, and has a much lighter cone and voice coil structure. The low mass allows it to respond more rapidly to high-frequency signals, while its smaller diameter gives the sound a wide polar dispersion instead of "beaming" it forward, as happens when the cone diameter is comparable to the wavelength of the sound. At very high frequencies, even an ordinary tweeter cone may be too large to give the desired response, necessitating a second crossover to a still smaller speaker. This is known as a "three-way" system, in contrast to the simple "two-way" system comprised of a woofer and a single high-frequency driver.

Here are some considerations on the relationship between the size of the several drivers and the choice of crossover frequencies. In a typical small speaker system, with a woofer 8 inches or less in diameter, it is feasible to cross over to the tweeter as high as 2000 Hz, or even higher in some cases. At that frequency, a specially designed dome or small cone tweeter is used instead of merely a miniature version of the woofer. With a cone diameter of 1 to 1½ inches such a speaker can give satisfactory results up to 15,000 Hz or even beyond. While it is possible (and sometimes done) to cross over to a third "super tweeter" at a very high frequency, such as 7,000 to 10,000 Hz, the benefits would be negligible. The high-frequency dispersion

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might be improved by using a second, smaller tweeter, but the effect is likely to be rather subtle.

Suppose that a larger woofer, 10 or 12 inches in diameter, is used. Such a speaker cannot function optimally much above 1000 Hz, and the crossover to the next driver usually takes place between 500 and 1000 Hz. At that frequency, a small dome tweeter cannot be used either because its light voice coil could easily be burned out by the concentration of program energy in the midrange. Furthermore, the large cone excursions needed would be impractical for such a driver.

To cover this frequency, a larger version of the dome tweeter is sometimes used (this can be expensive). But more frequently, the midrange driver is a conventionally appearing cone unit that's about 3 to 5 inches in diameter. This can handle the midrange power, but its useful upper frequency limit is perhaps several thousand hertz. For full-range reproduction, there is a second crossover to a true tweeter, usually in the 3000-to-5000-Hz range. From this we can see that a speaker based on large low-frequency drivers or designed for use at high volume levels has to have three drivers do what can be done fairly well at lower levels by a smaller two-way system.

Sometimes we encounter four-way systems, although this is a refinement limited to fairly exotic and expensive speakers. Usually, a very small supertweeter is added to a more conventional three-way system, with a crossover at 10,000 Hz or even higher. Alternatively, the fourth driver can be added at the low-frequency end, crossing over from the woofer to an upper-bass or lower mid-range driver in the 100-to-300-Hz region. The upper-bass speaker is normally a small woofer that measures about 8 inches in diameter. Together with the higher frequency drivers, it acts as the woofer of a three-way system.

If a super tweeter is used, especially at frequencies near the limits of human hearing, its benefits may be marginal. Little program material has much content in that range, except for noise. Thus, the principal benefit of a super tweeter may be an airier quality due to improved dispersion.

The rationale for using a very low woofer crossover frequency is that the large woofer cone excursions at low frequencies tend to modulate higher frequencies in the program band handled by the woofer. Even if the speaker is perfectly linear, high frequencies radiated by a cone simultaneously handling low frequencies will be frequency-modulated (the Doppler effect). This produces a modulation distortion very much like that resulting from woofer nonlinearity. By restricting the woofer to a narrow frequency range, the likelihood of such intermodulation is reduced. Of course, this places an added burden on the next higher frequency driver, which often carries the bulk of the audible program content and must do so with a minimum of distortion.

We have seen how the number of crossovers in a speaker system is determined by the limitations of its individual drivers, the cabinet size, and the degree of

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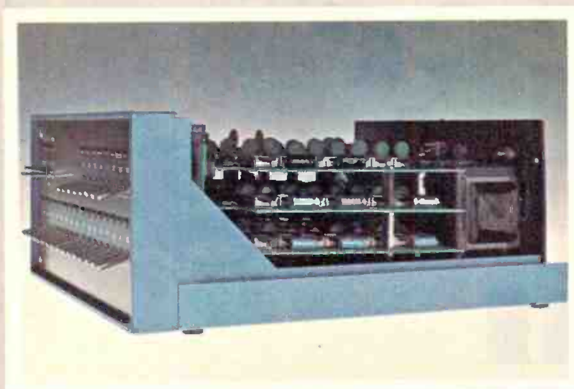

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subjective refinement that is desired. (It is difficult, if not impossible, to actually measure the benefits of some multi-way speaker systems, especially in view of the aberrations introduced by *any* crossover network, let alone a four-way network.)

Having made side-by-side comparisons between two- and three-way systems based on similar drivers and cabinet dimensions, we can attest to the added openness imparted by a good three-way design. It is a fairly subtle effect, however, and might not be detectable without such a comparison. On the other hand, we have often been impressed by the similarity in sound quality between some good, small two-way speaker systems and vastly larger (and more expensive) three- or four-way systems. There is not much mystery to this effect, since it means that the speakers involved have been designed to give a uniform energy response with better than average dispersion. Their similarity is clearly evident in the measured frequency response. Consequently, it is not surprising that they sound very much alike in their basic octave-to-octave balance and freedom from coloration. The low-frequency limitations of the small speakers are usually evident only below 50 Hz or so, where most programs have little energy.

The Speakerlab 7 speaker reviewed here is a three-way system, and from its use of two full-size (10- and 12-inch) woofers it is easy to understand why a three-way design was necessary. The first crossover at 700 Hz was dictated by the high-frequency limitations of the woofers, and a rather large horn driver was needed in the midrange to operate down to that frequency. A horn of this size cannot do a good job at the highest audio frequencies, making it necessary to cross over to a second smaller horn at 5000 Hz. A speaker with the efficiency and power handling ability of this one could not have been made with a simple two-way configuration or in a smaller cabinet. ◇

AKAI MODEL GX-270D-SS FOUR-CHANNEL TAPE RECORDER

Synchronous recording function permits multitrack taping.

HIRSCH-HOUCK LABS REPORT

Paradoxically, at a time when interest in quadraphonics is not especially strong, a number of open-reel tape recorders on the market feature 4-channel capabilities. The indication here is that home recordists are using these decks to build up multitrack recordings in a manner similar to that used by professional recording studios, rather than for recording and listening to 4-channel tapes.

Akai's Model GX-270D-SS 4-channel open-reel tape recorder is in this category, having the synchronous recording capability that makes it possible to obtain multitrack recordings. Its "Quadra Sync" recording system can be used in both the 2- and 4-channel modes. The deck also features a direct-driven capstan, 7½- and 3¾-ips (19.1 and 9.5 cm/s) speeds, and a bidirectional playback feature for stereo operation. The transport is solenoid controlled.

The recorder measures 18.3"H × 17.3"W × 7.5"D (46.5 × 44 × 19.5 cm) and weighs 39.2 lb (17.8 kg). Its nationally advertised value is $875.

General Description. An ac servo motor is used to directly drive the capstan of the recorder, eliminating the belts and pulleys usually found in tape drives. Pushbutton switches are used to select the operating speed and simultaneously switch in the appropriate equalization characteristic. The hubs can accommodate tape reels up to 7" (17.8 cm) in diameter. Each hub is driven by its own eddy-current motor.

The bidirectional playback mechanism can be initiated either automatically by conducting foil on the tape's leader or manually by pressing a switch. The main transport functions are controlled by six pushbutton switches, through solenoid actuators. They include normal and fast speeds in both directions, STOP, and REC interlock functions. A "flying start" recording can be made from play by simultaneously holding down the normal play button and pressing the REC button. A separate PAUSE button stops the tape without disengaging the recording function.

A small PITCH CONTROL knob to the left of the tape heads can be used to adjust the tape speeds over a nominal ±5% range. It has a detented center position, which gives the nominally correct tape speed. This control operates when the transport is in both the record and the playback modes. So, it can be used to correct the pitch of a reference track when making a Quadra Sync recording. Below the PITCH CONTROL are the POWER switch and two TAPE SELECTOR buttons (for low-noise and wide-range tapes) and the speed selector buttons.

There are five pushbuttons in the Quadra Sync system. Four are for individual channel selection and the fifth allows you to select either the 2- or the 4-channel mode of operation.

Four VU meters light according to the mode selected. In the 2-channel mode, only the channels 1 and 3 meters light, while in the 4-channel mode, all four meters light. A red light above each meter glows when that channel is in the recording mode. This gives a very clear indication of the operation of the Quadra Sync system, since pressing any of the system's buttons disables the erase and record function for that channel, simultaneously extinguishing the corresponding red light.

The settings of the concentric playback level controls do not affect the meter readings. A MONITOR switch con-

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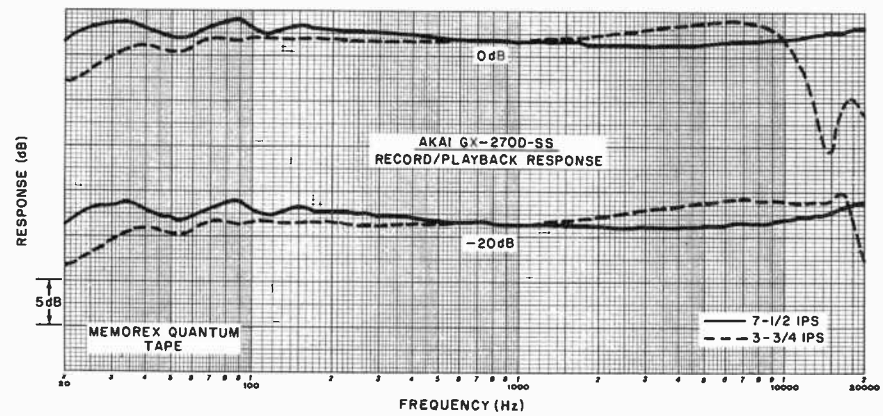


Record/playback response using Memorex Quantum tape at 7½ and 3¾ ips.

nects either the input signal or the playback amplifier output to the line output terminals. Four separate ¼" (6.4-mm) phone jacks are provided for the microphones, which should be medium impedance (600-ohm) dynamic types. There are also two stereo phone jacks for monitoring the front and rear channels. For best results, the phones should have an 8-ohm impedance. Below each VU meter is a concentric pair of recording level controls for that meter's channel (one each for the MIC and line inputs, which can be mixed).

On the rear of the recorder are the four pairs of line inputs and outputs and a socket for an optional remote control accessory.

The specifications of the Model GX-270D-SS are consistent with the requirements for a high-quality home tape recorder. Based on the use of Scotch 211 or an Akai tape, they include: frequency response to 21,000 Hz at 7½ ips and to 15,000 Hz at 3¾ ips; with wow and flutter less than 0.07% and 0.1% at the two speeds; less than 1% distortion at 1000 Hz and 0 VU; and better than 54 dB S/N ratio, referred to a +6-VU recording level.

Laboratory Measurements. The record/playback frequency response of the tape deck was measured with several types of tape, using the "wide range" selector position, to determine which best matched the factory settings of the recorder. Although the differences were not large, we found that Memorex Quantum gave the best results; it was subsequently used for the remainder of the tests. Akai SRT-F and Scotch 212 were quite similar to it in performance, while TDK Audua and Maxell UD35-7 had a rising high-end response.

The 7½-ips frequency response was ±2 dB from 20 to 24,500 Hz at a 20-dB recording level and was virtually the same at 0 dB. There was no sign of tape saturation at 0 dB with any of the tapes used. The 3¾-ips response was within ±2.5 dB from 30 to 18,500 Hz, and tape saturation rolled off the 0-dB output above 7000 Hz.

The playback frequency response, measured with Ampex test tapes, was within ±1.5 dB from 50 to 15,000 Hz at 7½ ips. It was ±1.5 dB from 50 to 7500 Hz at 3¾ ips. Both results represent the frequency limits of the tapes.

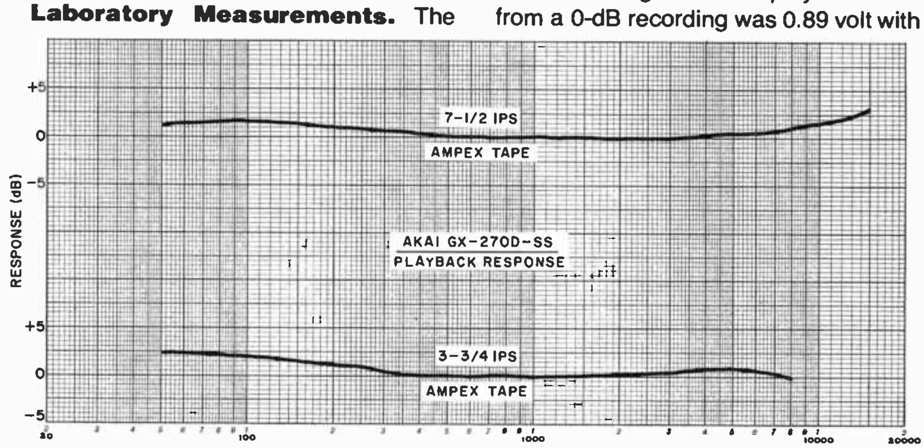
A line input of 75 mV or a microphone input of 0.28 mV was necessary for a 0-dB recording level. The playback level from a 0-dB recording was 0.89 volt with the Memorex tape. (It varies somewhat with the tape used.) The playback distortion at 0 dB at either speed was 0.38% to 0.40%, which is well below the rated value. The reference 3% distortion was reached at a recording input of +10 dB.

The unweighted S/N ratio, referred to the 3% distortion level, was 59 dB at both speeds. With IEC "A" weighting, it was 65.5 dB. With CCIR/ARM weighting, the S/N was 61 dB at 3¾ ips and 64 dB at 7½ ips. The noise level through the microphone inputs was only 3.5 dB higher than through the line inputs.

The flutter of the GX-270-SS was a very low 0.04% at both speeds, which is probably the result of using a direct-drive capstan motor. The PITCH CONTROL had a range of +6.6% to −4.8% at 3¾ ips, and from +5.5% to −4.1% at 7½ ips. In fast forward and rewind, an 1800' (550-m) reel of tape was handled in 100 seconds. The meters responded more slowly than real VU meters, indicating 80% of steady state on 0.3-second tone bursts. The headphone volume was not adjustable and was quite low with 200-ohm phones but fairly good with 8-ohm phones.

User Comment. The operation of the recorder was simple and straightforward, for both conventional operation and for making "Quadra Sync" recordings. The solenoids, which operated with audible "clunks," had a logic system that enabled the buttons to be operated in any sequence without going through STOP. Pressing a normal speed button while the tape was in fast motion (or going in the opposite direction) brought the tape to a smooth, swift stop, after which it paused for a few seconds before resuming play.

On the machine tested, we did not find any effect on the sound when we operated the TAPE SELECTOR buttons. Neither the frequency response, nor the distortion, nor the noise level were affected by this control in any way that we could hear or measure. Also, although the head cover carries the inscription "Auto Reverse," this feature is not mentioned in the instruction manual, nor are there any instructions given on how to install the conductive tape for automatic reversal. A couple of pieces of foil are included with the recorder, with a cryptic statement that they should be installed on either the dull side *or* the shiny side of the tape. We tried both, and the system operated properly with the foil on either side of the tape. Even if the autoreverse feature is not used, it is still very convenient to be able to play the second pair of



Playback frequency response of the recorder using Ampex test tapes.

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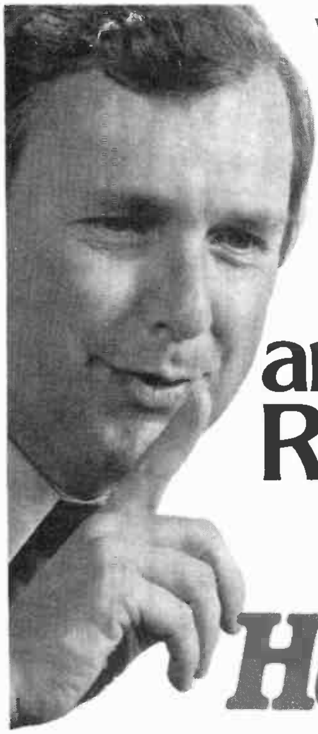

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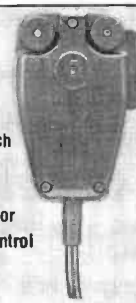

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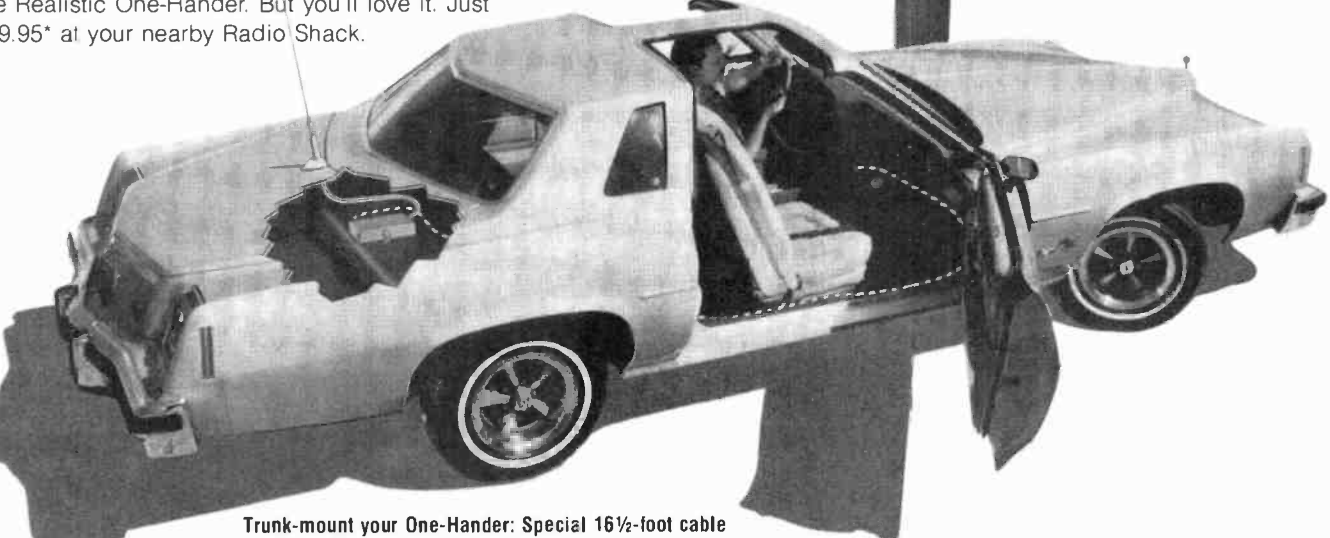

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At 7½ ips, the sound quality of the recorder leaves little to be desired. When we recorded interstation hiss from an FM tuner, we could hear only a minute brightening of the playback in comparison to the incoming signal. This was consistent with the measured frequency response of the recorder. But at 3¾ ips, the brightness was quite noticeable, even without an A-B comparison.

This deck will appeal most to the serious amateur recordist who wants to try his hand at multi-track-sync recording. It is a versatile machine, equally at home with recording and playing back 2- and 4-channel tapes or with creating one's own "professional"-style recordings. We were impressed by the manner in which it surpassed every one of its published specifications, usually by a wide margin.

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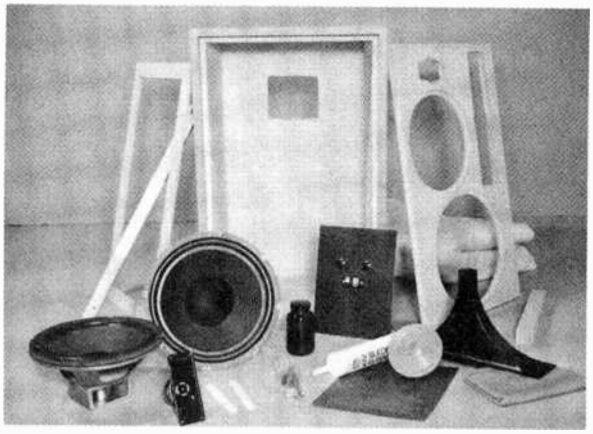
SPEAKERLAB MODEL S7 SPEAKER SYSTEM KIT

Assemble-it-yourself, three-way speaker system employs four drivers.



HIRSCH-HOUCK LABS REPORT

The Model S7 three-way speaker system is one of the six speaker kit models from Speakerlab. This second from the top-of-the-line kit features an air-suspension system to achieve good bass response in a relatively small enclosure. (Top of the line has a folded-corner-horn design.)

As with all speaker systems kits from Speakerlab, the Model S7's enclosure box is supplied already assembled, requiring only the application of an oil finish (materials supplied) to complete the "wood work." The various elements in the kit—drivers, crossover network, fiberglass insulation, etc.—are mechanically mounted and interconnected.

The Model S7's transducer complement consists of a horn tweeter, horn midrange driver, 12" (30.5-cm) cone-type woofer, and 10" (25.4-cm) cone-type woofer. Crossover frequencies are nominally at 700 and 5000 Hz, and L pads are provided for adjusting the midrange driver and tweeter balance. Zeners protect the tweeter.

Speakerlab recommends that an amplifier rated at a minimum of 15 to 25 watts/channel be used to drive the Model S7 speaker systems. Maximum guaranteed safe power for the speaker systems is 150 watts rms/channel. Nominal impedance is 4 ohms.

The front and back of the speaker system's walnut-veneer enclosure are made of ¾" (19.1-mm) thick particle board, while the remainder of the box has an additional layer of ¾" plywood added to its thickness. The enclosure measures 29"H × 18"W × 15⅛"D (73.7 × 45.7 × 38.4 cm). The assembled speaker system weighs 85 lb (38.6 kg). Price is $279 per speaker system kit.

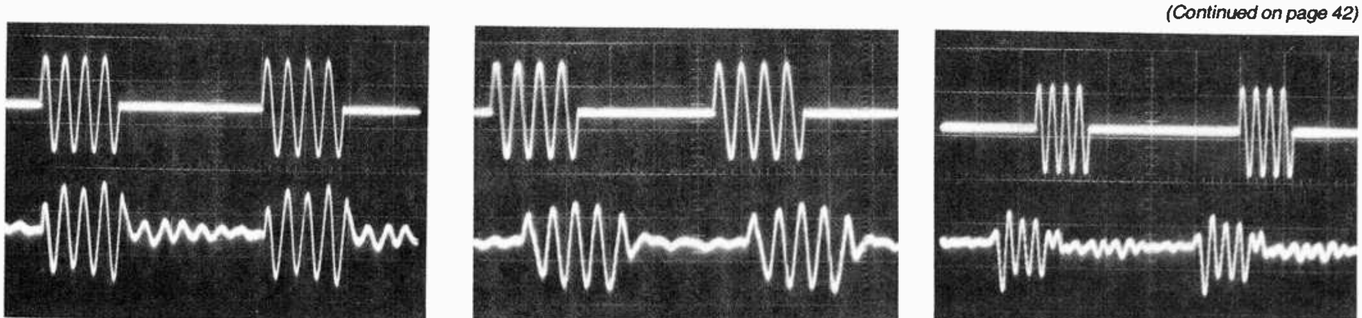
Kit Assembly. The Speakerlab kit contained everything required to assemble, wire, and finish the speaker system except scissors, stapler, caulking gun, and sandpaper. (The last item is used to gently sand the edges of the box and any rough spots.) A cartridge of silicone rubber adhesive, supplied with the kit, is used instead of screws for driver and subassembly mounting.

The prewired crossover network/input terminal/L pad assembly mounts first over its cutout in the cabinet via a bead of silicone adhesive. Next, the fiberglass wool sheets are cut with scissors to rough sizes and then stapled to all internal walls of the speaker cabinet except the front panel. Once this is done, short lengths of Velcro fastener tape are stapled to the front panel at all four corners.

The front board on which the drivers mount fastens to the cabinet via a thick bead of silicone rubber adhesive between it and the enclosure's particle board liner. A 2" × 2" (5.1 × 5.1 cm) brace is then white glued between the inside rear wall and the rear wall of the front panel between the woofer cutouts to add rigidity and to reduce the possibility of mechanical resonances in the bass range. Finishing nails driven through both walls into the ends of the brace keep the brace from moving while the glue is setting.

Heavy-gauge wires with push-on terminals connect to the drivers from the crossover/L-pad assembly. The drivers then mount in their respective cutouts with the aid of beads of silicone rubber adhesive. No screws are used to hold the drivers in place. The silicone adhe-

(Continued on page 42)



Tone-burst response for (left to right) 100, 1000, and 7000 Hz.

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The CT-64 terminal kit offers these premium features: 64-character lines, upper/lower case letters, switchable control character printing, word highlighting, full cursor control, 110-1200 Baud serial interface, and many others. Separately the CT-64 is $325, the 12 MHz CT-VM monitor $175.

$395 4K 6800 Computer
The SWTPC 6800 comes complete with 4K memory, serial interface, power supply, chassis, famous Motorola MIKBUG® mini-operating system in read-only memory (ROM), and the most complete documentation with any computer kit. Our growing software library includes 4K and 8K BASIC (cassettes $4.95 and $9.95; paper tape $10.00 and $20.00). Extra memory, $100/4K or $250/8K.

Other SWTPC peripherals include $250 PR-40 Alphanumeric Line Printer (40 characters/line, 5 x 7 dot matrix, 75 line/minute speed, compatible with our 6800 computer and MITS/IMSAI); $79.50 AC-30 Cassette Interface System (writes/reads Kansas City standard tapes, controls two recorders, usable with other computers); and other peripherals now and to come.

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_____ $325 for the CT-64 Terminal
_____ $175 for the CT-VM Monitor
_____ $395 for the 4K 6800 Computer
_____ $250 for the PR-40 Line Printer
_____ $79.50 for AC-30 Cassette Interface
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As an indication of how career areas compare, the consumer area of electronics (of which TV is a part) makes up less than one-fourth of all electronic equipment manufactured today. Nearly twice as much equipment is manufactured for the communications and industrial fields. Still another area larger than consumer electronics is the government area. That is the uses of electronics in such areas as research and development, the space program, and others.

Just as television is only one part of the consumer field, these other fields of electronics are made up of many career areas. For example, there are computer electronics, microwave and satellite communications, cable television, even the broadcast systems that bring programs to home television sets.

As you may realize, career opportunities in these other areas of electronics are mostly for advanced technical personnel. To qualify for these higher level positions, you need college-level training in electronics. Of course, while it takes extra preparation to qualify for these career areas, the rewards are greater both in the interesting nature of the work and in higher pay. Furthermore, there is a growing demand for personnel in these areas.

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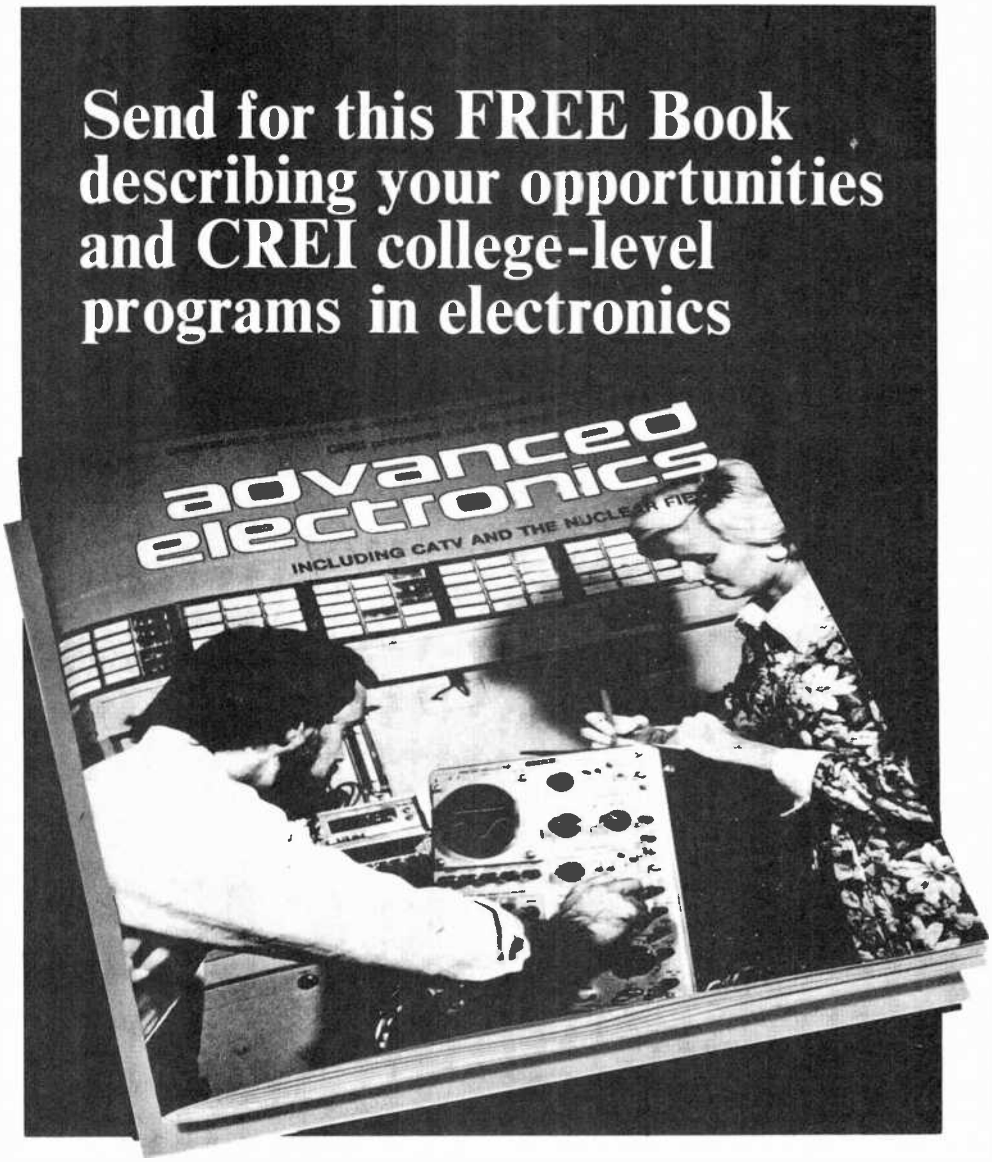

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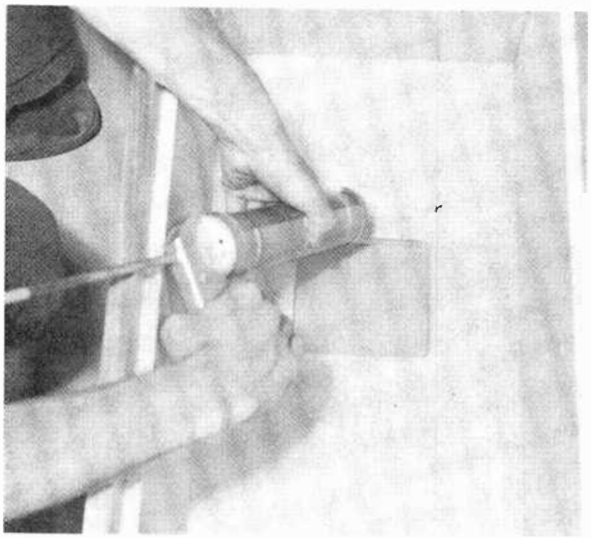
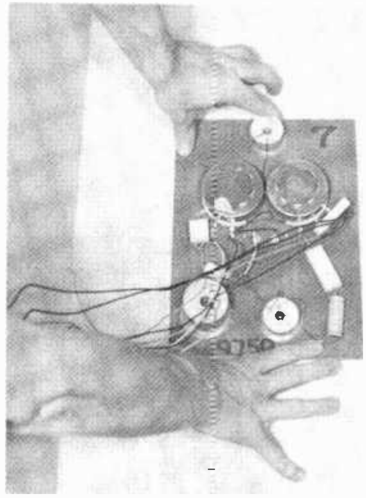
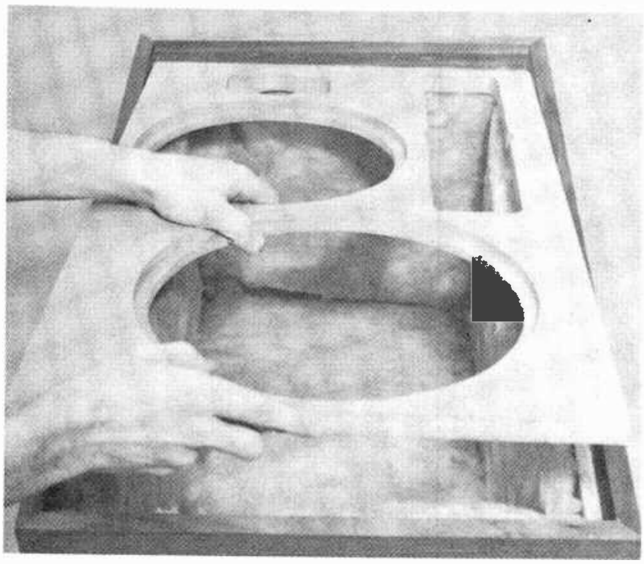
JULIAN HIRSCH AUDIO REPORTS (continued from page 36)



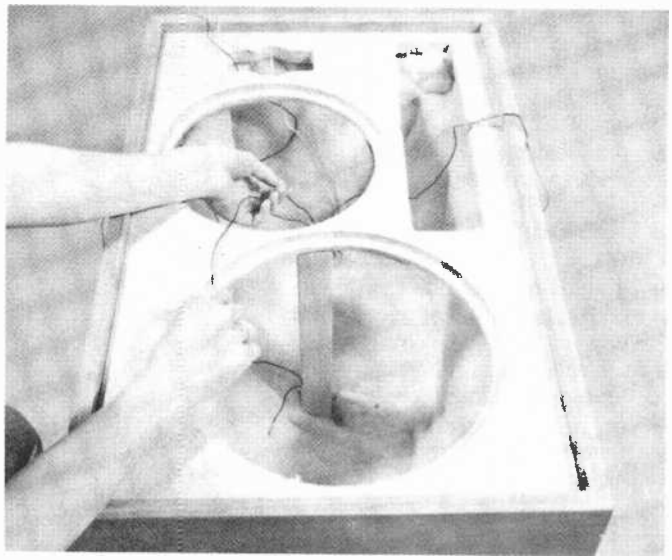
Using a caulking gun, a bead of silicone rubber adhesive is applied around the opening in the enclosure for mounting the electronic assembly.



The prewired assembly, holding the crossover network, input terminal, and L pads is pressed into the adhesive.



Cabinet is lined with fiberglass and front panel attached, the latter again secured by adhesive.



Crossover network leads are pulled through the driver openings. Note supporting wood brace.

sive serves as both mounting and air sealing mediums. The front panel cutout for the horn tweeter is slightly longer in length to permit the driver to slip into place. Consequently, once the tweeter is in place, two small pieces of wood, supplied trimmed to the proper sizes, are glued to the panel to cover up the openings at both ends of the driver horn.

A choice of two different ways of finishing the grille assembly is possible with the materials supplied in the kit. One is a plain flat grille that merely requires the grille cloth to be stretched over and stapled to a ready-made frame. The other is to make the grille assembly three dimensional. To do this, four pieces of wood are glued together to form a frame that is then glued to the ready-made frame. After rounding the edges of the frame, the grille cloth is stretched over the whole and stapled into place. In either case, Velcro strips are fastened to the frame at the inside rear corners to hold the grille assembly in place.

We allowed four hours for the cemented pieces to set before using the speaker system, which was lying on a floor so that the full weight of the drivers bore down on the silicone adhesive cement/gaskets. We tested the speaker systems beforehand, though, propping them up just enough to permit us to connect cables from our amplifier to them and to permit us to adjust the balance controls.

Once the cements had set and we were satisfied with the operation of the speaker systems, we used No. 150 dry sandpaper to smooth all exterior surfaces of the cabinets. Then we proceeded to pour small amounts of the oil supplied with the kit on one side after another, rubbing it in lightly with No. 400 wet-paper sandpaper. Excess oil was wiped off with a paper towel. Then we allowed the wood to soak up the oil and dry for about two hours. For the finishing touch, we installed the grille assembly, and the system was ready to go to work.

Laboratory Measurements. The middle and high-frequency response of the speaker system was measured in the reverberant field of our room at a distance of 12′ to 15′ (3.7 to 4.6 m) from the drivers and with the midrange and tweeter level controls set to maximum. To eliminate room interactions at low frequencies, the woofer response was measured separately, with the microphone placed in the plane of the mounting board. Since the system has two dif-

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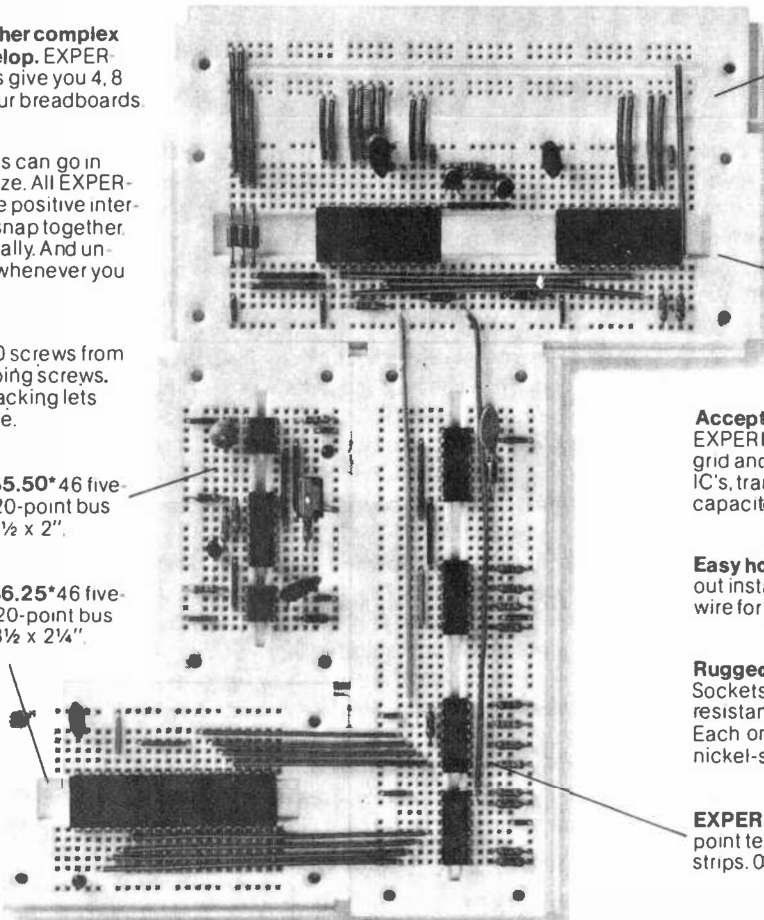

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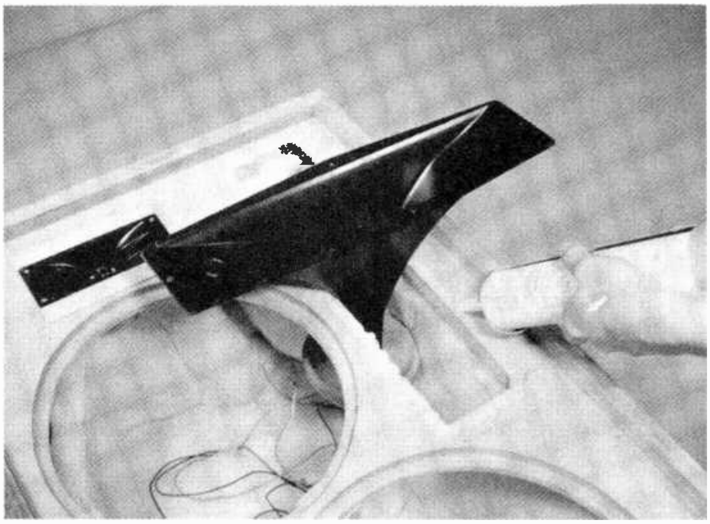


The midfrequency horn driver is prepared for enclosure mounting.

Completed system without grille.

ferently sized woofers, separate measurements were made on each.

The reverberant frequency response was very good. Also, the woofer response was smooth and flat, without a glitch in the upper part of its range. When the two curves were spliced together, the response was within ±3 dB from 35 to 6000 Hz and rose at higher frequencies. Of course, the shape of the high-frequency curve would vary considerably with different settings of the level controls.

The reasons for using two different woofers are not obvious, since the measured frequency response from each was the same, although the larger cone delivered about 2 dB more output. The output of the woofer reached a maximum between 60 and 80 Hz, falling at a rate of 24 dB/octave below 60 Hz and at about 6 dB/octave above 80 Hz.

The rated impedance of the speaker system is 4 ohms, a fact that was confirmed by our tests. It measured 4 ohms at 2 Hz and in the 100-Hz region, with a bass resonance rise to 15 ohms at 50 Hz. The impedance was in the 10-to-12-ohm range at all frequencies above a few hundred hertz.

User Comment. For most of our listening tests, the speaker systems were on tilt stands supplied by Speakerlab. This raised the cabinets about 8" (20.3 cm) above floor level and tilted them back to provide better coverage for the typical seated listener.

In our live-versus-recorded test, the Speakerlab S7 was highly accurate in the upper midrange and at high frequencies. We observed some added warmth in the lower midrange. It did not show up on the response curve, however, and may have been associated with the room's characteristics.

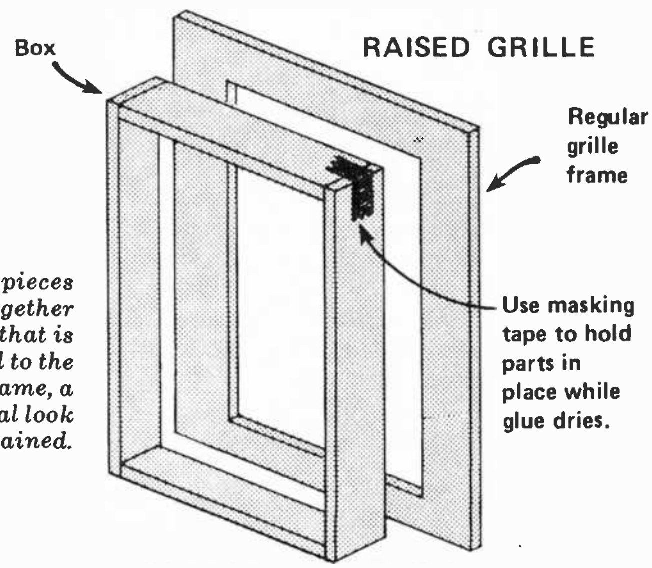
The S7's 4-ohm speaker impedance gives one a sense of higher speaker efficiency as compared to equivalent 8-ohm speakers since it draws more power at a given volume-control setting. Note, however, that one cannot safely use *two* sets of speaker systems when using 4-ohm ones, even if the remotes are 8-ohm types, as most amplifiers will not be able to handle it. For obtaining maximum power from one set of speakers, however, the 4-ohm types are ideal.

All in all, this is a very fine speaker system. We found it to be equally suited to all kinds of music. Since its balance must be set by ear, the end result naturally depends on the builder's ability to set up both balance controls properly. (Instructions are provided with the kit.)

Assembling this kit was an interesting job. The instruction manual was clearly written and illustrated, and most informative. It took us about two hours to complete each speaker system, excluding waiting time for glue drying. Not having any screws to which to secure the speaker elements eliminated the possibility of damaging the cone by mistakenly moving the driver above it owing to the always surprising heavy weight of the element. But, even if this or any other damage is done, the manufacturer will send a new part, no questions asked. And if you happen to be the unhandiest person around and cannot complete the kit, Speakerlab will finish it for you at no charge (customer pays freight). If you should need help with the kit, there's a toll-free number where you can obtain fast, free assistance.

For those who want to make their own enclosures, speakers and the crossover can be purchased separately for $191 each channel.

For more information, write Speakerlab, 5500 35th Ave., N.E., Seattle, WA 98105.



By using four pieces of wood glued together to form a box that is then glued to the regular frame, a three-dimensional look for grille is obtained.

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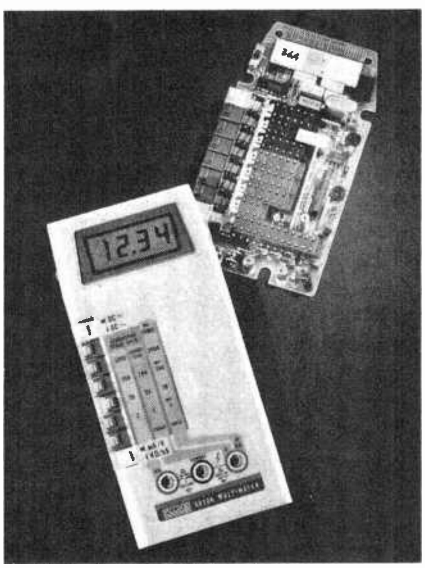

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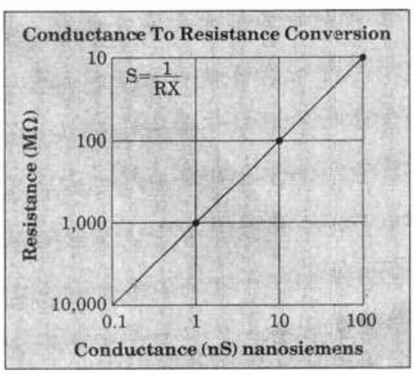

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Popular Electronics®
SEPTEMBER 1977

1/2-Octave Real Time Audio Analyzer

BY BOB JONES AND RICHARD MARSH

Used with a mike and oscilloscope, it displays system output to permit accurate matching to room acoustics.

PART 1

IT'S COMMON knowledge that an equalizer can shape a sound system's frequency response. But adjusting multiple equalizer bands for flat audio response in a room is a challenge. This project, an audio Real Time Analyzer, provides a solution to the problem. It generates a graphic representation of the system's output with sufficient detail (20 half-octave bands) to allow quick, accurate matching to room acoustics when used with a calibrated microphone and a dc-coupled oscilloscope.

Furthermore, the RTA can be used to check the frequency response of such components as preamps, power amplifiers, etc. The RTA can also function as a sound pressure meter, as a noise analyzer (energy per frequency band), and as an aid in the design of speaker systems and crossovers.

A block diagram of the RTA is shown in Fig. I. Input signals are selected by *S1* from MIC or AUX sources. Microphone signals are boosted to line level by a preamp with a gain of 200. A buffer amplifier then passes the MIC or AUX signal to twenty half-octave active bandpass filters. Each filter passes only that portion of the input signal within its passband. These filtered ac components are then rectified by diodes (one for each filter) and smoothed by RC combinations. The resulting dc levels, proportional to the amount of energy within each passband, are scanned sequentially by a 24-channel multiplexer. Finally, the multiplexed signal is buffered and presented at the RTA output.

At this point, dc levels can be applied to the vertical amplifier of the oscilloscope. Variations in vertical deflection from one band to the next will *linearly* reflect differences between dc levels, and hence between the energies contained in the filter passbands. However, in audio work, voltage variations are usually expressed in decibels. A logarithmic converter has therefore been incorporated into the RTA, allowing direct readout of signal levels in dB from the CRT trace. The multiplexing and display functions of the RTA are carried on so quickly that all bands are shown simultaneously or in "real time."

Circuit Details. The input stage of the Analyzer is shown schematically in Fig. 2. A balanced differential amplifier, *IC1*, allows the use of long lines and low-impedance microphones due to its good common mode rejection characteristics. This amplifier has a voltage gain of 200, determined by *R2* and *R4*, and boosts microphone input signals to line level. External frequency compensation for the op amp is provided by *R6* and *C1*. Capacitor *C2* prevents any dc level at the output of *IC1* from reaching microphone level control *R7*.

Signals from either the microphone preamp or a source connected to the AUX input are selected by *S1* and applied to buffer amplifier *IC2*. Frequency compensation is provided by *C3*. The low-impedance output of *IC2* drives the parallel inputs of the half-octave filters.

Each active filter employs one IC (*IC3*

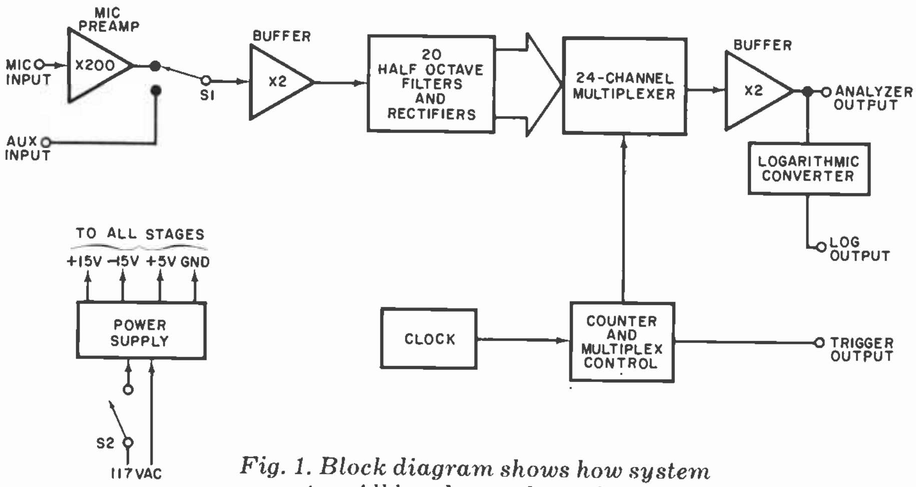


Fig. 1. Block diagram shows how system operates. All bands are shown in real time.

PARTS LIST

C1,C106,C118 through C165—0.01-µF, 50-V disc ceramic capacitor
C2,C4—15-µF, 10-V tantalum capacitor
C3,C45 through C64—20-pF, 5%, 500-V silver mica capacitor
C5 through C44—See text and Table I. Close tolerances are essential.
C65 through C104—1-µ-F, 50-V 1 ceramic capacitor
C105—1.5-µF, 50-V ceramic capacitor
C107—500-µF, 50-V electrolytic capacitor
C108,C109—50µF, 50-V electrolytic capacitor
C110,C111—10-µF, 20-V tantalum capacitor
C112—50-µF, 10-V tantalum capacitor
C113 through C117—See Part II
D1 through D20—1N4148 switching diode
D21 through D24—1N4003, HEP R0052 or equivalent
F1—1-ampere slow-blow 3A6 fuse
IC1—LM725CH operational amplifier
IC2,IC3 through IC22—LM301AH operational amplifier
IC23—NE555 timer
IC24,IC26—SN7490 decade counter
IC25—SN7404 hex inverter
IC27—9301 (Fairchild, or equiv.) BCD-to-decimal decoder*
IC28 through IC30—AM3705D (National Semiconductor, or equiv.) PMOS eight-channel multiplexer**
IC31—LM741CH operational amplifier
IC32—MC7815CP or HEP C6114P +15-volt voltage regulator
IC33—MC7805 or HEP C6110P +5-volt voltage regulator
IC34—MC7915CP or HEP C6123P -15-volt voltage regulator
J1—Microphone connector (Cannon XLR-3-13 or equivalent)
J2 through J4—BNC connector
LED1-20-mA LED (TIL32 or equivalent)
The following resistors are ⅛-watt, 1% tolerance, metal-film components.
R1 through R3—1000 ohms
R4,R5—200,000 ohms
R35 through R74—See text and Table I.
The following resistors are ¼-watt, 5% tolerance carbon components.
R6—47 ohms
R9,R12,R14,R95 through R114,R138,—10,000 ohms
R10,R11—100,000 ohms
R13—5000 ohms
R115 through R134—3.3 Megohms
R135—330 ohms
R136—560 ohms
R137—20,000 ohms
R139—300 ohms
R7—10,000-ohm, single-turn Cermet potentiometer*
R8—100,000-ohm, single-turn Cermet potentiometer*
R15 through R34—50,000-ohm, 20-turn, Helitrim Cermet potentiometer (Beckman 66X or equivalent)*
R75 through R94—100,000-ohm, single-turn miniature Cermet trimmer potentiometer (Beckman 91W or equivalent)*
S1—Dpdt miniature toggle switch
S2—Spst miniature toggle switch
T1—Triad F91-X universal transformer or equivalent 40-volt center-tapped transformer.*
Misc.—IC sockets or Molex Soldercons, printed circuit boards, heat sinks, line cord, fuseholder, pc board spacers, suitable enclosure, knobs, coaxial cable, hookup wire, machine and self-tapping hardware, solder, etc.
Note: The following is available from Southwest Technical Products Corp; 219 W. Rhapsody, San Antonio, TX 78216: set of three etched and drilled pc boards for $19.00

*Available through distributors such as Allied Radio or Newark Electronics.
**Consult a National Semiconductor local distributor or sales representative.

through *IC22*) in a Wein-bridge circuit, as shown in Fig. 3. The parallel legs of the filters are formed by *R35* through *R54* and *C5* through *C24*, and the series legs by *R55* through *R74* and *C25* through *C44*. The values of these components are chosen according to the formula for the center frequency of the filter passband: $f_C = 1/(2\pi RC)$. Note that each RC pair (series and parallel) has the same time constant. Potentiometers *R15* through *R34* control filter gain and Q. When properly adjusted, the bandwidth of each filter is exactly one-half octave. With filter center frequencies spaced one-half octave apart, the skirts of the filter response curves will cross over 12 to 18 dB down. This is satisfactory for most audio work.

To achieve the value of Q necessary for narrow bandwidth, the resistors and capacitors in the series and parallel legs of each filter must have close tolerances. Resistors should have tolerances no greater than 1%, and capacitors no greater than 3%. Band-to-band variations in filter gain can be trimmed by LEVEL ADJUST potentiometers *R75* through *R94*. Each filter output is rectified and filtered into a proportional dc voltage by *D1* through *D20*, *C85* through *C104*, *R95* through *R114* and *R115* through *R134*. A long time constant is employed in the RC filter to average low-frequency components and reduce display bounce.

The digitally controlled multiplex system requires a reference time base or clock. In this project, IC23, a free-running 555 IC timer, generates the necessary clock pulses (Fig. 4). Duty cycle and frequency are determined by *R135*, *R136*, and *C105*. Too high a frequency causes excessive display bounce with a varying input such as random noise. Too low a clock frequency results in display flicker which is hard on the eyes. A clock rate of 2000 Hz was chosen to avoid both undesirable effects.

Clock pulses are applied to *IC24*, a 7490 decade counter wired to count from 0 to 7, then reset to 0 on the eighth clock pulse. Therefore, a total of eight different output states on three data lines (2^0, 2^1, 2^2) are available. These outputs allow selection of any one of eight FET gates in a 3705 PMOS IC multiplexer. All required decoding circuitry is on the 3705 chip. Of course, twenty channels are needed, not just eight. This is why *IC26* and *IC27* (7490 and 9301, respectively) are employed. The multiplex circuit is shown in Fig. 5. Each 3705 (three required for 24-channel capacity) has an enable line (E). This allows sequential multiplexer activation.

Decade counter *IC26* (7490) is wired to count from 0 to 2, and then reset to 0 on the next pulse from *IC25F*. For the first seven clock pulses (refer to timing diagram Fig. 6), *IC26* has a 0 output. This is decoded by *IC27*, a 9301 BCD-to-decimal decoder, as a select line one (MPX1 Select) command. Accordingly, multiplexer *IC28* is activated. The rectified outputs of the first eight filters are

(continued on page 50)

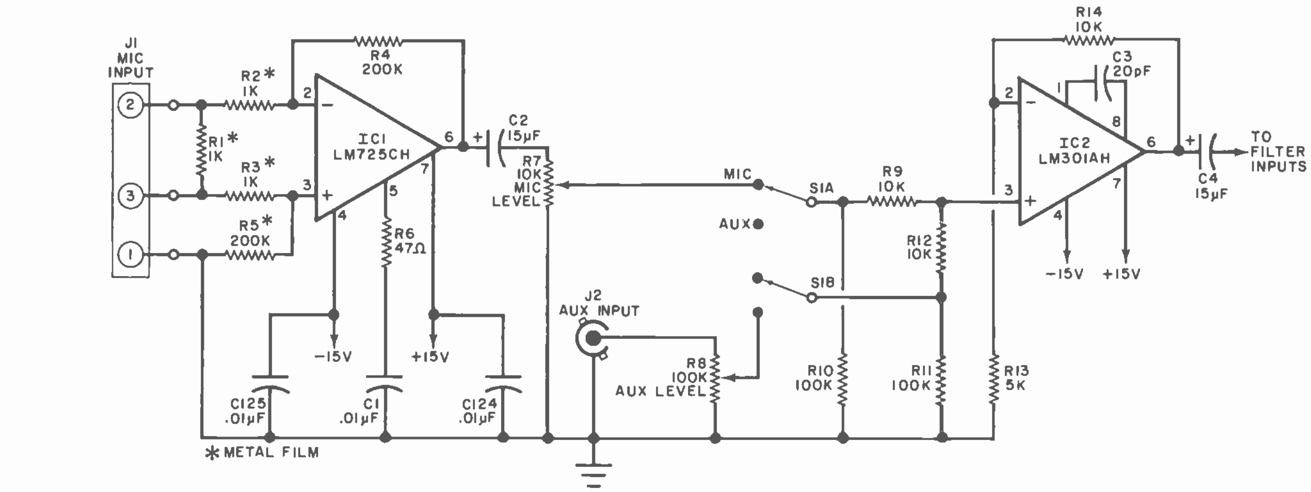


Fig. 2. Input stage includes a balanced differential amplifier, IC1, and buffer, IC2.

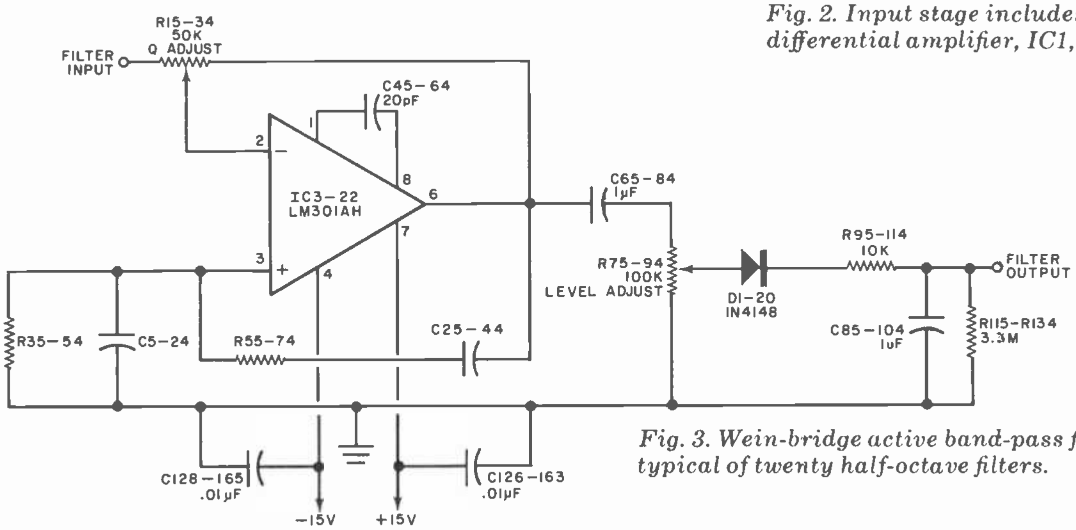


Fig. 3. Wein-bridge active band-pass filter, typical of twenty half-octave filters.

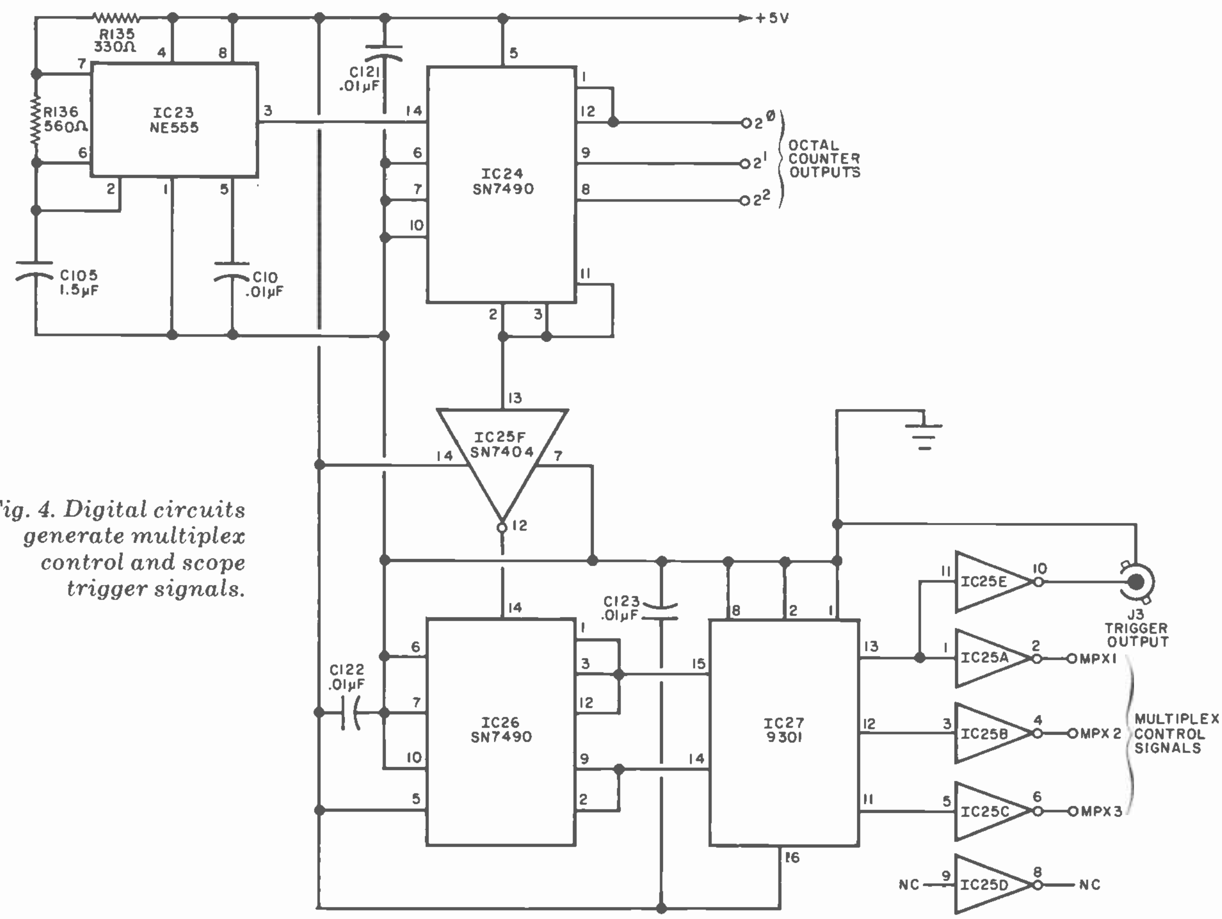


Fig. 4. Digital circuits generate multiplex control and scope trigger signals.

scanned and sequentially passed to output buffer amplifier *IC31*, a 741 op amp with a voltage gain of two. On the eighth clock pulse, *IC24* will revert to a 0 output, *IC26* will increment to 1, causing MPX2 Select to go high and activating *IC29*. Thus, the outputs of filters 9 through 16 are scanned and passed to *IC31*. On the sixteenth clock pulse, *IC24* causes *IC26* to increment to 2, and *IC27* issues an MPX3 Select command which enables *IC30*. Accordingly, the rectified outputs of filters 17 through 20 are scanned and passed to the buffer. At clock pulses 21 and 22, a ground (0 volt) is sent to the scope for base line reference. At clock pulses 23 and 24, *IC30* sends +5 volts (boosted by *IC31* to 10 volts) to the scope for maximum level reference. (Input signal levels should be adjusted to fall within these extremes.) At clock pulse 24, *IC24* and *IC26* reset themselves to zero, MPX1 Select again goes high and the process is repeated. Also, a positive-going transition at clock pulse 24 is used for scope triggering.

The power supply for the Analyzer is shown schematically in Fig. 7. Transformer *T1* (40 V CT) and diodes *D21* through *D24* form a bridge rectifier. Ca-

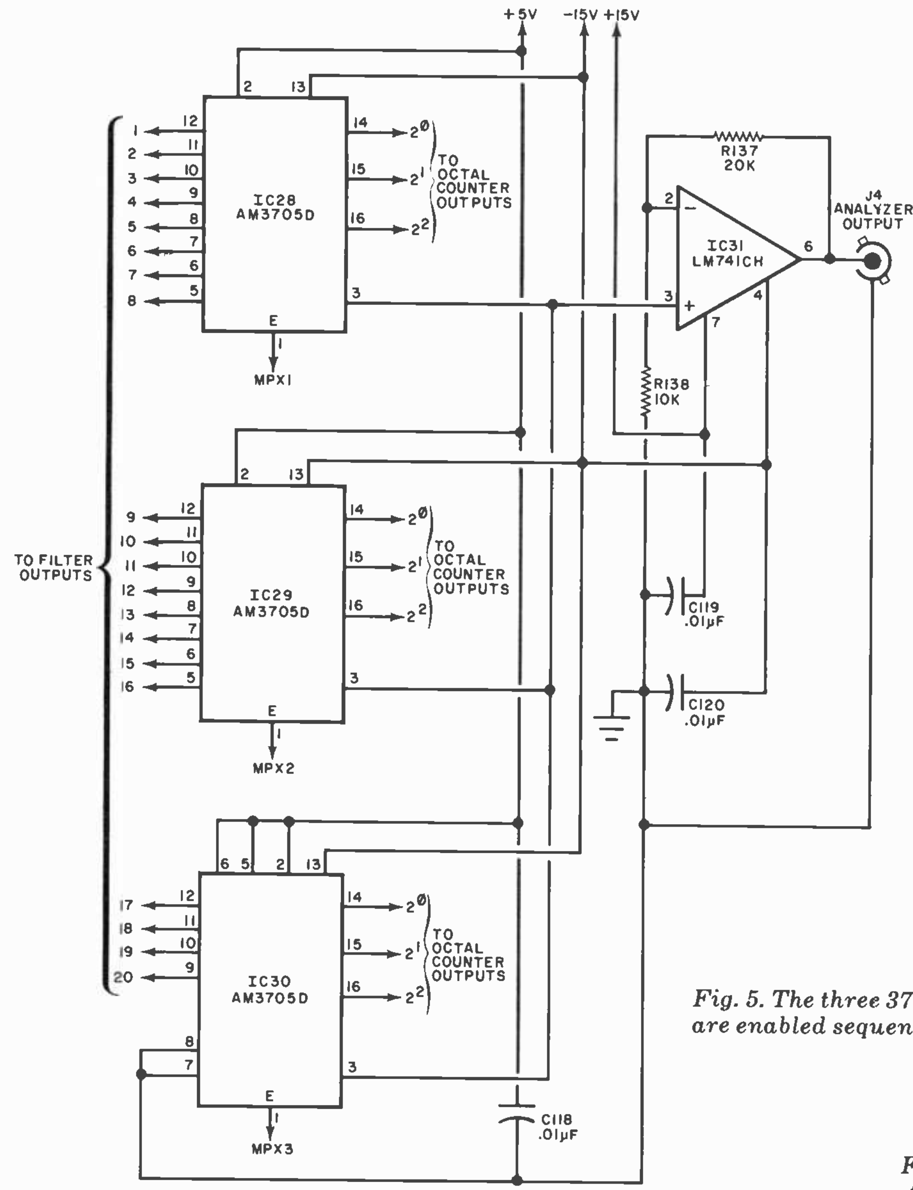
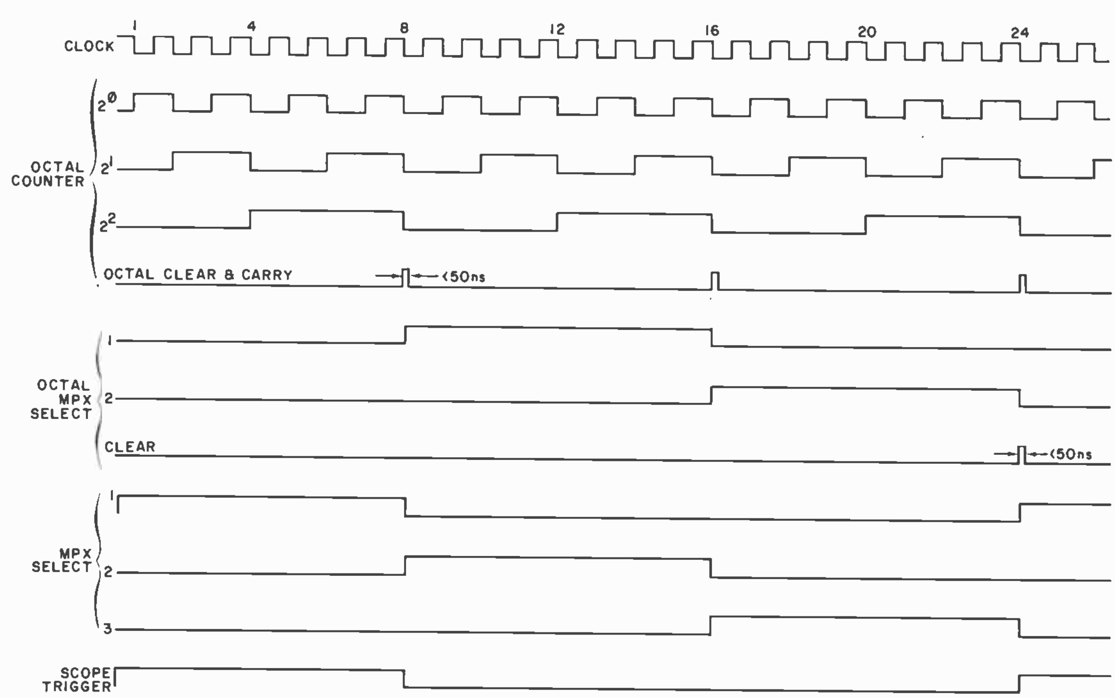


Fig. 5. The three 3705 multiplexer IC's are enabled sequentially.

Fig. 6. The timing diagram below shows the clock waveform (top) and the events that occur at various clock pulses.



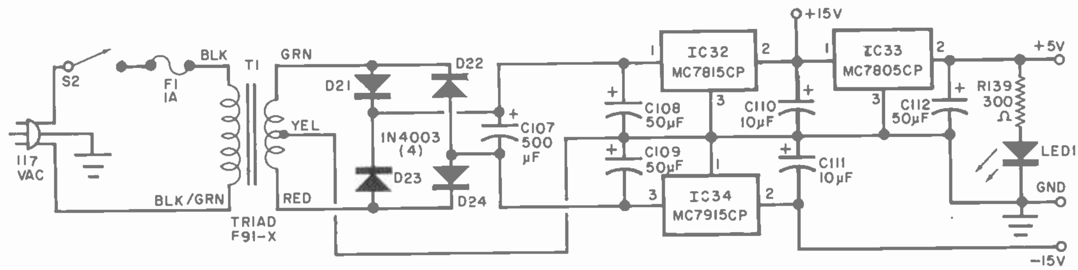


Fig. 7. Schematic of power supply circuit shows bridge rectifier and voltage regulators.

TABLE I—FILTER VALUES

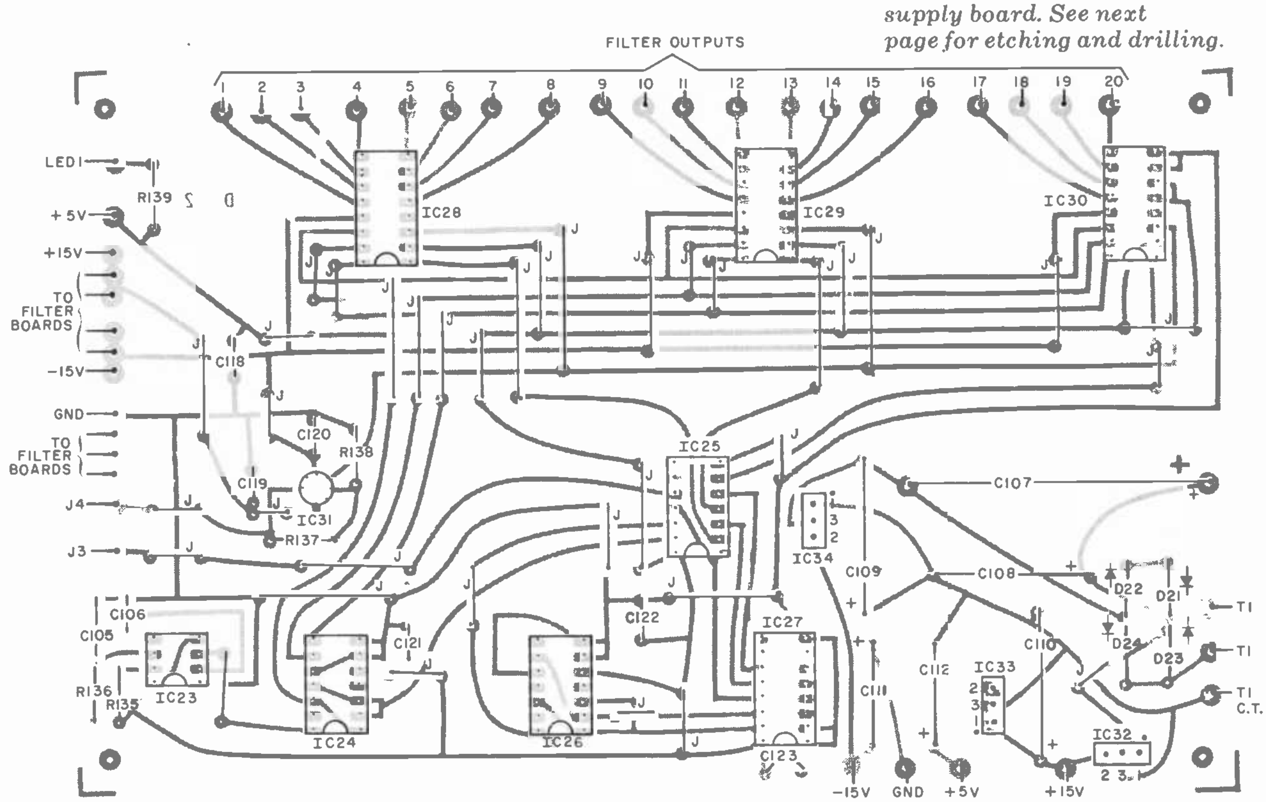
Filter	Center Frequency f_C (Hz)	Resistors (ohms)	Capacitors (μF)
1	22.4	R35, R55—68, 100	C5, C25—0.1
2	31.5	R36, R35—75,000	C6, C26—0.068
3	45	R37, R57—51,100	C7, C27—0.068
4	63	R38, R58—38,300	C9, C29—0.047
5	90	R39, R59—38,300	C9, C29—0.047
6	125	R40, R60—26,100	C10, C30—0.047
7	180	R41, R61—26,100	C11, C31—0.033
8	250	R42, R62—28,700	C12, C32—0.022
9	355	R43, R63—46,400	C13, C33—0.01
10	500	R44, R64—31,600	C14, C34—0.01
11	710	R45, R65—31,600	C15, C35—0.0068
12	1000	R46, R66—23,700	C16, C36—0.0068
13	1400	R47, R67—23,700	C17, C37—0.0047
14	2000	R48, R68—23,700	C18, C38—0.0033
15	2800	R49, R69—26,100	C19, C39—0.0022
16	4000	R50, R70—38,300	C20, C40—0.001
17	5600	R51, R71—28,700	C21, C41—0.001
18	8000	R52, R72—42,200	C22, C42—470pF
19	11200	R53, R73—31,600	C23, C43—470pF
20	16000	R54, R74—28,700	C24, C44—360pF

pacitors *C107*, *C108*, and *C109* provide input ripple filtering to IC voltage regulators *IC32*, *IC33*, and *IC34*. Capacitors *C110*, *C111*, and *C112* provide output filtering. Resistor *R139* limits current to *LED1*, the front panel power indicator.

Construction. The RTA is most easily assembled on three printed circuit boards (four if the optional log converter is desired). Etching and drilling and component placement guides for the Digital and Power Supply Board, Filter Board 1, and Filter Board 2 are shown in Figs. 8, 9, and 10, respectively. (See Table I for RC values for each filter.)

Mount all components on the pc boards using the minimum heat and solder required for good connections. Pay close attention to the polarity and basing of electrolytic (aluminum and tantalum) capacitors, diodes, transistors, and integrated circuits. The use of IC sockets or

Fig. 8A. Parts placement guide for digital and power supply board. See next page for etching and drilling.



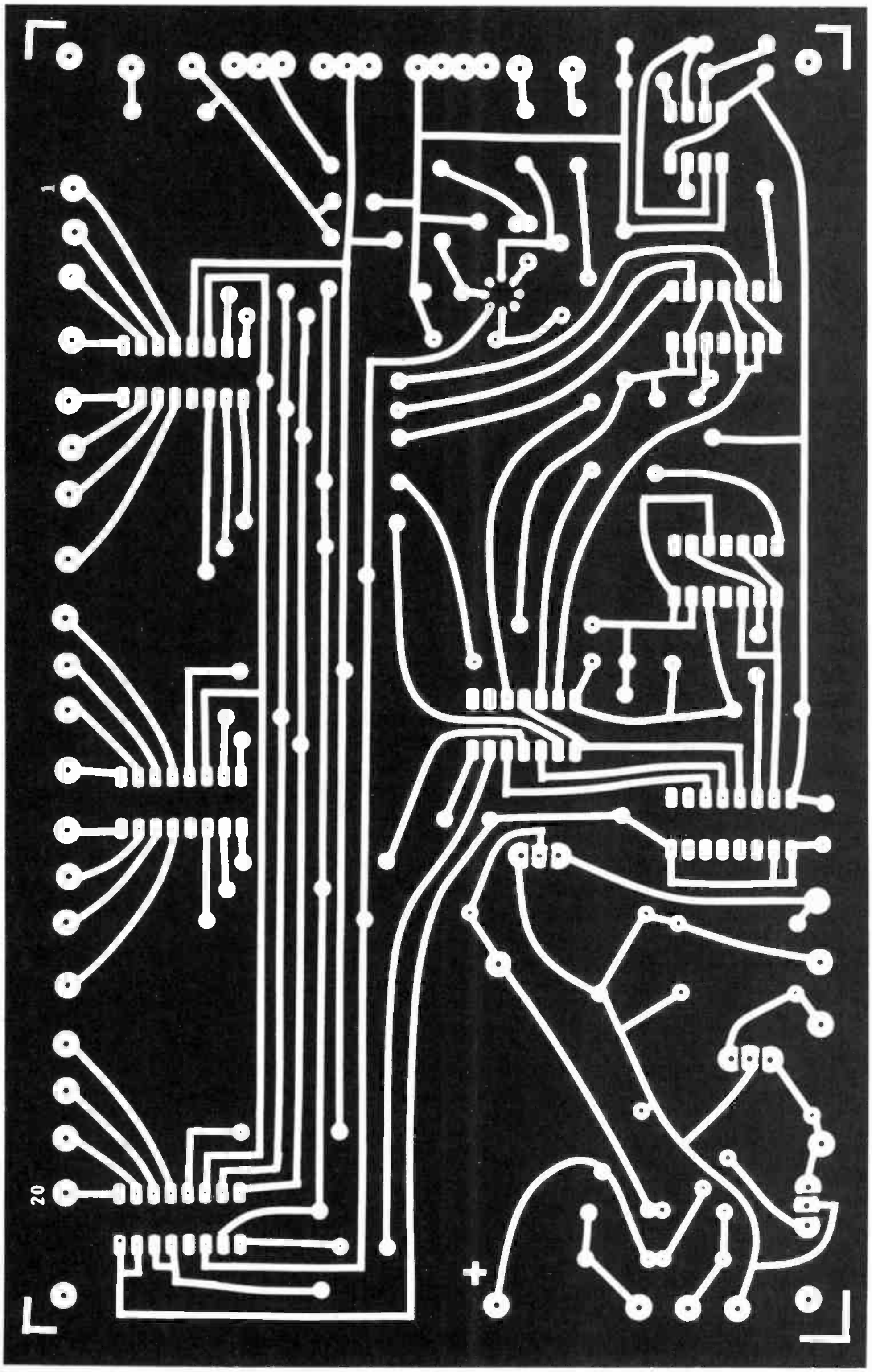


Fig. 8B. Etching and drilling guide for digital and power supply board.

Molex Soldercons for all IC's is recommended. *All* signal lines to and from the boards should be shielded (small-diameter coax is ideal). The power transformer should be mounted as far away from the boards as possible to minimize hum.

This transformer (*T1*) is a "universal" transformer, and not all of its color-coded leads are used. Cut short any unused

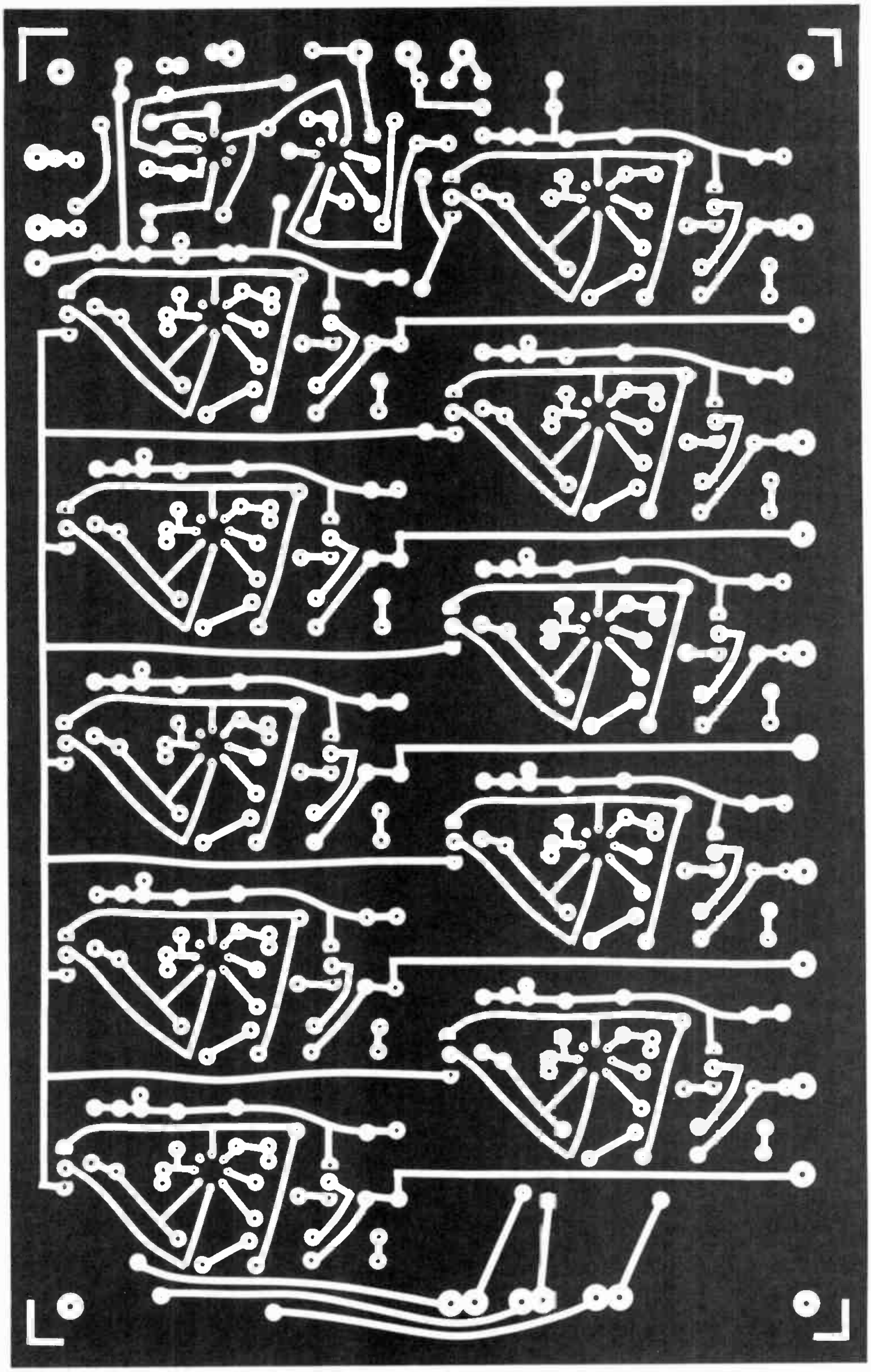


Fig. 9A. Use this pc board for Figs. 9B and 10 on next page.

leads and cover the ends with heat-shrink tubing. Also, be sure to use heat sinks on the voltage-regulator IC's.

In the authors' prototype, the pc boards (except the log converter) were stacked to conserve space. If you want to stack the boards, be sure to leave sufficient clearance for easy access to the LEVEL ADJUST and Q ADJUST potentiom-

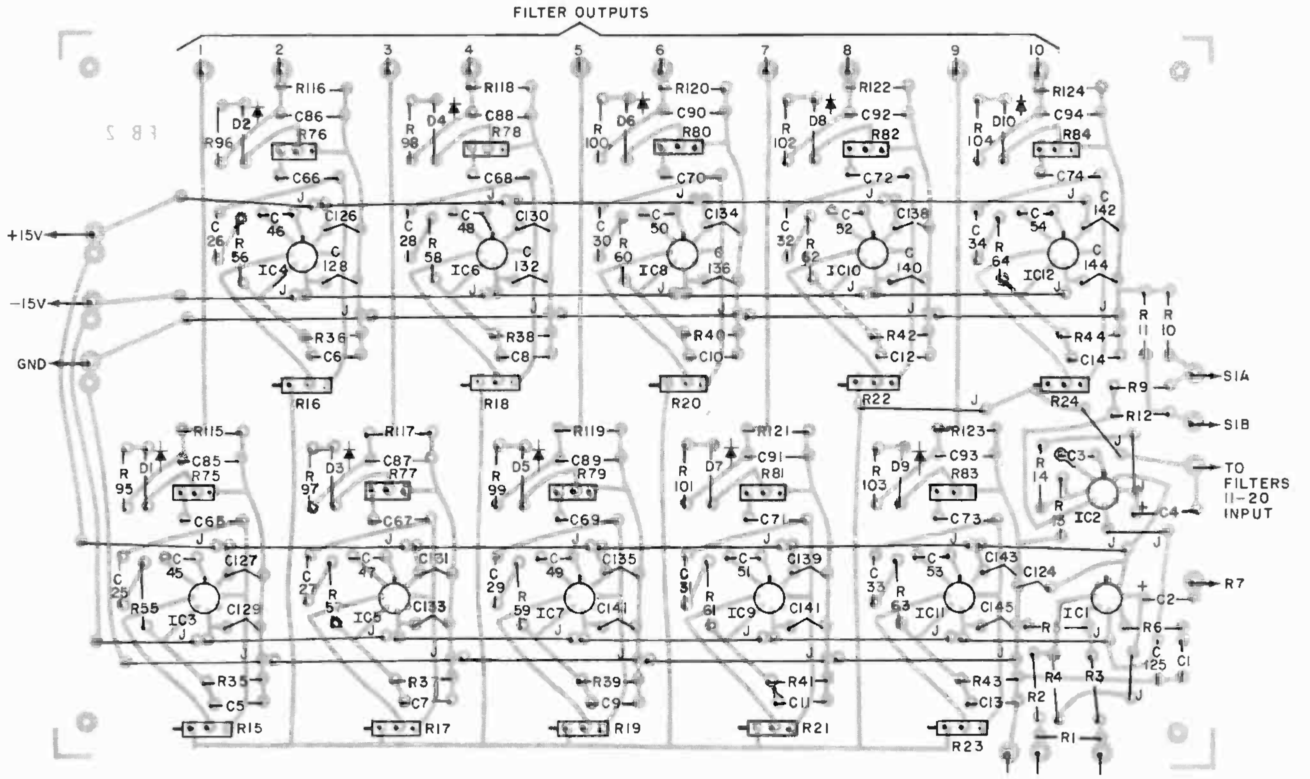


Fig. 9B. Parts placement for filter board #1. See Fig. 9A on previous page for etching and drilling.

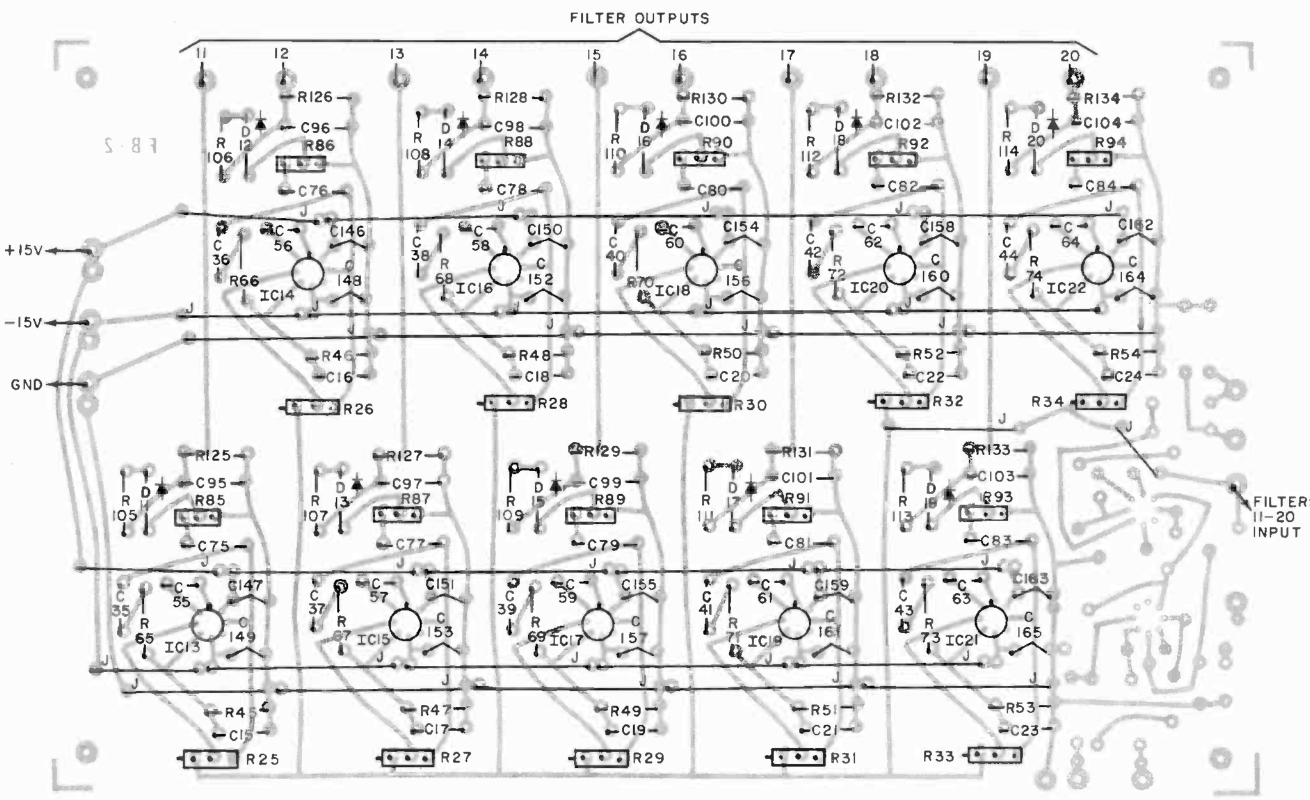


Fig. 10. Parts placement for filter board #2. See Fig. 9A for etching and drilling.

eters. These controls should be mounted on the filter boards so that all adjustment screws point toward power supply pads and away from input pads.

The prototype was enclosed in a 15″ x 10″ x 5″ (38.1 x 25.4 x 12.7 cm) metal cabinet. Switches *S1* and *S2*, LEVEL controls *R7* and *R8*, jacks *J1* through *J5*, and *LED1* were mounted on the front panel. The fuseholder and line cord strain relief were mounted on the rear.

Part II of this article will describe an optional log converter for direct readout of the scope trace in dB. Calibration and RTA use will also be covered. ◇

BUILD A TRANSFORMERLESS DC-TO-DC VOLTAGE DOUBLER

High-efficiency, high-current solid-state circuit doubles the input dc level.

BY MARLOWE J. BUCHANAN

FOR MANY years, the only reasonable nonmechanical means of generating high dc potentials from low voltages in the medium-to-high-power range has been the oscillator-driven transformer. This type of converter has two major drawbacks—the average experimenter may not have the knowledge or the materials to design and build his own transformer/converters, and the power consumption is relatively high, making the converters inefficient at currents much below their ratings.

The capacitive voltage doubler described here is superior to normal converters in many applications. For example, it can be used to extend the range of a low-voltage power supply or to run a medium-power audio system in a vehicle. Capable of very high efficiencies, the converter can easily be adapted to the voltage and power needed.

Circuit Operation. Basically, the circuit shown in Fig. 1 acts as a set of high-speed electronic switches that alternately charge *C3* and *C4* to the supply voltage and then connect the capacitors in series with the supply and load. The output load in effect "sees" the sum of the voltages across *C3* and *C4* and the supply voltage. Since *C3* and *C4* are driven 180° out-of-phase, this is a true full-wave voltage doubler.

Transistors *Q7* and *Q8* and their associated components form a multivibrator that has an operating frequency of roughly 6000 Hz with a 12-volt dc input supply. This oscillator produces two square waves that are 180° out-of-phase with each other and are used to drive *Q5, Q6, Q9,* and *Q10.* Resistors *R1* through *R4* are selected to limit base current to 3 mA. Drive transistor pairs *Q5/Q9* and *Q6/Q10* produce equal and opposite square waves that have extremely fast rise and fall times and are capable of sinking or sourcing a minimum of 100 mA to the output transistor pairs (*Q1/Q2* and *Q3/Q4*).

When *Q7* conducts, *Q2, Q3, Q5,* and *Q10* are driven into saturation. Capacitor *C3* charges through *Q2* and *D3,* while *C4* discharges through *Q3, D2* and

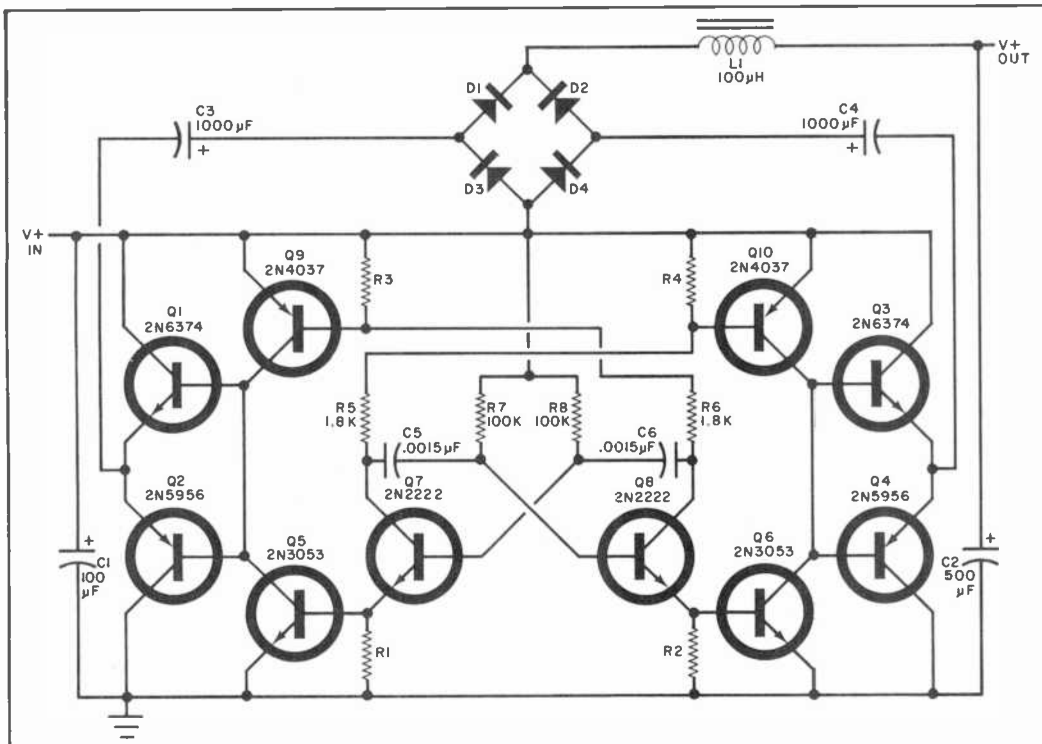


Fig. 1. The boosted dc output voltage is the sum of input dc plus charge on C3 and C4. The two capacitors are oppositely charged by multivibrator.

PARTS LIST

C1—100-µF, 25-V electrolytic capacitor
C2—500-µF, 50-V electrolytic capacitor
C3, C4—1000-µF, 50-V electrolytic capacitor
C5,C6—0.0015-µF, 50-V capacitor
D1 through D4—50-V, 6-A rectifier diode (or bridge)
L1—100-µH, 4-A, 0.1-ohm dc resistance (or less) choke
Q1,Q3—2N6374 or similar transistor
Q2,Q4—2N5956 or similar transistor
Q5,Q6—2N3053 or similar transistor
Q7,Q8—2N2222 or similar transistor
Q9,Q10—2N4037 or similar transistor
Following resistors are ¼ or ½ watt, 10%:
R1 through R4—For input of 6 volts, omit; for 9 V, use 1000 ohms; for 12 V, use 330 ohms; for 15 V, use 180 ohms; for 18 V, use 120 ohms; for 21 V, use 100 ohms; for 24 V, use 82 ohms.
R5,R6—1800 ohms
R7,R8—100,000 ohms
Misc.—10-watt heat sink, suitable enclosure, heavy-gauge wire, mounting hardware, etc.

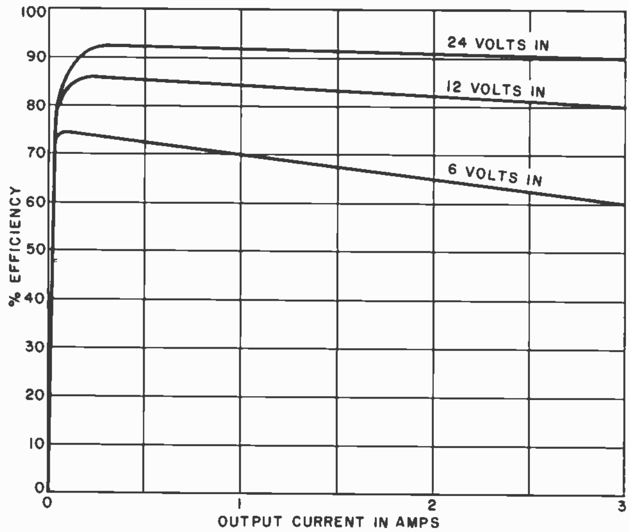


Fig. 2. With 12-volt power source, the efficiency remains above 80% even with full load. The higher the input voltage, the higher the efficiency.

the output load. When *Q8* conducts, the process reverses itself, with *C3* discharging through the output load, *Q1*, and *D1*, while *C4* charges through *Q4* and *D4*. Capacitor *C1* helps prevent high-frequency pulses from entering the supply, while *L1* and *C2* filter the output.

Construction. Since circuit operation is not critical, any convenient means of construction can be used to build the converter. However, for maximum efficiency and minimum ripple, the following should be observed:

Keep all leads, especially those to the output devices, as short as possible. Even the minor inductance of long wires can cause ripple in the output at the high switching frequency used in this voltage converter.

Use 12- or 14-gauge wire for power lines and making connections to output transistors *Q1/Q2* and *Q3/Q4*. If you elect to assemble the circuit on a printed circuit board, use at least ¼″ (6.4-mm) wide copper traces to interconnect the output devices. These measures will eliminate resistive voltage losses.

Connect *C1* as close as possible to the emitter leads of *Q5/Q6* and *Q9/Q10* to minimize ripple feedback into the voltage source.

No heat sinking is required for outputs up to 1 ampere. At higher currents, *Q1* to *Q4* must be on a heat sink that has a thermal resistance of 5°C/watt.

Use. The major loss of efficiency in a capacitive voltage doubler is the inherent voltage drop across the diodes and output transistors. Hence, it is not possible to exactly double the supply voltage, the difference being 1.4 volts with no load to 4.8 volts with a 3-ampere load. Since these losses are a fixed function of the output current, overall efficiency will increase dramatically with higher operating potentials, as shown in Fig. 2. Efficiencies in excess of 98% at several hundred watts can be achieved by a capacitive voltage doubler adapted for 100 volts input. These doublers also have very low ripple, typically less than 200 mV at a 3-ampere output.

The other loss of efficiency is the power consumed by the multivibrator and drive transistors. This is generally less than 150 mW at a 12-volt dc input, which accounts for the circuit's ability to achieve high efficiencies over 98% of its operating range. This sharply contrasts with the much lower efficiencies obtainable with transformer-based converters.

If the circuit shown in Fig. 1 does not satisfy your needs, there are a number of adaptations you may wish to try. For example, higher currents or potentials can be handled by substituting appropriately rated devices and slightly altering the multivibrator. Higher efficiencies can be obtained by substituting germanium power transistors for *Q1* through *Q4* and replacing the rectifiers with four suitable germanium power rectifiers (transistors with the base tied to the collector or emitter). For currents less than 100 mA, *Q1* through *Q4* can be omitted; *C2, C3, C4* need be rated at only 50 μF; and the rectifier diodes (*D1* through *D4*) can be rated at 1 ampere each.

A voltage tripler can be made by adding two 1000-μF capacitors and another bridge rectifier between ground and the common emitters of the output transistors. However, triplers work at lower efficiencies and with considerably reduced output current capability.

It is possible to use the output of one doubler as the input voltage source for another doubler. Two doublers connected in this manner provide about 36 volts output from a 12-volt battery. ◇

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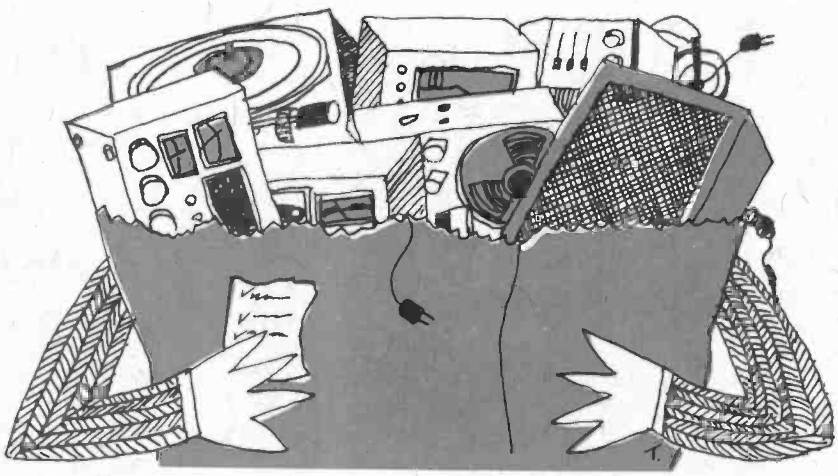


The Basics of Buying HI-FI COMPONENTS

YOU can run down to your neighborhood appliance store, hand the clerk around $99.95, and come away with a "home music system" that will deliver music received via AM or FM broadcasting and probably play records as well. Or, you can go to your favorite furniture shop and spend a few hundred dollars or more for a console cabinet containing unspecified electronic elements that will do the same thing. Finally, you can shop for individual audio components, spending anywhere from a few hundred dollars to many thousands of dollars and, again, end up with a home music system that reproduces radio broadcasts, records, and even tape recordings. These three divergent approaches to home music reproduction have some things in common—but they are also poles apart in terms of the kind of sound you will hear.

Crammed inside the $99.95 compact system and the one-piece console are circuits which pick up radio signals and translate them back to audio signals, circuits which amplify the minute signals picked up by a self-contained record player with its tonearm and cartridge, and even a pair of loudspeakers which translate all these signals back to audible sound. Audio electronics can be further broken down into the "tuner" or radio section, the "preamplifier" or control section, and the "power-amplifier" section which activates the loudspeakers. Even a tiny portable transistorized radio contains all these elements, but you would hardly classify the sound you hear from such a portable as "high fidelity."

In order for a loudspeaker (or, a pair of loudspeakers in the case of stereo or four loudspeakers for quadraphonic sound) to reproduce music, its cone or diaphragm must vibrate, for sound is nothing more than rapid compressions or expansions of the air around us. When the air vibrates rapidly, we hear a high-pitched tone. Slower vibrations of air impinge upon our hearing mechanism to create the hearing sensation of a low-pitched note—or one of low *frequency*. But, whenever a pair of loudspeakers is mounted in the same cabinet as the delicate record-playing tonearm and pickup, the fairly violent vibrations of that speaker (needed to reproduce sound) are also transmitted via the cabinet structure to the tone-arm and pickup, the fairly violent vibrations of that speaker (needed to reproduce sound) are also transmitted via the cabinet structure to the tone arm and its phono pickup stylus. If you try to turn up the volume to life-like levels, the vibrations generated by the speaker system can initiate a "vicious circle." They are re-amplified by the record player, reproduced as greater and greater vibrations from the speakers and so on, until the entire system takes off in an annoying "howl" which is called "acoustic feedback."

Interestingly, most all-in-one systems do not exhibit this phenomenon. The reason they don't is because the electronics built into such systems is generally restricted in its ability to reproduce *all* musical tones in their proper relative intensity. Since low-frequency tones (bass) involve more intense vibrations, the ability of the electronics of such systems to reproduce those tones is often severely restricted. In other words, you don't hear all the music contained in the actual record!

The first requisite of a true high-fidelity system is that it reproduce *all* musical tones faithfully. So it's imperative that loudspeakers are separated from the rest of the system—a condition easily achieved with separate components. Faithfulness of musical reproduction also means that sounds must not contain *more* tones than were present in the original program. In high-fidelity terms, that means low or negligible distortion. Distortion, broadly defined, includes *any* extraneous sounds such as harmonically related tones, electrically generated hum, or random noise or hiss. In short, the reproduced music should be an exact replica of the original performance as contained in the record or other program source. The minimal electronics, poor-quality record players, and undersized, unbaffled loudspeakers contained in most all-in-one radio-phonographs and "compacts" are simply incapable of this kind of reproduction.

Building-block Flexibility. There are other distinct advantages in the component approach to high-fidelity sound. Over the brief history of high fidelity we have witnessed a progression from monophonic sound (in which all music is reproduced in one-dimensional form from a single loudspeaker), to two-dimensional stereophonic sound (in which two speakers are used to give the listener an added sense of spatial realism), to 4-channel or quadraphonic sound (in which the listener gains true concert-hall ambience reproduced from four properly positioned loudspeakers). Owners of "compacts" or consoles found their equipment hopelessly obsoleted as each of these advances gained acceptance. Owners of quality component systems, on the other hand, were able to update and *add* to their basic systems without any loss of their original investment.

Clearly, this building-block approach to good sound makes sense economically. As a further example, suppose that your primary interest is in a good record-playing system. You might elect to purchase a system consisting of a good *amplifier*, a pair of speakers, and a separate turntable or record-playing system at the outset. Then, if taste and budget dictate, you can add a stereo FM/AM *tuner* at a later date, connecting it in seconds to the system you already enjoy. You might also wish to upgrade one component in a system while retaining the others, which is easily achievable with an audio component system. Finally, you might even want to add tape recording and playback facilities to your expanding system by purchasing a *tape deck* of the *open-reel, cassette*, or *cartridge* variety. All of these added program sources will utilize the basic *amplifier* electronics and speaker systems purchased initially. You may even want sound in other listening rooms (a bedroom, or a den). This can be provided by the addition of another pair of speakers which can be connected to most high-fidelity component amplifiers or *receivers* and switched in by means of suitable front-panel controls. Moreover, one can add an equalizer, noise-reduction system, or other accessory component to an audio component system in order to obtain more realistic sound.

Electronic Options. There are three basic approaches to assembling the electronics of a hi-fi system. The most popular of these involves the purchase of a component called a *receiver*. This single unit will contain all the circuitry needed to pick up AM, FM, and stereo-FM radio signals, the necessary *preamplifier* and control circuits whereby program sources are selected and adjusted for proper listening, and the *power amplifier* section needed to drive the loudspeaker systems.

In the early days of hi-fi, all-in-one receivers were rather limited in their ability to deliver sufficient power to the loudspeakers. Today, you will find all-in-one receivers which boast power-output ratings higher than 100 watts per channel. Because all of the electronics is combined on a single chassis, the receiver represents the most economical approach to a hi-fi component system. A common power supply, a single front panel, a single cabinet enclosure and other parts-in-common result in savings that cannot be obtained from wholly separate components.

Nevertheless, a visit to your hi-fi dealer will reveal an array of separate amplifiers as well. So-called *integrated amplifiers* combine two of the three previously referred to electronic sections—the preamplifier-control portion and the power-amplifier section. We already mentioned a possible reason for choosing this option. You may want to forego FM and AM radio at the outset and concentrate on good record reproduction (or possibly tape). A *tuner* can always be purchased later and will interconnect easily with any integrated amplifier, even if your purchase is made many years from now. Furthermore, you will often find that an integrated amplifier has additional control refinements and perhaps more signal input facilities than an all-in-one receiver—another possible reason for its selection as the basic component of a system. You may also

be able to purchase a more powerful integrated amplifier for the same amount of money that would be required for a more moderately powered complete receiver unit.

A third option, offering perhaps the greatest flexibility of all (and generally the most costly), is to purchase a separate tuner, a separate preamplifier-control unit, and a separate *basic power amplifier*. This arrangement is not nearly as popular as the other two, and usually represents the choice of those audio enthusiasts who demand the ultimate in flexibility, superior performance specifications (lowest distortion and very-high-power-output capability), and other operating features not found either in complete receivers or integrated amplifiers.

Irrespective of which of these three types of component systems you choose to assemble, you'll want to familiarize yourself with the more important technical performance specifications listed in manufacturers' advertising brochures. Tuner, preamplifier, and amplifier specifications mean the same thing whether they are used to describe those individual sections in a complete receiver, an integrated amplifier, a separate tuner, a separate preamplifier-control unit, or a basic power amplifier.

What about 4-channel sound? Multiple-channel sound is certainly not new. As early as the 1930's, moviegoers thrilled to the multi-channel Walt Disney production of "Fantasia," in which listeners were surrounded by music reproduced over as many as six separate speaker systems. For many years, recording studios have used multiple tape tracks to record individual instrumentalists and vocalists under optimum studio conditions. These tape "tracks" were then "mixed down" to two-channel "stereophonic" final products in the form of stereo records. Only in 1970 did 4-channel sound reach the home music listener—first as 4-channel tapes and later in a variety of disc formats.

Musically, there are two distinct approaches to 4-channel sound. The "classical" approach involves the reproduction of the ambience of the concert hall itself. Any concert goer will readily admit that much of the sound he or she hears at a live concert is reflected from the walls and ceiling of the hall itself, rather than from the performers on stage. It is this ambient quality which distinguishes the live performance from its recorded and reproduced equivalent in a home listening room of restricted dimensions. By recording two additional channels, using microphones at the rear of the concert hall and reproducing these channels over similarly positioned speakers behind the listener, it is possible to create a sense of vast space in the home listening environment which is not achievable with conventional two-channel reproduction systems.

Given the extra pair of channels, it is also possible to assign different instruments or soloists to specific channels so that the listener finds himself in the center of the "performance" when playing back recordings. This alternate recording approach to quadraphonic sound is particularly effective when applied to modern pop and rock music, affording the listener a sense of involvement not otherwise attainable.

Recording four channels on tape is relatively simple. Both 8-track cartridges and open-reel tapes have multitrack capability. Cassettes do not.

In the case of phonograph records, there are two basic systems. One called "matrixing," is a process of combining or encoding the four original program channels into two complex audio programs. These two "encoded" channels can then be applied to the record groove much like a stereo program. Suitable decoder circuits, often built into a four-channel amplifier or receiver, "decode" the two channels into four separate signals approximating those which were recorded at the beginning of the process.

The two most popular matrix techniques currently in use in the United States are the SQ system, developed by CBS and the QS system developed by Sansui. Both are capable of excellent 4-channel reproduction and each can be further enhanced by the addition of circuits called "4-channel logic" which increase apparent separation between channels. In addition to matrix records, there are also so-called discrete or CD-4 records which actually contain four separate programs in the single record groove. Because of the very high frequencies contained in these CD-4 discs (developed jointly by RCA and the Japan Victor Company of Japan), a new cartridge or phono pickup is required. Moreover, a turntable used for playing CD-4 records should have low-capacitance phono cables for best results.

A 4-channel home music system is necessarily more costly than a stereo system of equal power and performance capabilities. Any 4-channel system requires four separate loudspeakers as well as four amplifiers (the latter often combined in one unit).

Before deciding whether to buy 2- or 4-channel equipment, listen to each type of system in a properly equipped demonstration room at your audio dealer. Bear in mind that, whether you elect to buy 4-channel or stereo, the important criteria of low distortion, good frequency response, and adequate power output apply to each type of system. If your budget is limited, you might be better off starting with a good stereo component system rather than settling for an inferior quadraphonic system. Separately available decoders, demodulators, and extra amplifiers and speakers can be added to any existing stereo sound system at any time in the future.

Hi-Fi Shopping Tips. Shopping for a hi-fi component system can be fun—or it can be a frustrating experience. There are four general sources of supply. (1) You can visit an audio specialist dealer who sells nothing but high-fidelity component equipment. (2) You can shop in a branch of one of the many electronic-supply stores that sell other specialized electronic equipment in addition to hi-fi, but generally have listening rooms set aside for hi-fi component selection. (3) You can order components from a variety of mail-order or catalogue houses (some of whom also have retail stores in many cities), or (4) you can visit a "discount" establishment which has a variety of merchandise available in sealed factory cartons but provides no facilities for equipment auditioning. Your choice of supplier will generally depend upon how much (or how little) personalized service you require.

The first two categories of retail establishments generally offer the most service. If you are starting from "scratch," it is essential that you be able to listen to the components you plan to buy. As a matter of fact, the first components you should select are your loudspeakers, since there is the greatest variation in sound amongst the hundreds of speaker models currently available. Zeroing in on the loudspeakers that sound best to you also puts you in a better position to decide on how powerful an amplifier or receiver you will need, since some speakers require far more power than others to deliver a given loudness level.

Generally, the well-equipped audio dealer who offers auditioning facilities and technically trained sales personnel will offer less of a discount than the "mail order" or "warehouse" type of retailer, since his overhead costs are higher. In return for the somewhat higher price you pay, you will obtain the aforementioned advantages that may or may not be important to you. ◇

Dynamic Noise Reduction Systems and Expanders

BY WILLIAM S. GORDON

THE QUEST for noise reduction in high-fidelity equipment has challenged audio engineers for decades. As far back as 1947, H. H. Scott introduced a "Dynaural Noise Suppressor," to deal with the noise problem; and the Dolby noise-reduction system (professional version) was demonstrated in the mid-sixties. The age of noise suppression was really ushered in for serious audiophiles, however, when the Dolby NR system was incorporated into cassette decks in the late sixties.

Since then, a great deal has been done to make noise reduction a realistically inexpensive and practical means of obtaining the maximum enjoyment out of hi-fi equipment. In this article, we will examine a host of noise-reducing systems that have come onto the consumer market and describe how the different schemes work.

Two Categories. Noise-reduction systems can be grouped into two categories: Those that rely on preprocessed (encoded) signals and those that operate on "raw" (unprocessed) signals. Examples of the first category are the Dolby A and B systems, JVC's Automatic Noise Reduction System (ANRS), and the dbx system. In the latter category are Phase Linear's "Autocorrelator," Philips' Dynamic Noise Limiter (DNL), and Burwen's noise-reduction system.

The devices that encode the signal before recording or transmission first pass the signal through an encoder and then through a decoder. In essence, these "two-pass" systems are noise-preventive devices because they do nothing to remove noise already in the program but attempt to prevent it from creeping in between the encoder and decoder. The unencoded "single-pass" systems attempt to remove noise already in the program.

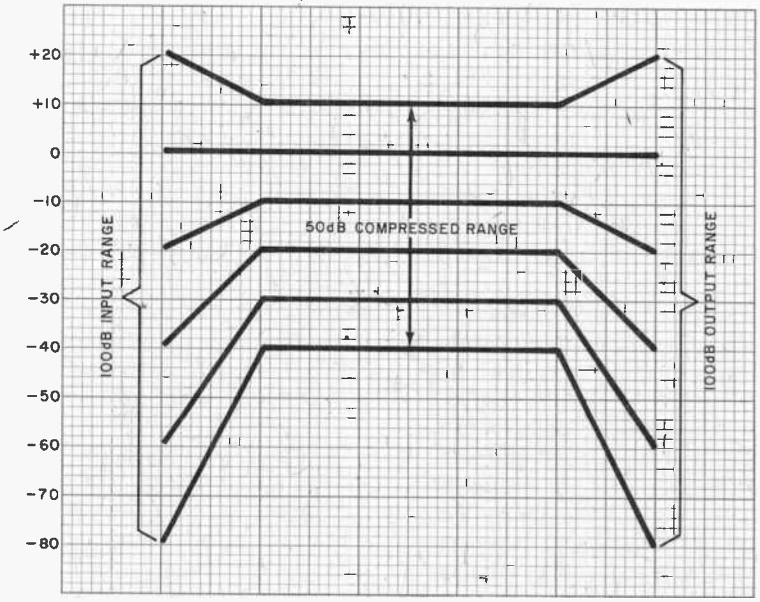
Two-pass processors generally employ complementary signal compressors and expanders, called companders. During processing, the dynamic range of the signal is compressed so that a two-fold increase in the input signal causes less than a two-fold increase in the output. The actual input/output characteristic depends on the compression ratio used. For example, a 3:2 ratio causes a 2-dB output increase for every 3-dB increase in the level of the input signal. This means that a 60-dB dynamic range can be compressed into an output signal with only a 40-dB range.

Compression is important because the dynamic range of many program sources exceeds the range of modern state-of-the-art hi-fi equipment, especially tape recorders and FM tuners. A symphony orchestra can have an 80-dB dynamic range, but a recorder might have a range of only 55 or 60 dB. By using a 2:1 compression ratio, the entire 80-dB orchestra range can be compressed down to 40 dB, which is well within the average recorder's capabilities to handle.

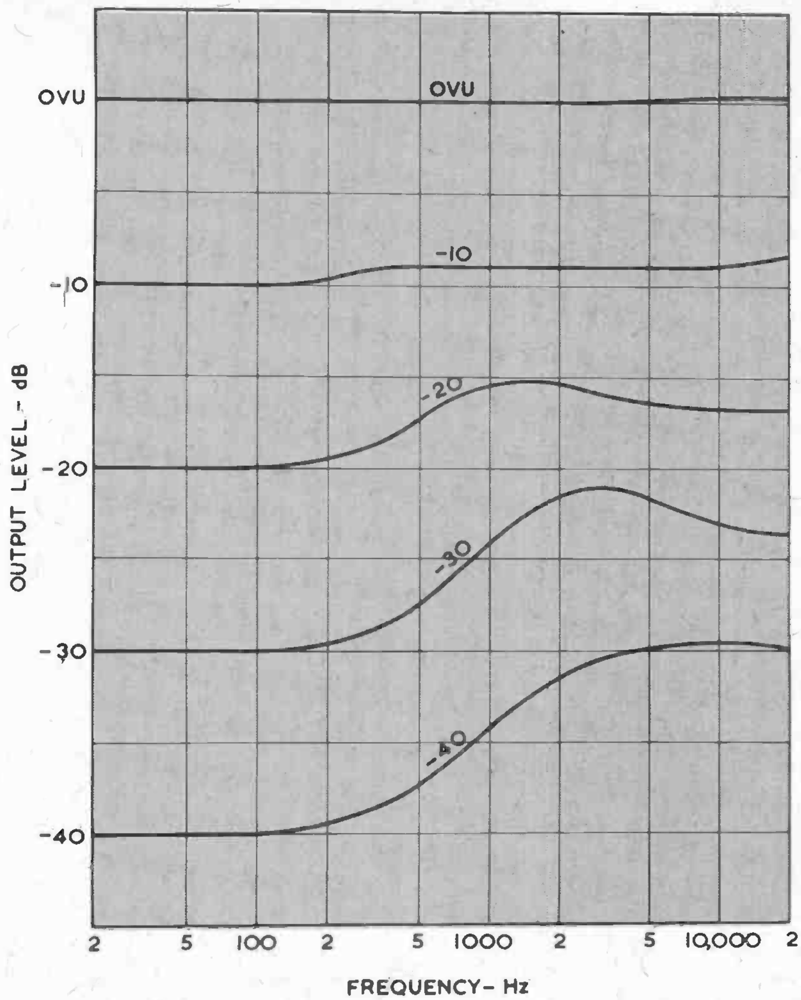
The signal-to-noise ratio (S/N) can give you an idea of the capabilities of a piece of equipment. The maximum level a device can handle is determined by the point at which distortion reaches an unacceptable level (generally 3% THD in consumer equipment and 1% in professional equipment). The minimum level that can be handled is determined by the "noise floor." Signals that are lower in level than the residual noise of the equipment are lost in the hiss and hash at the noise floor.

With sufficient compression, a wide dynamic range program can be squeezed into the limited range available in a tape recorder. This assures that the program peaks will not be too high to handle, while keeping the minimal signals above the noise floor.

A compressed signal must be expanded to restore its original dynamic range. An expander is the mirror image of a compressor. In it, a two-fold increase in program level at the input results in a greater than two-fold increase in the expander's output signal. To restore the original dynamics of the signal in the above example, a 2:3 expansion ratio would be used. Hence, the 40-dB compressed signal would be expanded back up to its original 60-dB dynamic range. This opens up the top of the range and simultaneously pushes down the noise floor. The net effect appears as a reduction in the residual noise, so



The 2:1 linear compander characteristic of the dbx system illustrates how dynamic range is compressed and then restored.



Dolby encoding characteristics show output level changes in decibels versus frequency over entire 20-to-20,000-Hz range.

the system qualifies as a "noise-reduction" system.

How Companders Work. Compressors and expanders are basically amplifiers whose gain is varied by a voltage. (Such a device is known as a voltage-controlled amplifier, or vca.) They also include detectors that measure the signal level and produce the voltage that controls the gain of the amplifiers.

The time constants of the detector circuits must be chosen very carefully. If they are too short, the detector responds very rapidly and follows the low-frequency signals. The vca's gain "chases" the low-frequency signals, increasing distortion and modulating the rest of the signal with a low-frequency tone. A very long time constant causes the detector to respond very slowly to the average signal level. Sudden transients get through before the gain of the vca can be reduced. The transient will not be compressed and will cause the system to overload. Since the transient is detected, the signal for the vca to reduce its gain will be delayed. Then, an audibly discrete interval later, the vca's gain reduces where no reduction is required and a "dropout" will be heard in the program.

Another audible flaw in wideband, widerange companders is "breathing." When the input signal disappears or is greatly reduced in level, the gain of the compressor increases and boosts the level of any noise present in the signal. When the music level increases, the level of the noise decreases, and when the music level decreases, the noise floor comes up. As the system operates under these conditions, it sounds like it is "breathing." Note that this is not noise introduced by the recorder between the compressor and expander (which is reduced by compander action) but noise in the signal prior to compression.

Enter the Dolby System. The Dolby noise-reduction system was originally designed to combat the problems inherent in companders. The professional Dolby A system divides the frequency spectrum into four bands, each of which is processed separately. This was done so that an increase in midband energy would not reduce the level of the lows and highs. Where there might be a lot of midband energy but little high-frequency content, the processor reduces the midband level to avoid overloading the recorder. At the same time, it keeps the gain at the high end up so that the highs are not pushed down near the noise floor. This is important because psychoacoustic tests reveal that low-frequency signals do not mask high-frequency noise, nor do high-frequency signals mask low-frequency noise. (Masking psychoacoustically makes one less aware of noise when a strong signal is present than when it is absent. Masking of noise is effective only in the frequency range of the signal; hence, Dolby's use of the four-band approach to the problem.)

The Dolby system employs the processor only on low-level signals, which are boosted above the noise floor, while high-level signals emerge unchanged. The lower the level of the signal, the greater the boost. Hence, the processor is used only when signal levels approach the noise floor. The action of the system is less noticeable to the listener and overcomes the objections of previous full-range companders.

The final improvement in the Dolby system is that the attack time of the compressor is variable. If the signal level increases dramatically, the attack time is very fast to minimize the time the system is overloaded. For less severe increases in level, the attack automatically slows down to minimize low-frequency distortion and modulation of the music by low-frequency tones.

Having become the standard of the professional recording industry, the Dolby A system was later simplified and became the Dolby B system familiar to consumer products. The B system reduces cost by processing signals in only the band where high-frequency hiss resides. To make it more effective, the processor's upper frequency cutoff is made to automatically vary with signal level. As the level drops, the system processes a larger bite of the upper-frequency band. Since hiss is the major source of audible noise in hi-fi tape recording, the system is quite effective.

Since only low-level signals are processed by the Dolby A and B system and in the consumer B version only a portion of the audible band is processed, there is a limit to how much noise reduction can be achieved. In the case of the B system, this is approximately 10 dB. And since the processor does not operate over the entire dynamic range of the signal, the signal must be standardized and matched for the decoder to properly track the encoder. Hence, the reference level, the so-called "Dolby Level," must be maintained to calibrate the chain.

It is the signal itself that "tells" the decoder where and how much expansion to use. If the level into the decoder is too low, the expansion will begin at too high a level. This will upset the original balance of the program. Similarly, if the input to the decoder is too high, expansion will not occur soon enough.

JVC followed Dolby's lead with its ANRS device, which functions in a manner quite similar to the operation of the Dolby B system. In fact, Dolby B tapes can be decoded by the ANRS circuit with quite good results.

The dbx System. The foremost competitor of the Dolby system is the noise reduction system developed by dbx Inc. This is a "classical" compander in that it operates over the entire dynamic range of the music. However, it has improvements over previous companders that make its action virtually inaudible.

The dbx system is a linear 2:1 compander that compresses the 80-dB dynamic range of the symphony orchestra down to a mere 40 dB. On the decoding end, the 40-dB range is expanded back up to 80 dB, pushing down the noise that was introduced by the tape-recording process to an inaudible level.

Since the dbx system operates linearly over the full dynamic range, matching of signal levels is not particularly important. Any 1-dB rise in input results in a 2-dB rise at the output of the expander. There is no "threshold" below which the system operates as there is in the Dolby B system. (Note, however, that any irregularities in recorder frequency response or any amplitude perturbations, such as dropouts, that are introduced will be magnified by a ratio of 2:1.)

One way dbx avoids the problems of classical companders is that it employs an rms detector to drive the vca, rather than the usual peak or average detector used by previous companders. The rms detector measures the power of the signal and is unaffected by the phase distortion introduced in the taping process. Peak or averaging detectors, on the other hand, are affected by phase shifts.

Another solution is the use of variable attack times that quickly respond to large changes in level and slowly respond to small changes. Both attack and release times vary with the signal level and are optimized to simulate the time response of the human ear.

The final solution is the use of high-frequency preemphasis before compression with complementary deemphasis after expansion. This helps to reduce the effect of breathing by a factor of 12 dB.

The S/N improvement of the dbx system is in the range of 40 dB, which contrasts sharply with the 10-dB improvement provided by the Dolby B system. Although the Dolby system has a huge head start in the recording industry, there may soon come a time when the system developed by dbx will replace it as *the* standard one in use.

Single-Pass Systems. So far, our commentary has focused on two-pass systems designed to reduce noise only during the recording (or transmitting) process. Such systems do not reduce the noise already in the program. A great deal of work has been done to remove the noise already in the program, and the result is the single-pass system.

Two of these new systems are the Philips DNL and Burwen DNF that are both dynamic low-pass filters. The Philips system was developed specifically to reduce noise in unencoded cassette recordings. (It is not widely available in the U.S.) The Burwen system is more flexible and can be used for tapes and discs. Both systems consist of low-pass filters whose cutoff frequencies are automatically controlled by the program level. When there is a lot of high-frequency program energy, the filter "opens up" to let it through. Then when the high-frequency program energy is small, the cutoff frequency of the filter shifts downward to cut out the highs and the hiss. In essence, if there is enough high-frequency program energy to mask the hiss, the bandwidth of the DNF opens up to 30,000 Hz. But if the highs are missing and, hence, are unavailable to mask the hiss, the bandwidth narrows. In the absence of any signal, the Burwen DNF system starts to roll off above 500 hertz.

The constants of the detector circuit that senses the program level are critical. The filter must open up rapidly to let a transient through and should close down rapidly to prevent a burst of noise from following a brief transient or record tick. However, too fast a response tends to be audible. Consequently, the attack and release times are made variable according to the magnitude of the signal change. Depending on the program material and the control settings, the newest Burwen system provides from 5 to 14 dB of noise reduction. Since it is a single-pass system, it operates on any program source.

The Phase Linear "Autocorrelator" is more complex than the dynamic noise filters. It actually attempts to distinguish between music and noise by electronic means. Noise is typically random in nature and contains many frequency components that are not related to each other, which makes it incoherent or uncorrelated. Music, on the other hand, contains mathematically related tones and is coherent, with a high correlation factor. The Autocorrelator consists of bandpass filters and a circuit that analyzes the signal for its degree of correlation. If it determines that the signal is music, it passes it through and those filters that correspond to the harmonics of the signal are activated to pass the overtone structure. If the signal is determined to be noise, the filters close down. It is obvious that this is a more sophisticated approach to noise elimination than the dynamic noise filter.

Another sophisticated type of noise-reducing device is SAE's Model 5000 pop and click filter. The premise used here is that clicks and pops are characterized by a rapid rise and decay, while music should exhibit a more gradual decay. Once a click or pop has been detected, that section of the program is gated out and the previous program section is recalled and inserted in its place. Since the click or pop is very short in duration (on the order of 1 ms), this substitution goes undetected by the ear.

Most of the time, the Model 5000 remains completely passive. A threshold control establishes the sensitivity of the detection circuit. This is necessary because different records may exhibit slightly different characteristics.

Conclusion. So far, noise-reduction systems have provided some impressive results. The effort to develop better systems is still going strong, but what the future has in store is difficult to predict. As things now stand, the most dramatic steps have been taken to reduce noise. Most of what is left is the refinement of the systems we now have and the addition of a few more decibels of noise reduction.

One or more of the noise-reducing devices we have mentioned certainly has a place in every high-quality hi-fi system. In fact, we can expect to see these devices incorporated into higher-quality hi-fi amplifiers and receivers in the future, just as all high-fidelity cassette decks now have noise-reduction systems built into them. ◇

Matching Tapes to Recorders

BY LEN FELDMAN

WHETHER you own a new open-reel tape deck or a super-performing stereo cassette deck, you'll have to decide which type of tape to use to get the best possible performance. If cassettes are what you need, you can buy a 60-minute (C-60) cassette tape for as little as 99¢ or you can spend up to $5.00 for the same amount of recording time. In the case of open-reel tapes, an 1800-ft (550-m) reel may cost less than $6.00 or you may spend more than twice that amount for the same tape length. Which kind of tape you buy will depend on the type of recording you intend to do and the kind of tape deck you own.

For open-reel tape, selection involves physical considerations almost as much as electrical performance or fidelity. Broadly speaking, the two basic "grades" of tape are "standard and "high-energy," each of which requires a different bias setting on your machine. Lower priced standard tapes often have more residual noise and somewhat poorer frequency response than "premium" tapes, though they may be suitable for noncritical recording applications.

Generally, 1-mil-thick tape, with its 1800-ft capacity on a 7-in. (17.8-cm) reel, offers the best compromise between tape storage bulk and playback quality. Almost all open-reel tapes use ferric-oxide particle coatings even though there are still some differences between the products of different manufacturers. Mechanical differences in reel construction and accuracy of tape splitting and dimensions and uniformity of coatings account for the wide differences in prices.

In contrast to open-reel tape recording, the quality of recording obtained with a cassette deck is more critically dependent on the compatibility (or lack of it) between the tape and the machine with which it is used. A growing number of tape deck manufacturers make specific recommendations of tapes that work best with their products. However, even these suggestions require an understanding of the kind of recording to be made and the nature of different tape formulations.

Correct Bias. A high-frequency bias signal must be added to the program signal to be recorded to reduce the distortion normally caused by the nonlinear transfer characteristic of magnetic tape. However, not all tape formulations require the same amount of bias for best results. Normally, ferric-oxide coated tapes require less bias than do chromium-dioxide (CrO_2) tapes. Several new formulations that combine ferric-oxide particles with other elements such as cobalt (in a single-compound layer) also require the high bias settings of CrO_2.

In cassette tape testing, most manufacturers determine the correct reference bias for a given tape by recording a fairly high frequency (usually around 6300 Hz) onto the tape while observing playback output as bias is gradually increased. At some bias setting, the output reaches a peak, after which a further increase causes the output level to drop off. The reference bias for the tape is set at the point where the output level has dropped off by about 2.5 dB beyond peak. Usually, a standard reference tape is tested in this way, and its optimum bias point is identified as the "0 dB" reference bias. Then, the tape under investigation is compared with the 0-dB reference bias specified in dB.

In Fig. 1 are shown the results of this test when performed on a well-known, low-noise, ferric-oxide tape. The optimum bias has been established at a −1-dB setting, relative to the standard 0-dB bias point. In Fig. 2, the same test was performed on a CrO_2 cassette; and the optimum point for bias was +2 dB (with reference to the standard 0-dB bias point of the reference tape). This means that the CrO_2 tape requires a bias setting that is 3 dB higher than that for the low-noise, ferric-oxide sample.

For any practical tape, the bias strength that results in the highest output at middle and low frequencies is greater than the ideal for high frequencies. Conversely, if the bias is adjusted to favor the highs, the middle and low frequencies suffer in terms of realizable output. Whatever bias point is selected, some degradation of signal-to-noise (S/N) ratio and overload distortion will occur in some part of the audio frequency spectrum. While increased bias tends to reduce distortion, no one setting can guarantee overall distortion reduction by the maximum amount at all frequencies. Thus, bias settings are always a compromise, and the best tape permits the most favorable compromise.

To demonstrate the effect of overbiasing and underbiasing, we recorded a continuously sweeping series of frequencies (20 to 20,000 Hz) on a strip of ferric-oxide tape at a fairly high recording level. The results are shown in Figs. 3 (underbiasing) and 4 (overbiasing). Note in Fig. 3 that high-frequency re-

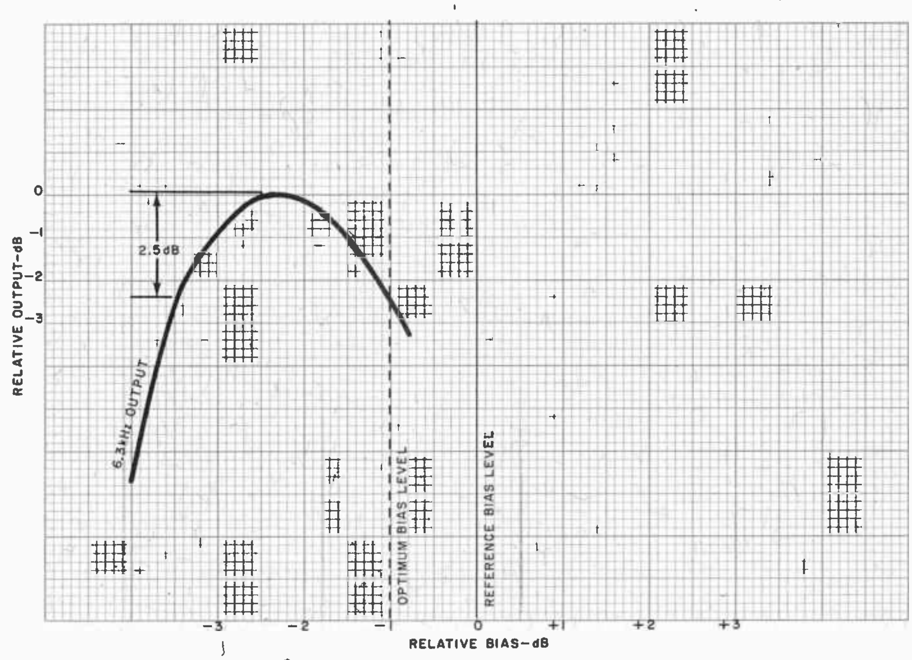


Fig. 1. Determining the bias level for a sample low-noise tape.

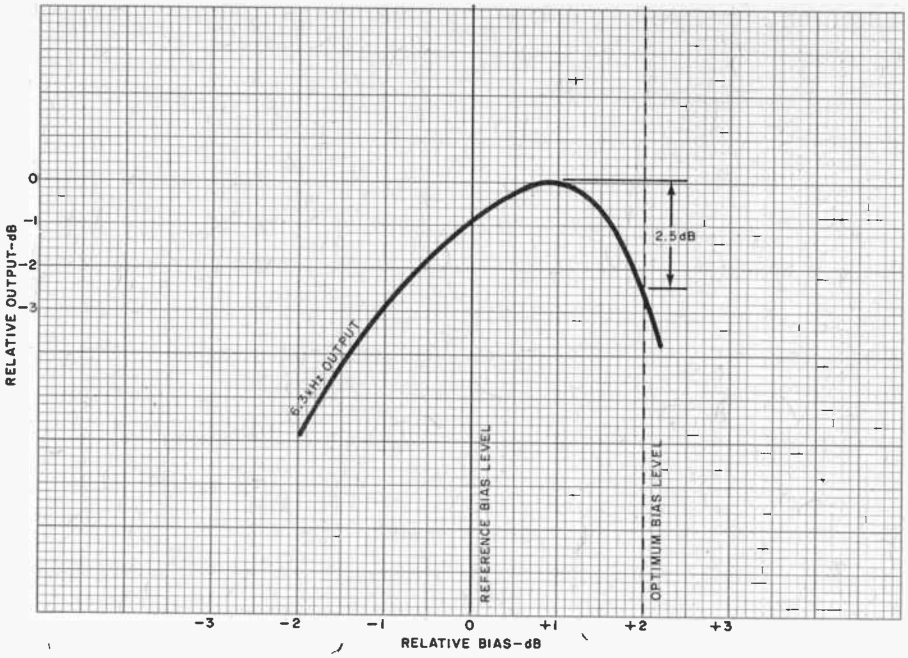


Fig. 2. Determining the bias level for a sample of CrO_2 tape.

sponse obtained in the underbiased condition is excellent. In fact, there is even a slight rise in response above 10,000 Hz before the response rolls off in the 20,000-Hz region. In Fig. 4, however, the response begins to fall off gradually above 1000 or 2000 Hz and really takes a giant dip beyond 10,000 Hz. Each vertical division in the photo equals 10 dB of amplitude.

From the results shown in Figs. 3. and 4, one might conclude that the best performance from any tape is obtained with underbiasing. However, the curves do not reveal what happens to harmonic distortion if a given tape's bias is set too low. In Fig. 5, the spectrum analyzer was used once more to examine the distortion and noise components of a reproduced 1000-Hz signal, as recorded on the underbiased deck. The large spike at the center represents the desired fundamental output (1000 Hz), while the spikes to the right, notably at 3000 and 5000 Hz, are components of third- and fifth-harmonic distortion. The third-harmonic component is only about 33 dB below the fundamental or about 2.2% of the signal content. The random spikes represent residual tape noise as reproduced during playback of the 1000-Hz recorded signal.

Figure 6 shows what happens to a 1000-Hz signal in the overbias condition that resulted in the frequency response of Fig. 4. The third-harmonic distortion component has gone down to about 44 dB below the fundamental. This corresponds to distortion of about 0.6% but there is little if any evidence of fifth-harmonic contribution, and the general random noise content is much lower.

Equalization. Once the proper bias for a given tape has been selected, it is still possible to tailor the frequency-response capabilities of that tape by a process called equalization. Up to a certain frequency, if a recording is made on magnetic tape, the playback system "reads" that signal with a rising amplitude characteristic as the frequencies are increased. Since we want a "flat" frequency response, a rolloff in response is built into the playback electronics so that the net response, hopefully, will be flat.

Playback equalization in a tape deck is generally standardized and fixed to obtain reasonably flat playback results from any tape recorded on one tape deck and played back on another.

Recording equalization, however, is variable and is designed to match the particular tape you use and generally involves a specified amount of treble "boost" added to the record electronics to compensate for the high-frequency rolloff that occurs above a given high frequency. As with bias, record equalization is often adjustable by means of a switch on the deck's control panel. Most equalization switches have only two or three positions that generally approximate the right playback conditions for many of the tapes on the market.

In recent years, manufacturers of cassettes have tried to make tapes that give best results when used with the most commonly available equalization settings of most machines. The two most popular settings of equalization are 70 and 120 μs, the figures representing the time constant provided by the resistor-capacitor combination that gives the required 6-dB/octave response slope. The 120-μs equalization setting begins to boost high frequencies during recording at a lower turnover point than does the 70-μs setting that has been standardized for CrO_2 tapes and some of the more exotic ferric-cobalt tapes.

Let us see what happens to the response if the wrong setting is used for a given tape during the recording process. For one series of tests, a ferric-cobalt tape requiring the 70-μs equalization was used. After adjusting the bias for optimum, the proper equalization switch position was set and a frequency response check was run. The result (the lower trace in Fig. 7) shows a good, flat response curve, similar to that shown in Fig. 3, but with somewhat greater rolloff at the high end because of the correctly adjusted bias. Without altering the bias setting, the run was repeated with the 120-μs equalization setting. The result is the upper trace in Fig. 7. Overboosting during recording resulted in an overemphasized rising high-end response during playback.

Next, a low-noise ferric-oxide tape was tried. It normally requires the 120-μs equalization characteristic. With this equalization and the correct bias setting, we obtained the upper trace in Fig. 8. The response is nice and flat to well beyond 15,000 Hz. In a second sweep, the equalization switch was set to 70 μs; and, as can be seen in the lower trace, the response during playback rolled off severely, starting at about 2000 Hz.

Characteristics. Here are details on other key specifications.

Sensitivity of a given tape is the decibel difference between the output and input levels when an input 20 dB below the reference level (0 dB) is recorded on a tape. If the recorder used for this test has been biased properly, equalized flat and input/output adjusted to be equal for a standard reference tape (a German DIN standard, known as Bezugsband 4.75/3.81 tape is often used as the standard), the data obtained is the sensitivity of the tape under test relative to the reference tape. For cassette tapes, 333- and 12,500-Hz tones are used for sensitivity tests. Typical results obtained for standard and high-output tapes are plotted against bias settings in Fig. 9. As can be seen at the "optimum bias" inter-

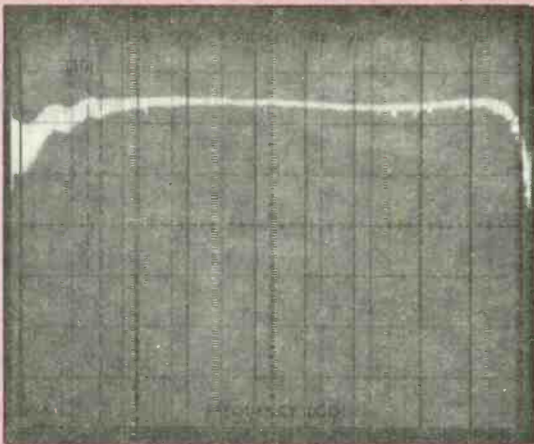


Fig. 3. Too low a bias may improve a tape's high-end response but degrade other performance characteristics.

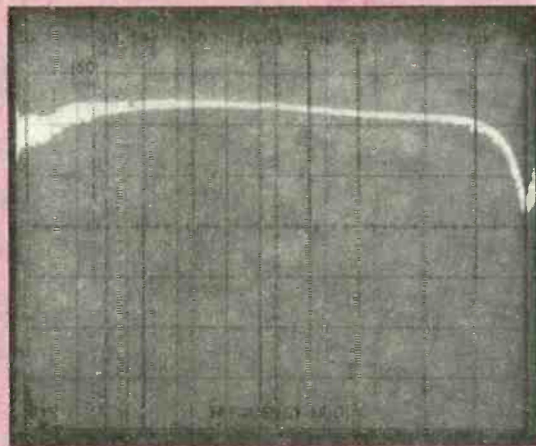


Fig. 4. Overbiasing causes high-frequency roll-off in tape playback as shown here.

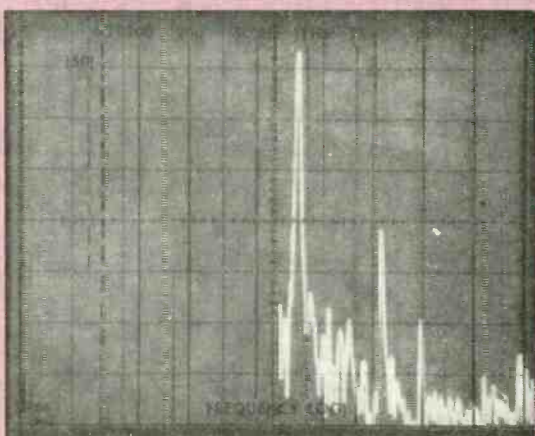


Fig. 5. Under-biased tape sample reproduces 1-kHz signal with high third-order harmonic distortion.

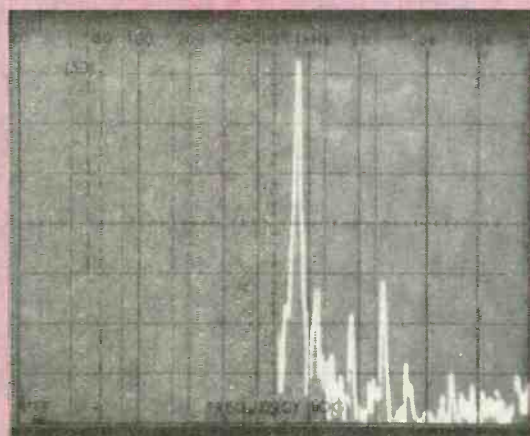


Fig. 6. Increased bias lowers third-order harmonic distortion content for this 1-kHz recorded test signal.

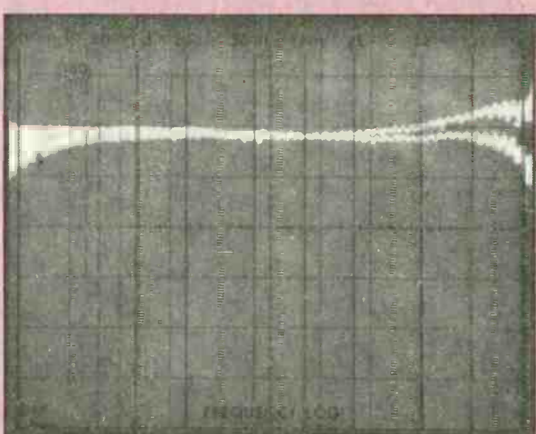


Fig. 7. Upper trace, with rising high-end response during playback occurs when sweep frequencies are recorded onto tape requiring CrO_2 equalization with switch set to "standard" position. Lower sweep was plotted using correct setting.

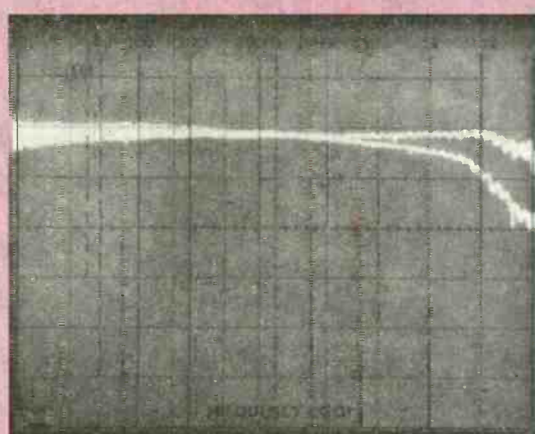


Fig. 8. When CrO_2 equalization setting is used with standard ferric-oxide tape, response at high end has severe rolloff (lower trace). Upper trace shows response obtained with correctly set equalization switch for this tape.

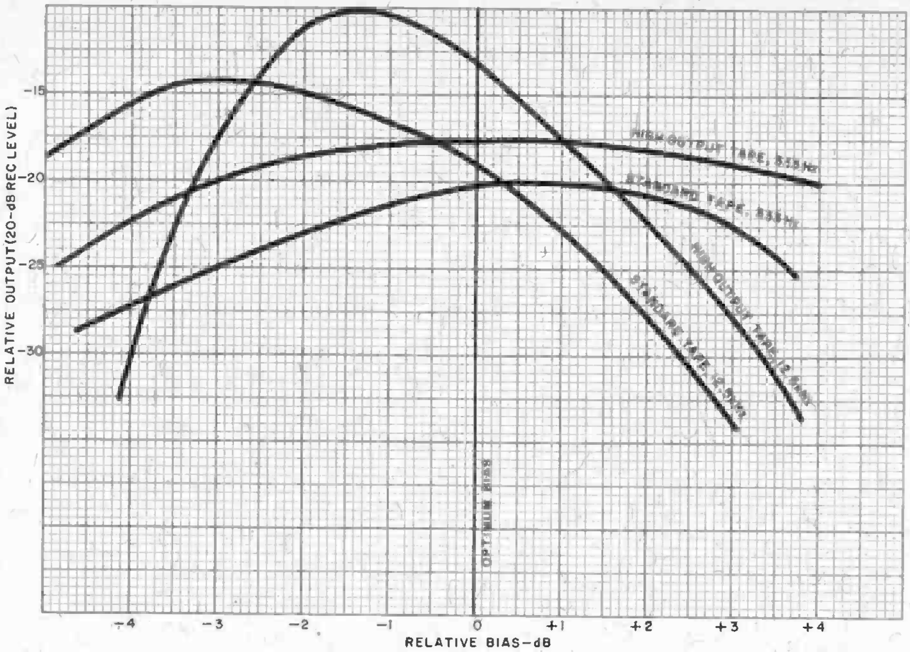


Fig. 9. Relative output sensitivities of standard and high-output tapes.

section, the high-output tape is more sensitive than the standard tape by nearly 2 dB at middle frequencies and by 6 dB at 12,500 Hz. This means that the higher-output tape affords a few extra decibels of dynamic range above the noise threshold.

Maximum modulation level is the recorded output level of a given tape that exhibits 3% third-order harmonic distortion. It is sometimes plotted as a function of bias level. In Fig. 10, are plotted the maximum output levels of two different tapes that have widely differing maximum output-level characteristics. The frequency used for maximum output level in cassettes is usually 333 or 1000 Hz. Some tape manufacturers also specify maximum output at a high frequency; in the case of cassette tapes, a 12,500-Hz signal is usually used for these tests.

Biased tape noise is also often specified by tape makers. This is the level of residual tape noise (referred to a specific reference level) when it has been recorded with bias signal only and with the bias signal weighted or modified by the use of a standard noise-weighting network. The biased tape-noise level for the two tapes tested in connection with maximum output level is also shown in Fig. 10. The difference between the noise level and the maximum modulation constitutes the maximum dynamic range of each tape.

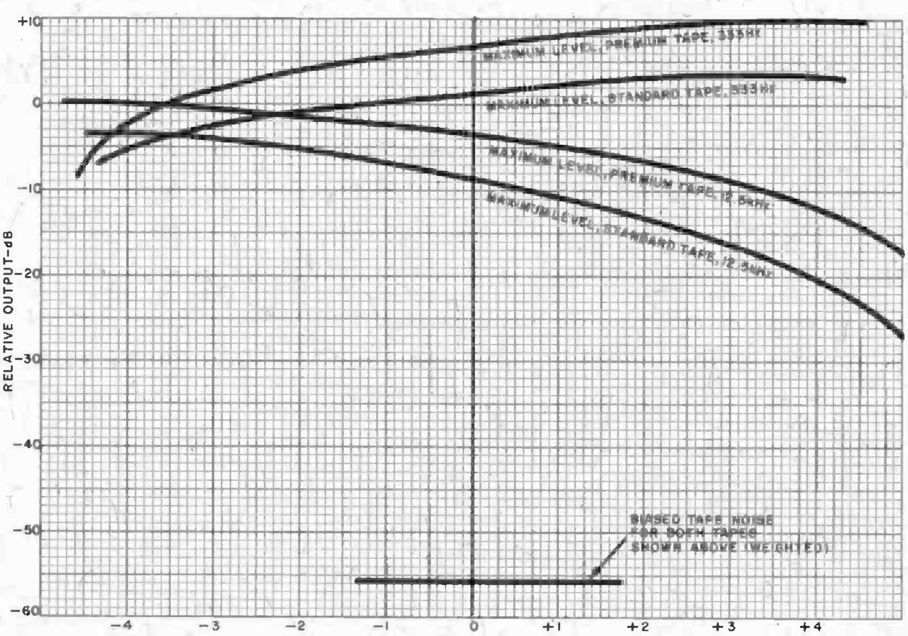


Fig. 10. Maximum output levels and biased tape noise for two types of tape.

Tape Is Different. As we have seen, tape cannot be looked upon in the same way that we consider other program sources in high fidelity, such as phonograph discs or FM signals. All discs are recorded with the same equalization and, therefore, only one fixed setting of playback equalization (RIAA) is required in preamplifier circuits. There are, of course, differences in disc quality that result from the use of different grades of vinyl from which discs are pressed. However, these differences are minor when compared with the differences that exist among the many grades of cassette tapes available.

Radio FM signals also employ a form of equalization known as "preemphasis," which has long been standardized in this country. Hence, all tuners provide correct deemphasis for FM reception, and difference in program quality depends on signal strength and the overall quality of a tuner or receiver.

In our discussion of the electrical properties of cassette tapes, we haven't stressed mechanical properties. These include: accuracy of tolerances maintained in the cassette housing (which can affect smoothness of tape travel); uniformity of magnetic coating and smoothness of the coated surface (both of which, if poor, can cause dropouts or momentary lapses of reproduced sound); tensile strength of the plastic base material itself (poor tensile strength can lead to tearing or stretching after repeated use); friction-reducing techniques used to insure smooth, uniform tape motion within the cassette housing; etc.

All of these qualities, in some measure, determine the price of a casette and its usefulness for recording applications. Obviously, if all you want to record are baby's first words or a business conference, response to beyond 15,000 Hz is of little importance. (Though mechanical reliability of the cassette itself may be of as great importance as if you were recording a once-in-a-lifetime live concert over FM.) On the other hand, if you want the finest results from your cassette deck (or even from your open-reel machine), it pays to research the question of which tape is best for you. It is important to choose the brand and type whose formulation in relation to the switch setting available on your tape deck has the right "compromises" for your needs. ◇

IC Multiplex Decoder Improves Stereo FM Performance

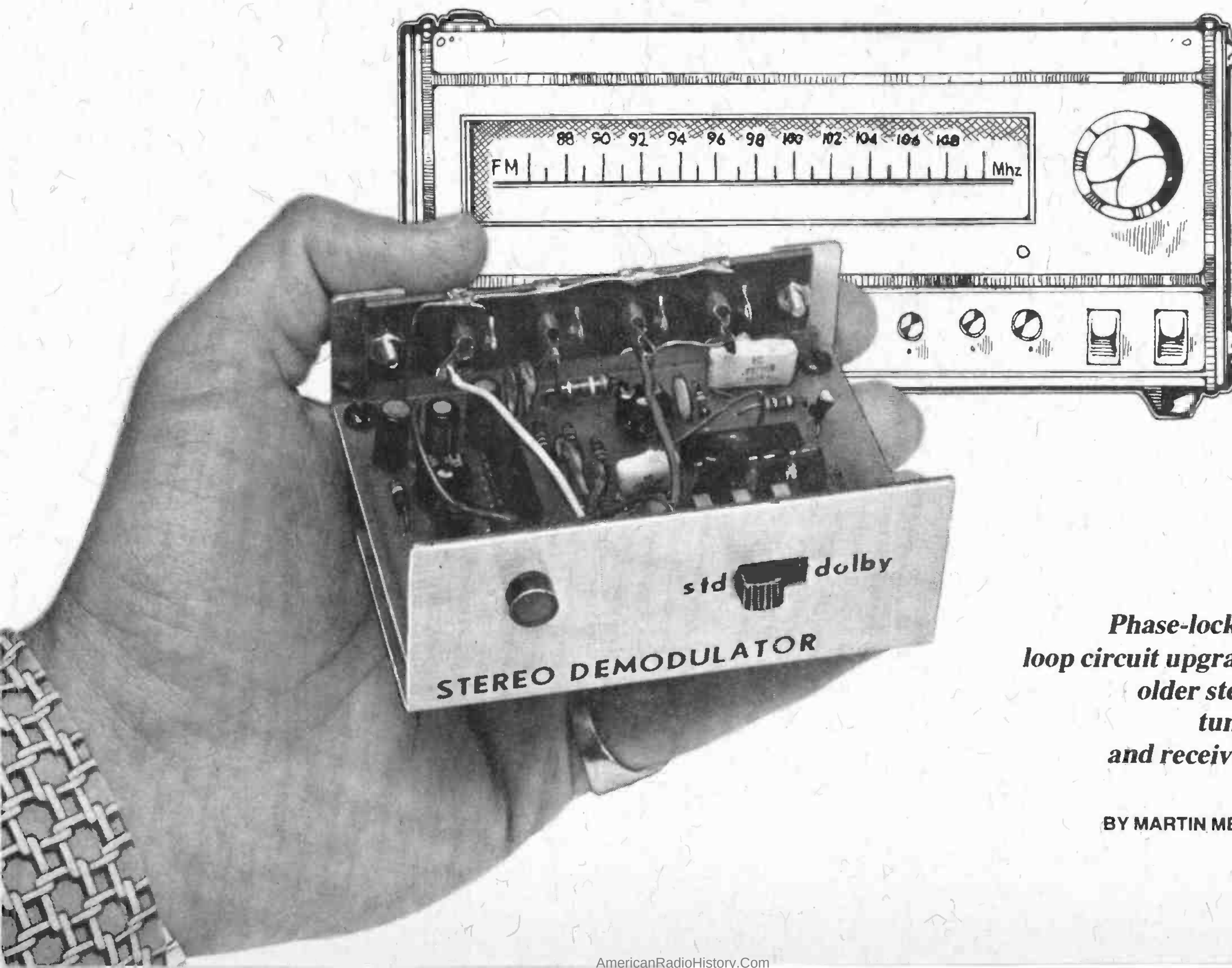
TODAY'S state-of-the-art audio components yield levels of performance unattainable a few years ago. However, most of us can't update our sound systems as frequently as technological advances are made. This project—an add-on phase-locked-loop multiplex decoder—will allow the user to improve the stereo FM demodulation of an existing receiver or tuner for about $25. Only a few hours of assembly and alignment time is required. The PLL decoder will not only improve channel separation and lower distortion levels, but will also select deemphasis time constants for standard and Dolby-FM broadcasts.

About the Circuit. The heart of the PLL multiplex demodulator is the LM1800A, an IC manufactured by National Semiconductor. A block diagram of the LM1800A is shown in Fig. 1. The phase-locked loop comprises a voltage controlled oscillator (vco), frequency dividers, phase detectors, low-pass filtering and an error amplifier. Also included are a voltage regulator allowing operation from 12-to-24-volt supplies, automatic stereo monaural switching, and use of a stereo indicator lamp.

In the absence of an input signal, no error signal is generated and the vco oscillates at a frequency designated as f_0. When a composite FM signal is applied to the input, the loop phase detector generates an error signal which is filtered and amplified. This amplified error voltage shifts the oscillating frequency of the vco to exactly 76 kHz. Filtering performed at the phase detector and error amplifier prevents modulation of the vco by the input signal.

The vco input frequency is divided by two, resulting in a 38-kHz carrier used in the synchronous demodulation of the composite signal. Passing the 38-kHz signal simultaneously through a pair of ÷2 counters produces two 19-kHz signals which are applied to the IC's two phase detectors. If the 19-kHz pilot signal drops below the level at which a satisfactory stereo signal can be recovered, an electronic switch causes the IC to produce a monaural output.

The schematic diagram of the complete multiplex detector is shown in Fig. 2. Input signals are capacitively coupled by *C5* to level control *R5*. Capacitor *C4* passes the composite FM input to the base of *Q1*, which amplifies it to a level



Phase-locked-loop circuit upgrades older stereo tuners and receivers.

BY MARTIN MEYER

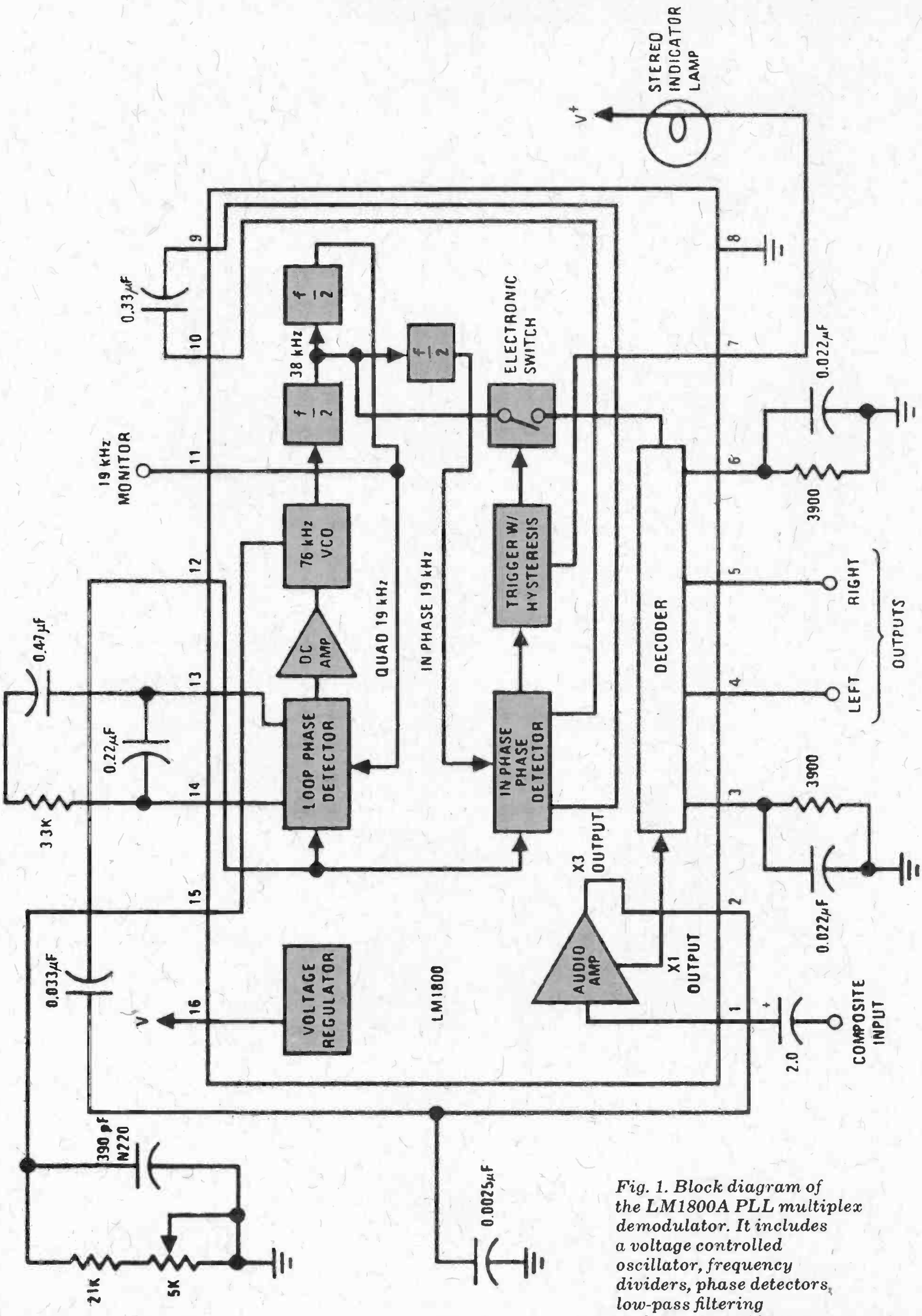


Fig. 1. Block diagram of the LM1800A PLL multiplex demodulator. It includes a voltage controlled oscillator, frequency dividers, phase detectors, low-pass filtering and error amplifier.

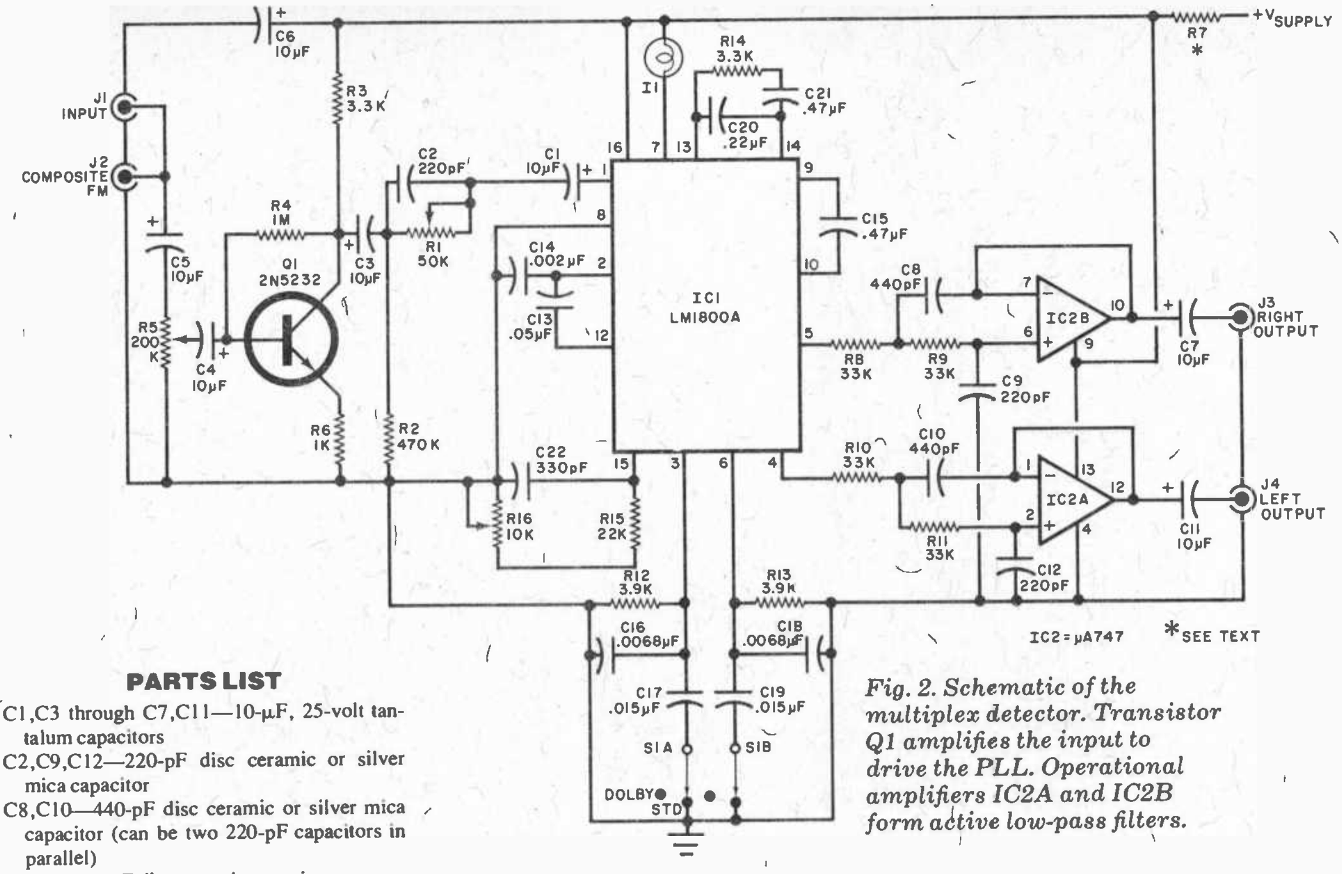


Fig. 2. Schematic of the multiplex detector. Transistor Q1 amplifies the input to drive the PLL. Operational amplifiers IC2A and IC2B form active low-pass filters.

PARTS LIST

C1,C3 through C7,C11—10-µF, 25-volt tantalum capacitors
C2,C9,C12—220-pF disc ceramic or silver mica capacitor
C8,C10—440-pF disc ceramic or silver mica capacitor (can be two 220-pF capacitors in parallel)
C13—0.05-µF disc ceramic capacitor
C14—0.002-µF disc ceramic capacitor
C15, C21—0.47-µF Mylar capacitor
C16,C18—0.0068-µF, ± 10% Mylar capacitor
C17,C19—0.015-µF, ± 10% Mylar capacitor
C20—0.22-µF Mylar capacitor
C22—330-pF disc ceramic or silver mica capacitor
I1—12-V, 35-mA pilot light
IC1—LM1800A PLL multiplex decoder
IC2—747 dual operational amplifier
J1 through J4—RCA phono jacks
Q1—2N5232 npn silicon transistor
The following are linear-taper, pc trimmer potentiometers:
R1—50,000 ohms
R5—200,000 ohms
R16—10,000 ohms
The following are 10% tolerance, ¼-watt carbon-composition fixed resistors:
R2—470,000 ohms
R3,R14—3300 ohms
R4—1 Megohm
R6—1000 ohms
R7—See text.
R8 through R11—33,000 ohms
R12,R13—3900 ohms
R15—22,000 ohms
S1—Dpdt slide or toggle switch
Misc.—Printed circuit board, suitable enclosure, hookup wire, shielded cable, pilot light jewel, hardware, solder, etc.
Note—The following are available from Netronics Research and Development, Ltd., 333 Litchfield Road, New Milford, CT 06776: complete kit including all components, pc board, screened enclosure, less audio cables, $24.95; complete kit as above but less screened enclosure, $19.95. U.S. residents add $1.50 postage and handling; Canadians add $3.00. For receiver connection info, send schematic, SAS envelope and $1 (free if purchasing kit). Connecticut residents add 7% sales tax.

that will properly drive the phase-locked loop. The parallel combination *C2R1* provides compensation for high-frequency rolloff in the tuner's i-f and detector stages. Resistors *R12* and *R13* and capacitors *C16* through *C19* provide deemphasis for multiplex decoder *IC1*. When *S1* is in the STD position, the standard 75-µs FM deemphasis characteristic appears. Placing *S1* in the DOLBY position changes the deemphasis to 25 µs, which corresponds to the reduced preemphasis used in Dolby-encoded broadcasts.

Operational amplifiers *IC2A, IC2B,* and their associated components form active low-pass filters with 16,000-Hz cutoff frequencies and 12-dB/octave slopes. These filters attenuate any 38-kHz carrier and 67-kHz SCA components which would otherwise appear at the left and right audio outputs. If allowed to pass, these signals could cause beats and whistles when program material is recorded on tape. Indicator *I1* glows in the presence of stereo pilot carrier. Jack *J2* is wired in parallel with input jack *J1*, providing access to the composite FM signal for such accessories as 4-channel and SCA demodulators.

Construction. Printed circuit guides for the project are shown in Fig. 3. Mount all components on the board, paying close attention to pin basing and polarities of semiconductors and electrolytic capacitors. Power can be tapped from any +12- to +24-volt dc source. The tuner's i-f stage or existing multiplex decoder is usually powered by a +15- to +20-volt supply which can be utilized for this purpose. Select the value of *R7* in kilohms according to the equation:

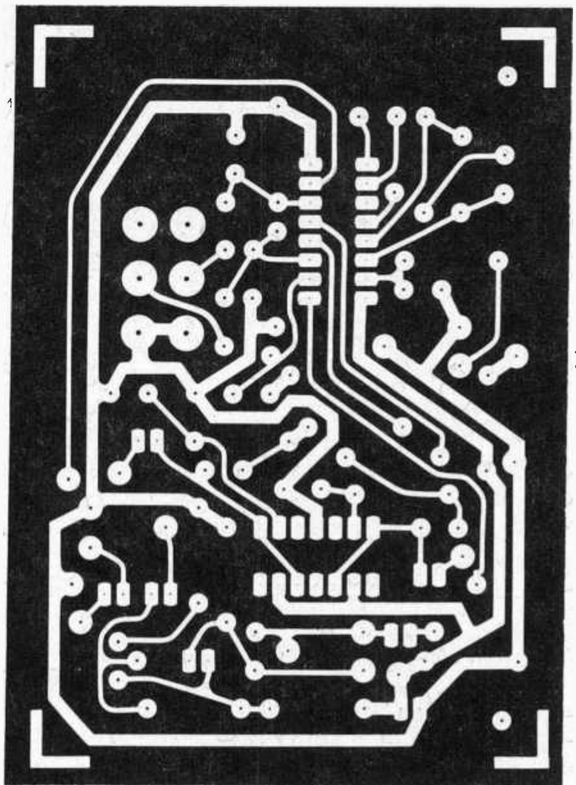
$$R7 = (V_{supply} - 12)/55$$

A one-watt carbon composition resistor will have adequate heat dissipation capability for this application.

The tuning lamp used in the author's prototype (and supplied with the kit) draws 35 mA at 12 volts. If you substitute another incandescent lamp or a LED and current limiting resistor, modify the equation for the value of *R7*. Replace the 55 mA in the denominator with the sum of 20 mA (the current required by the PLL and active filters) and the

TABLE I
LM1800A SPECIFICATIONS

Stereo Separation—100 Hz: 40 dB
1000 Hz: 45 dB
10,000 Hz: 45 dB
SCA Rejection: 50 dB
Total Harmonic Distortion: 0.2 %
Ultrasonic Frequency Rejection: 45 dB



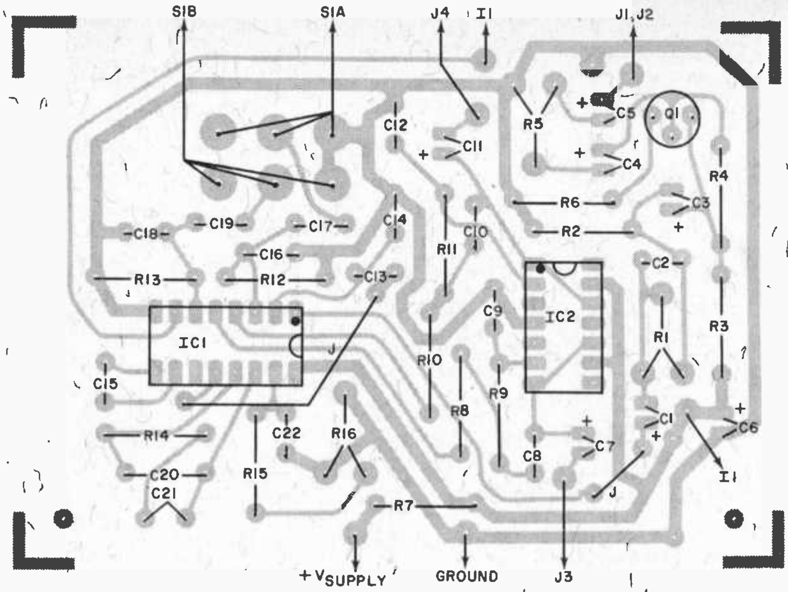


Fig. 3. Etching and drilling guide for multiplex decoder is shown at left. Component placement guide is above.

current required by the indicator. For example, if a LED and resistor drawing 20 mA are used, the denominator would be 40 mA.

The project can be mounted in the tuner cabinet or housed in a separate enclosure. If it is placed in the tuner cabinet, mount *S1* on the rear panel of the tuner and connect it to the pc board via low-capacitance shielded cable such as RG-59-U. The same type of cable should also be used to conduct the composite FM signal from the detector output to the input of the multiplex decoder.

If your tuner or receiver has a "composite FM" or "FM detector" output jack, the required signal is available there. If not, you will have to locate the FM detector and tap the signal at that point. The partial schematic of a typical FM receiver is shown in Fig. 4. The composite signal is obtained by disconnecting the existing multiplex decoder and tapping the signal at point A.

The left and right audio outputs are available at jacks *J3* and *J4*. If you are using the project in place of the multiplex decoder in a tuner, you can either use these jacks in place of those in the tuner, assuming the decoder is mounted externally. If it is mounted internally, you can disconnect the outputs of the existing multiplex decoder from the output jacks on the tuner's rear panel and connect the outputs of the decoder's active filters.

Similarly, if you have a receiver and are mounting the project in an external enclosure, you can connect the decoder's outputs to the tape monitor circuit. Mounting the decoder inside the receiver cabinet suggests an internal connection. Remove the output leads at the ex-

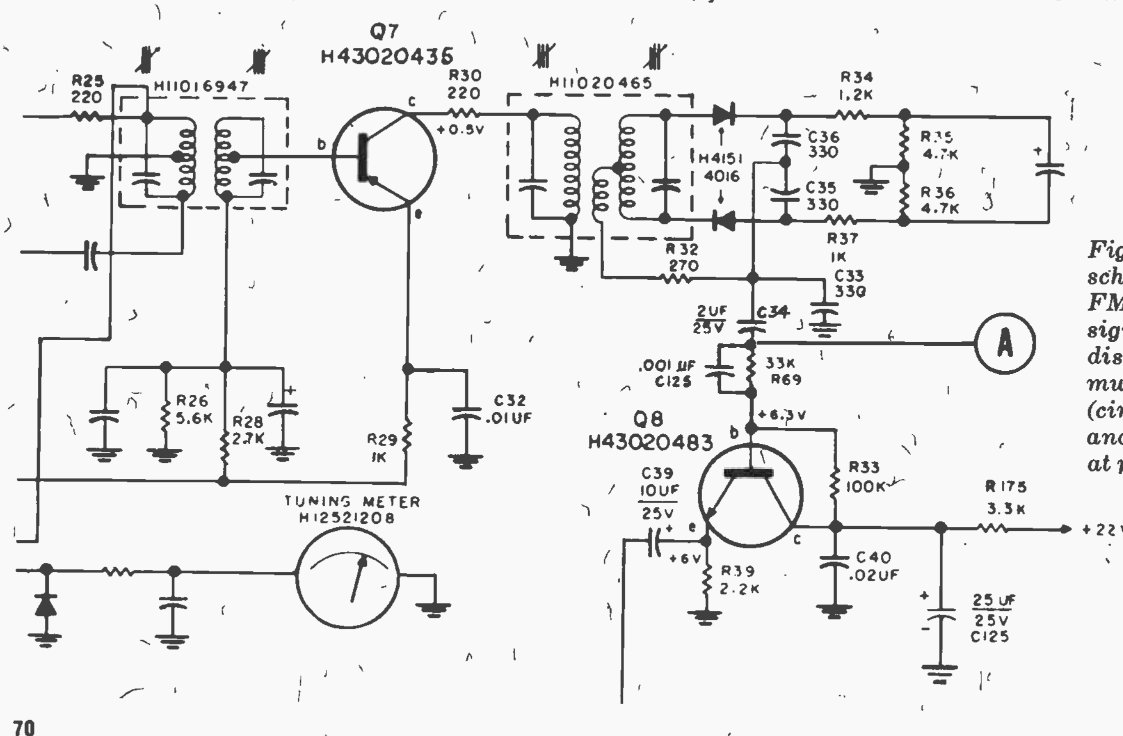


Fig. 4. Partial schematic of typical FM receiver. Composite signal is obtained by disconnecting existing multiplex decoder (circuit below C34) and tapping signal at point A.

isting multiplex decoder running to the appropriate lugs on the receiver's MODE switch. Then connect them to the decoder's active filter outputs.

Alignment. When properly aligned, the project will provide performance as outlined in Table I—assuming no degradation in the tuner's i-f and FM detector. Two typical receivers were used with the PLL decoder. Results are shown in Table II. The alignment procedure about to be described requires no test instruments, but will yield good results. The author was able to improve the stereo separation only 2 dB when instrument alignment was performed with an expensive FM stereo generator.

Rotate potentiometers *R1* and *R16* to the midpoint of wiper travel, and *R5* for maximum signal drive at the base of *Q1*. Turn on your receiver and tune in a station broadcasting in stereo. Indicator *I1* should glow. If not, adjust *R16* until it does. Then turn *R16* fully clockwise. If *I1* still glows, adjust *R5* until the indicator just goes out. Slowly rotate *R16* counterclockwise until the lamp begins to glow. Note the position of the control. (It may be necessary to adjust *R5* slightly.)

Next, turn *R16* fully counterclockwise, adjusting *R5* again if necessary to extinguish the lamp. Slowly rotate *R16* clockwise until the lamp glows, noting the position of the control. Set *R16* midway between the two positions noted. Adjust *R5* until the lamp goes dark, then slowly turn it until the lamp just starts to glow. Advance the wiper of *R5* another 10°. This will properly tailor the input level to decoder *IC1*.

Potentiometer *R1* is included in the circuit for adjustment if test equipment or a cooperative FM broadcast engineer is available. Since all stations must conduct tests and certify the quality of their signals once a year, you can easily check out adjustments. Call several local stations and ask when they will perform the tests. If it is late at night, the engineer might turn off a channel for 30 seconds or so. While only one channel is being transmitted, adjust *R1* for maximum separation at any mid-band frequency. Note, however, the setting of *R1* will not have a critical effect on the performance of the decoder and can simply be left midway between the two adjustment extremes. ◇

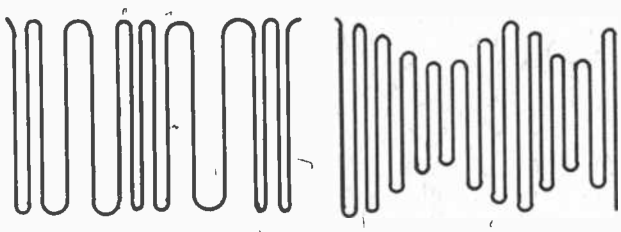
TABLE II—RECEIVER MODIFICATION RESULTS

	Sony STR-6060FW		Harman Kardon SR900	
	Before	After	Before	After
Stereo Separation—100Hz:	20 dB	32 dB	25 dB	30 dB
1000 Hz:	28 dB	42 dB	32 dB	42 dB
10,000 Hz:	18 dB	30 dB	25 dB	33 dB
Total Harmonic Distortion (1000 Hz):	0.5%	0.3%	0.6%	0.25%

Quiz of Audio Basics

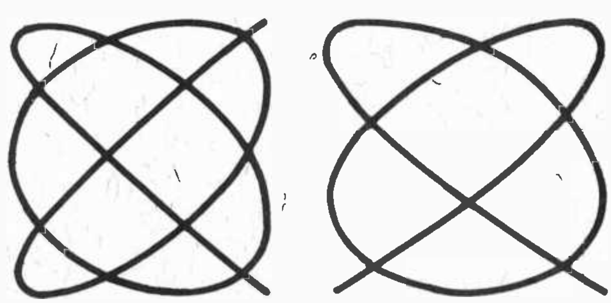
BY ROBERT P. BALIN

1 Which of these audio waveforms indicates the use of tremolo and which is vibrato?



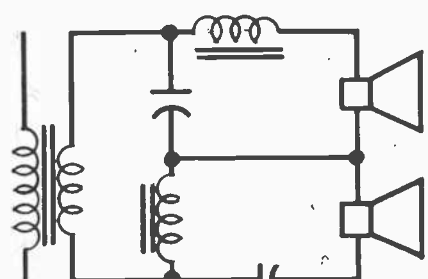
A B

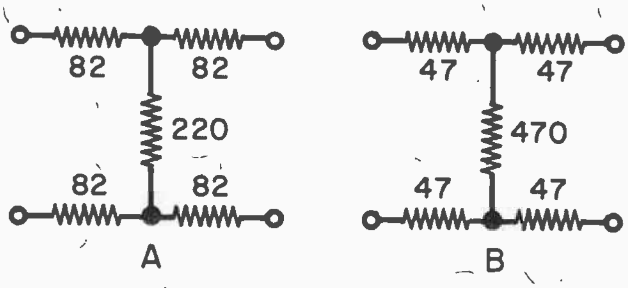
2 If the vertical frequency used to produce these Lissajous patterns is 1000 Hz, which has a horizontal frequency of 1200 Hz and which is 1250 Hz?



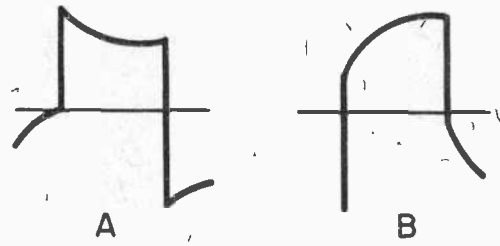
A B

3 With this crossover network, which speaker is the woofer and which the tweeter?

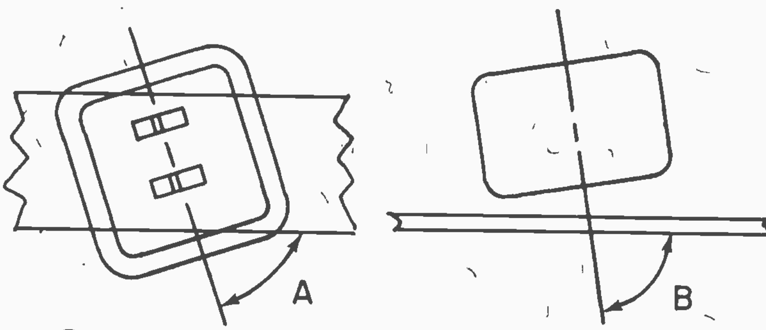




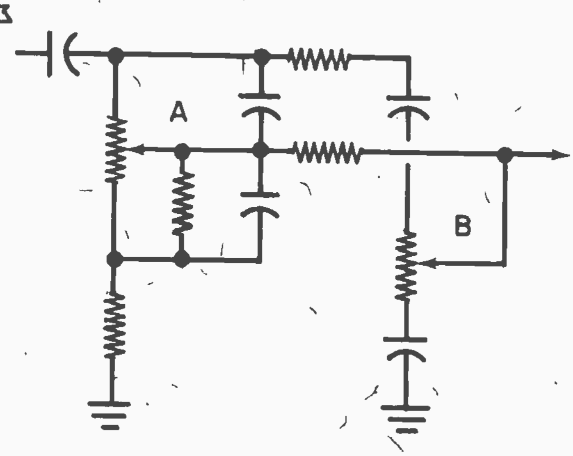
4 Of these 300-ohm attenuator pads, which produces a 6-dB signal voltage loss and which a 12-dB loss?



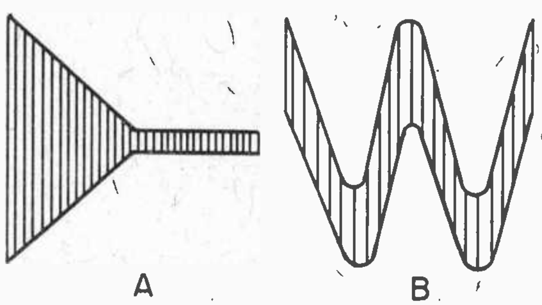
5 Which of these square-wave audio test signals indicates low-frequency attenuation and which high-frequency?



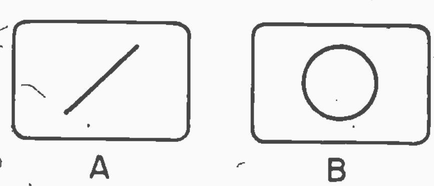
6 Which tape-head condition produces an azimuth error and which a zenith error?



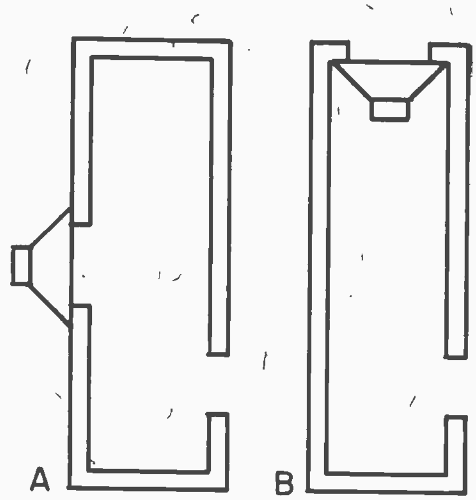
7 In this phono-amplifier tone control circuit, which pot is for treble and which is for bass?



8 Which audio test signal has been affected by intermodulation and which by overmodulation?



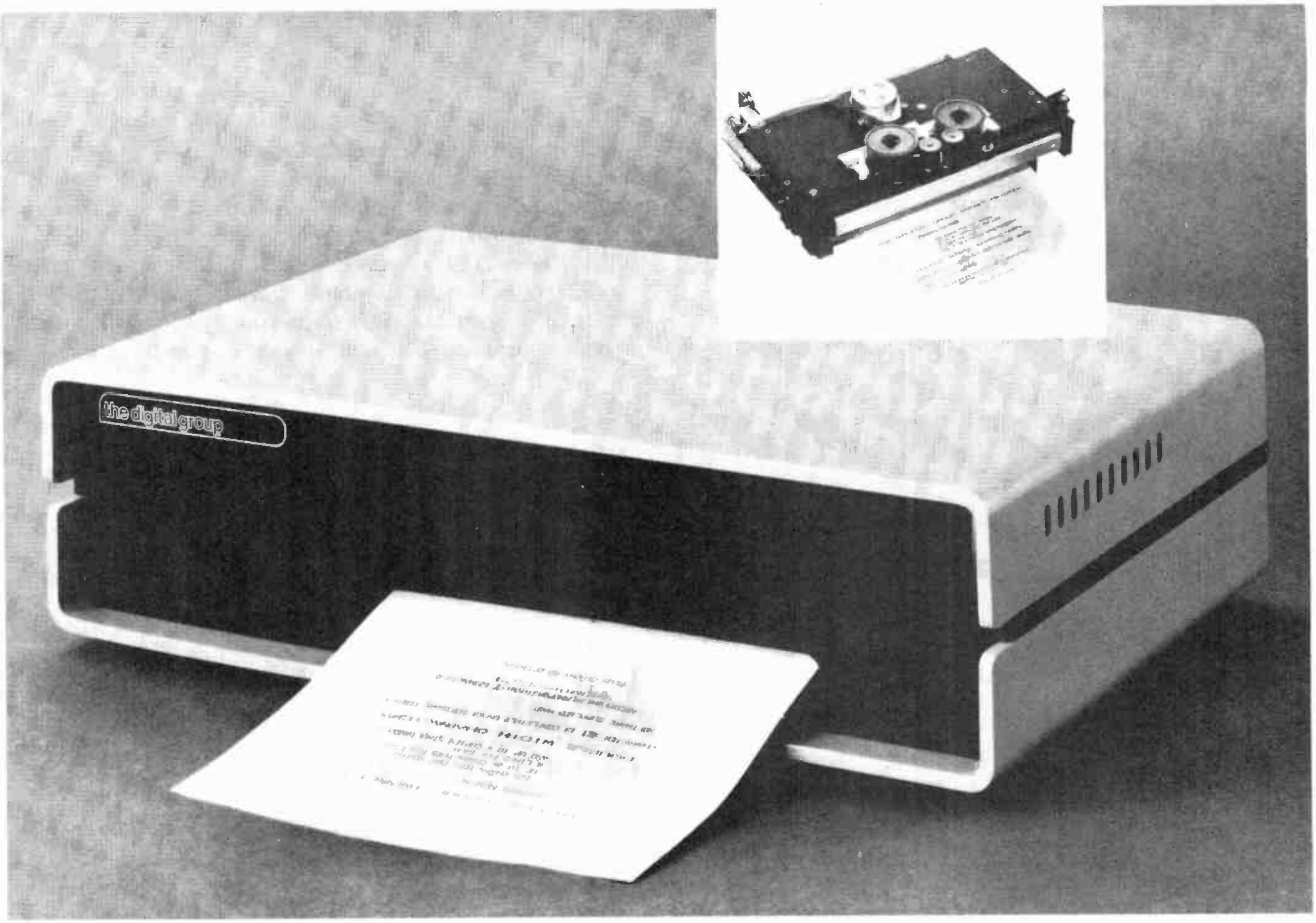
9 Which scope pattern indicates that two audio sine waves are in phase and which that they are 90° out of phase?



10 Which speaker baffle is known as a resonant column and which as an air coupler?

ANSWERS

1. Tremolo, B; vibrato A.
2. 1200 Hz, A; 1250 Hz, B.
3. Woofer, A; tweeter, B.
4. 6-dB, B; 12 dB, A.
5. Low-frequency, A; high, B.
6. Azimuth, A; Zenith, B.
7. Treble, B; bass, A.
8. Intermodulation, B; over, A.
9. In phase, A; 90° out, B.
10. Column, B; coupler, A.


the digital group

FIRST WEST COAST COMPUTER FAIRE BY TOM MUNNECKE

SAN FRANCISCO was the setting last April for the First West Coast Computer Faire, which may become the Woodstock of the personal computing movement. Almost 13,000 people attended the 165 exhibits, 107 lectures, 17 home-brew demonstrations and two banquets.

The crowd was as kaleidoscopic as one would expect in San Francisco. Among them were a blind man seeking braille production equipment and voice synthesizers; Berkeley pamphleteers warning of government restrictions against home computers; artists looking for a new medium for artistic expression; and a father looking for aids for his deaf child.

Banquet speakers told of the coming revolution in home computing. Ted Nelson predicted that the "cybecrud" coming out of the large computers would be counteracted by the masses of personal computers. What used to be a topic for science fiction writers has come true, with the help of MPU's.

There were 37 conference sessions, covering everything from "Tutorials for the Computer Novice" to "Heretical Proposals." Commercial exhibitors had on display all their latest products, including electronic music synthesizers, speech

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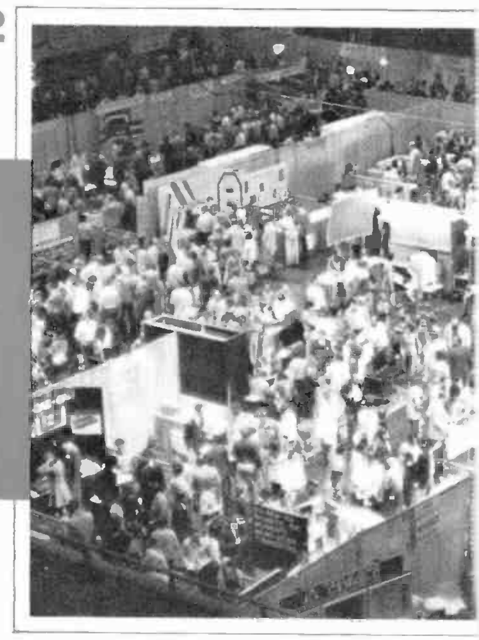

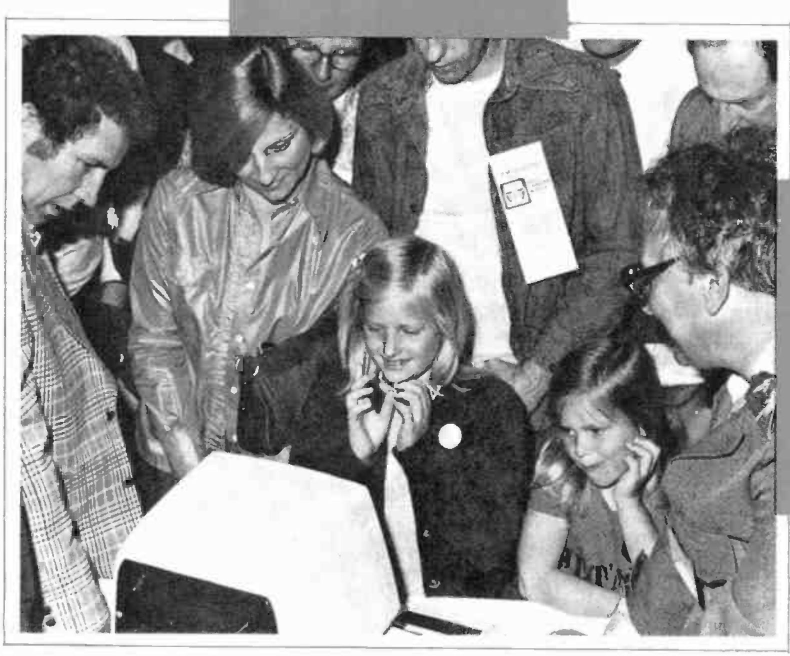

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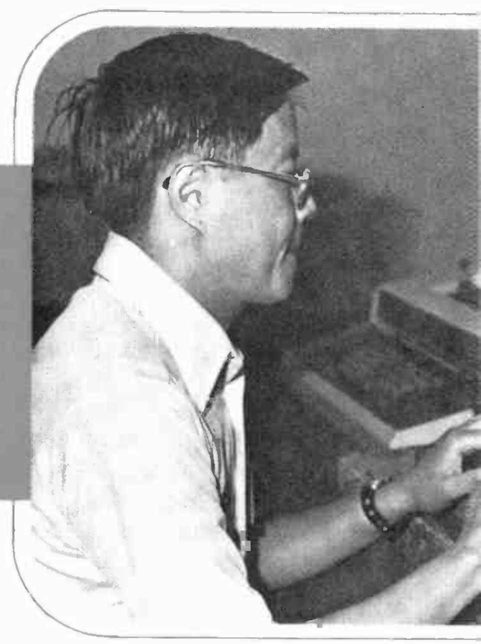

1 Prototype of Commodore's PET 2001, an "appliance-type" computer based on the 6502 MPU. Computer provides built-in BASIC, a graphics or character-oriented CRT, cassette storage, and 4k of RAM in a factory-assembled unit.

2 A portion of the exhibit hall, where 165 vendors displayed their wares to 12,750 people. The crowd and the size of the exhibition made it almost impossible to see all of the interesting computers on display.

3 Dr. Franz Frederick, Lafayette, Indiana, shows his "turtle" to Michael Rubinstein. Built in three weeks from surplus parts, it is controlled by a homebrew 6800 system to draw pictures while moving about the floor.

synthesizers and recognizers, and 64k memory boards.

A new class of computers emerged at the Faire—the so-called appliance computer. Meant to be purchased much as one would buy a television receiver or stereo tuner, these computers are complete systems that require no assembly. Apple Computers, Inc., showed the Apple II, a 10-lb (4.5-kg) microcomputer with keyboard, color-TV and audio cassette interfaces, game paddle, and BASIC built-in for $1300. Commodore International had a working prototype of its PET 2001 computer, which has a CRT, keyboard, cassette drive, IEEE 488 interface, and built-in BASIC; price goal is the $500-$600 range. Commodore sees the personal computing market as a merger of the electronic games and calculator markets and expects the same dramatic decline in prices as more of the semiconductor manufacturers join in the competition.

There was a general air of amazement at both the number and sophistication of the products offered by the vendors. Since the January, 1975 POPULAR ELECTRONICS article introducing the Altair 8800 microcomputer, a dozen new companies have emerged to offer Altair-compatible mainframes; memory boards have increased 16 times in capacity; an array of compatible peripherals is being offered; and a whole new generation of computers has emerged. And all those people came to San Francisco to see it happen. ◇

3

5

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4 Angela and Joanna Prelesnik, of Santa Clara, react to the PET's showing of their lunar landing module's crash on the moon. MOS Technology 6502 architect Chuck Peddle is shown looking on at left.

5 Dennis Wong, from Mountain View, shows his computer-based payroll system for small businesses. System consists of a Processor Tech. SOL microcomputer, a North Star Floppy Disk, and Memorex printer, all for less than $3000.

6 Rich Gold's "Mr. Computer" is based on a KIM-1 and 200-byte program. Its coded messages (via LED displays in its mouth) are interpreted by Rich in storybook form. He plans to add video graphics and electronic music output.

BUILD "cabonga" PART 2

How to use various accessories to achieve greater flexibility.

BY JAMES BARBARELLO

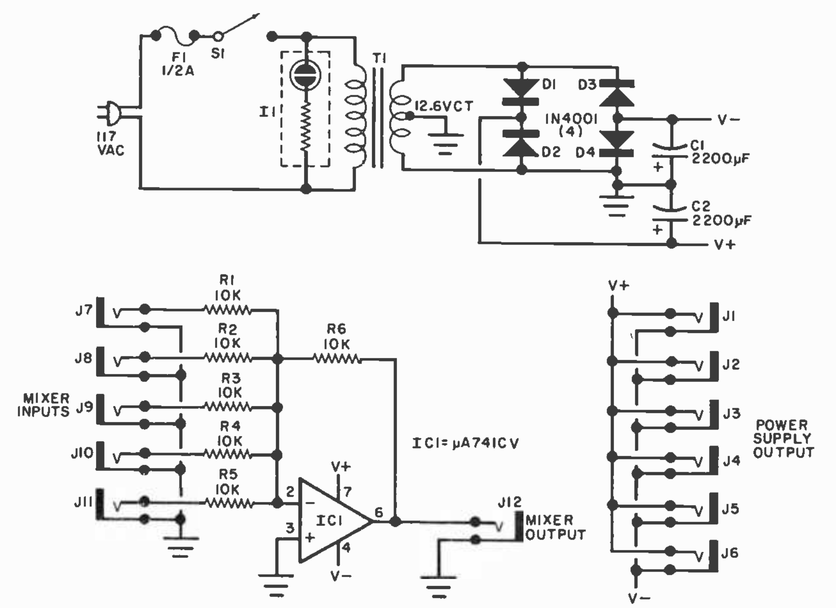
LAST MONTH, we described the circuitry and construction of the Cabonga electronic percussion synthesizer. Now here are four accessories—the Snare Drum Adapter, the Auto Trigger, the Sound Modifier, and the Combiner/Power Pack. Methods of interconnecting them with each other and the Cabonga will be shown. The result of these patches will be a flexible and expandable percussion synthesizer system.

The Cabonga has two jacks which, until now, you have not used. They are marked EXTERNAL TRIGGER and EXTERNAL POWER. The EXTERNAL TRIGGER jack will be used with the Auto Trigger and the Snare. The EXTERNAL POWER jack will accept ±9 volts from the Combiner/Power Pack. Actually, all Cabonga system components could be powered by 9-volt batteries. Cost, however, makes this an unattractive proposition in a multi-component system.

The Combiner/Power Pack will not only provide ±9 volts dc (if 117 volts ac is available), but also includes a unity-gain active mixer. This mixer will sum up to five input signals and present them at a low-impedance output. In practice, all Cabonga components will operate with supplies ranging from ±8 to ±15 volts dc. Accordingly, the Combiner/Power Pack does not include such features as voltage regulation, foldback current limiting, etc. If you're a purist, you can add them; but you will probably not be able to *hear* any difference.

The schematic of the Combiner/Power Pack is shown in Fig. 6. A full-wave bridge composed of *D1* through *D4* rectifies ac from *T1*, a 12.6-volt, 1.2-ampere center-tapped transformer. Pulsating dc produced by the bridge is filtered by electrolytic capacitors *C1* and *C2*. The ±9-volt output of the power supply is routed to jacks *J1* through *J6* and to *IC1*, the unity-gain summing amplifier.

Etching and drilling and parts placement guides are shown in Fig. 7. Be sure to observe polarities and pin basing of semiconductors and electrolytic capacitors. The Combiner/Power Pack should be housed in an enclosure measuring about 9¼" × 4" × 2½" (23.5 × 10.2 × 6.4 cm). The top and bottom of each wall should be rabbeted to provide a ⅜" (9.5-mm) deep × ¼" (6.4-cm)



COMBINER/POWER PACK PARTS LIST

C1, C2—2200-µF, 16-V electrolytic capacitor
D1 through D4—1N4001 silicon diode
F1—½-ampere fuse
I1—120-V ac neon pilot lamp assembly (Radio Shack 272-703 or equivalent)
IC1—µA 741CV operational amplifier
J1 through J6—Miniature phone jack
J7 through J12—Standard phone jack
R1 through R6-10,000-ohm, ¼-watt, 10% carbon composition resistor
S1—SPST switch
T1—12.6-V, 1.2-A transformer
Misc.—Printed circuit board, ac line cord, etc. See photo p. 80 for kit prices.

Fig. 6. Schematic of Combiner/Power Pack. The former is a full-wave rectifier with filters.

BILL OF MATERIALS

1—Piece 1/32" aluminum 8⅜" × 2-15/16"
1—Piece 1/16" phenolic stock 1¾" × 1¼"
2—Pieces ¾" pine or plywood 9½" × 2½"
2—Pieces ¾" pine or plywood 3-1/16" × 2½"
1—Piece ¼" plywood 8-7/16" × 3"
1—Piece ⅛" rubber matting 8-7/16" × 3"
1—Piece black vinyl 28" × 5"
10— No. 4 × ½" sheet metal screws
1—⅜" grommet
Misc.—Contact cement, etc.

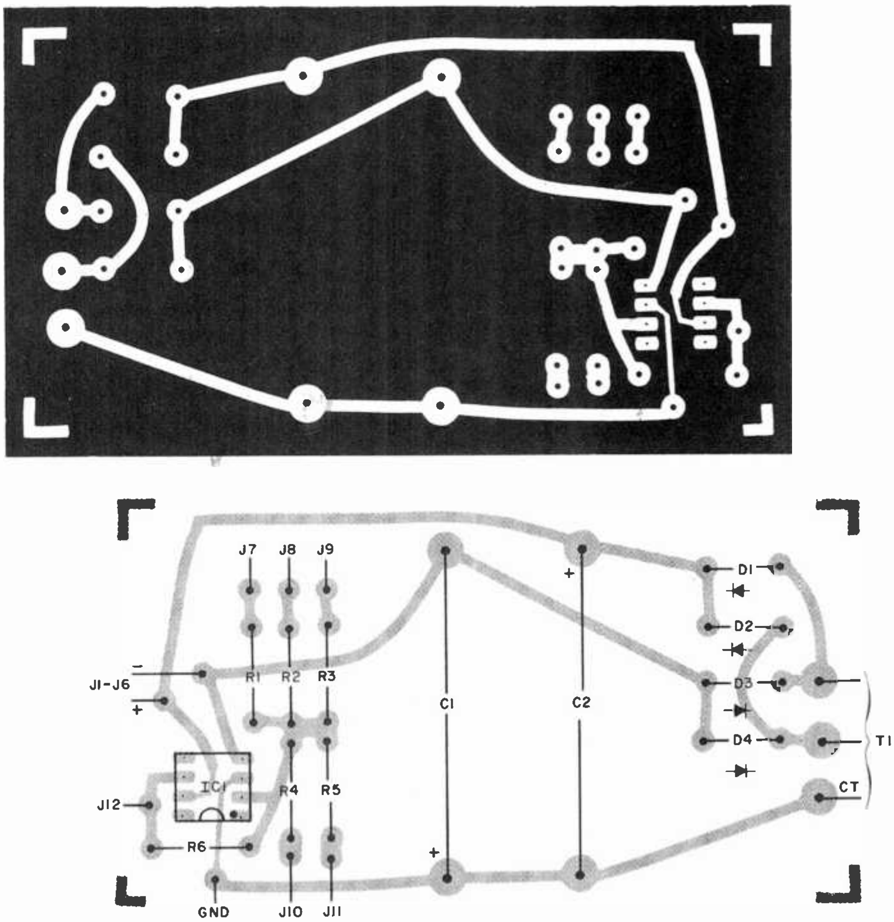


Fig. 7. Guides for Combiner/Power Pack board.

"shelf" on which to mount the top and bottom plates. This will enable the plates to be flush with the top and bottom of the walls. Round all top and bottom edges of the walls with sandpaper.

Form a top plate from an 8⅜" × 2-15/16" (21.3- × 7.5-cm) piece of 1/32" (0.8-mm) aluminum stock. Holes should be drilled for the mixer input and output and power output jacks, for the line cord, power switch and pilot light. The power output jacks, as well as the EXTERNAL POWER jacks on the Cabonga components, must be isolated from the aluminum top plates. This is because the "ground" portions of the jacks are at −9 volts. Isolation can be ensured by drilling the holes for the jacks with 7/16" (1.1-cm) bits. The jacks should be mounted on a 1¾" × 1¼" (4.4- × 3.2-cm) piece of 1/16" (1.6-mm) phenolic.

An 8-7/16" × 3" (21.4- × 7.6-cm) piece of ¼" (6.4-mm) plywood forms the bottom plate. If you wish, you can fashion a sheet of ribbed rubber runner to the outer surface of the bottom plate with contact cement. The runner will provide an antiskid surface for the Combiner/Power Pack. The case can be covered with a 28" × 5" (71.1- × 12.7-cm) piece of black vinyl. Secure the vinyl to the case with contact cement by wrapping it around the perimeter. At each corner, slit the vinyl and trim it as necessary. Carefully fold the vinyl over the top and bottom edges and into the rabbets.

Wire the jacks, switch, etc., according to the schematic diagram. When all connections have been made, secure *T1* and the pc board to the bottom plate, and the top and bottom plates to the case. Make one patch cord from a convenient length of shielded audio cable, terminating its ends with miniature phone plugs and prepare one patch cord terminated with standard phone plugs for each Cabonga. Also make one terminated with miniature phone plugs and one terminated with subminiature phone plugs for each Auto Trigger or Snare.

To test the Combiner/Power Pack, plug one power patch cord (terminated with miniature phone plugs) into a power output jack. Then connect the line cord to a wall socket and close *S1*. Indicator *I1* should glow. Attach the negative probe of a voltmeter to the barrel of the miniature phone plug, and the positive probe to the plug tip. The meter should read 17 to 20 volts dc. If you read only half of this voltage or zero volts, turn off the Combiner/Power Pack and disassemble the enclosure. Check your wiring for shorts. When the reading is correct, attach the negative probe to the aluminum top plate and the positive probe to the plug tip. A reading of 8.5 to 10 volts dc should be obtained.

Turn off the power by opening *S1*. Then remove the patch cord from the power plug. As the plug barrel comes out of the jack, it momentarily touches both terminals of the jack and shorts them together. The Combiner/Power Pack's supply can take a direct short for a second or two without damage to its components. As a rule, however, you should turn off the power before making any power patch cord changes.

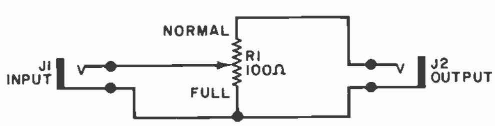
Connect a Cabonga to the power supply and mixer circuits to verify that both are functioning correctly. Successively try each power and mixer input jack to be sure they are correctly wired.

The Modifier. Most often, the damped sinusoidal output of the Cabonga is the signal you will use. But there will be times when a certain amount of clipping is needed. For example, the peaks of the Cabonga output should be clipped somewhat to get a "crisp" sound like that of a good bongo. This also produces a better sounding tom-tom.

The schematic diagram of the Modifier is shown in Fig. 8. The circuit is simply a 100-ohm potentiometer. It presents a variable load of from 0 to 100 ohms to the output stage of the Cabonga. As the load resistance decreases below the value required for "crispness," various sound effects can be obtained. Although the load resistance as seen by the Cabonga varies, the Combiner/Power Pack input sees a constant 100-ohm signal voltage source.

The Modifier, as well as the Auto Trig-

Fig. 8. Modifier is simple potentiometer circuit shown here.



MODIFIER PARTS LIST

J1, J2—Standard phone jacks
R1—100-ohm, linear-taper potentiometer
Note—See photo p. 80 for kit price.

BILL OF MATERIALS

Same as for Auto Trigger, less phenolic stock and one ¾" diameter knob.

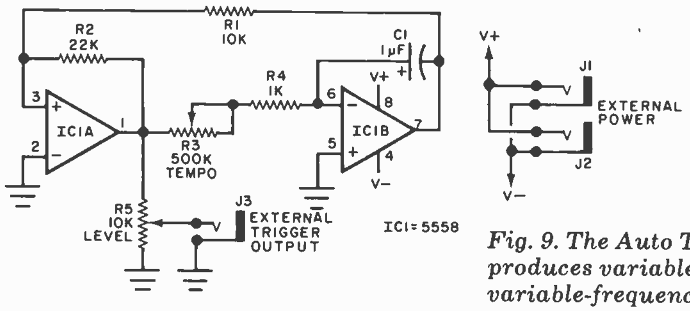


Fig. 9. The Auto Trigger produces variable-level, variable-frequency square waves.

AUTO TRIGGER PARTS LIST

C1—1-µF, 16-volt electrolytic capacitor
IC1—5558 dual operational amplifier
J1, J2—Miniature phone jack
J3—Subminiature phone jack
R1—10,000-ohm, ¼-watt, 10% carbon composition resistor
R2—22,000 ohm, ¼-watt, 10% carbon composition resistor
R3—500,000-ohm, audio-taper potentiometer
R4—1000-ohm, ¼-watt, 10% carbon composition resistor
R5—10,000-ohm, linear-taper potentiometer
Misc.—Printed circuit board, hookup wire, etc. See photo p. 80 for kit prices.

BILL OF MATERIALS

1—Piece 1/32" aluminum 4" × 2"
2—Pieces ¾" pine or plywood 5-1/16" × 2"
2—Pieces ¾" pine or plywood 2-1/16" × 2"
1—Piece ⅛" rubber matting 4-¾" × 2-¾"
1—Piece 1/16" phenolic stock 1½" × ½"
1—Piece black vinyl 16½" × 3½"
4—No. 4 × ½" sheet metal screws
2—¾" diameter knobs

ger and Snare, should be housed in enclosures measuring about 5¼" × 3⅛" × 2" (13.4 × 7.9 × 5.1 cm). The enclosures should be constructed from the same materials as used for the Cabonga itself and the Combiner/Power Pack, rabetted, and finished with black vinyl and rubber matting. Top plates can be made from 4" × 2" (10.2- × 5.1-cm) pieces of 1/32" (0.8-mm) aluminum stock. Two standard phone jacks and the 100-ohm potentiometer are mounted on the Modifier top plate. Wire them as per Fig. 8.

To test the Modifier, patch the output of the Cabonga to input jack *J1*, and the output of the Modifier (*J2*) to the mixer input of the Combiner/Power Pack. Place *R1* in its NORMAL position. Play the Cabonga and slowly rotate *R1* toward its FULL position. You will notice that the sound becomes "crisp." As the control is rotated further, the sound will become more and more distorted and lower in volume. At the extremity of wiper travel, the output will be a steady oscillation if your potentiometer's minimum resistance closely approaches zero ohm. (This will not damage the Cabonga output state.)

The Auto Trigger. Before we discuss the Auto Trigger, let's review how the Cabonga has been triggered until now. When the head is struck, switch *S1* closes and applies a pulse to the active filter, resulting in a damped sinusoidal output. The amplitude of the trigger pulse determines the amplitude of the output signal. Jack *J1* (EXTERNAL TRIGGER) is connected in parallel with *S1* so that an external pulse source can cause the generation of a percussive output.

The Auto Trigger is such a pulse source. It produces a variable level (0 to 9 volts), variable-frequency (0.5-to-400-Hz) square waves. Its circuit, shown schematically in Fig. 9, is not complicated. Only seven components are used. Operational amplifier *IC1A*, one half of a 5558 dual op amp IC, is used as a comparator. The other half, *IC1B*, is used as an integrator. When the comparator output changes states, a pulse is generated. This pulse is integrated by *IC1B* into a ramp whose slope depends on the amount of signal current supplied to the integrator, and thus on the values of *R3* and *R4*. When the output of the integrator reaches one-half of the supply voltage, the comparator changes states again. The process then repeats itself.

Resistors *R3* and *R4*, and capacitor *C1* determine the frequency of oscillation. It can be varied over a wide range by adjusting TEMPO control *R3*. The upper limit of oscillation is governed by *R4*. Square waves appear at the output of *IC1A* and are coupled to *J3* by LEVEL control *R5*. Power is derived from the Combiner/Power Pack and coupled to *J1* or *J2*. An extra power jack is provided for patching to other accessories.

Etching and drilling and parts placement guides for a suitable schematic are shown in Fig. 10. Be sure to observe the polarity of *C1* and the pin basing of *IC1* when mounting them on the board. Construct an enclosure and top plate to the dimensions and style previously described. Note that jacks *J1* and *J2* must be isolated from the aluminum top plate, which is at ground potential.

Connect a power patch cord between the Combiner/Power Pack and *J1* or *J2* of the Auto Trigger. Then connect a patch cord terminated with subminiature phone plugs between the Cabonga's EXTERNAL TRIGGER jack (*J1*) and the Auto Trigger output (*J3*). Turn the Auto Trigger's TEMPO and LEVEL controls fully clockwise. Then close the Combiner/Power Pack's power switch and monitor the mixer output. You will hear an output signal about once every two seconds. As the TEMPO control is rotated, the trigger rate will increase. Rotating the LEVEL control will vary the output signal's volume from minimun to maximum.

The Snare Drum Adapter. The snare sound is the most difficult to synthesize because a snare drum produces three different sounds simultaneously. As the drumstick strikes the top head, the sharp sound of the strike is heard. At the same time the sound of the drum itself (actually a medium-size tom-tom) is produced. The bottom head also vibrates and causes the snare wires touching it to move.

We can synthesize this complex sound by combining three different components: a high-level, short-duration pulse; an exponentially damped sine wave; and filtered noise. The damped sinusoid is already available at the Cabonga output. We can therefore use the Cabonga to trigger an accessory that

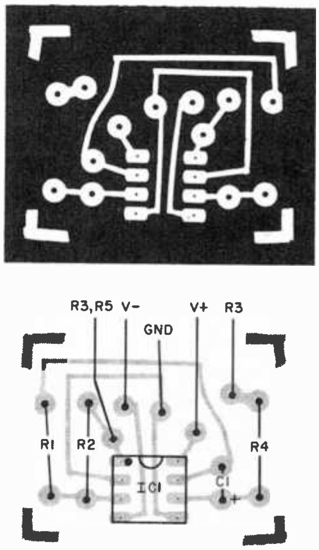


Fig. 10. Guides for Auto Trigger board.

will produce the other two components and mix them all together to produce a synthesized snare.

That is exactly what the Snare Drum

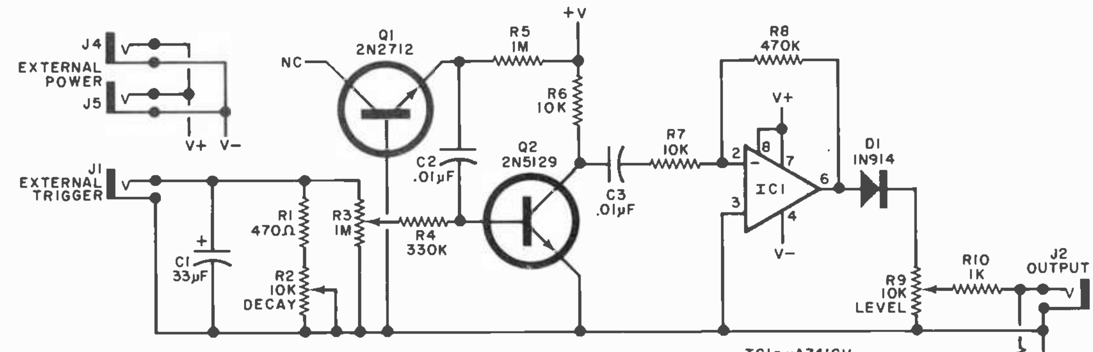


Fig. 11. Snare Drum Adapter first produces signal that approximates white noise.

SNARE DRUM ADAPTER PARTS LIST

C1—33-µF, 16-volt electrolytic capacitor
C2, C3—0.01-µF disc ceramic capacitor
D1—1N914 or 1N4148 silicon diode
IC1—µA 741CV operational amplifier
J1—Subminiature phone jack
J2, J3—Standard phone jack
J4, J5—Miniature phone jack
Q1—2N2712 npn silicon transistor
Q2—2N5129 npn silicon transistor
The following fixed resistors are ¼-watt, 10% carbon composition components.
R1—470 ohms
R4—330,000 ohms
R5—1 megohm
R6, R7—10,000 ohms
R8—470,000 ohms
R10, R11—1000 ohms
R2, R9—10,000-ohm, linear-taper potentiometer
R3—1-megohm trimmer potentiometer
Misc.—Hookup wire, printed circuit board, etc. See photo p. 80 for kit prices.

BILL OF MATERIALS

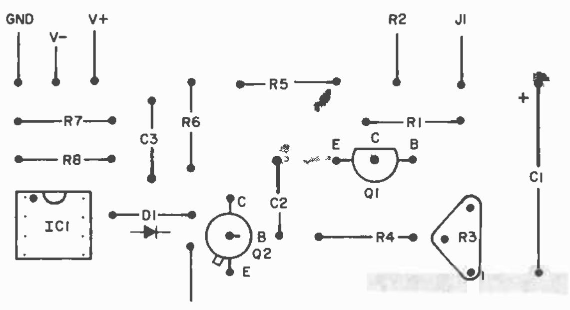
Same as for the Auto Trigger

Adapter does. It is shown schematically in Fig. 11. Noise generator *Q1* produces a continuous signal that approximates white noise. Capacitor *C2* couples this noise to the base of *Q2*.

When a voltage spike is applied to the Snare's EXTERNAL TRIGGER jack (*J1*), it charges *C1*. Such a spike is available when the Cabonga's trigger switch closes as the head is struck. Depending on the values of *R1* and *R2*, the voltage across *R3* decays exponentially with a time constant equal to the product of *C1* and (*R1+R2*). A portion of this voltage envelope (determined by the setting of *R3*) is also applied to the base of *Q2* via *R4*. The voltage envelope causes *Q2* to conduct and pass the noise signal.

Transistor *Q2*'s output is filtered and capacitively coupled by *C3* to a high-gain amplifier. At the input to op amp *IC1*, the signal comprises a high-level spike and a very low-level noise component. Amplifying the signal by a factor of 47 (determined by the ratio *R8/R7*) produces a useful effect. The initial spike, whose amplitude is already approaching the positive supply voltage, is relatively unaltered while the noise component is amplified and equalized in level with the spike.

However, the high gain has an undesirable side effect—it greatly accentuates the internal noise of the inexpensive op amp. To eliminate this noise, *D1* is placed in series with the op amp output The diode will not pass signals below 0.7 volt, so the unwanted noise, which would sound like a low-level hiss, is eliminated but the desired signal is allowed to pass. In the process, we get a bonus—the noise is made to sound more realistic by clipping off its bottom half. Resistors *R10* and *R11* combine the Cabonga and Snare waveforms into a single output, available at output jack *J2*. Potentiometer *R9* serves as a LEVEL control for the snare signal.



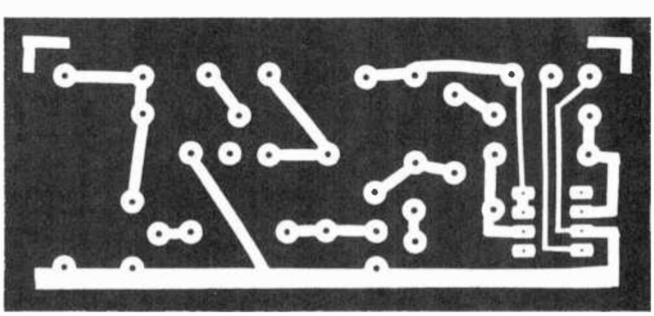


Fig. 12. Use the etching and drilling guide below and component placement at left to make Snare Drum Adapter board.

Etching and drilling and component placement guides are shown in Fig. 12. Mount the components on the board, observing polarities and pin basing of the semiconductors and electrolytic capacitors. Construct an enclosure and top plate to the dimensions and style previously described. Note that jacks *J4* and *J5* must be isolated from the aluminum top plate, which is at ground potential. Trimmer potentiometer *R3* is installed on the pc board. The other potentiometers are mounted on the top plate.

Patch external power to *J4* or *J5*, and run patch cords from the Cabonga output and external trigger jacks to *J3* and *J1*, respectively. Interconnect the Snare

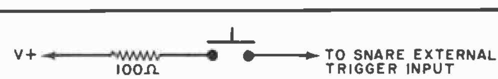
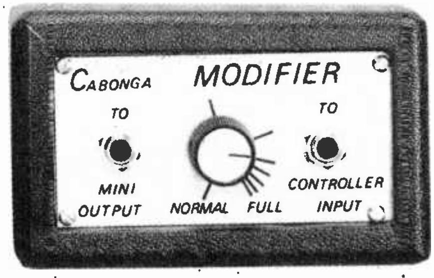


Fig. 13. Simple circuit to trigger Snare.

output ($J2$) to the Combiner/Power Pack's mixer input. Place the thumbwheel of $R3$ at the midpoint of its rotation. While striking the Cabonga drum head, adjust the setting of $R3$ in either direction until you obtain the most pleasing sound. As you strike the head, you will hear the sound of the strike, the tom-tom and the noise simultaneously. The relative loudness of the strike sound as compared to the noise is governed by $R3$, so you might have to make a compromise adjustment of the trimmer potentiometer. Adjust the output level to obtain a balanced snare sound.

Use the circuit shown in the Fig. 13 to trigger the Snare. It will result in a fair approximation of a cymbal. Then trigger the Snare with the Auto Trigger. For a different effect, prepare a patch cord from a single piece of stranded hookup wire. Solder the hookup wire to the tips of two subminiature phone plugs. Connect the patch cord to the Auto Trigger output and the Snare EXTERNAL TRIGGER input. Turn both Snare controls to maximum. By adjusting the Auto Trigger TEMPO and LEVEL controls, you can create such effects as the sound produced by a biplane.

Using the Cabonga System. The Cabonga and its accessories form an expandable synthesizer system. As with any electronic musical instrument, the best way to realize its full potential is to experiment. Here are some hints. It is always best to turn off the power before making any patch cord changes. As previously mentioned, this prevents inadvertent damage to the power supply diodes. It's the only restriction on use of the system that should be observed. Let your imagination dictate system configurations and patches.



Cabonga accessories are shown here and below. Following are available from JAL Assoc., Box 107, Eatontown, NJ 07724: Combiner/P-P pc board at $3.50, complete kit, $27; Snare pc board, $3.50, complete kit, $16.95; Auto Trig. pc board, $1.50, complete kit, $12.95; Modifier complete kit, $7.50. All postpaid. NJ residents add 5% sales tax.

A three-head system is shown in Fig. 14. (You may prefer a fivehead system.) Cabonga 1 is set up as a snare, Cabonga 2 as a tom-tom and Cabonga 3 as an automated bass drum, resulting in an electronic drum set. Set the Modifier control to give a crisp tom-tom sound.

C and B to D. When you play either the Congas or Bongos, you'll hear both pairs simultaneously.

The Auto Trigger can be used in many different ways. Adjust its output frequency for about 2 Hz and use it to trigger the Cabonga. Briskly rotating the Cabonga PITCH control back and forth will produce an effect reminiscent of the "musical percolator" that appeared in television coffee commercials.

By increasing the tempo and rotating the PITCH control from minimum to maximum, you'll hear a sound effect common to science fiction movies. If the tempo is set just right, you will hear an "echo" as the bubbling sound increases in pitch. Stepping up the tempo even more causes the sound to become a continuous oscillation. The Cabonga then acts like a variable bandpass filter (waa waa), and the PITCH control functions as the bandpass frequency selector. You can also trigger the Snare with the Auto Trigger to create such sounds as that from a locomotive, breathing, and others which are difficult to describe!

The Controller and Power Pak is necessary to connect all the other units together.

As mentioned in Part I of this article, the Cabongas can be interconnected via their EXTERNAL TRIGGER jacks. Tune two Cabongas an octave apart and interconnect them. You will note that the sound produced is much fuller than that from just one. Another possibility using four Cabongas is as follows. Tune two (A and B) as a Conga set and two (C and D) as a pair of Bongos. Interconnect A to

On the more practical side, you can use a number of Cabongas and Modifiers to make a fairly realistic steel drum set. The Modifier, as previously mentioned, is most useful when synthesizing a Bongo or tom-tom.

Those are some ideas to get you started. As you experiment more and more, you will probably create sounds that no one else has even thought of! ◇

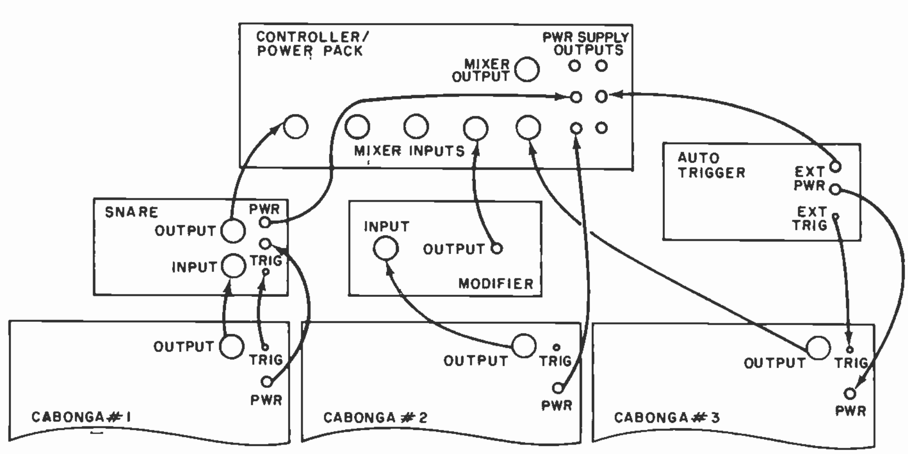
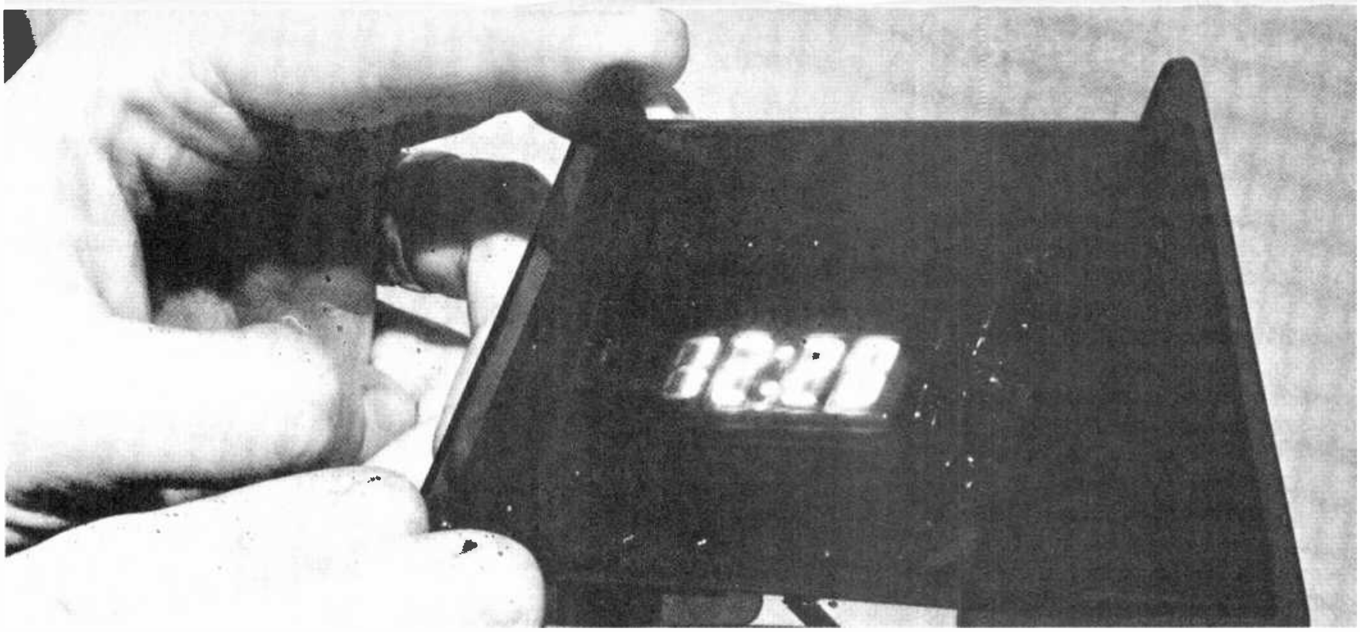


Fig. 14. This interconnection diagram shows how to set up a three-headed Cabonga system.



HOW TO CUSTOM DESIGN
PLASTIC CASES FOR PROJECTS

BY JOHN HUFF

An auto-clock case is used to describe cutting, bending, joining, etc.

YOUR electronic projects deserve to be housed in attractive and reasonably priced "custom designed" cases. As a modern hobbyist, you don't have to make do with utility boxes that do not complement your projects. Instead, you can design your own inexpensive and attractive plastic cases, thanks to the ready availability of acrylic plastic sheets and tubes.

Acrylic plastic is easier to work with than wood—and with the same tools used in woodworking. It can be cut, filed, sanded, glued, and even bent to permanently conform to a desired shape. Available under such brand names as Plexiglas, Lucite, and Safe-t Vue, it comes in crystal clear, color-tinted transparent, translucent, and opaque sheets in 1/16", ⅛", and ¼" (1.6, 3.2, and 6.4 mm) thicknesses.

This article describes how to work with acrylic plastic to custom design and fabricate cases for your electronic projects. To illustrate the step-by-step procudure to use, we also include a digital Kar Klok project to assemble (see box). The Kar Klok is built around National Semiconductor's new MA1003 clock module, a printed circuit assembly containing a four-digit 0.3" (7.6-mm) high fluorescent display, time base, clock chip, and all necessary driving circuitry.

Working With Acrylic. Just about any brand of acrylic plastic can be used by the electronics hobbyist because all have the same basic physical properties. However, some types of acrylic are easier to work with than are others. Most acrylic pieces made by the cast method can be cemented together with a solvent that actually dissolves the mating surfaces and forms a monolithic weld joint in minutes. More difficult to work with are the acrylics made by a continuous conveyor-belt process, which require a thickened type of cement (airplane dope) that takes an hour or more to set. Needless to say, cast acrylic, such as Plexiglas G, is your best first choice. Ask for Plexiglas G (or similar cast-type acrylic) at your local hardware or hobby/craft store.

Acrylic sheets come with a special protective paper on both surfaces to prevent scratches. This paper makes an ex-

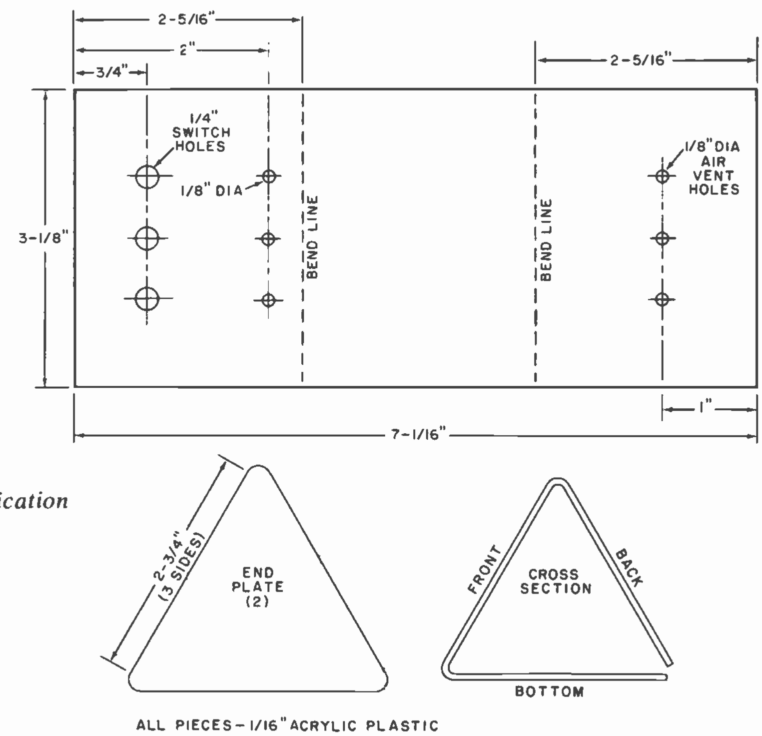


Fig. 1. Fabrication details for the Kar Klok case.

cellent surface for marking cutting lines and the centers of holes to be drilled.

The plastic can be cut with a saw or a special scribing tool. You can use a jigsaw, hacksaw, coping saw, or saber saw for cutting. However, scribing is easier if all you have to do is cut straight lines. Curved lines and circles still require cutting with a saw.

The fabrication details for the Kar Klok (see box) case are shown in Fig. 1. Mark all necessary lines and hole centers on the protective paper on the acrylic sheet.

The scribing tool, which sells for about $2.00 wherever the plastic is sold, looks like a miniature harpoon. In use, the sharp point of the tool is guided along the cut line with moderate downward pressure, using a straight edge, as shown in Fig. 2. Once the line is scribed, the plastic is placed over the edge of a table, scribed line up and in direct alignment with the edge of the table, and struck sharply on the side overhanging the table. The snapping action yields a very straight, clean edge. The snapped edges must then be lightly smoothed with fine sandpaper before being cemented. Edges that are not to be cemented can be buffed to a crystal sheen with a drill-mounted muslin wheel and a special buffing compound (about $3.00 for wheel and compound) or with fine steel wool and soap and water.

Cutting holes is done with ordinary drill bits, as shown in Fig. 3. It is important to note that during the drilling operation, the sheet of plastic must be firmly held or clamped to a piece of wood to prevent it from riding up the bit and cracking. Square and rectangular slots can be made by drilling a small hole and cutting with a coping saw.

Since the Kar Klok case pictured in the lead photo and dimensioned in Fig. 1 is triangular in shape, it is necessary to bend the acrylic plastic sheet to conform to this shape. The trick to making accurate bends is to use a bending jig and heat only those portions of the plastic that are to be bent. Do not heat the entire surface of the plastic.

Acrylic plastic bends at about 300° F (about 150° C). It bends best if the protective paper is peeled off before the heat is applied. You can heat the plastic along the bend line in several ways, the easiest of which is to use the specially made strip heater element that sells for about $8.00 from the same dealers who handle the plastic. This heater element requires a simple wood strip that keeps it about ¼" (6.4 mm) away from the plastic. Detailed instructions come with the element.

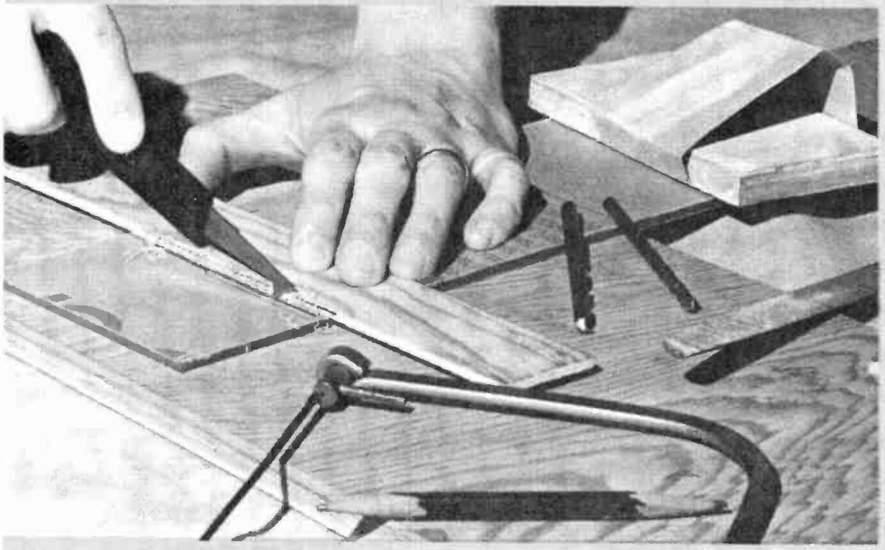


Fig. 2

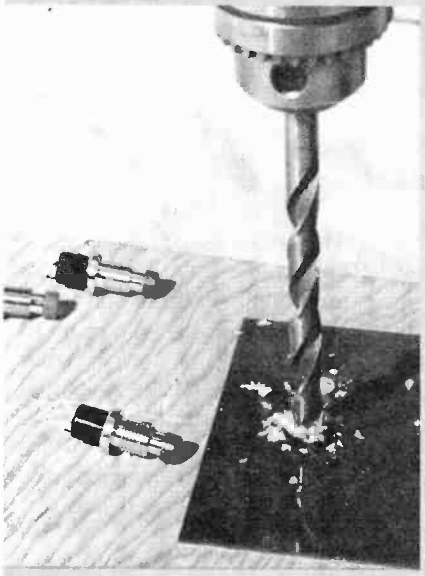


Fig. 3

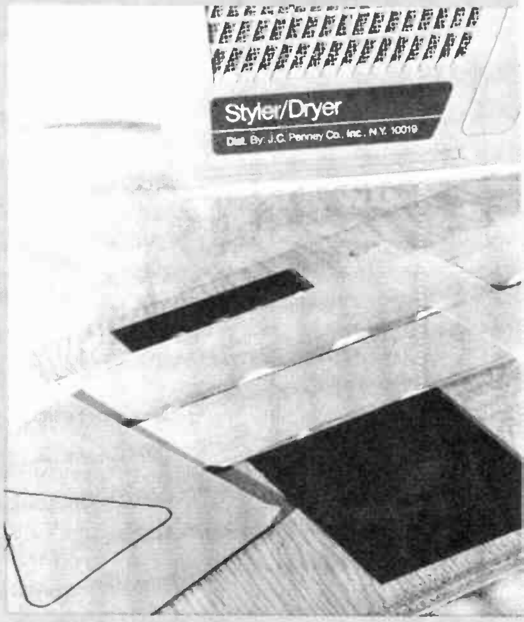


Fig. 4

Fig. 2. The acrylic scribing tool, obtainable wherever the plastic is sold, looks like a small harpoon and is used to scribe a line, following a straight edge, where the plastic is to be broken.
Fig. 3 Acrylic is easily drilled by holding the plastic firmly to a wooden base. Here, holes are being drilled for pushbutton switches. Square and rectangular slots can be made by drilling a hole and cutting with a coping saw.
Fig. 4. Acrylic bends at about 300° F. Here strips of wood faced with cloth for protection, are placed on both sides of bend mark and heat is applied by a 1000-watt hair dryer.
Fig. 5. Heat for bending can also be obtained from a 500-watt photoflood bulb.
Fig. 6. Once the plastic has been heated, it can be bent using a jig as shown here. Note that the actual crossection of the case has been drawn on the bottom of the jig. Jig corners are 4-inch nails.
Fig. 7. Acrylic solvent cement is easily applied and dries in minutes. Here one end of the clock case is being glued to the main frame.
Fig. 8. If preferred, an acrylic cylinder can be used for the body of the clock with square end pieces as shown here.

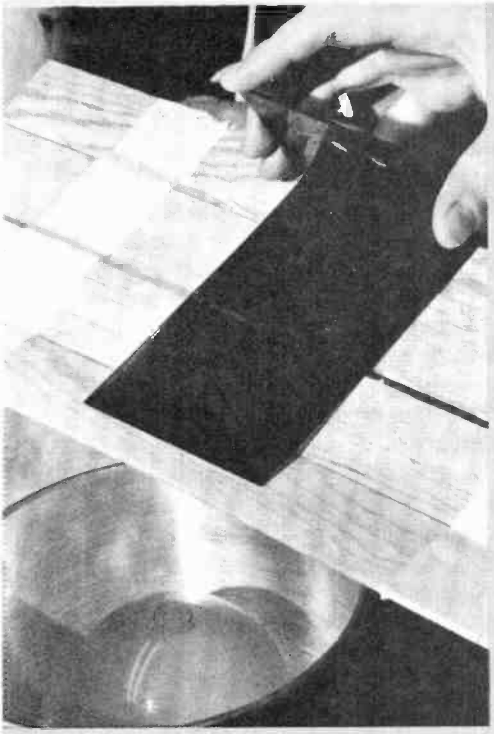


Fig. 5

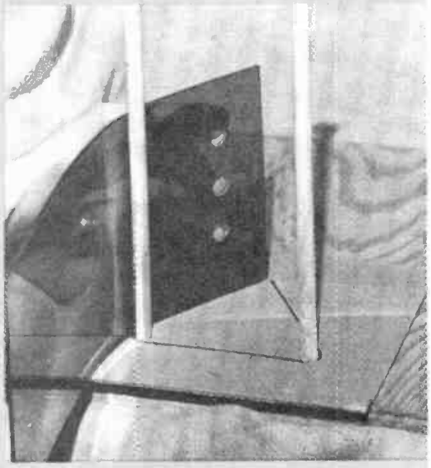


Fig. 6

Fig. 7

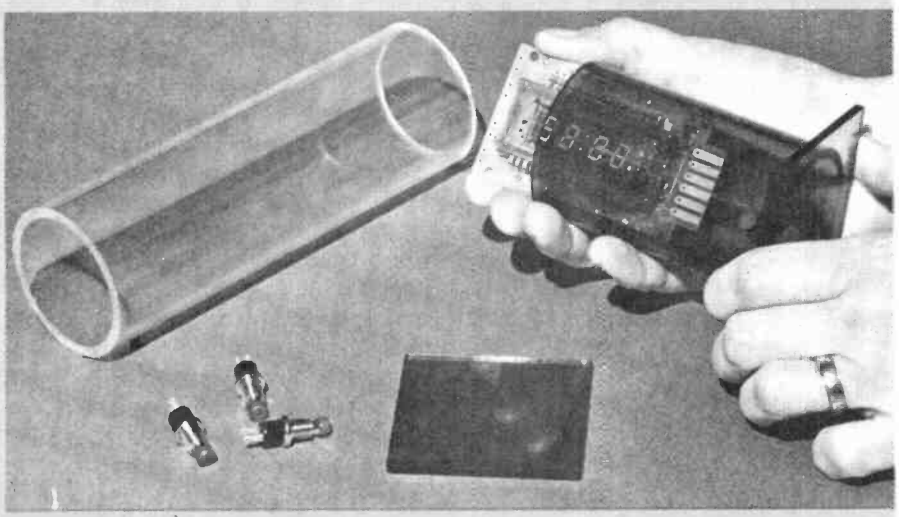


Fig. 8

Another bending technique is to place the plastic sheet on a flat surface, place a ¼" thick strip of wood on both sides of the bend line (face the strips with soft cloth or cotton to prevent them from scratching the plastic), and use a blow-type hair dryer to heat along the line. Details are shown in Fig. 4. The hair dryer must be rated at a minimum of 1000 watts. How well it heats the plastic depends on the chemistry of the particular sheet of acrylic you use. Do not hold the dryer too close to the plastic or the air flow will be restricted and the heat fuse will blow.

Still another approach that works for heating the plastic is to use a 500-watt photoflood lamp. Again, use wood strips to frame the bend line. Hold the plastic about 10" (25.4 cm) away from the lamp as shown in Fig. 5.

Once the plastic has been heated, it can be bent to shape using a bending jig as shown in Fig. 6. Note here that, to get the angles correct during bending, the actual-size crossection of the body of the clock case is drawn on the base of the jig. A 4" (10.2-cm) long nail is then driven into the indicated corners of the drawing and the plastic is aligned with the drawing and gently bent around the nails. When the bending operation is complete, there will be a small open slot where the ends of the plastic sheet do not quite meet. This slot is used for running the wires between the vehicle's electrical system and the clock module, without drilling holes.

Next, cut the triangular end pieces for the case from the same plastic sheet from which the case body was cut, using Fig. 1 as a guide. After sanding the edges smooth and buffing them, cement one side piece to the case body as shown in Fig. 7. Slip the clock module into the case. Then fasten down the pushbutton switches in their appropriate holes and route the electrical-system hookup wires through the slot in the body of the case. Cement the other side piece to the case.

Decide where in your vehicle you want to mount the Kar Klok and cement Velcro strips to the bottom edges of the case end pieces with the solvent cement and to the dashboard with a silicone adhesive. Finally, route the wires coming from the clock module into your vehicle's electrical system (see box for hookup details). The use of Velcro strips to mount the clock allows you to remove the clock and put it out of sight to reduce the possibility of theft.

A Simpler Case. Perhaps you do not

wish to go to the bother of bending a sheet of acrylic plastic to make a case for your Kar Klok. In this event, you can substitute an acrylic cylinder for the body of the clock and use square end pieces (see Fig. 8). Select tubing with a 1¾" (44.5-mm) inner diameter and ⅛" (3.2-mm) wall thickness and cut it to 3⅛" (8 cm) in length. The end pieces should form squares that measure 2¼" (57.2 mm) on each side from ⅛" or ¼" thick acrylic plastic sheet.

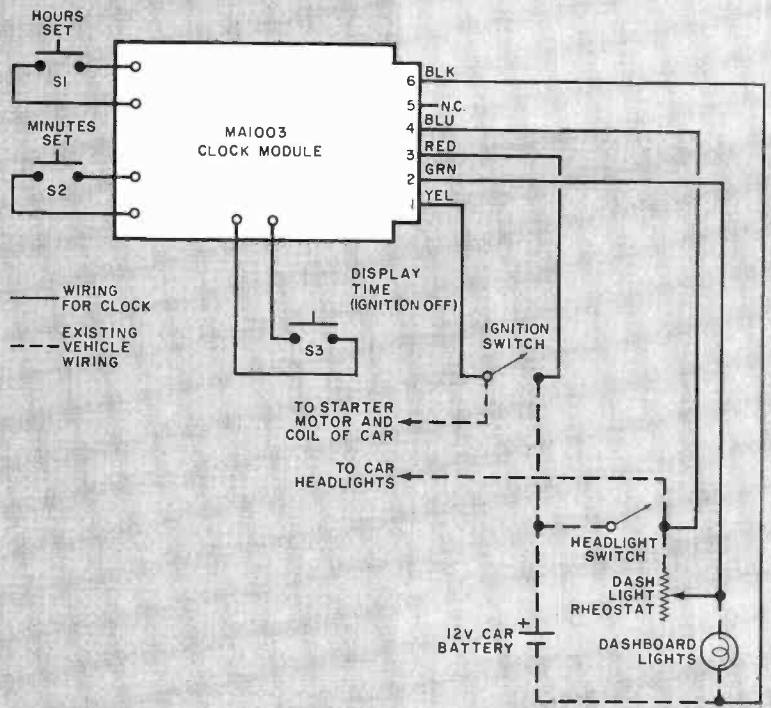
Acrylic tubing for craft work is usually crystal clear. However, if you prefer a transparent color tint, solvent-based dyes that simply brush onto the plastic are available. You can use the crystal clear tubing as is with crystal clear or color tinted end pieces to better show off the Kar Klok's "innards."

To locate the holes for the three pushbutton switches, slip the module into the acrylic tube and note and mark where the holes should be drilled. When you drill the holes for the switches, drill a fourth hole of the same diameter for the wires that connect to the vehicle's electrical system to exit the case. Then drill a line of ⅛" holes at the top and bottom of the case, spacing them about ⅜" (9.5 cm) apart to allow air to cool the clock module when it is installed in the case.

Cement one end piece to the cylindrical body. Slip the clock assembly into the case, fasten down the switches in their appropriate locations, and route the electrical-system hookup wires through the hole drilled for them. Then cement the other end piece to the case. Finally, use Velcro strips to mount the Kar Klok to your dashboard and connect the wires to your car's electrical system as shown in the box.

In Closing. The world of acrylic plastic provides the electronics hobbyist with a practical and inexpensive means for custom designing and fabricating cases for his projects. In this article, we have detailed the basic techniques for working with acrylic plastics. With a little practice and by exercising some imagination, you can be making custom cases for all your projects in short order. For example, you might substitute wood for the end panels of your cases or use a wood base with a brushed aluminum pedestal on which to mount an acrylic-cased project. The combinations of materials and styles are almost limitless.

The Kar Klok project presented here is a practical automotive accessory that is particularly suitable for exercising your imagination in designing custom plastic cases. ◇



ABOUT THE CLOCK

As shown in the schematic diagram, the Kar Klok is a very simple project to put together. It is built around National Semiconductor's new MA1003 clock module that requires the addition of only three momentary-action pushbutton switches and five wires to be connected into the vehicle's electrical system.

With the Kar Klok wired as shown, the display will be on continuously as long as the vehicle in which it is installed is running. The clock remains powered even with the ignition turned off, but power is removed from the display to conserve battery power. However, even with the ignition off, the time can be displayed on demand simply by pressing switch *S3*.

Switches *S1* and *S2* provide the means for setting the hours and minutes for the correct time. These switches are activated only when the ignition is on. With the ignition turned off, the time-setting switches are disabled.

Basically, only three connections need be made from the vehicle's electrical system to the clock module. Constant dc power from the positive battery terminal, with the ignition on and off, is made to pad 3 on the module, while the negative side of the battery, or chassis ground, goes to pad 6. The ignition-controlled display on/off connection goes from the other side of the ignition switch to pad 1.

Optionally, you can add brightness control to the display by connecting a lead from the headlight switch to pad 4 on the module. Now, when the headlights are turned on, the brightness of the display is reduced by two thirds, which reduces glare under nighttime driving conditions. Additionally, if your car is equipped with a dashboard-light level control (rheostat), a final wire from the wiper lug of the control to pad 2 on the module allows you to control the brightness of the display from full to about one-third brightness. No connections need be made from the vehicle's electrical system to pads 2 and 4 on the module for the clock to operate.

The green vacuum fluorescent display consists of four 0.3" (7.6-mm) digits with a colon between the minutes and hours. The green display allows the use of blue, green, or yellow filters.

The clock module itself is protected against automotive voltage transients and reversals. It is designed to keep time with supply potentials of nominally 12 volts down to approximately 9 volts dc. The clock draws 5 mA when operated with the vehicle's ignition off.

For wiring between the clock module and the vehicle's electrical system, it is best to use 20-gauge stranded hookup wire. You can use 22- or 24-gauge stranded hookup wire between the switches and module. (A kit of parts, including the MA-1003 clock module, three pushbutton switches, and triangular case described elsewhere in this article, is available for $26.95 from: Digi-Key, Box 677, Thief River Falls, MN 56701. Please ask for the Kar Klok kit. Minnesota residents, please add state sales tax.)

Solid State

IC AUDIO PREAMPLIFIERS

By Lou Garner

SEMICONDUCTOR devices have been used in audio amplifiers ever since the transistor first became a practical commercial product. In fact, to a large degree it was the continuing search for improved and more efficient audio amplifiers and switches which led to the invention of the transistor by scientists of the Bell Telephone Laboratories in the late 1940's. The first consumer application of transistors was as audio amplifiers in hearing aids, followed shortly thereafter by their use in the audio sections of AM radio receivers and as preamplifiers for vacuum tube operated audio systems. As time passed, the mass production of junction transistors for the hearing aid industry resulted in a surplus of units which didn't meet the critical requirements of hearing aid designs but which, nonetheless, were excellent amplifiers. These devices were made available to the retail market through local distributors as moderately priced "experimenter's transistors," opening a whole new field for the experimenter and hobbyist.

Originating back in the heydays of vacuum-tube amplifiers, the preamplifier often was an afterthought—that is, an extra retrofitted circuit used to boost relatively weak signals prior to processing by a conventional amplifier. Sometimes the preamp, as it came to be known, was incorporated as part of an external signal source, such as a condenser microphone or magnetic phono pickup. In other cases, the preamp was an add-on circuit mounted directly on the main amplifier chassis and using the same power source. In still other cases, it was a separate piece of self-contained equipment with an integral supply as well as input and output jacks. In those early days, the preamp generally was a single- or dual-stage circuit designed to furnish some frequency compensation as well as modest gain. It seldom was equipped with gain or tone controls, however, for these were found in the main amplifier assembly.

Today's preamp designs range from simple single-purpose configurations to complex circuits with nearly as many controls as an oscilloscope. Depending on equipment performance requirements, the preamp may be used only as a buffer or isolation amplifier. More often, it serves to provide additional gain and impedance matching as well as frequency compensation, equalization, and control. While early solid-state audio preamps usually employed from one to four discrete transistors, current designs commonly feature one or more integrated circuits. General-purpose operational amplifiers are perhaps the most widely used devices as preamps, with FET-input types increasingly popular among design engineers because of their high input impedance characteristics.

Typical IC audio preamp designs are illustrated in Figs. 1 through 4. Abstracted from manufacturers' data sheets, application notes and similar published literature, these circuits all feature standard devices and commercial components and, therefore, are suitable for a variety of experimenter and hobbyist projects. Generally, layout and lead dress are not overly critical as long as good wiring practice is observed. This permits the circuits to be assembled using standard construction techniques, including pc or perf boards, solderless wirewrap, or conventional point-to-point wiring. In general, too, dc circuit power may be obtained either from batteries or well filtered and regulated ac line operated power supplies, at the builder's option. Since the required assembly and wiring time is but a few man-hours for most of the circuits, the designs are excellent for weekend projects.

Selected from data sheets published by the Signetics Corporation (811 East Arques Ave., Sunnyvale, CA 94086), the four simple audio preamp circuits shown in Fig. 1 are based on the NE542 dual low-noise preamp IC. However, the general designs may be used with a variety of amplifier IC's having similar electrical characteristics, including the LM381, LM381A, and LM387, with few, if any, changes in component values. Of course, pin connections vary with different IC's and an adjustment in dc supply voltages may be required for some types to achieve optimum performance. Of the four IC's in-

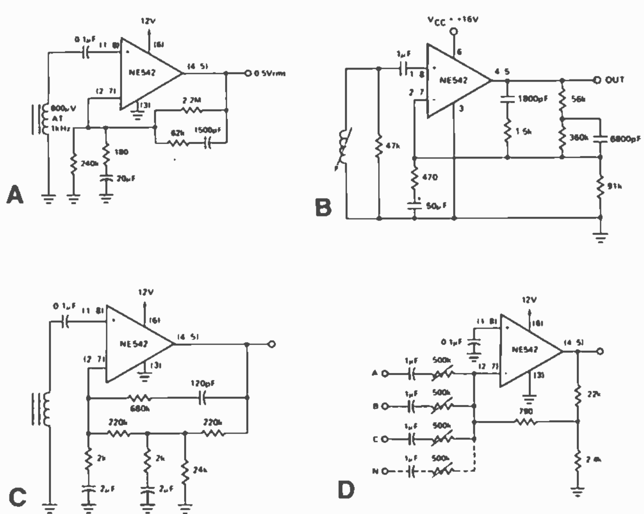


Fig. 1. Audio preamp circuits: (A) tape playback; (B) RIAA phono; (C) NAB tape preamp; (D) mixer.

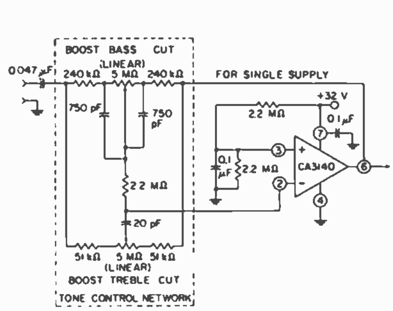


Fig. 2. This Baxandall tone control circuit uses a BIMOS unit.

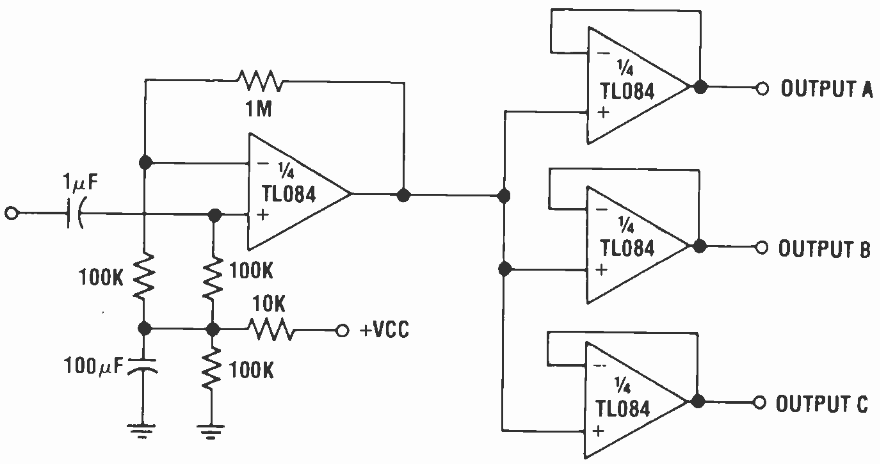


Fig. 3. This audio distribution amplifier circuit features multiple isolated outputs and can be used effectively in electronic musical instruments to achieve special effects.

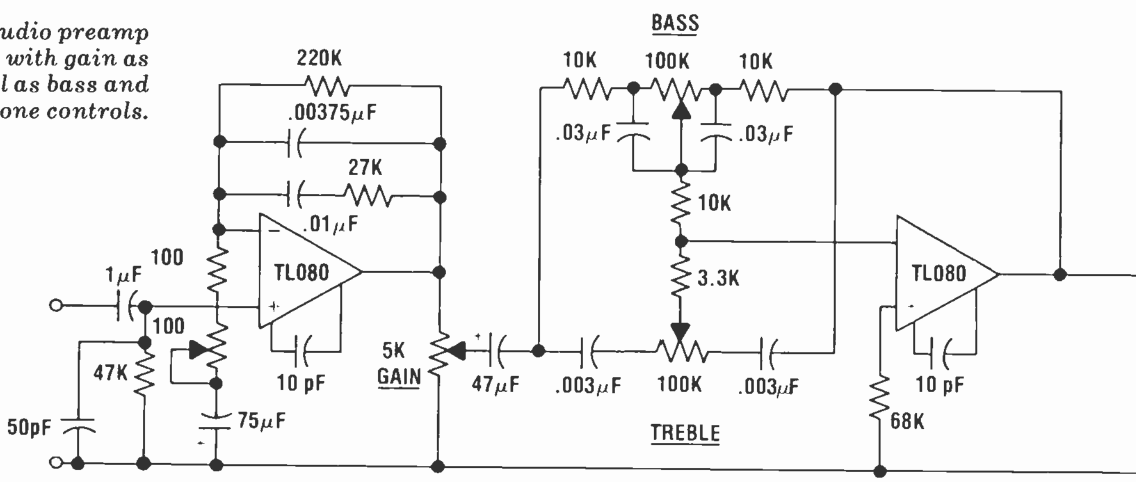
dicated, types NE542 and LM387 are supplied in 8-pin Mini-DIP's, while types LM381 and LM381A are furnished in standard 14-pin DIP's. All contain dual amplifiers, permitting a single device to be used for two-channel (stereo) systems.

A typical magnetic tape playback preamp circuit is illustrated in Fig. 1A. Requiring relatively few components, the circuit will deliver 0.5 V rms output when driven with an 800-μV input signal (nominally, at 1 kHz) by the pickup coil. A modified preamp design providing RIAA equalization for use with standard magnetic phono cartridges is given in Fig. 1B. Intended primarily for broadcast equipment applications, a two-pole fast turn-on NAB tape preamp circuit is shown in Fig. 1C. Finally, a multiple input audio mixer circuit with independent gain controls is illustrated in Fig. 1D. All four preamp circuits are designed for operation on conventional single-ended dc power supplies.

Featuring a BIMOS device, the Baxandall tone-control circuit shown in Fig. 2 is one of a number of suggested applications described in a 20-page data brochure (File No. 957) published by RCA (Solid State Division, Box 3200, Somerville, NJ 08876) for the CA3140 op amp family. As described in April's column, the CA3140 is a dual-technology unit which combines a high-impedance MOSFET input stage with a bipolar output amplifier in a single op amp. The CA3140 devices are furnished in standard 8-lead TO-5 type metal cases. Using linear potentiometers, the Baxandall circuit, according to RCA, can furnish up to ±15 dB bass and treble boost or cut at 100 Hz and 10 kHz, respectively, while providing a full peak-to-peak output of up to 25 V to at least 20 kHz. The amplifier's output is only −3 dB down at 70 kHz from its 1-kHz reference level. With the controls set for a flat frequency response, the circuit offers unity (0 dB) gain. As shown, the circuit is intended for operation on a single-ended dc power supply. It can be modified easily for operation on a dual ±15-V dc source, however, simply by removing the offset bias network and returning pin 3 (+input) to circuit ground while connecting pin 4, bypassed to ground with a 0.1-μF capacitor, to the negative supply terminal rather than to ground; all other circuit connections remain unchanged.

In contrast to the multiple input mixer described earlier (Fig. 1D), the audio distribution amplifier circuit illustrated in Fig. 3 features multiple isolated outputs. It can be used effectively in electronic musical instruments for special effects as well as in PA, music distribution, and intercom systems requiring multiple drives for several power amplifiers to achieve high output levels. It also can be used in light organ, audio control, and test instrument designs. Abstracted from 20-page Bulletin CB-248, published by Texas Instruments, Inc. (P. O. Box 5012, Dallas, TX 75222), the distribution amplifier employs a type TL084 quad operational amplifier. A member of TI's BI-FET family, the TL084 comprises four identical JFET input op amps in a single 14-pin DIP. The device can be operated on dc supply voltages of up to ±18 V, with each amplifier section offering an input impedance of 10^6 megohms, a unity gain bandwidth of 3 MHz, a slew rate of 12V/μs, internal compensation, and continuous integral output short-circuit protection. Individual amplifier pin connections are not identified in the schematic diagram because the amplifier sections are interchangeable and the final selection can be made best by the equipment designer to achieve optimum layout and lead

Fig. 4. An audio preamp complete with gain as well as bass and treble tone controls.



dress. In all cases, however, dc power supply connections are to pins 4 (+) and 11 (−).

Another TI BIFET circuit is given in Fig. 4—an audio preamp complete with gain as well as bass and treble tone controls. Intended for general purpose applications, the preamp can provide more than adequate drive for standard power amplifier designs. The circuit features the TL080, a single JFET input op amp which is offered in both 8-pin MiniDIP and TO-99-L style packages. Except for requiring external compensation (10-pF capacitors), the TL080's electrical characteristics are essentially similar to those of the individual amplifiers in the TL084, discussed earlier. The device's pin assignments are the same as those of such standard op amps as the LM301A, LM308, and μA748.

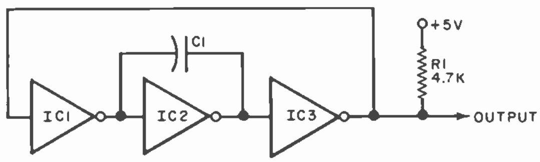


Fig. 5. Square-wave oscillator circuit can deliver signals from 1 Hz to 1 MHz as value of feedback capacitor is varied.

Right On! In last January's annual "predictions" column, you may recall, I predicted a further breakthrough in the pricing of digital electronic watches . . . that commercially available watches would be offered in the "ten-dollar range." Ah so! *Texas Instruments, Inc.*, which originally broke the twenty-five dollar price barrier for digital watches, per an even earlier prediction, *has done it again*! In a recent press release, TI announced a reduction in the suggested retail list price of its model 503 sports/youth watches from $19.95 to a low *$9.95*!

Reader's Circuits. If the bulging mail bag is any indication, many of our readers have been quite busy devising and testing new circuits.

While on the subject of mail—a personal word to those of you who may have written and not received answers to your letters and postcards. The volume of mail generated by a magazine with a readership of 400,000 is simply too much for one guy to acknowledge personally. However, be assured that all letters are read and given full consideration. If you don't receive an answer to your inquiries promptly (or even at all), it isn't due to a lack of interest. It's simply because we don't have time. But please, please keep us posted about your interests and keep sending those interesting circuits.

We have a twenty-year old French-Canadian reader, Guy Isabel (1725, Henri-Bourassa East Blvd., Apt. 25, Montreal, Quebec, H2C lJ8, Canada), to thank for the simple and inexpensive square-wave oscillator circuit illustrated in Fig. 5. It is capable of delivering signals at frequencies ranging from 1 Hz to 1 MHz as the feedback capacitor's value, *C1*, is varied from 300 μF to 300 pF. The circuit may be used as a "clock" in digital applications, as a simple square-wave generator for test instruments, or as a basic tone source for alarms and electronic musical instruments.

The duty cycle is approximately 50% and is independent of the feedback capacitor's value. The three active devices making up the oscillator, *IC1*, *IC2*, and *IC3*, are three sections of a standard type 7405 TTL open-collector hex inverter. Pull-up resistor *R1* is a half-watt unit, while capacitor *C1* may be a ceramic, plastic-film, paper or electrolytic type, depending on

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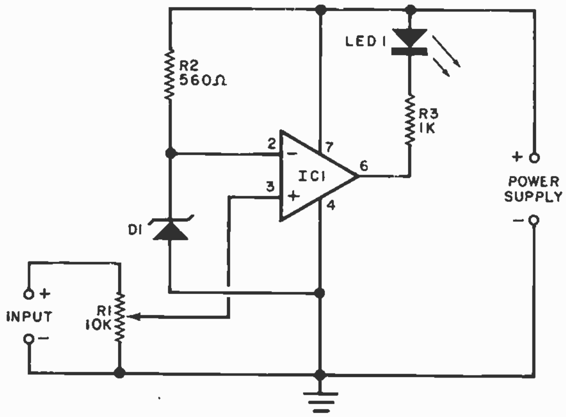


Fig. 6. This dc low-voltage monitoring circuit uses a standard op amp IC as a voltage comparator and to drive the LED output indicator.

value. With neither parts placement nor wiring arrangement critical, the circuit can be assembled in a small metal or plastic case with an integral dc power source as a self-contained instrument or incorporated as part of a more complex piece of equipment, at the individual builder's option.

Ted Reiter (1442 Brook Drive, Titusville, FL 32780), a frequent contributor to these pages, suggests that his dc low-voltage monitoring circuit might be of value to other experimenters and hobbyists. Ted's circuit, Fig. 6, uses a standard op amp, *IC1*, as a voltage comparator and output indicator driver. In operation, a portion of the monitored voltage, determined by *R1*'s adjustment, is compared to a fixed voltage obtained from a zener reference network, *R2-D1*, by *IC1*. As long as the monitored voltage remains at or above its present monitor point (determined by *R1*'s setting), the output indicator, *LED1*, remains dark. If the voltage drops below this level, however, the indicator is activated.

The circuit can be set to operate within millivolts of a chosen setpoint level. Standard components are used in the design: *IC1* is a type 741 op amp, *R1* a conventional potentiometer, *R2* and *R3* one-quarter or one-half watt resistors, *D1* a 3.3-volt zener, and *LED1* a familiar red LED. A 12-volt dc power supply is suitable for monitoring input voltages of up to 12 volts, but a 15-volt power supply should be used for higher levels (up to 13.8 V). Since the circuit is essentially a dc amplifier, neither layout nor lead dress are critical.

Seeking a simple combination clock and single-pulse signal source for his digital experiments, Charles D. Baker (1141-18 Minto Ave., Kenora P9N 3K1, Ontario, Canada), devised the circuit in Fig. 7. Intended for operation on a standard TTL 5-volt dc source, the instrument can be used as a conventional clock, a two-phase clock, or a manually operated single-pulse generator.

The instrument's single active device is a standard TTL hex inverter, *IC1*. Three of the inverter sections are coupled together as a ring oscillator, with feedback capacitor *C1* determining the frequency of operation (or clock rate). Shunt resistor *R2* biases one inverter section into its active region to insure oscillation. Two of the sections are interconnected as a modified one-shot, delivering a negative-going output pulse, while the remaining section serves as a conventional inverter/buffer to deliver positive-going pulses.

The instrument's mode of operation is determined by function switch *S1*. When *S1* is in its PULSE position, output pulses are delivered each time pushbutton switch *S2* is depressed, discharging C2 through *R4*, and delivering a step signal through series isolating resistor *R1*. Between pulses, *C2* is recharged through *R5*. When *S1* is in its CLOCK position, the ring oscillator drives the one-shot through *R1*, and a continuous series of positive- and negative-going pulses is developed at a rate determined by *C1*'s value.

Readily available components are used in the circuit. The hex inverter is a standard 7404. Capacitor *C1*'s value and type are determined by the clock rate needed; and *C2* is a

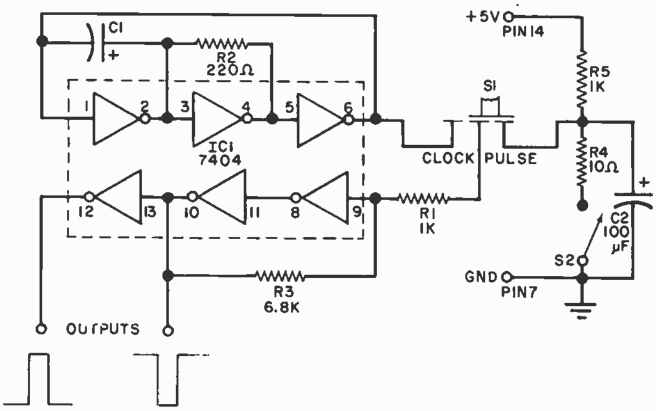


Fig. 7. Simple circuit using standard TTL hex inverter can be used as a conventional clock, two-phase clock, or single-pulse generator.

100-μF, 6-volt electrolytic. Function switch *S1* is a spdt toggle, slide, or lever switch, while *S2* is a spst, momentary contact, NO pushbutton switch.

At the builder's option, the instrument may be housed in a small metal box, a plastic case, or in a probe body. If assembled in a box or case where there is ample space, the builder may wish to include several different values for *C1*, selectable by means of a multi-position rotary switch, to provide a choice of clock rates. Typical values may range from a fraction of 1 μF to as high as several thousand μF. According to Charles, the ring oscillator can be operated at rates from 1 Hz to 1 MHz, depending on *C1*'s value.

Device/Product News. A new series of high-voltage, high-current, silicon npn transistors, types RCA9113, RCA9113A, and RCA9113B, has been announced by RCA's Solid State Division (Box 3200, Somerville, NJ 08876). Designed for use in off-line switch-mode power supplies, inverters, converters, pulse-width-modulated regulators, and motor controls, the new transistors feature high-voltage capability, fast switching speeds, and low saturation voltages, together with high SOA ratings for both forward- and reverse-bias conditions. With a peak collector current rating of 22 A and a maximum power dissipation of 175 W (at 25°C), the new transistors are supplied in standard TO-3 packages.

Motorola Semiconductor Products, Inc. (Box 20912, Phoenix, AZ 85036) has announced some new devices of potential interest to hobbyists and experimenters, including an extremely stable 2.5-V reference source and a monolithic automotive electronic ignition control IC.

Designed for critical instrumentation and D-A converter applications, the new voltage-reference source, type MC1403/1503, features a maximum output voltage variation of only 1% (±25 mV) and a typical temperature coefficient of 10 ppm/°C. It also features a line regulation of 3 mV (max) at input voltages from 4.5 to 15 V or 4.5 mV (max) from 15 to 40 V, together with a load regulation of 10 mV (max) at output currents from 1 to 11 mA.

Intended for circuits utilizing a flux-averaging sensor instead of conventional ignition "points" and condensers, the ignition control IC, type MC3333, is designed to drive a Darlington power transistor which supplies the current required by a high-energy ignition coil. Housed in a 14-pin DIP, the MC-3333 can operate at battery voltages from 4 to 24 volts.

Fairchild's Optoelectronics Division (4001 Miranda Ave., Palo Alto, CA 94303) has plunged into the hobbyist market with the introduction of a series of electronic construction kits. Designated as *Solid State Technology Kits*™, the new line includes an alarm clock-calendar (Model 0100), a wall clock (Model 0101), and an automotive digital clock. All of the kits feature LED displays. Future products planned for the line include additional clocks, a DVM and a frequency counter.

Meanwhile, another Fairchild division (Components Group, 464 Ellis Street, Mountain View, CA 94042) has announced a new 2-A monolithic voltage regulator designed primarily for use in power supplies for home-base CB radio equipment. The new device, type μA78CB, features a fixed output voltage of 13.8 volts, internal thermal overload protection, short-circuit limiting, a peak current capability of better than 4 A, and an output voltage tolerance of 5% over the 0° to 125°C temperature range. Available in both TO-3 and TO-220 packages, the new regulator can dissipate up to 20 watts. ◇

Experimenter's Corner

By Forrest M. Mims

LASER DIODES

IN OCTOBER the semiconductor laser diode will celebrate its fifteenth birthday! Even in this era of complex integrated circuits, the laser diode remains one of the most remarkable electronic components yet invented.

In some ways the laser diode closely resembles its first cousin, the light emitting diode (LED). For example, both diodes produce infrared or visible light when electrons recombine with holes at a forward-biased pn junction.

and communications applications.

The laser diode is nothing more than a carefully made LED with an ultra-flat junction and two tiny mirrors. The mirrors face one another and produce the internal feedback which leads to *stimulated emission of radiation*, the process responsible for laser action. Stimulated emission occurs naturally when a light photon emitted by an excited electron strikes a second excited electron and forces it to recombine with a hole. The

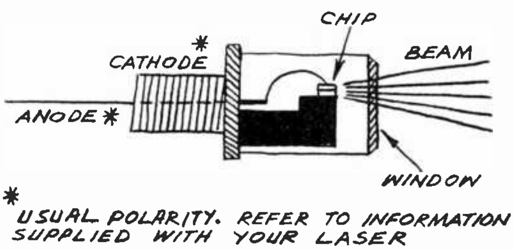


Fig. 1. How a typical laser diode works.

The electrons are excited to a higher than normal energy level, enabling them to cross the potential barrier formed by the junction. When they fall into holes after crossing the junction, they give up their excess energy in the form of radiated heat and light. The better the diode is, the more light than heat it produces.

This method of light generation, is called *spontaneous emission*, as it's pretty much a random process. Electrons and holes recombine whenever the opportunity presents itself, and the result is a chaotic jumble of light waves. Fortunately, the relatively constant energy levels the electrons can occupy before crossing the junction limits the energy each electron can absorb. This restricts the radiated light to a reasonably narrow band of wavelengths (100–150 nanometers). Light is emitted at a *much* faster rate (within a few tens of nanoseconds) than that from most other sources. That's why LED's and laser diodes are ideal for detection, ranging,

result is *two* photons having almost identical frequency and traveling in perfect phase with one another. As you can see, stimulated emission is a type of amplification. Normally it occurs only rarely, but the two feedback mirrors of a laser cause stimulated photons to be reflected back and forth within the laser material and the result is a cascade of oscillating photons—or laser light.

Most laser diodes are made by producing precise, sandwich-like junctions in wafers of gallium arsenide (GaAs) or other efficient light-producing semiconductors. The wafers are then cleaved into thin bars, which are sawed into individual laser chips several mils on a side (about the size of the dot on this letter "i"). The cleaving process gives each chip two perfectly parallel facets which serve as the mirrors. Individual chips are usually installed in a protective package with a plastic (OK) or glass (much better) window and a miniature, built-in heat sink (Fig. 1).

Driving Laser Diodes. Both LED's and laser diodes will produce recombination radiation when driven at very low levels of forward current. Lasers, however, will not lase until the forward current exceeds a level called the *threshold* (J_{th}). Above J_{th}, the optical power from the laser increases linearly with current. Many lasers will emit several watts or more when pulsed with 10- or 20-ampere pulses.

You may have read about the new generation of laser diodes which can be operated *continuously* without having to be cooled to the temperature of liquid nitrogen. Primarily designed for high-bandwidth communications through glass fibers, these lasers are a delight to use, but are temperature-sensitive and limited to several milliwatts of output power. They are not yet available at hobbyist prices.

Single heterostructure (SH) lasers, the kind you can buy at bargain prices from some of the suppliers who advertise in POPULAR ELECTRONICS, have a J_{th} of 5-10 amperes. Apply this much current to a SH laser diode and the chip will literally explode! The only safe way to drive an SH laser without cooling it with liquid nitrogen is to use current pulses no more than 200 nanoseconds wide.

The avalanche transistor circuit shown in Fig. 2 offers an excellent way to generate high-current pulses only 50-75 nano-seconds wide. Different transistors avalanche at different voltages, so you'll have to select a specific transistor for your particular laser. Briefly, you should *NOT* connect a laser to the circuit until you have selected and verified the operation of *Q1*. Remember—laser diodes don't like too much

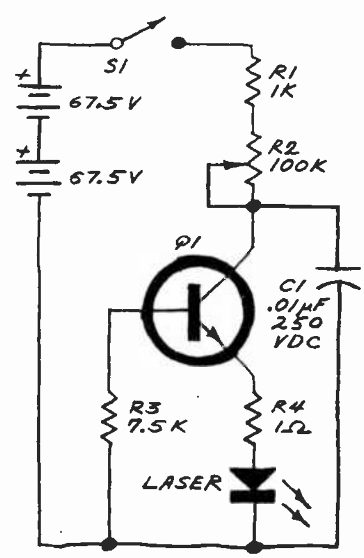


Fig. 2. Avalanche transistor circuit.

drive current! A good rule of thumb is to limit the maximum current to 2.5–3 times the threshold current. Both values are usually supplied with the laser.

Select *Q1* by connecting a *short* copper wire in place of the laser and a fast oscilloscope (at least 15 MHz) across current monitor *R4*. This resistor must be carbon composition, *NOT* wirewound. Use ten 10-ohm carbon resistors in parallel if you can't find a suitable 1-ohm component. Keep *all* leads in the current discharge path (*Q1*, *C1*, *R4*, and the *LASER*) as short as possible. The height of the pulses on the scope screen in volts will equal their peak current in amperes. Many, but not all, transistors will oscillate in this circuit. You should have good results with most common npn silicon switching transistors such as 2N914, 2N2222, 2N3643, 2N4400, 2N5188, HEP50, etc.

After the driver circuit is working and *Q1* is selected and in the circuit, you can install the laser. Pay attention to its polarity! Don't expect a spectacular red beam. Although the beam is truly impressive to see, it's invisible. To verify its presence, you'll need a photodetector sensitive to the 900-nanometer infrared radiation. Silicon photodiodes driving fast amplifiers work best. Phototransistors and silicon solar cells are marginal detectors because they have very slow response times. Photoresistors simply will not work.

To *see* the beam you'll need an infrared image converter such as a snooperscope or silicon vidicon TV camera. The cheapest way to see the beam is to order a plastic, phosphor-coated infrared viewing card from Kodak Special Products Sales, Rochester, NY 14650. The viewing card costs about $30—but that's a bargain compared to the cost of an image converter.

With the help of an image converter or viewing card you can quickly squeeze the 20- x 40-degree beam from the laser into a pencil-thin beam as narrow as that emitted by the popular helium-neon laser. All you need is a convex *f1* lens. A good source for lenses and other optics is the Edmund Scientific Co., Edscorp Bldg., Barrington, NJ 08007.

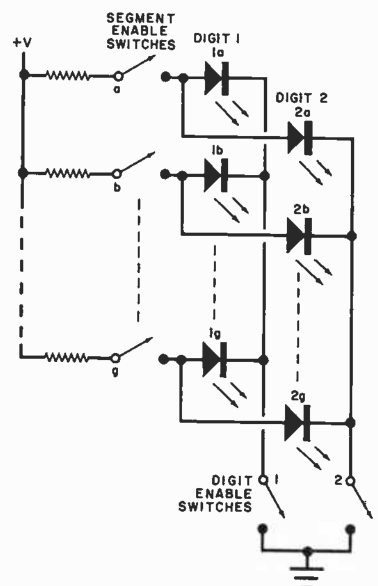
Safety Considerations. Fortunately, the beam emitted by most laser diodes is reasonably safe because of its low average power. Nevertheless, as with any bright light source, you should avoid viewing the beam directly. You should also avoid pointing the beam at other persons or toward reflective surfaces. ◇

Hobby Scene

By John McVeigh

MULTIPLEXED LED DISPLAYS

Q. ***In the Solid State Column on p.73 of the August 1976 issue, I saw the schematic for a stopwatch with a 6-digit display. Each segment's like digits (a through g) are connected in parallel, but none of the common cathodes of each display is grounded. Can you explain how the circuit works?—Santiago M. Quijano U., Bogota, Columbia.***



A. This is an example of a multiplexed display (see diagram). When a particular SEGMENT ENABLE switch is closed, the anodes of all like segment diodes—say, segment *a* in digits *1* and *2*, represented as *1a* and *2a*—are connected through a current-limiting resistor to the positive supply. However, unless the DIGIT ENABLE switches are closed, the cathodes are left floating above ground and no current can flow through the diodes. Thus the LED segments remain dark.

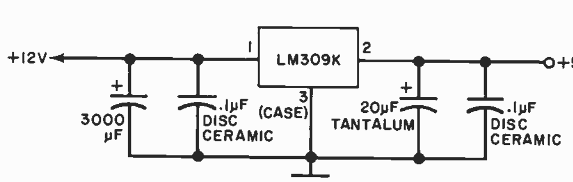
Now, if DIGIT ENABLE switch *1* is closed but switch *2* left open and SEGMENT ENABLE switches *a* through *f* are closed, digit *1* will form a "0." Opening DIGIT ENABLE switch *1*, closing switch *2* and closing SEGMENT ENABLE switch *g* will cause digit *1* to go dark and cause digit *2* to form an "8." If this process is repeated very quickly, the two digits will appear to form "08" without any display flicker.

This is the basic principle of operation in a multiplexed LED display. Gates and counters take the place of the mechanical switches, with their outputs either sourcing or blocking (segment enable outputs) current or sinking or blocking (digit enable outputs) current. A high-speed clock provides the necessary time reference. A large-scale integration chip (LSI) such as the Intersil ICM7205 contains all multiplex circuitry "on board." That's why the common cathodes are not shown grounded in the stopwatch schematic. The major advantage of multiplexed over direct-drive LED displays is reduced current demand—an important consideration in battery-powered equipment.

CAR CLOCK POWER SUPPLY

Q. ***I plan to build a digital clock/timer using a clock chip and a crystal-controlled time base. Do you have a circuit to reduce the car's 12-volt power source to +5-V dc with adequate regulation for the IC's?—Tom Ritch, Austin, TX.***

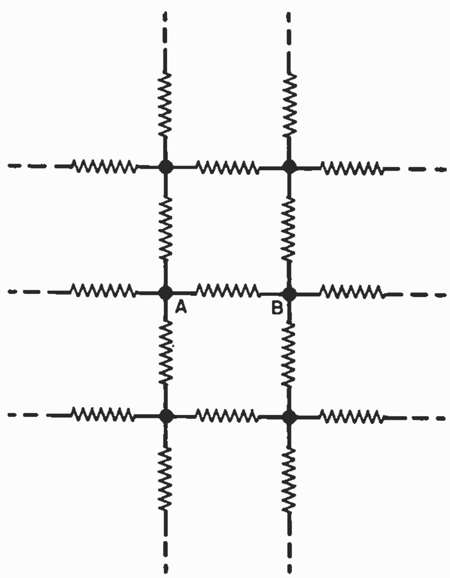
A. You can use an LM309K IC regulator to step the 12 volts down to 5 volts regulated, as shown in the figure. Be sure to adequately heat sink the IC. Capacitors are used on both sides of the regulator to keep noise off the line, thus improving the stability of the regulator.



RESISTOR QUIZ

I would like to thank all the readers who have written in response to the Resistor Quiz in the July issue. Although some wrote suggesting answers such as 0 ohm, ¼ ohm, ⅓ ohm, and ⅔ ohm, most arrived at the correct answer of ½ ohm. As you will recall, the problem involved finding the effective resistance between points A and B in the infinite matrix of 1-ohm resistors. Of those who reported the correct answer, some used a "shotgun" approach by having a computer solve the problem for a very large but finite matrix. Others suggested the following, elegant solution.

Connect a one-ampere current source between node A and infinity so that 1 ampere flows into node A. By symmetry, the current will split into four ¼-ampere components, each of which will flow through one of the four resistors. Then



remove the current source and connect it between node B and infinity so that 1 ampere flows from node B. Again, the symmetry of the lattice dictates that ¼ ampere will flow into node B from each of the four resistors connected to it.

The superposition theorem allows us to sum the resulting currents from both configurations. Accordingly, the current through the resistor connected directly between A and B is ¼ + ¼ or ½ ampere. By Ohm's law, the voltage across the resistor, E_{AB}, is ½ ampere times 1 ohm, or ½ volt. Ohm's law also tells us that the effective resistance between A and B is E_{AB} divided by I_T, the total current in the matrix. In this case, I_T is one ampere. Thus, R_{AB}, the effective resistance between A and B, is ½ volt divided by 1 ampere, or ½ ohm.

Product Test Reports

GENERAL ELECTRIC MODEL 3-5825 AM/SSB CB TRANSCEIVER

Features high average modulation and good noise suppression.

GENERAL ELECTRIC's Model 3-5825 AM/SSB transceiver is designed to provide total communication capability on the Citizens Band. It operates on all 40 channels and employs a digital frequency synthesis system and the now customary seven-segment LED channel display. Special features to be found in this transceiver include internal burn-out circuit protection, an antenna-failure indicator (AWI), and a quick-release mobile-mounting setup.

The transceiver also has the following complement of controls and features: RF GAIN, SQUELCH, CLARIFIER, and VOLUME controls; illuminated S/r-f meter; switchable anl/noise blanker; AM/LSB/USB mode selector; transmitter-on LED and modulation peak indicator; automatic level control (alc) and automatic modulation control (amc); HI/LO TONE switch; detachable dynamic microphone; PA operation; jacks for external speakers; bottom-facing speaker; operation from a 12-volt dc negative- or positive-ground power system; reverse-polarity protection; line filter; and electronic switching and voltage regulation.

The transceiver measures 10 5/8"D × 7½"W × 2½"H (27 × 19.1 × 6.4 cm). $329.95.

Technical Details. On SSB, the receiver employs single conversion to a 10,695-kHz i-f and uses a crystal filter for selectivity and sideband selection. Three 10,695-kHz i-f stages, two of which are direct coupled, precede the SSB product detector, while carrier injection is provided by a 10,695-kHz crystal oscillator (bfo). A second conversion to 455 kHz is employed for AM, which uses a ceramic filter for selectivity.

A diode-protected transistor stage precedes the first mixer. The second mixer, used for AM, is of the balanced-diode type. Three 455-kHz i-f stages precede the AM diode envelope detector and agc, following which is the anl that can be switched in and out simultaneously with the noise blanker. The latter employs an r-f amplifier, detector, and pulse amplifier that cause the output of the first mixer to be interrupted (gated) by the noise pulses.

The audio section, including the power-output amplifier, is incorporated into a single integrated circuit. The squelch system is a three-stage amplified system that is activated by the agc.

A phase-locked-loop (PLL) scheme is used for frequency control. It contains the usual 10,240-kHz crystal oscillator, from which the standard reference is derived. This oscillator is also used for the second conversion to 455 kHz for AM reception.

The voltage-controlled oscillator (vco) at the first mixer functions at a frequency 10,695 kHz higher than the CB signal. Its comparison signal is obtained through a down mixer and a 10,052.5-kHz crystal oscillator and dividing setup that is controlled by the channel selector switch. This signal is applied to an IC phase comparator, along with the standard reference. The LED display consists of the usual decoder/driver circuitry.

On transmit in the AM mode, a 10,695-kHz crystal signal from the bfo is difference-mixed with the vco signal to provide the on-channel carrier. The mixer is followed by a two-stage r-f preamplifier, driver, and final power amplifier. The latter two stages are collector-modulated as usual from the audio section in the reciever, which contains automatic modulation control (amc). A multisection output network provides impedance matching to 50-ohm loads and attenuation of harmonics.

An Antenna Warning Indicator (AWI) comes on if a short or open circuit or other malfunction in the antenna system causes a high SWR to be detected by a sensing element in the transmitter. This indicator immediately apprises the user of a problem. It functions only on AM. If the malfunction is not noticed immediately, the manual states that built-in circuit protection will permit the transmitter to be operated for up to five minutes before damage occurs.

The usual type of SSB transmitting system is used in this transceiver. It consists of a balanced modulator and crystal sideband filter, followed by the transmitter mixer, where the signal is combined with the 10,695-kHz crystal signal for USB use. This crystal signal is shifted to 10,692 kHz, along with a +3000-Hz change in the vco to set up the initial signal at the proper side of the filter for LSB use.

Laboratory Tests. The receiver's sensitivity measured 0.8 μV for 10 dB (S + N)/N with 30% modulation at 1000 Hz on AM with a nominal 0.5-μV signal at 6 dB (S + N)/N. In either case, it produced a maximum sine-wave audio output of 3.25 watts at less than 2% THD with a 1000-Hz test signal into 8 ohms. SSB sensitivity was nominally 0.18 and 0.1 μV for 10 and 6 dB S/N.

Operating from the standard test source of 13.8 volts dc, the transmitter carrier output on AM was 3.75 watts. Up to 100% modulation was possible, and at microphone levels 25 dB more than needed for 50% modulation, the THD with a 1000-Hz signal was less than 2% (10% with a 400-Hz signal). Adjacent-channel splatter with 1000-Hz or voice signals was at least 60 dB down and no overmodulation was observed. The 6-dB audio response was 500 to 2400

Hz, and transmitter frequency tolerance was within ±2 Hz of −83 Hz.

The r-f power output on SSB was 9 watts PEP using test tones and 12.75 watts PEP during voice operation. The unwanted-sideband and carrier suppression were 55 dB on USB and 60 dB on LSB. The audio response was 300 to 2800 on LSB and 380 to 3100 Hz on USB. Third-order distortion products were 29 dB below two test tones (35 dB below PEP) at 10 watts PEP, while at 12 watts PEP, they were 23 dB below test tones (29 dB below PEP). Above 10 watts PEP, some flattopping was noted, accounting for the deterioration we observed at 12 watts PEP.

The range of the squelch threshold was 0.5 to 550 μV. The agc held the audio output level to within 8 dB on AM and 13 dB on SSB with an r-f input change of 20 dB at 1 to 10 μV. It held to 15-dB on AM and 20 dB on SSB with an 80 dB change at 1 to 10,000 μV. The S meter registered S9 with a nominal 50-μV input signal.

Image rejection was 65 dB (primary) and 60 dB (secondary). I-f and other unwanted spurious-signal rejection measured greater than 80 and 60 dB, respectively. AM adjacent-channel rejection and desensitization was 58 dB minimum. Unwanted sideband suppression was at least 60 dB at 1000 Hz. The 6-dB audio response was 575 to 1600 Hz on AM and 600 to 2000 Hz on SSB (the clarifier control works only on SSB receive), with the upper end extending 300 to 400 Hz higher with the tone control set to HI.

User Comments. As our measurements indicate, receiver sensitivity, selectivity, and unwanted-signal responses, plus the use of the r-f gain control, provided good reception under adverse conditions. The ANL/NB combination enhanced receiving performance, with our lab tests showing that the original S/N versus sensitivity was maintained in the presence of impulse noise 100 dB above 1 μV/MHz bandwidth. Vehicle tests were also excellent.

We obtained good quality and high audio output power even with weak r-f signal levels. Use of the tone control let us set up the sound to suit our own taste. In this respect, the HI tone position provided us with the best intelligibility. On the other hand, the LO position helped to minimize noise.

The transmitter performed nicely, providing high average modulation levels without overmodulation or adverse splatter. The excellent unwanted-sideband suppression on SSB made dual-channel operation (simultaneous use of one frequency with two separate conversations, one on LSB and the other on USB) possible without interference between the two.

The transceiver is enclosed in a well-shielded case. The rotary controls are clearly identified and convenient to use. The mode and channel selector knobs have grip bars for easy operation. We particularly like the mode switch setup at the top of the panel, with the center position for AM and the LSB and USB positions to the left and right.

Another nicety is that the clarifier control has ±1 to ±5 calibration points, with a detent at the center position. This makes for quick retuning.

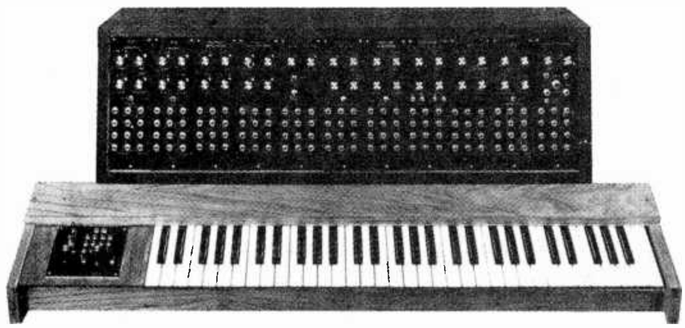
The edgewise meter is somewhat easier to read than is usually the case. Miniature toggles are used for switching some functions, such as the tone control (which has fixed HI and LO settings).

Aside from good overall performance and convenient handling, the transceiver offers the mobile user the advantages of SSB for enhanced CB communication. Of course, the inclusion of AM operation allows the user to communicate where the "other" station is not equipped for SSB.

CIRCLE NO. 103 ON FREE INFORMATION CARD

ARIES SYSTEM 300 ELECTRONIC MUSIC SYNTHESIZER

Has five-octave keyboard and 12 functional modules.



THE ELECTRONIC music synthesizer has added a whole new dimension to modern music. The basic characteristic that sets it apart from other musical instruments is flexibility. A synthesizer can produce almost as many different sounds as the player can imagine. That's why electronic music comprising many synthesizer tracks is so dramatic, and why many rock bands now use the synthesizer as a primary keyboard instrument.

The Aries System 300 is a two-voice, modular electronic music synthesizer. It has a five-octave keyboard with keyboard interface and 12 functional modules: two envelope generators; voltage-controlled amplifier (vca); two voltage-controlled oscillators (vco's); voltage-controlled filter (vcf); dual low-frequency oscillator/lag/inverter; sample-and-hold /clock/noise generator; balanced modulator; dual mixer; power supply; and an audio output/power control module. Cases, keyboard, and modules are available separately (see box). The keyboard in its case measures 43″L × 10″D × 4″H (110 × 25.4 × 10.2 cm) and the synthesizer cabinet measures 34½″L × 10″H × 10″D (88 × 25.4 × 25.4 cm).

General Description. At the heart of the System 300 synthesizer is the AR-317 voltage-controlled oscillator (vco) module. It produces and simultaneously provides four waveforms at amplitudes of 10 volts peak-to-peak. The ±5-volt sine, sawtooth, and triangle waves are centered on a 0-volt reference, while the variable-width pulse output oscillates between 0 and 10 volts.

Exponential circuitry provides 1-volt/octave (1/12-volt/semitone) control over a very wide range. Two potentiometers and a RANGE switch permit manual control from 0.03 to 30 Hz and from 16 to 16,000 Hz. External control voltages can determine the output frequency over a 0.002-to-50,000-Hz range. Four control inputs, one with a level control, are provided. The control inputs are summed so that each +1-volt input doubles and each −1-volt input halves the output frequency. Inputs are also provided for pulse-width modulation and frequency syncing with an external square-wave or pulse generator.

The basic waveform produced by this

module is the triangle. Its frequency is determined by an exponential current source varied by the control inputs. The source provides charging current for timing capacitors selected by the RANGE switch. A loop composed of two operational transconductance amplifiers, a complementary pair of bipolar transistors, and a JFET generate the triangle waveform.

The triangle wave is buffered and presented at the appropriate output jack. It also drives an open-loop op amp and a waveform converter circuit, which results in variable-width (5% to 95%) pulse and sinusoidal outputs. The sawtooth is generated by a separate loop driven by a secondary output of the exponential current source. This sawtooth circuit is pulse synchronized to the main oscillator loop.

The AR-312 envelope generator produces a 0-to-10-volt signal that is normally used as a control input for a vca or voltage-controlled filter (vcf). The ATTACK, DECAY, SUSTAIN, and RELEASE controls shape the output waveform. When a positive gate signal is applied to the input, the envelope generator can accept trigger pulses. Upon receipt of a trigger pulse, the generator's output increases exponentially from 0 to 10 volts, at a rate determined by the setting of the ATTACK control. The attack time is variable from 2 ms to 4 s. A level detector conducts when the output reaches 10 volts, causing the main timing capacitor to discharge at a rate determined by the setting of the DECAY control. The output voltage decays exponentially until it equals a threshold selected by the SUSTAIN control and remains at this level until the gate signal is removed. When this occurs, the output exponentially decays to 0 volt at a rate determined by the setting of the RELEASE control.

Four outputs (wired in parallel) and two gate and trigger inputs are provided. Pressing a MANUAL GATE switch activates and triggers the envelope generator. When the button is released, the output signal decays to ground. This module also includes a four-jack, front-panel patch point.

Dynamic control of an audio signal is performed by the AR-316 vca, which is designed around a CA3080 operational transconductance amplifier. One of two op amps sums four control inputs (one with an attenuator); the other serves as an output gain stage. Setting the MODE switch to LIN causes the vca's gain to be determined by the ratio (control voltage)/10. In the EXP position, the gain is determined by the formula gain (dB) = 10(V − 10), where V is the control voltage in volts. This allows a 10-dB/volt control.

Four audio inputs, two of which are connected by level controls, can be applied and summed by the CA3080. An INITIAL GAIN control acts as a front-panel master gain control. Depending on its setting and the magnitude of the control inputs, the gain will vary from −100 to 0 dB. The vca can handle audio inputs up to ±10 volts peak and control inputs up to +10 volts maximum.

Control over the tonal characteristics of synthesizer waveforms (and those of other electrical musical instruments) is furnished by the AR-327 multimode vcf. Audio input signals are summed by an op amp mixer and passed through one or more active filters. Control inputs are mixed by another op amp, whose output drives an exponential generator module. The module controls op amps that set the frequency response of the active filters. Low-pass, high-pass, band-pass, and peak/notch outputs are available simultaneously. (The notch or peak mode is switch selectable.) Response is 12 dB/octave, and Q is adjustable from 0.5 to 512 by means of a RESONANCE control. One audio and one control input are connected to front-panel attenuators.

Exponential control, an important vco feature, is also provided. The cut-off frequency of the filter increases one octave for each +1-volt increase of the control input and decreases one octave for each −1-volt increase. A FREQ control, together with any control inputs, determines the cutoff frequency over a 16-to-16,000-Hz range.

Three modules contain independent circuits that perform separate functions. The AR-324 module has two low-frequency oscillator's (lfo's) that simultaneously provide ±5-volt triangle, 0-to-10-volt sawtooth, and 0-to-10-volt square-wave outputs over a frequency range of 0.3 to 30 Hz. The oscillators can be synchronized to an external pulse or square-wave generator by means of a SYNC input. As in the vco, the sawtooth is generated independently. Differentiated pulses from the square-wave circuit control the discharge of the capacitor across which the sawtooth is developed. Thus, the sawtooth is synchronized to the other waveforms.

The lag circuit in this module is essentially a low-pass filter. A potentiometer determines the time constant (1 ms to 1 s) of an RC circuit. The output of the lag is buffered by a unity-gain voltage follower. Also included in the module is a variable-gain inverter. Inputs are coupled to a standard op-amp inverter through a variable attenuator. The maximum voltage gain is −1. Both the lag and inverter can handle peak signals of ±10 volts.

The second multifunction module is the AR-318 sample-and-hold/clock/noise generator. When a positive-going pulse is applied to the trigger input of the sample-and-hold circuit, a FET switch turns on and allows a capacitor to charge up to half the instantaneous signal voltage. (The input is passed through a 2:1 attenuator.) The switch then turns off to prevent the capacitor from further charging or discharging.

A FET op amp output buffer multiplies the capacitor voltage by two and presents it at the sample-and-hold output. When a positive signal of at least 2 volts is applied to the GATE input, the FET switch is kept on continuously. In this "track-and-hold" mode, the input follows the output exactly. If the gate signal is removed, the output remains at the instantaneous signal voltage at the time of removal. The circuit can also be activated by a MANUAL TRIGGER switch.

The clock is a voltage-controlled, low-frequency oscillator with 0-to-10-volt sawtooth, square-wave, and trigger (narrow pulse) outputs. The frequency range is 0.3 to 30 Hz. Inputs are provided for frequency modulation and syncing to an external pulse or square-wave source. A switch allows either the clock or an external source to provide trigger and gate signals for the sample-and-hold circuit.

The third function of this module is to provide three noise signals. White noise is developed by amplifying and filtering the output voltage from a reverse-biased transistor junction. Pink noise is obtained by passing the white noise through a −3-dB/octave low-pass active filter. The pink noise is rectified, filtered, and amplified to create a slowly varying random waveform. The random and pink-noise outputs are 4 volts rms, with equal energy per cycle between 0.4 and 7 Hz and equal energy per octave between 16 and 16,000 Hz, respectively. The 7-volt rms white-noise signal has equal energy per cycle between 16 and 16,000 Hz.

The AR-315 module contains a balanced modulator and two general-purpose attenuators. The balanced modulator has X and Y inputs. Signals applied to these inputs are fed to a four-quadrant multiplier IC whose output drives an op amp in the differential mode. When the circuit is properly trimmed, the output voltage is XY/10, where X and Y are the input signal levels in volts. If either or both inputs is zero, the output is zero. The levels can be independently controlled for each input. The two attenuators in the module can be used at any point in a synthesizer patch.

Signal summing is performed by the AR-323 dual mixer. Each mixer has four inputs, two of which have polarity selection switches and level controls. This allows both addition and subtraction of audio signals, envelopes, etc. Outputs are provided for the A and B mixer separately, as well as combined A + B and A − B. These allow the module to be used as a single eight-input mixer. Six op amps are used for signal summing and inverting. Maximum signal levels are ±10 volts.

The voltages required by the various modules in the system (+5, +15, −15 volts) are supplied by the AR-322 power supply module. IC voltage regulators, large heat sinks, and electrolytic capacitors are used in the module. The three current-limited (1-ampere) output voltages are available at three parallel-wired octal sockets.

The AR-326 output and power control module switches ac from the line to the power supply and contains two independent audio output amplifiers. The amplifiers are each mounted on separate pc cards and consist of an op amp driver and a complementary pair of transistors operating in class AB. The output signals are routed to a headphone jack and two output phono jacks. The module can drive headphones, high-impedance (40 ohms or more) speakers, or power amplifiers. Two four-jack patch points are provided as are jacks at which +10 and −10 volts are available. The power supply's ac line switch and pilot light are mounted on the front panel of the AR-326 module.

All of the modules described so far mount in the AR-310 cabinet. Eleven modules (all but the power supply) have front panels and all of these except the output power and control module plug into 22-pin edge connectors, which bus power from the power supply module.

Patching can be accomplished in one of two ways. First, patch cords terminated with miniature phone plugs can be inserted into front-panel jacks. This allows the user to make hundreds of different patch combinations according to his own ideas of how the synthesizer should be used. Alternatively, all inputs and outputs at the edge connectors can be hard-wire patched, or limited-patch switching can be developed via the edge connectors.

Also included in the System 300 are the AR-311 keyboard, AR-313 keyboard interface, and AR-320 keyboard case. The preassembled keyboard has 60 precision resistors that form a voltage divider. One set of gold-plated key contacts connects a specific tap on the voltage divider to the keyboard voice bus. The voltage on this bus depends on the specific key depressed. The lowest key produces 0 volt and the highest, five octaves away, produces 5 volts. Each ascending key produces an 83.3-mV increase over the key to the left, resulting in 1 volt/octave voicing.

The keyboard voice voltage tracks the lowest key depressed. However, another "auxiliary voice" voltage is developed when two keys are pressed simultaneously. The magnitude of this voltage depends on the keyboard interval created by the two keys. A second set of gold-plated contacts is used to generate gate and trigger signals.

The AR-313 keyboard interface produces four output signals. The GATE signal is at +10 volts and remains on as long as any key is held down. The TRIG-

GER output is a ±10-volt, 1-ms pulse that appears each time a key is pressed. The VOICE output is a dc voltage that is proportional to the lowest key held down. It remains at its last level after the key is released.

When the interface is properly tuned and trimmed, the lowest key (C) produces a 0-volt "voice" signal. The C# key produces 83.3 mV, etc. Hence, each octave adds one volt, which raises the output frequency of the vco by one octave. The "aux voice" output appears only when more than one key is pressed at the same time. Its voltage is proportional to the interval between the highest and lowest keys depressed. When one or no key is depressed, this output is 0 volt.

The interface's TUNING control adds or subtracts voltage from the VOICE output over a 1.5-octave range. It has no effect at or near its center position. Glide or slur from one key to the next is provided by the portamento circuit. The PORTAMENTO control determines the glide time that is essentially independent of the keyboard interval in the NORMAL mode. In the LINEAR mode, the glide takes longer for larger intervals. Placing the PORTAMENTO switch in the OFF position disables the circuit.

The AUX TRIM and VOICE TRIM are front-panel screwdriver-type controls that are used to set the output intervals to 1 volt/octave. After initial adjustment, they need not be disturbed.

ARIES SYSTEM 300 ELECTRONIC MUSIC SYNTHESIZER

AR-311 Keyboard	$119.00
AR-313 Keyboard Interface	67.00
AR-320 Keyboard Case	48.00
AR-312 Envelope Generator (2, each)	55.00
AR-327 Multimode VCF	149.00
AR-316 VCA	63.00
AR-315 Balanced Modulator and Attenuators	62.00
AR-317 VCO (2, each)	115.00
AR-318 Sample-and-Hold/Clock/ Noise Generator	59.00
AR-323 Dual Mixer	65.00
AR-324 Dual LFO/Lag/Inverter	65.00
AR-322 Power Supply	92.00
AR-326 Output and Power	59.00
AR-310 Synthesizer Cabinet	89.00
System Price (Kit form)	1195.00
System Price (Assembled)	1895.00

Assembling the Kit. This is a fairly complex kit to assemble. Actually, it is a collection of mini-kits. Each of the modules can be assembled and tested independently. After completing the power supply module, we put together the synthesizer cabinet from precut lumber. Then we installed the power supply and edge connectors to be ready for each of the other modules.

Next, we assembled the keyboard, keyboard interface, and keyboard case. The keyboard case comes precut and drilled, and the keyboard itself is preassembled. The interface circuitry is housed on two printed circuit boards. The interface boards (as well as those in the other modules) are not silk screened with component locations, but assembly was not difficult because larger-than-life parts placement diagrams were provided with the instructions.

With two exceptions, each Aries module worked perfectly the first time it was powered. One was due to a wiring error. The other was a result of a marginal circuit's design given tolerance of parts. Trouble was experienced with the dual lfo's. Correct waveforms were obtained at the square and triangle wave outputs, but a +10-volt level appeared in place of the sawtooth outputs. Aries was contacted for advice by telephone. Following a few suggestions from Jim Bastable (now one of the Aries partners), the beginnings of a sawtooth appeared.

Further experimentation on our and Aries' parts resulted in a solution to the problem, which involved a few changes in component values. Aries has modified the circuit in line with our results, and informed us that although previous module purchasers had not contacted them about the sawtooth, they would all be informed of the change.

We performed the various circuit adjustments with the aid of a multimeter, frequency counter, and oscilloscope. These instruments are not absolutely necessary for making the adjustments, but they do make them easier to perform and yield accurate results. Easy-to-follow trim instructions are provided with each module.

The last part of assembly was to finish the wood that makes up the two cases. This is an option left to the builder's tastes, but it is well worth the effort, since it results in an instrument that looks as good as it sounds. Two coats of stain and then two coats of polyurethane were applied to all exterior surfaces of the keyboard and synthesizer cabinets.

Total assembly time for the System 300 was about 95 hours, not including the three hours or so required for trimming adjustments. We noted during assembly that all components supplied were of high quality. In many cases, components with tolerances closer than specified in the parts lists were supplied.

User Comment. Modern electronic music synthesizers fall into two categories, performance types and studio types. The performance synthesizer is polyphonic, computerized, and looks like and is played in a manner similar to an electronic organ. The studio synthesizer, on the other hand, is usually monophonic or has two- or three-note chord capabilities. Most studio synthesizers are made up of combinations of different modules that are designed to be interconnected as required by jacks and patch cords. With this type of instrument, the musician has a more deliberate, subtle control over each note he generates. He can patch as conditions require. As each note is generated, he can record it and, at the end, perform a mix-down to obtain the final "composition."

The Aries System 300 is decidedly a studio synthesizer. It looks solid and substantial. More importantly, it sounds as good as it looks.

The fact that this is a kit and is modular in design gives the user a wide range of possibilities for designing the instrument to meet his own specialized needs.

We were impressed with the way Aries has covered the classical spectrum of function modules in the System 300. As laid out, the system gives the musician a practically infinite palette. Each of the modules that make up the system performed with clean precision, and we were unable to exhaust the patch combinations possible.

On the negative side, we found the control parameters to be too husky and too responsive. We would have preferred to be able to spread the control over a larger, smoother range. For example, the amplitude of a control signal applied to the vco for vibrato (frequency modulation) had to be cranked down to the very threshold of the input level control to be within acceptable limits. We could have passed the control voltage through one of the two attenuators and thence to the input level control, but that would have been awkward and wasteful.

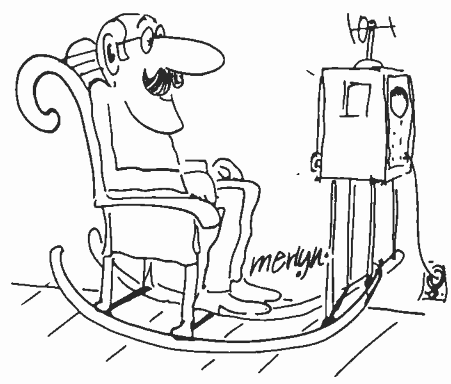
A similar problem was noted with the noise generator. It would have been preferable if the noise generators had had built-in attenuators because noise is seldom used at full volume. Patching the noise signal from its source to an attenuator and then to another module is a nuisance. In short, the Aries synthesizer is a bit too spunky, and it has too many muscles.

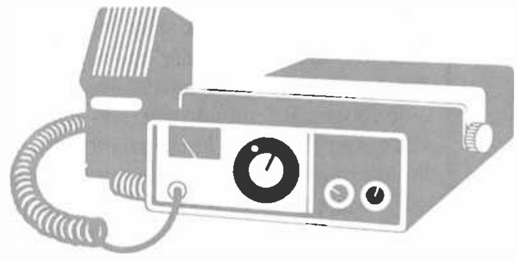
For us, the ultimate test of any synthesizer is in musical composition, using multitrack overdubbing. We usually try to construct a piece in four stages, using simul-sync on a 4-track tape recorder. Using the System 300, we began by patching up an automatic percussion rhythm, using white noise and a sine wave at low audio frequency. The sampler module was used to control the filter's cutoff frequency. (Signals were taken from the filter's bandpass output.) The pulse output of a low-frequency oscillator was used to trigger the envelope generator. The result was a pseudo bass drum and brushed cymbal. The drum, controllable from the keyboard, was played as a bass line rhythm on the first track of the 4-track tape recorder.

Next, we set up and played a chromatic cymbal on track two to complement the walking bass. Then a voice patch with an envelope and vibrato that approximated the human voice was recorded on track three as a melodic figure manipulated in conventional ballad fashion. Finally, a supporting contrapuntal line was added, using a stringy sound. When we were through, we were pleased with the result. The Aries system had accomplished everything we asked of it.

In sum, the Aries System 300 is for serious music and meticulous recording applications. It was obviously designed by an engineer who takes pride in his craft. The system may be a bit complicated and clumsy to program, but then it is definitely not a toy. However, we learned at press time that another model, using the same internal design, will be available to permit one to override the patch-cord interconnect system at will. This would give the option of using the unit as a highly flexible studio synthesizer or as a "live" performance synthesizer with less control flexibility. So it is possible, you see, to have your cake and eat it, too.

(The User Comments in this report were prepared by Robert A. DeVoe, Professor of Education at Fairleigh Dickinson Univ. in New Jersey. Mr. Devoe has conducted radio and classroom courses in the Humanities and Electronic Music and is an accomplished composer of electronic music. His work has won the Armstrong award for excellence in FM broadcasting and the John Hay Fellows Award in Humanities. He is also the author of *Electronmusic*: A Comprehensive Handbook, published by Electronic Music Laboratories, Inc., Box H, Vernon, CT 06066.)





CB Scene

By Ivan Berger

BETTER EMERGENCY SERVICES ARE NEAR

THE ODDS on someone's hearing when you call for help on Channel 9 are going up. The government is raising them. And you can help.

The government's goal is to knit together law-enforcement officials, medical and emergency services, automobile clubs and such volunteer CB monitoring groups as REACT and ALERT into a network which will put every CB-equipped car in the country within reach of fast emergency assistance. To implement that goal, a new program has been set up that's called National Emergency Aid Radio, or NEAR.

Independent efforts at coordinating CB with emergency services have been going on successfully for years, of course. REACT and the other monitor groups, for example, have teams to listen to Channel 9 in systematic shifts, so that there is always someone there to hear and relay calls for help. Several states have equipped their highway patrol cars with CB. Some Smokeys have even equipped their official vehicles at their own expense.

The results have been impressive. Where the police are equipped to hear them, CB'ers now often report *to* Smokey, telling him of reckless drivers, accidents, traffic jams, hazardous conditions and other emergencies. Such experiences doubtless helped the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) to recognize CB radio communication as "the only existing method convenient to the public at large by which the motorist can enter the response system from his vehicle," and to set up NEAR.

The program will be federally funded, but must be implemented by the individual states. That leaves it up to each state to decide how it will allocate its NEAR funds: to buy CB equipment for local police and emergency services, to set up public information programs, to train CB monitors in emergency reporting procedures, and to pay the costs of administering NEAR. States may even elect not to participate at all.

Those states which do participate will be assigned easily-recognized call signs for use in legally communicating with other CB operators. These callsigns will consist of the letter "K," the state's two-letter abbreviation, and the number 0911—"KNY-0911" for New York, for instance, or "KCA-0911" for California. (Since each state government is a single licensee, all its CB units share a single callsign.)

No money is allocated for direct use by volunteer monitors. However, there are ways that they can benefit indirectly. Local or state governments can set aside space in government facilities for volunteers' use, and may even provide equipment there. But the equipment will remain the government's, not the volunteers'. NEAR funds can also cover expenses directly relating to monitoring activities, such as long-distance telephone calls made in response to emergencies.

Where groups like REACT will benefit directly is in closer contact between government and volunteers. We understand that each state *must* collaborate with volunteer monitors (and with other volunteer groups, such as Civil Defense) in setting up a NEAR Advisory Council and a NEAR plan. Without such collaboration, the state won't qualify for Federal NEAR funds.

The volunteer monitor groups must meet several criteria, though. For instance, they must be primarily devoted to emergency communications monitoring, have demonstrated their capabilities and earned community support, and have state or national affiliations.

Independent monitoring will still be encouraged. NEAR funds spent on public infcrmation and education will probably result in more and more CB users' learning what Channel 9 is for and how to use it. This part of the program has already borne some fruit. It's a handy, common-sense book called the *Citizens Band Monitor Guide*. Some of its hints and reminders struck are especially worth noting.

Four C's. The book stresses the four "C's": an effective NEAR monitor should be Calm, Courteous, Correct and Concise. The book gives some specific tips on how to accomplish this:

- "The monitor must remain the link between the need and the help until that help arrives. That includes getting and relaying further information from the caller, and relaying or giving advice on lifesaving or other emergency procedures that the caller may be able to handle in the meantime.
- "Keep in mind that most calls for help come from a place of stress. The caller may be excited, shaken, alarmed, frantic and even hostile. Your job is to remain clam and instill calm and confidence in your caller. . . . However, you should *not* tell him to 'calm down.' This will only make him think you don't appreciate the seriousness of the situation."
- The *Guide* gives two pages of suggestions on how to deal with such common and uncommon emergencies as aircraft accidents, fires, lost children, stalled cars and tornados. For each of 26 such incidents, it suggests what information a monitor should elicit from the caller, which government services should be alerted, and what special instructions should be relayed back to the caller. (Oddly, I noticed no sign of another common-sense suggestion: that the phone numbers of all these services should be kept at the monitoring station.)
- 10-codes are listed in large type, for easy reading. But the *Guide* also points out that "You should *never* use 10-codes with parties who would not understand them," though "you should be able to understand them, nevertheless."
- Get the information in a regular sequence. You can't ask everything at once, and you have to ask important things first." The book suggests one possible such sequence: first ask the nature of the problem, then the caller's

location and phone number (if applicable), then the specific location of the incident, the caller's name, and more details of the incident itself.

- "Explain why it will take time to check for information, and that you will call back. A party waiting on a 'dead phone' may become irritable and uncooperative."
- To simplify evaluation of the NEAR program's effectiveness, a monitor logbook designed for input to a computer will be made available. This will be for use only by Monitor Base Stations designated by State CB NEAR Programs. Data to be filled in includes the time delay between occurence of the incident and notification, nature of the incident, type of response agency notified, and the time the action was completed, as well as identification of the calling source and the monitor unit.
- Monitors should be able to identify an emergency's location even when the caller is a stranger to the area. The *Guide* suggests that monitors equip themselves with road, street and topographical maps and guides.
- Monitors should use words and phrases that are easy to transmit and understand, should avoid local jargon which callers en route through the area might misunderstand, and should speak slowly and clearly.
- For clarity, it's wise to learn the International Phonetic Alphabet (Alpha, Bravo, Charlie, Delta, etc.), but not to overuse it. If reception is clear and the name is common, it's enough to relay it as 'S-M-I-T-H, Smith." You don't have to slow it down to "Sierra, Mike, India, Tango, Hotel."

A NEAR monitor log has been designed, too, that's divided into sections: (1) identification, (2) incident, (3) location, (4) notification source, (5) action taken. The latter's time is to be expressed in 24-hour clock time. The forms can be produced locally for distribution to monitors. Interestingly, forms can be used for input to a computer so that information can be readily extracted. Number codes are used throughout, even for the type of emergency.

If you'd like to read the whole *Citizens Band Monitor Guide*, it's available for 80¢ a copy ($1.00 minimum on mail orders) from the Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402. Order Stock No. 050-003-00235-6.

You can also find out who's working on NEAR in your state by contacting REACT, 111 E. Wacker Dr., Chicago, IL 60601. ◇

Heath Company, Dept. 010-330
Benton Harbor, Michigan 49022

 CIRCLE NO. 5 ON FREE INFORMATION CARD

Computer Bits

By Hal Chamberlin

UPDATE ON MICROPROCESSOR DEVELOPMENTS

OVER THE past year, there has been a flood of new microprocessor IC's and related peripheral IC's coming on the market. Many have been rumored in the past but are now finally available. These new IC's are important to casual as well as advanced computer hobbyists because they will show up shortly in new hobbyist-oriented equipment offerings.

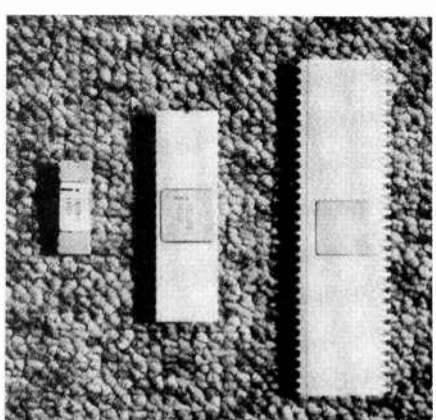
One obvious overall trend in microprocessor IC's has been toward true single-chip central processing units or even complete computers. With today's CPU chips, one merely adds memory, address decoding, and bus buffering to have a complete, expandable computer. The newest "computers on a chip" have the CPU, erasable read-only memory, read-write memory, and a couple of input-output ports all in one IC! Although these are not as easily expanded, they are ideal for use in terminals or intelligent game machines.

Another trend is toward I/O systems on a single chip. The TMS5501 IC from Texas Instruments, for example, combines a complete UART with baud-rate generator for serial I/O, a parallel input port, a parallel output port, 5 (count them) interval timers, and a vectored interrupt system into one IC! Another example is the MCS6530 from MOS Technology (now part of Commodore) and Synertek. This IC offers 1k bytes of read-only memory, 64 bytes of read-write memory, two *bidirectional* (programmable for input or output) parallel ports, and a very versatile interval timer. As a matter of fact, two of these are used in the KIM-1 to hold the monitor and provide its extensive I/O capabilities.

Complete peripheral controllers are also appearing in chip form. Most notable is the fact that no fewer than three different floppy-disk controller IC's are now available. Most of them are flexible enough to handle the disk formats in common use by hobbyists as well as the "standard" and more complex IBM format for which the chips were designed. Another IC that has been announced but is not yet available is a video display chip with *programmable* line length and number of lines., Even the character read-only memory is built-in.

Memory developments certainly have not taken a vacation either. Static 4k memory chips have become cost effective alternatives to the common 1k 2102 chips and are now appearing in 16k-byte memory boards for the hobbyist. Earlier problems with dynamic memory chips have been overcome by correct board design and will be emerging as the price-performance leader in memory for the hobbyist since 4k dynamic memory chips are now selling for as little as $2.70 in large quantities. Finally, the availability of 16k dynamic memory IC's makes possible the single-board "full gallon" (64k) memory system. In fact, IMSAI has announced a 64k memory board for its systems.

The 8080 Field. Even though the 8080 is the most popular microprocessor chip for hobbyist systems and has also enjoyed considerable success in commercial systems, many significant improvements in the family have become available in the last year. Improved versions of the original 8080 that run at higher speeds are now available. The fastest is the 8080A-1 which can run at a clock speed of 3.125 MHz or over 60% faster that the standard 8080. Of course these higher speeds require faster memory to be of any benefit but many of the newer memory boards run fast enough.



Size of microprocessors grows in proportion to sophistication of internal logic. Left to right, an 8008, 8080, and the latest 16-bit micro, a 9900 IC.

To most people however, the most significant development is of course the Z-80. This microprocessor chip was introduced by Zilog, a spinoff company from Intel, the originators of the 8080. The Z-80 is fast; selected versions run at 4-MHz which is twice as fast as the 8080. Additionally, some instructions require fewer clock cycles to execute than the 8080 equivalents. The main attraction of the Z-80 for hobbyists however has been its extended instruction set. Besides all of the 8080 instructions, the Z-80 has many new ones. The most impressive class is the block search and move instructions. A single instruction, after the proper parameters have been loaded into registers, can perform a function that normally requires an entire subroutine. Besides the obvious savings in memory space, the block instructions execute much faster than the subroutine would. Other improvements are indexed addressing modes which simplify some types of programming and a duplicate set of registers which eliminates the need to save registers during interrupt.

One of the newest developments from Intel is designated the "MCS-85" family. Central to this family of chips is the 8085 microprocessor. This chip essentially combines the CPU, clock generator, and system bus controller functions onto one IC. In addition, 4 individually maskable vectored interrupts are included right on the CPU chip thus solving a bad problem with the original 8080. One of the most significant improvements is relaxed bus timing specifications. At equivalent throughput speeds, the 8085 allows memory access to stretch out as long as 1025 ns whereas the 8080 allows only 570 ns thus requiring a memory almost twice as fast. Even when the 8085 is sped up 50% to 3 MHz, the 575 ns allowed for memory access is longer than an 8080 at normal speed thus allowing a faster system without faster memory. Even with all of these improvements, the 8085 will execute all 8080 programs without changes.

Other 8-Bit Processors. Of course

the other microprocessor manufacturers have not twiddled their thumbs over the past year. Motorola has just announced faster versions of its popular 6800. The MC68A00 runs 50% faster at 1.5 MHz and the MC68B00 runs fully twice as fast at 2 MHz. Likewise, the 6502 microprocessor from MOS Technology is available in higher speed versions. The A suffix part is twice as fast at 2 MHz, the B suffix runs at 3 MHz, and the "dash C" part smokes at 4 MHz. Remember when comparing clock speeds that the above chips generally accomplish about as much in one clock cycle as an 8080-type chip does in three clock cycles.

National Semiconductor's SC/MP microprocessor has also been improved. It is now an n-channel MOS chip which means easier interfacing and a single 5-volt power supply. Additionally the speed has been doubled to 4 MHz (which is divided by 4 internally). Even with these improvements, its price remains the same.

The F-8 microprocessor originated by Fairchild normally requires at least two chips to make a complete CPU. However Mostek has recently announced a single chip F-8 that combines memory, an interval timer, and I/O ports all on the same chip.

16-Bit Microprocessors. To many people the ultimate hobby computer simply must have a full 16-bit minicomputer style instruction set. Accordingly, recent developments in 16-bit microprocessors are of great interest. A significant trend with the 16-bitters has been to try to get it all on one chip even if it means a larger IC package as shown in the photo.

The PACE was the first single-chip 16-bit microprocessor to be introduced. Although National Semiconductor has not made any significant improvements in the chip itself, the price has improved considerably. From an initial figure of nearly $200 (in 100 quantity), the price has recently fallen to only $20.

Speaking of price reductions, the CP1600 processor by General Instruments has been recently repriced at $8! The architecture is somewhat strange but the price is hard to beat and it is a 16-bit device.

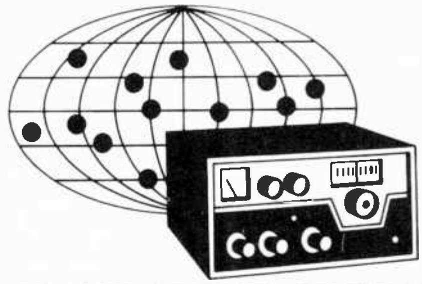
Another 16-bit processor which has been rumored for awhile is now available. It is the 9900 from Texas Instruments. This IC is unique in many respects. Most striking is the 64-pin package which looks more like a small printed circuit board with leads than a ceramic IC. The instruction set in many ways resembles that of a DEC PDP-11, a very popular minicomputer. An interesting design innovation is that the "registers" are not in the CPU but are in regular read-write memory. Another feature is the inclusion of real multiply and divide instructions which take only about 20 microseconds to execute. The standard 9900 requires a 16-bit wide memory but a "soon-to-be-introduced" version (the 9980) can work with an 8-bit data bus and memory while retaining the same extensive 16-bit instruction set. This means that CPU boards using the 9980 might be compatible with the S-100 bus structure. The 9980 will also be packaged in a more conventional 40-lead package.

Bipolar Bit Slices. While not really microprocessor chips, the bipolar bit slices are building blocks that can be used to design custom computers and instruction sets with much less effort and far fewer parts than would be required with standard logic. Since they are made with high-speed Schottky transistors rather than MOS transistors, the speed of a system constructed with bipolar slices is much greater. Major innovations in this area are sharply lower prices and the availability of 4-bit wide units along with a host of support chips. Of significance to the hobbyist is the fact that a couple of hobbyist manufacturers are readying CPU boards made with the bit slices. These will be compatible with the S-100 bus and immediately provide the user with a vastly superior CPU while still using the rest of the existing system. Since the bit slices are *microprogrammed*, it is possible that a standard feature would be an *emulation mode* in which the instruction set of a popular microprocessor such as the 8080 would be recognized as well as the improved instruction set offered with the new CPU.

Bipolar bit slices will probably also show up in specialized floating-point arithmetic units. The purpose of these is to execute the arithmetic operations needed by BASIC language systems much faster than typical software routines do.

If the past is any indication, new microprocessor developments will continue to be made at an ever accelerating pace.

Correction. In last month's column, the price of the Heathkit H9 CRT terminal was given as $350. It should have been $530. ◇



DX Listening

By Glenn Hauser

PUBLICATIONS

AN AMAZING amount of excellent printed material relating to international radio is available, once you know how to get it. Most of it you would never find, no matter how long you looked, even in the largest libraries. It's produced by enthusiastic individuals, with expertise in their specialties, even though they are nonprofessionals. Here's a selection of such publications, and how to get them.

Review of International Broadcasting is a monthly magazine in which listeners exchange views on programming. It fills the vacuum left by most DX clubs, which emphasize picking up stations, rather than listening to their programming—which, after all, is the reason stations broadcast. Sample, 50¢ or 12 issues for $6.00 from Glenn Hauser, WUOT, University of Tennessee, 245 C&E Bldg., Knoxville, TN 37916.

Down Under DX Survey, a quarterly, mimeographed bulletin, concentrates on Asian stations, with extensive band surveys, special reports, etc. Only active contributors may join the group, but anyone may order individual issues, for 6 IRC's (International Reply Coupons) from Down Under DX Circle, 7 Donald Road, Burwood, Victoria, Australia 3125.

Far Eastern DX Review is a similar bulletin compiled by four Japanese experts (in English), but is monthly and Xeroxed. Samples are 8 IRC's or $2. A year by air is $20, or by surface mail, $15, from Japanese Association of DXers, Box 1766 Tokyo Central, Tokyo 100-91, Japan.

Russian Reporting Guide is a separate JADX publication, available for 4 IRC's from the address above. Claims to be "the most detailed guide for reporting in Russian and for understanding domestic services in the USSR."

USSR High-Frequency Broadcast Newsletter provides otherwise hard-to-get schedules of Soviet transmissions based on monitoring: including educated guesses on the transmitter sites actually used, contradicting official information from the USSR itself. Sample for SASE, or 12 issues of the approximately monthly publication for only $3, from Roger Legge, Box 232, McLean, VA 22101.

World Broadcasting Information is a weekly compilation of schedules, and monitored developments in broadcasting, by and for professionals, but available to individual subscribers. Costs vary around $60 per year, but a free sample is offered from: Organiser, News & Publications, BBC Monitoring Service, Caversham Park, Reading, England.

DX Information Service Catalog is free from Radio Nederland, Box 222, Hilversum, Holland. Lists free technical courses, antenna booklets, etc.

Mail-a-Prop is a two-page fortnightly summary of propagation condition predictions, compiled by George Jacobs, primarily for amateurs, but also can be applied by listeners to other bands. Sample and rates from Mail-a-Prop, Box 86, Northport, NY 11768.

SPEEDX Utility Guide attempts to do for nonbroadcast listening what the World Radio-TV Handbook does for broadcasting. This year's edition is $6.95 from SPEEDX, Box E, Elsinore, CA 92330.

Listen to the World on Shortwave—Ask Me! Red and white vinyl bumper stickers are also available from SPEEDX, at 50¢ each.

Handler Enterprises, P.O. Drawer CC, Northfield, Il 60093, offers a free catalog of its reasonably priced station lists, primarily of military and government utility stations, difficult to obtain elsewhere.

GILFER Associates provides a number of books about aspects of DX listening, and a line of equipment. Ask for catalog. GILFER, Box 239, Park Ridge, NJ 07656.

National Radio Club provides extensive reprints of technical and nontechnical articles dealing with mediumwave reception and gear; for a list, send an SASE to NRC Publications Center, Box 401, Gales Ferry, CT 06335.

Worldwide TV-FM DX Association

does the same with articles on vhf/uhf reception and equipment. Ask for a catalog from WTFDA Reprint Service, Box 202, Whiting, IN 46394.

ANARC Directory of DX Club Publications extends even further the list given here. Send a #10 SASE with 24¢ postage to Association of North American Radio Clubs, 557 N. Madison Ave., Pasadena, CA 91101.

EDXC List of 600 DX Publications of the World is available for 5 IRC's from European DX Council, Box 250325, D-4630 Bochum, German Federal Republic.

International Broadcast Institute publishes case studies of broadcasting in different countries, intended for scholars, but may be of interest to the serious DX listener. Ask for a list of publications available, from IBI, Tavistock House East, Tavistock Square, London, WC1H 9LG, England.

Comings & Goings. South Africa's Radio Five, the successor to Mozambique's "LM Radio", planned to come up in August via two new 100-kW shortwave transmitters, probably using 31 or 41m in the daytimes, and 75m at night. Meanwhile, the international service, Radio RSA is overhauling its four 250-kW transmitters and replacing them with three 500-kW senders.

Radio Voice of the Gospel, a Lutheran station in Ethiopia, was nationalized in March, and renamed Radio Voice of Revolutionary Ethiopia. The latest schedule we have shows the only frequencies in use to be 6015 and 7180 kHz, opening at 1300 GMT in Somali, when they should be audible in western North America via long path, but not during the English program at 1630.

Both Vatican Radio in Italy for the Catholics, and HCJB in Ecuador for the Evangelical Protestants, are installing 500-kW transmitters and gigantic rotatable antennas to improve their outreach.

Australia is planning a new domestic shortwave service for its Northern Territory, transmitted both from Darwin, and from Adelaide, South Australia. Also, $63 million (Australian) has been appropriated to modernize Radio Australia overseas transmitters in Victoria, and further expansion on the west coast is also being considered including between Australia and overseas.

Radio Nacional Brasilia abruptly suspended its international service in mid-June, citing technical reasons. The reasons were really political, however. The Brazilian government couldn't wait until next year when RNB is slated to get five new transmitters. It decided instead to take RNB off the air so its one transmitter could be used for domestic broadcasts into Amazonia—where foreign broadcasts have been dominating the airwaves. No date of return was given, and there was a note of sadness in announcer John Morris's voice. We'll certainly miss this friendly, soft-line station.

But another friendly Latin American station made a comeback in June—Radio Clarin, from the Dominican Republic. They've had power supply problems for their 50-kW transmitter on 11700 kHz. Rudy Espinal, host of the English program at 2330 GMT, on his first day back on the air, intimated that the time would be changed, or there would be an additional broadcast at a more convenient hour for Europe.

BBC's Far Eastern Station is moving from Malaysia across the Straits to Singapore. As the move is in phases, for a time BBC will be broadcasting from both countries, and not telling us which frequency is from which.

WYFR is also moving, from Massachusetts to Florida, near Lake Okeechobee, where there's more room for expansion; they too will be broadcasting from both locations until the move is complete. ◇

ENGLISH-LANGUAGE SHORTWAVE BROADCASTS FOR SEPT. & OCT.

by Richard E. Wood

TO EASTERN NORTH AMERICA

TIME-EOT	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
6:28 a.m.-8:00 p.m.	1028-2400	**Montreal, Canada (Northern Service)	G	9.625, 11.72 (includes French, etc.)
7:00-7:25 a.m.	1100-1125	Tirana, Albania	F	9.50, 11.985
7:00-9:00 a.m.	1100-1300	Melbourne, Australia	G	9.58
		London, England	G	5.99 (via Sackville), 6.195 (via Antiqua)
7:00-10:00 a.m.	1100-1400	**VOA, Washington, USA	G	5.955, 9.73
8:00-8:30 a.m.	1200-1230	Jerusalem, Israel	G	11.655, 15.23, 15.415, 17.795, 17.815
8:00-8:55 a.m.	1200-1255	Peking, China	F	11.685
8:10-8:30 a.m.	1210-1230	**Santiago, Chile	G	9.566, 11.81, 15.15
8:15-8:30 a.m.	1215-1230	Athens, Greece	P	15.345, 17.83
		HCJB, Quito, Ecuador	G	11.745
8:30-9:00 a.m.	1230-1300	Stockholm, Sweden	G	15.305
8:30-9:20 a.m.	1230-1320	Trans-World Radio, Bonaire, N.A.	G	15.255 (Sat., to 1420 Sun.)
8:30-11:30 a.m.	1230-1630	HCJB, Quito, Ecuador	G	11.745, 15.115
9:00-9:25 a.m.	1300-1325	Helsinki, Finland	G	15.105
9:00-9:30 a.m.	1300-1330	London, England	G	5.99 (via Sackville), 6.195 (via Antiqua), 11.775 (via Antiqua: Sat., Sun. from 1200)
9:15-9:45 a.m.	1315-1345	Berne, Switzerland	G	15.14
10:00-10:15 a.m.	1400-1415	**Montreal, Canada	G	15.29, 17.78
10:00-10:30 a.m.	1400-1430	Stockholm, Sweden	G	15.305
11:00 a.m.-12 noon	1500-1600	London, England	G	17.84 (via Ascension), 9.58 (via Sackville Sat., Sun.)
11:15-11:30 a.m.	1515-1530	Athens, Greece	F	11.73, 15.345, 17.83
12 noon-12:15 p.m.	1600-1615	London, England	G	9.58 (via Sackville) 17.84 (via Ascension)
12 noon-12:30 p.m.	1600-1630	Oslo, Norway	F	15.175 (Sun.)
12:04-12:56 p.m.	1604-1656	**Paris, France	G	11.705, 11.89, 11.93, 11.965, 15.20, 15.30, 15.425, 17.72, 17.795 (from Sept. 24: 1704-1756)
12:15-1:09 p.m.	1615-1709	London, England	G	9.58 (via Sackville; Sat., Sun.-1745)
12:42-12:50 p.m.	1642-1650	Hilversum, Holland	G	15.19, 17.775, (alt. 17.825; Mon.-Fri., via Bonaire)
12:45-1:00 p.m.	1645-1700	**Montreal, Canada	G	15.325, 17.82
1:00-4:00 p.m.	1700-2000	**Kuwait, Kuwait	G	9.555, 12.085 (varies)
2:00-2:30 p.m.	1800-1830	**Montreal, Canada	G	15.26, 17.82
		**Kampala, Uganda	F	15.325 (Tues., Thur., Sat., Sun.)
2:50-4:00 p.m.	1850-2000	**Abidjan, Ivory Coast	G	11.92 (Sun.)
3:00-3:30 p.m.	1900-1930	**Montreal, Canada	G	15.26, 17.82
		**Tehran, Iran	F	9.022, (from Oct.: 2000-2030)
3:00-6:00 p.m.	1900-2200	**Jeddah, Saudi Arabia	F	11.855
3:30-4:00 p.m.	1930-2000	**Montreal, Canada	G	11.855, 15.325, 17.735
		**Baghdad, Iraq	F	9.745
4:00-4:30 p.m.	2000-2030	Jerusalem, Israel	G	7.4125, 9.63, 9.815
4:00-5:00 p.m.	2000-2100	Accra, Ghana	F	11.85 (irregular)
4:00-5:20 p.m.	2000-2120	**Hilversum, Holland	G	11.73 (via Talata)†
4:30-5:00 p.m.	2030-2100	**Montreal, Canada	G	11.855, 15.325, 17.82
4:50-5:50 p.m.	2050-2150	**Havana, Cuba	G	11.865, 17.75
5:00-5:50 p.m.	2100-2150	**Johannesburg, S. Africa	F	5.98, 7.27, 9.585
5:15-6:00 p.m.	2115-2200	London, England	G	9.58, 11.78

5:30-6:50 p.m.	2130-2250	Hilversum, Holland	G	9.715, 11.73 (exc. Sun.)†
6:00-6:15 p.m.	2200-2215	**Belgrade, Yugoslavia	F	6.10, 7.24, 9.62
6:00-6:30 p.m.	2200-2230	Oslo, Norway	F	11.85, 15.175 (Sun.)
6:00-6:45 p.m.	2200-2245	London, England	G	6.175, 9.51 (both via Sackville), 9.58, 11.78
6:00-7:15 p.m.	2200-2315	**Cairo, Egypt	G	9.805
6:00-8:00 p.m.	2200-2400	Montreal, Canada	G	5.96 (Mon.–Fri.)
6:00-8:30 p.m.	2200-0030	Ankara, Turkey	G	9.515, 11.88
6:30-7:00 p.m.	2230-2300	Jerusalem, Israel	G	7.4125, 9.435, 9.63, 9.815, 11.655
		Moscow, U.S.S.R.	G	5.94, 6.125, 7.10, 7.115, 7.205, 7.355, 7.44
6:30-7:20 p.m.	2230-2320	Johannesburg, S. Africa	G	5.98, 9.585, 11.90
6:30-8:30 p.m.	2230-0030	Ankara, Turkey	G	9.515, 11.88
6:45-7:30 p.m.	2245-2330	London, England	G	5.975, 6.175, (via Sackville), 7.325, 9.58
6:50-7:10 p.m.	2250-2310	**Santiago, Chile	F	9.566, 11.81, 15.15
7:00-7:30 p.m.	2300-2330	Stockholm, Sweden	G	6.045, 6.12, 9.695
		London, England	G	5.975, 6.175 (via Sackville), 7.325, 9.58 (via Ascension)
		Vilnius, U.S.S.R.	G	7.15, 7.215, 7.245, 7.29, 7.32, 7.40
7:00-7:50 p.m.	2300-2350	**Buenos Aires, Argentina	G	11.71 (Mon.-Fri.)
7:00-9:30 p.m.	2300-0130	Moscow, U.S.S.R.	G	5.94, 6.125, 7.10, 7.115 (via Bulgaria), 7.205, 7.355, 7.44
7:30-7:55 p.m.	2330-2355	Helsinki, Finland	P	11.755
7:30-11:30	2330-0330	London, England	G	5.975, 6.12 (via Sackville), 6.175 (via Antigua), 7.325, 9.51 (via Sackville; from 0030, Greenville), 9.58 (from 0030, via Ascension)
7:45-8:45 p.m.	2345-0045	Tokyo, Japan	F	11.705, 15.30
8:00-8:25 p.m.	0000-0025	Tirana, Albania	G	7.065, 9.75
8:00-8:30 p.m.	0000-0030	Oslo, Norway	F	6.18, 9.645 (Sun.)
8:00-8:55 p.m.	0000-0055	Sofia, Bulgaria	G	9.70 (alternate 9.705, 7.115)
		Peking, China	G	11.675, 11.945, 15.06
8:00-9:00 p.m.	0000-0100	**VOA, Washington, USA	G	6.19, 9.67, 11.83, 11.895
8:00-10:45 p.m.	0000-0245	**Luxembourg	F	6.09
8:00 p.m.-1:06 a.m.	0000-0506	**Montreal, Canada (Northern Service)	F	6.195, 9.625 (includes Eskimo, etc.)
8:15-8:30 p.m.	0015-0030	Athens, Greece	F	9.76, 11.73
8:15-8:45 p.m.	0015-0045	Brussels, Belgium	F	9.725 (varies)
8:40 p.m.-1:00 a.m.	0040-0700	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.915
9:00-9:15 p.m.	0100-0115	Vatican, City	G	5.995, 6.015, 9.605, 11.70
9:00-9:20 p.m.	0100-0120	Rome, Italy	F	6.01, 9.575
9:00-9:30 p.m.	0100-0130	Montreal, Canada	G	9.535
9:00-9:45 p.m.	0100-0145	Berlin, Ger. Dem. Rep.	P	9.73
9:00-9:55 p.m.	0100-0155	Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 9.63, 9.74
9:00-11:00 p.m.	0100-0300	Melbourne, Australia	F	15.32, 17.795
9:00-11:30 p.m.	0100-0330	Havana, Cuba	G	9.685, 11.725
9:00 p.m.-12 mdt.	0100-0400	Madrid, Spain	G	6.065, 11.88 (exc. Sun.)
9:10-9:30 p.m.	0110-0130	**Santiago, Chile	F	9.566, 11.81, 15.15
9:30-9:50 p.m.	0130-0150	Cologne, Ger. Fed. Rep.	G	6.01, 6.04 (via Antigua), 6.075, 6.10 (via Malta), 9.565, 9.605, 11.685 (via Malta)
9:30-9:55 p.m.	0130-0155	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
9:30-10:25 p.m.	0130-0225	Bucharest, Rumania	F	5.99, 6.19, 9.57, 9.69, 11.775, 11.94
9:30-11:00 p.m.	0130-0300	Moscow, U.S.S.R.	G	5.94, 6.07 (via Sofia), 6.125, 7.105, 7.115 (via Bulgaria), 7.205, 7.355, 7.44
9:45-10:15 p.m.	0145-0215	Berne, Switzerland	G	5.965, 6.135, 9.725, 11.715
10:00-10:30 p.m.	0200-0230	Budapest, Hungary	F	6.00, 7.215, 9.585, 11.91 (Exc. Sun.)
		Oslo, Norway	P	6.18, 9.645 (Sun.)
		Montreal, Canada	G	9.605, 9.655
		Warsaw, Poland	P	6.095, 6.135, 7.27, 9.675, 11.815, 11.84, 15.12
10:00-10:55 p.m.	0200-0255	Peking, China	F	9.94, 12.015, 12.055, 15.06
10:00-11:20 p.m.	0200-0320	Hilversum, Holland	G	6.165 (via Bonaire)†
10:00-11:30 p.m.	0200-0330	Cairo, Egypt	G	7.12, 9.475
10:10-10:30 p.m.	0210-0230	**Santiago, Chile	F	9.566, 11.81, 15.15
10:15-10:30 p.m.	0215-0230	Athens, Greece	F	9.76, 11.73
10:30-10:55 p.m.	0230-0255	Tirana, Albania	G	6.20, 7.30
10:30-11:00 p.m.	0230-0300	Stockholm, Sweden	F	6.115, 9.695
10:30-11:15 p.m.	0230-0315	Berlin, Ger. Dem. Rep.	P	9.73
11:00-11:30 p.m.	0300-0330	Budapest, Hungary	F	6.00, 7.215, 9.585, 11.91 (Tues., Fri.)
		Kiev, U.S.S.R.	G	5.98, 7.215, 7.245, 7.39, 7.40, 9.78
		Lisbon, Portugal	F	6.025, 11.935
11:00-11:35 p.m.	0300-0335	Warsaw, Poland	P	6.095, 6.135, 7.27, 9.675, 11.815, 15.12
11:00-11:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (both via Tirana)
		Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 9.63, 9.74
11:00 p.m.-12 mdt.	0300-0400	Moscow, U.S.S.R.	G	5.94, 6.07 (via Sofia), 6.125, 7.115 (via Bulgaria), 7.205, 7.355, 7.44
11:10-11:30 p.m.	0310-0330	**Santiago, Chile	F	9.566, 11.81, 15.15

11:30-11:55 p.m.	0330-0355	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
11:30 p.m.-12:30 a.m.	0330-0430	London, England	G	5.975, 6.175 (via Antigua)
11:30 p.m.-12:50 a.m.	0330-0450	Havana, Cuba	G	9.685, 11.725, 11.76
12:00 mdt.-12:15 a.m.	0400-0415	Budapest, Hungary	F	6.00, 7.215, 9.585, 11.91 (Tues., Fri.)
12:00 mdt.-12:25 a.m.	0400-0425	Bucharest, Rumania	F	5.99, 6.155, 6.19, 9.57, 9.69, 11.775, 11.94
12:00 mdt.-12:30 a.m.	0400-0430	Oslo, Norway	F	6.18, 9.645 (Sun.)
12:30-1:00 a.m.	0430-0500	London, England	G	6.175 (via Antiqua)
		Tirana, Albania	G	7.30, 9.48
12:50-2:00 a.m.	0450-0600	Havana, Cuba	G	11.725, 11.76
1:00-1:15 a.m.	0500-0515	Jerusalem, Israel	G	5.90, 7.425, 9.63, 9.82, 11.96, 12.045
1:00-1:30 a.m.	0500-0530	Lisbon, Portugal	F	6.025, 11.935
1:00-2:30 a.m.	0500-0630	London, England	G	6.175, 9.51 (both via Antigua)
2:30-3:30 a.m.	0630-0730	London, England	G	6.175 (via Antigua)

TO WESTERN NORTH AMERICA

TIME-PDT	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
4:00-4:15 a.m.	1100-1115	Tokyo, Japan	P	5.99
4:00-5:25 a.m.	1100-1225	Trans-World Radio, Bonaire, N.A.	G	11.815
4:00-6:00 a.m.	1100-1300	London, England	G	5.99 (via Sackville), 6.195 (via Antigua),
4:00-7:00 a.m.	1100-1400	**VOA, Washington, USA	G	5.955, 9.73
		**4VEH, Cap-Haitien, Haiti	G	9.77, 11.835
5:00-5:15 a.m.	1200-1215	Tokyo, Japan	P	5.99
5:00-5:30 a.m.	1200-1230	**Tashkent, U.S.S.R.	F	9.60, 11.925
5:10-5:30 a.m.	1210-1230	**Santiago, Chile	F	6.195, 9.566, 11.81
5:15-5:30 a.m.	1215-1230	HCJB, Quito, Ecuador	G	11.745
5:15-5:45 a.m.	1215-1245	Copenhagen, Denmark	F	15.165 (Sat.)
5:30-6:20 a.m.	1230-1320	Trans-World Radio Bonaire, N.A.	G	15.255 (Sat.; 1420 Sun.)
5:30-9:30 a.m.	1230-1630	HCJB, Quito, Ecuador	G	11.745, 15.115
6:00-6:15 a.m.	1300-1315	Tokyo, Japan	P	5.99
6:00-6:30 a.m.	1300-1330	London, England	G	5.99 (via Sackville), 6.195 (via Antigua), 11.775 (via Antigua; Sat., Sun. from 1200)
6:30-6:50 a.m.	1330-1350	**Santiago, Chile	F	6.195, 9.566, 11.81
6:30-8:00 a.m.	1330-1500	**Delhi, India	F	11.81
7:00-7:30 a.m.	1400-1430	Tokyo, Japan	G	9.505
		**Tashkent, U.S.S.R.	G	9.60, 11.925
7:00-8:20 a.m.	1400-1520	**Hilversum, Holland	G	11.74 (via Talata)†
7:00-9:55 a.m.	1400-1655	Manila, Philippines (VOP)	F	9.58 (Closes 1555 Sun.)
8:00-8:15 a.m.	1500-1515	Tokyo, Japan	G	9.505
8:00-9:00 a.m.	1500-1600	London, England	G	17.84 (via Ascension) also 9.58 (via Sackville Sat., Sun.)
9:00-9:15 a.m.	1600-1615	Tokyo, Japan	G	9.505
		London, England	G	9.58, 15.365 (via Sackville), 17.84 (via Ascension)
9:04-9:56 a.m.	1604-1656	**Paris, France	G	11.705, 11.89, 11.93, 11.965, 15.20, 15.30, 15.425, 17.72, 17.80, 17.82, 17.85, (after Sept. 24; 1704-1756)
9:15-9:45 a.m.	1615-1645	Copenhagen, Denmark	F	15.165 (Sat.)
9:15-10.09 a.m.	1615-1709	London, England	G	9.58, 15.365
9:42-9:50 a.m.	1642-1650	Hilversum, Holland	G	15.19, 17.775 (alt. 17.825; Mon.-Fri., via Bonaire)
10:00-10:15 a.m.	1700-1715	Tokyo, Japan	G	9.505
10:00 a.m.-1:00 p.m.	1700-2000	**Kuwait, Kuwait	G	9.555, 12.085 (varies)
10:09-10:45 a.m.	1709-1745	London, England	G	15.365; Sat., Sun. also 9.58 (both via Sackville)
11:00-11:15 a.m.	1800-1815	Tokyo, Japan	G	9.505
11:00-11:30 a.m.	1800-1830	**Kampala, Uganda	F	15.325, (Tues., Thur., Sat., Sun.)
		Oslo, Norway	F	11.85, 15.175 (Sun.)
11:45 a.m.-1:00 p.m.	1845-2000	**Abidjan, Ivory Coast	G	11.92 (Sun.)
12 noon-12:10 p.m.	1900-1910	**Papeete, Tahiti	F	11.825, 15.17 (exc. Sun.)
12:00-12:15 p.m.	1900-1915	Tokyo, Japan	G	15.105
1:00-1:15 p.m.	2000-2015	Tokyo, Japan	G	15.105
1:00-2:20 p.m.	2000-2120	Hilversum, Holland	G	11.73 (via Talata)†
1:15-2:00 p.m.	2015-2100	**Kampala, Uganda	F	9.73 (Sun., Mon. Wed., Fri.)
1:30-1:50 p.m.	2030-2050	**Santiago, Chile	F	9.566, 11.81, 15.15
2:00-2:15 p.m.	2100-2115	Tokyo, Japan	G	15.105
2:00-3:00 p.m.	2100-2200	**Brasilia, Brazil	G	11.78 (alternates 15.245)
12:15-3:00 p.m.	2115-2200	London, England	F	9.58, 11.78
3:00-3:15 p.m.	2200-2215	Tokyo, Japan	G	15.105
3:00-4:30 p.m.	2200-2330	London, England	G	6.175, 9.51 (both via Sackville)
3:00-5:00 p.m.	2200-2400	**VOA, Washington, USA	G	17.82, 17.895, 21.61
		Montreal, Canada	F	5.96 (Mon.-Fri.)
3:30-4:00 p.m.	2230-2300	Jerusalem, Israel	G	7.4125, 9.815, 11.655
3:30-4:20 p.m.	2230-2320	Johannesburg, S. Africa	G	5.98, 9.585, 11.90
3:30-5:30 p.m.	2230-0030	Moscow, U.S.S.R.	G	9.635, 12.05, 15.14, 15.18, 15.455, 17.72
3:50-4:10 p.m.	2250-2310	**Santiago, Chile	F	9.566, 11.81, 15.15
4:00-4:30 p.m.	2300-2330	Tokyo, Japan	G	15.105
		Vilnius, U.S.S.R.	G	9.61, 11.69, 15.10
4:30-6:00 p.m.	2330-0100	FEBC, Manila, Phillipines	F	17.81

4:30-8:30 p.m.	2330-0330	London, England	G	6.12 (via Sackville), 6.175 (via Antigua), 9.51 (via Sackville; from 0030, via Greenville), 9.58 (from 0030, via Ascension)
5:00-5:15 p.m.	0000-0015	Tokyo, Japan	G	15.105
5:00-6:00 p.m.	0000-0100	**VOA, Washington, USA	G	11.83, 11.895, 15.40
5:30-6:00 p.m.	0030-0100	Moscow, U.S.S.R.	G	9.635, 9.78, 12.05, 15.14, 15.18, 15.445
		Kiev, U.S.S.R.	G	9.61, 11.69, 15.10
5:40 p.m.-12 mdt.	0040-0700	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.915
6:00-6:15 p.m.	0100-0115	Tokyo, Japan	G	15.105
6:00-6:30 p.m.	0100-0130	Moscow, U.S.S.R.	G	9.635, 9.78, 12.05, 15.14, 15.455
6:00-7:00 p.m.	0100-0200	Taipei, Taiwan	F	15.425, 17.89
6:00-8:00 p.m.	0100-0300	Melbourne, Australia	G	15.32, 17.795
6:00-9:00 p.m.	0100-0400	Madrid, Spain	G	6.065, 11.88 (exc. Sun.)
6:10-6:30 p.m.	0110-0130	**Santiago, Chile	F	6.195, 9.566, 11.81, 15.15
6:30-7:00 p.m.	0130-0200	Moscow, U.S.S.R.	G	9.635, 9.78, 11.86, 12.05, 15.14, 15.455
6:30-7:30 p.m.	0130-0230	Tokyo, Japan	G	15.195, 15.42, 17.725, 17.825
7:00-8:00 p.m.	0200-0300	Moscow, U.S.S.R.	G	9.635, 9.735, 9.78, 11.86, 12.05, 15.14, 15.455
7:30-8:00 p.m.	0230-0300	Stockholm, Sweden	P	6.115, 9.695
8:00-8:15 p.m.	0300-0315	Tokyo, Japan	G	15.105
8:00-8:30 p.m.	0300-0330	Kiev, U.S.S.R.	G	9.58, 9.635, 9.78, 11.86
		Montreal, Canada	G	5.96, 6.00, 9.605, 9.655
		Moscow, U.S.S.R.	G	9.735, 12.05, 15.455
8:00-8:50 p.m.	0300-0350	Taipei, Taiwan	G	11.825, 15.345, 17.89
8:00-8:55 p.m.	0300-0355	Peking, China	G	7.12 (via Tirana) 9.46, 9.78 (via Tirana), 11.65, 12.055, 15.06, 17.53
8:00-9:20 p.m.	0300-0420	**Johannesburg, S. Africa	F	5.98, 7.27
8:10-8:30 p.m.	0310-0330	**Santiago, Chile	F	6.195, 9.566, 11.81, 15.15
8:20-9:25 p.m.	0320-0425	**TIFC, San Jose, Costa Rica	F	5.055, 6.035, 9.645, (opens 0300 Sat., Sun.)
8:22-8:28 p.m.	0322-0328	Erevan, U.S.S.R.	G	9.54, 11.69, 11.75, 15.14 (Sat./Tue./Wed./Fri.)
8:30-9:15 p.m.	0330-0415	Berlin, Ger. Dem. Rep.	P	5.955, 6.08, 9.73
8:30-9:30 p.m.	0330-0430	Moscow, U.S.S.R.	G	6.03, 6.07, 6.15, 6.185, 7.13, 7.175, 9.58, 9.635, 9.735, 9.78
8:30-10:00 p.m.	0330-0500	London, England	G	6.175 (via Antigua)
9:00-9:15 p.m.	0400-0415	Tokyo, Japan	G	9.505
9:00-9:30 p.m.	0400-0430	Oslo, Norway	F	11.87 (Sun.)
		Budapest, Hungary	F	6.00, 7.215, 9.585, 11.91 (Tue. Fri.)
		Montreal, Canada	G	5.96, 9.655
9:00-9:55 p.m.	0400-0455	Peking, China	G	11.65, 12.055, 15.06, 17.53
9:30-10:00 p.m.	0430-0500	Berne, Switzerland	G	6.045, 9.725
		Vienna, Austria	P	6.015
		Sofia, Bulgaria	G	7.115, (alternate 9.70, 9.53)
9:30 p.m.-12:30 a.m.	0430-0730	Moscow, U.S.S.R.	G	6.03, 6.07, 6.15, 6.185, 7.13, 7.175, 7.29, 9.58, 9.635, 9.735
10:00-10:15 p.m.	0500-0515	Jerusalem, Israel	F	5.90, 7.4125, 9.63, 9.82, 11.96, 12.045
		Tokyo, Japan	G	9.505
10:00-10:30 p.m.	0500-0530	Lisbon, Portugal	F	6.025, 11.935
10:00-11:20 p.m.	0500-0620	Hilversum, Holland	G	6.165, 9.715, (via Bonaire)†
10:00-11:30 p.m.	0500-0630	London, England	G	6.175, 9.51, (both via Antigua)
10:00 p.m.-12 mdt.	0500-0700	**Wellington, New Zealand	G	6.105, 9.54
10:30-10:50 p.m.	0530-0550	Cologne, Ger. Fed. Rep.	G	5.96 (via Antigua) 6.10 (via Malta), 6.185, 9.545, 9.625 (via Montserrat)
11:00-11:15 p.m.	0600-0615	Tokyo, Japan	G	9.505
11:00-11:30 p.m.	0600-0630	Oslo, Norway	P	9.645, 11.87 (Sun.)
11:00 p.m.-12 mdt.	0600-0700	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
11:25 p.m.-1:55 a.m.	0625-0855	**Kuala Lumpur, Malaysia	G	9.75, 15.29
11:30 p.m.-12:30 a.m.	0630-0730	London, England	G	6.175 (via Antigua)
11:30 p.m.-12:50 a.m.	0630-0750	**Hilversum, Holland	G	9.63 (via Bonaire)†
11:30 p.m.-1:00 a.m.	0630-0800	Havana, Cuba	G	9.525
12:00-12:15 a.m.	0700-0715	Tokyo, Japan	G	9.505
12:00-3:30 a.m.	0700-1030	**Wellington, New Zealand	G	6.105
1:00-1:15 a.m.	0800-0815	Tokyo, Japan	G	9.505
1:00-3:00 a.m.	0800-1000	Manila, Philippines (VOP)	F	11.85
1:00-7:00 a.m.	0800-1400	**Port Moresby, Papua-New Guinea	G	4.89
2:00-2:15 a.m.	0900-0915	Tokyo, Japan	G	9.505
2:30-2:50 a.m.	0930-0950	**Santago, Chile	G	6.195, 9.566, 11.81
3:00-3:30 a.m.	1000-1030	Tokyo, Japan	G	5.99
3:00-3:50 a.m.	1000-1050	Pyongyang, Dem. P. Rep. Korea	G	7.203
3:50-4:10 a.m.	1050-1110	**Santiago, Chile	G	6.195, 9.566, 11.81

*Reception quality, East Coast (West Coast) location: G-good, F-fair, P-poor

**Not intended for North America, but receivable satisfactorily

†As of November, Radio Nederland, Hilversum, will reduce duration of English broadcasts from current 100 minutes to 50 minutes. Some starting times may change.

Days refer to local date in target area.

Operation Assist

If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist, POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)

United States Radio and TV Corp. "Neutrodyne" electric receiver (chassis 41— circa 1920's). Schematic diagram and parts list. John C. Whybrew, Box 387, Upland, IN 46989.

Heathkit Model 05 oscilloscope. Need service manual or any repair information. Andy Foremiak, Box 224, North Tonawanda, NY 14120.

Zenith combination AM, FM100, FM45 and 78 record player (chassis #8C21). Schematics and parts list or service manual. Dennis Main, Rt. 6, Box 218, Muncie, IN 47302.

Paco Model S-50 push-pull oscilloscope. Schematics and/or parts source. G. Denman, Rt. 3 Box 164, Grapeland, TX 75844.

Standard Model SR-500U AM/FM stereo receiver. Need H-203 IC (Sanyo part number LD 3141). William F. Gerdes, 732 Bowen St., Oshkosh, WI. 54901.

Waterman Model S-14-B oscilloscope. Manual or schematic. **Xam Mark** 2TA solid-state stereo amplifier. Output transistor number and/or schematic. John Schmitt, Jr., 16 Carlson Parkway, Cedar Grove, NJ 07009.

Weston Model 802 VU meter. Need source to match replacement in Dumont 137-P mixer. Rich Adams, 2303 Dulaire Rd., Greensboro, NC 27407.

Tektronix Type 315R oscilloscope. Schematic and/or operation manual. Tom Ramos, 2813 15th Ave. So., Minneapolis, MN 55407.

Bradford Model 51847 multiband portable radio. Schematic and/or service manual. Rex Faulkner, 2677 Estelle Ct., Smyrna, GA 30080.

Friden Model 130 calculator, **Triumph** Model 850 oscillograph, **Superior Instruments** Model TV-50A "Genometer" signal generator, **Lear** vhf-lf receiver, LRA-6A lf receiver and RT-10E transmitter, and **Omnirange** Model 2214A converter. Schematics, operation manuals and service information. James Marple, 2801 Sequoia Ln., Arlington, TX 76010.

Trio Model 9R-59D radio. Operation manual needed. Ed Davis, 831 N. Superior Ave., Decatur, GA 30033.

Hallicrafters Model S-22R (U.S. Navy version). Schematic and any other available information. T. Thompson, 330 Sunset Blvd. S.W. #19, Renton, WA 98055.

Hammarlund Model CB-23 transceiver. Schematic and/or service manual. E.R. Stutler, 934 Edison Ave., New Port Richey, FL 33552.

RCA Model WO-56A oscilloscope and **Dumont** Type 304A oscilloscope. Schematic and/or service calibration data. Mr. James A. Fillingham, Rte. 1 Box 380-A, Pelzer, SC 29669.

Philco Model 39-7 radio/phono combination console. Any available information. Don Sherr, 509 Hannes St., Silver Spring, MD 20901.

Nipon Model 141-DA "Busicom" electronic calculator. Schematic needed. Dale Williams, 134 Stage Rd., Newport News, VA 23606.

Bogen Model CHB-100 PA amplifier. Schematic, parts list or manual. Brian Burke, 5737 S. Maryland, Chicago, IL 60637.

Hammarlund Model HQ-100 receiver. Schematic, alignment information or any available data. Jeff Kientz, 15 E. Forest, Columbia, MO 65201.

Sencore "Caddy" bar generator. Owners manual needed. Wilbur Hostetter, 12472 136th St., Largo, FL 33540.

Accurate Instrument Co. Model 157 tube tester. Operating instructions needed. Ralph A. Ladnier, 4026C FCN, McGuire AFB, NJ 08641.

Grundig Model 8034-3435 (chassis #2) stereo record player. Schematic diagram needed. M.A.H. Siddiqi, 2121 N. Western Ave., Chicago, IL 60647

Precise Model 30 oscilloscope. Need operating instructions. Anthony Vilale, 5222 9th Ave., Brooklyn, NY 11220.

Electronics Library

110 CMOS DIGITAL IC PROJECTS

by R.M. Marston

If the schematics and typeface look a little different, it's because this book was first published in England. After a short introduction to COSMOS, the 110 projects are divided into six chapters of increasing complexity: 15 inverter, gate and logic circuits, 25 multivibrators, 10 dc lamp control, 25 relay switching, 25 sound generator and alarm, and 15 counting and dividing circuits. Nearly every circuit uses the RCA CD4001 quad 2-input NOR gate (same as Motorola MC14001); though the CD4013 dual D-type flip-flop (Motorola MC14013) is used a couple of times.

Published by Hayden Book Co., 50 Essex St., Rochelle Park, NJ 07662. 114 pages. $4.95 soft cover.

ARRL HAM RADIO OPERATING GUIDE

by the ARRL Headquarters Staff

This operating manual introduces the reader to the many different operating practices and interests within the hobby of amateur radio. It contains ten chapters, entitled: Getting Started; Message Handling—Fun with a Purpose; Contests—a Sure Way to Sharpen Skills; The Basic Intrigue of DX; Logging + QSLing = Awards; Repeaters—All the Ins and Outs; The Flea-Power Challenge; Communicating Visually; Vhf/uhf—Searching for New Horizons; Oscar—the New Frontier. Included are tips on operating frequencies, propagation conditions on each band, power levels, and a helpful appendix.

Published by the American Radio Relay League, 225 Main Street, Newington, CT 06111. 128 pages (8¼" × 11"). $4.00 in the USA and possessions, $4.50 elsewhere (soft cover).

LIGHT-BEAM COMMUNICATIONS

by Forrest Mims, III

The use of light beams to convey information is covered in this book. The history of the science is traced from primitive signal fires to sophisticated laser-beam communications links. Modern systems are covered by analysis of modulators, transmitters, detectors, transmission lines (fibre optics and waveguides), carrier sources, receivers, and "antennas." Atmospheric absorption is also discussed. The final chapter highlights experimental and operational systems developed since 1960.

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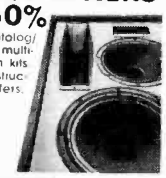

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7404	21	7451	27	74125	60
7405	24	7453	27	74126	81
7406	45	7454	41	74132	3 00
7407	45	7460	22	74141	1 15
7408	25	7472	39	74150	1 10
7409	25	7473	45	74151	1 25
7410	20	7474	45	74153	1 35
7411	30	7475	80	74154	1 25
7413	85	7482	1 75	74155	1 21
7416	43	7483	1 15	74157	1 30
7417	43	7485	1 12	74161	1 45
7420	21	7486	45	74164	1 65
7422	1 50	7489	2 49	74165	1 65
7425	43	7490	69	74166	1 70
7427	37	7491	1 20	74174	1 95
7428	33	7492	82	74175	1 95
7430	26	7493	82	74180	1 05
7432	31	7494	91	74181	3 55
7437	47	7495	91	74191	1 50
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4002AE	29	4023AE	29
4007AE	29	4024AE	1 50
4009AE	58	4025AE	35
4010AE	58	4026AE	1 49
4011AE	29	4028AE	1 60
4012AE	29	4029AE	2 90
4013AE	52	4030AE	65
4015AE	1 25	4037AE	4 50
4016AE	65	4040AE	2 40
4018AE	1 10	4044AE	1 50
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MC1036L	12 50	MC3021P	2 15
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HA1159	6 60	STK015	6.50	TA7150P	4 55	UPC1020H	5 50
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2SB54	.70	2SC535	.75	2SC838	.70	2SC1383	.75	2SD352	.80
2SB56	70	2SC536	.65	2SC839	.85	2SC1384	.85	2SD380	5.70
2SB77	70	2SC537	.70	2SC922	.55	2SC1409	1.25	2SD389	.75
2SB128	2.25	2SC563	2.50	2SC929	.70	2SC1410	1.25	2SD390	.75
2SB152	4.50	2SC607	1.25	2SC930	.65	2SC1447	1.25		
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2SB405	.85	2SC687	2.50	2SC1017	1.50	2SC1760	2.15	SK3048	3.25
2SB407	1.65	2SC696	3.00	2SC1018	1.50	2SC1816	4.50	SK3049	4.75
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2SB531	3.00	2SC756	3.00	2SC1167	4.25	2SD65	.75	40080	1.25
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1N914	10	2N960	.90	2N2219A	.30	2N2913	.75	2N3740	1.00	2N4401	.16
		2N962	95	2N2221	.25	2N2914	1.20	2N3771	1.75	2N4402	.16
2N173	1.75	2N967	.95	2N2221A	.30	2N2916A	3.65	2N3772	1.90	2N4403	.20
2N174	3.50	2N1136	1 75	2N2222	.25	2N3019	.50	2N3773	3.00	2N4409	.16
2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.40	2N4410	.16
2N327A	1.15	2N1300	1.00	2N2223	1.00	2N3054	.70	2N3823	.70	2N4416	.75
2N334	1.20	2N1301	1.10	2N2270	.40	2N3055	.75	2N3856	.20	2N5061	.30
2N336	.90	2N1302	1.25	2N2323	1.00	2N3227	1.00	2N3866	.85	2N5064	.50
2N338A	1.05	2N1303	.70	2N2324	1.35	2N3247	3.40	2N3903	.16	2N5130	.20
2N398B	1.50	2N1304	1.25	2N2325	2.00	2N3250	.50	2N3904	.16	2N5133	.15
2N404	75	2N1305	.75	2N2326	2.85	2N3375	6.50	2N3905	.16	2N5138	.15
2N443	2.50	2N1306	1.35	2N2327	3.80	2N3393	.20	2N3906	.16	2N5198	3.75
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2N501A	3.00	2N1308	1.50	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5296	.50
2N508A	.45	2N1309	.90	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5306	.20
2N555	.75	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5354	.20
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2N677	6.00	2N1557	1.15	2N2712	.18	2N3442	1.85	2N4036	.75	2N5400	.40
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2N706B	.75	2N1605	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5457	.35
2N711	.90	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.16	2N5458	.30
2N711B	1.10	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.16	CIO3Y	.25
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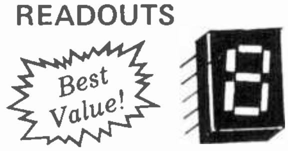

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74LS03	.26	74LS153	.70
74LS04	.30	74LS155	.69
74LS05	.32	74LS156	.76
74LS08	.26	74LS157	.95
74LS09	.26	74LS158	.85
74LS10	.26	74LS160	.85
74LS11	.35	74LS161	.85
74LS13	.58	74LS162	.85
74LS14	1.05	74LS163	.85
74LS15	.26	74LS168	.85
74LS20	.24	74LS169	.85
74LS21	.35	74LS170	2.00
74LS22	.35	74LS173	1.10
74LS26	.35	74LS174	1.00
74LS27	.35	74LS175	1.00
74LS30	.34	74LS190	.95
74LS32	.35	74LS191	.95
74LS37	.33	74LS192	.95
74LS38	.38	74LS193	.95
74LS40	.34	74LS194	.95
74LS42	.80	74LS195	.95
74LS51	.26	74LS196	.85
74LS54	.26	74LS197	.85
74LS55	.26	74LS251	.85
74LS73	.75	74LS253	.85
74LS74	.49	74LS257	.85
74LS76	.49	74LS258	.85
74LS86	.45	74LS260	.26
74LS90	.85	74LS266	.26
74LS92	1.00	74LS279	.55
74LS93	1.00	74LS290	.75
74LS109	.49	74LS293	.75
74LS112	.49	74LS295	.95
74LS113	.40	74LS298	.95
74LS114	.40	74LS365	.55
74LS125	.55	74LS366	.55
74LS126	.65	74LS367	.55
74LS132	1.00	74LS368	.55
74LS133	.35	74LS390	1.75
74LS136	.39	74LS393	1.45
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CD4001	.16
CD4002	.16
CD4007	.16
CD4009	.45
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CD4011	.16
CD4012	.16
CD4013	.29
CD4014	.75
CD4015	.75
CD4016	.29
CD4017	.80
CD4018	.80
CD4019	.39
CD4020	.85
CD4021	.90
CD4022	.90
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CD4046	.90
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CD4058	.90
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74C107	.29
CD4116	.39
CD4507	.40
CD4512	.50
CD4516	.85
CD4518	.85
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TTL

7400	.17	7473	.21
7401	.17	74H74	.45
7402	.17	7474	.35
7403	.17	7475	.55
74H04	.25	7476	.35
74S04	.30	7480	.45
7404	.17	7483	.76
7406	.25	7485	.89
7408	.17	7485	.35
7409	.17	7490	.71
7410	.17	7491	.71
7411	.25	7492	.71
7413	.45	7493	.67
7420	.17	7494	.90
7421	.17	7495	.71
7423	.35	7496	.85
7425	.27	74100	.96
7426	.25	74121	.31
7427	.17	74123	.61
7430	.25	74125	.44
7432	.30	74141	.71
7437	.35	74145	.97
7438	.35	74151	.71
7440	.17	74153	.81
7442	.60	74154	.97
7443	.60	74161	.91
7444	.65	74163	1.05
7446	.85	74164	1.05
74L47	1.75	74174	.91
7447	.81	74175	1.40
7448	.81	74180	.76
7450	.20	74181	2.25
7451	.17	74191	1.20
7453	.17	74192	1.20
7454	.17	74193	.95
7470	.35	74S195	1.05
7472	.21	74195	.65

LINEARS

LM301	30
LM307	30
LM309K	95
LM311	85
LM377	1 85
LM380 (8 pin)	75
LM3900	30
LM710	25
LM711	25
LM723	40
LM741	25
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NE553	1 95
NE555	.40
NE556	95
NE565	95
NE566	95
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1458	49
RCA3043	75
75491	.30
75492	.30

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- Freeze feat. on every mode
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- Field Tested over 1 Yr.
- 12 Hr., 60 Hz oper.

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OPTIONS — XTAL Time Base Components - $2.95 when purchased w/clock
Wood Clock Cabinet (A) — $4.00

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Includes: Filter & Back
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Dimensions (Inside)
A — 1-13/16"H, 5½"W, 4¾"D
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AC/DC - ALARM Clock Kit - 12/24 Hr.

$7.50 quantities of 1-5 $6.50 quantities of 6 & up

- Displays Hrs. & Min. - Switch to Min. & Secs. on Command.
- AM/PM Indication
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The kit will include a 5316 National Clock Chip, 4 Flourescent Display tubes, all electronic components, switches, controls & complete instructions, specs, etc. for clock and all optional Features. Other parts required or if desired are as follows:

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- Xformer (for AC oper.) — $1.00
- Speaker Alarm Kit — $2.00
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MM5314	$3.50
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Florescent Display gives Color Choice
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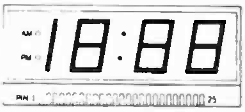

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Includes:
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Features:
- Hrs. & Min. Switch to Min. & Sec. on Command
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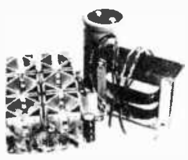

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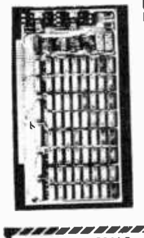

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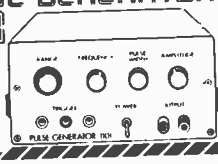

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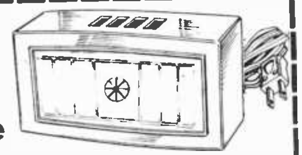

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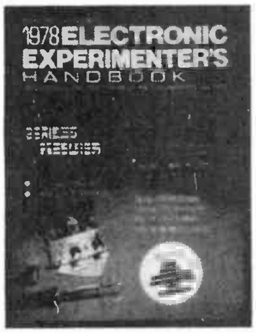

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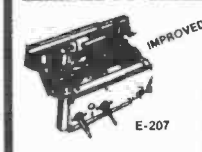

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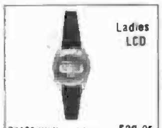

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- Connects almost one for one with 3817, 3817A or D (3817 available at $5.00 each).
- Typical segment current 8mA except colon, 10 hrs b & c and 10 min, a & d which are 16 mA
- Forward voltage drop 1.5 volts
- MAXIMUM FORWARD CURRENT — 25 mA

HP 5082-7300 Series — Multi-Digit

- ⅛" Ht. • Common Cathode • Dip Package
- 3 to 5 volts @ 5 mils per segment
- 7 segment Monolithic • Red Display

2 Digit	$ .79
3 Digit	.89
4 Digit	.99
5 Digit	1.19

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

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

SOLDERTAIL STANDARD (TIN)

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

SOLDERTAIL STANDARD (GOLD)

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

WIRE WRAP SOCKETS (GOLD) LEVEL #3

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

50 PCS. RESISTOR ASSORTMENTS $1.25 PER ASST.

SPECIAL

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

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$7.49 ea.**

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$34.95
batteries not included

- Battery Operated (Size C)
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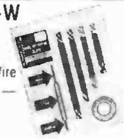
- Wraps 30 AWG Wire onto Standard DIP Sockets (.025 inch)

Complete with built-in bit and sleeve

WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP



- Tool for 30 AWG Wire
- Roll of 50 Ft. White or Blue 30 AWG Wire
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$11.95

WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

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 **$3.45 ea.**
- Cuts wire to desired length
- Strips 1" of insulation Specify — Blue-Yellow-White-Red

HEAT SINKS

205-CB 680-.75A

205-CB	Beryllium Copper w/Black finish for TO-5	$ .25
291-.36H	Aluminum for TO-220 Transistors & Regulators	$ .25
680-.75A	Black Anodized Aluminum for TO-3	$1.60
401-A	Black Anodized Aluminum — predrilled mounting holes for TO-3	$1.75

DIP SWITCHES SPST Slide Action

#206-4	(8 pin dip)	4 switch unit	$1.75 ea.
#206-7	(14 pin dip)	7 switch unit	$1.95 ea.
#206-8	(16 pin dip)	8 switch unit	$2.25 ea.

TV GAME CHIP SET — $14.95

Includes AY-3-8500-1 chip and 2.010 mhz crystal — if purchased separately would cost $18.95.

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400mm	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	8/1.00	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	6/1.00	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	1.50
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	$1.95
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2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1.95

TRANSISTORS

MPS A05	5/$1.00			PN4249	4/$1.00
MPS A06	5/$1.00			PN4250	4/$1.00
2N2219A	3/$1.00	PN3567	3/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	PN3568	4/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	PN3569	4/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3704	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3705	5/$1.00	2N4409	5/$1.00
2N2484	4/$1.00	2N3706	5/$1.00	2N5086	4/$1.00
2N2906A	4/$1.00	2N3707	5/$1.00	2N5087	4/$1.00
2N2907A	5/$1.00	2N3711	5/$1.00	2N5088	4/$1.00
2N2925	5/$1.00	2N3724	$ .65	2N5089	4/$1.00
2N3053	2/$1.00	2N3725	$1.00	2N5129	5/$1.00
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		2N4123	10/$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	.15	.13	.10	1.0/16V	.15	.13	.10
4.7/25V	.16	.14	.12	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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300	$ .71	373	2.42	723	.62
301	.29	376	.68	733	.89
302	.53	380	1.30	739	1.07
304	.80	380-8	1.25	741	.32
305	.71	381	1.75	747	.71
307	.26	382	1.75	748	.35
308	.89	531	2.95	1458	.62
309k	1.35	540	2.95	1800	2.48
310	1.07	550	.79	3900	.49
311	.95	555	45	7524	.71
319	1.13	556A	1.19	7525	.90
320T	1.39	560	3.39	8038	4.25
320K	1.39	562	3.39	8864	2.25
322	1.70	565	1.18	75150	1.75
324	1.52	566	1.95	75451	.35
339	1.58	567	1.95	75452	.35
340K	1.69	709	.26	75453	.35
340T	1.49	710	.35	75491	.71
372	2.93	711	.26	75492	.80

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TTL

7400	.13	7451	.17	74153	.89
7401	.16	7453	.17	74154	1.20
7402	.15	7454	.17	74155	.97
7403	.15	7460	.17	74156	.97
7404	.16	7464	.35	74157	.99
7405	.19	7465	.35	74158	1.79
7406	.26	7470	.30	74160	1.23
7407	.28	7472	.30	74161	.97
7408	.29	7473	.35	74162	1.39
7409	.19	7474	.28	74163	1.09
7410	.16	7475	.49	74164	.99
7411	.25	7476	.30	74165	.99
7413	.43	7483	.68	74166	1.25
7414	.65	7485	.88	74170	2.10
7416	.35	7486	.40	74173	1.49
7417	.35	7489	2.25	74174	1.23
7420	.16	7490	.43	74175	.97
7422	.30	7491	.75	74176	.89
7423	.29	7492	.48	74171	.84
7425	.27	7493	.48	74180	.90
7426	.26	7494	.78	74181	2.45
7427	.29	7495	.79	74182	.79
7430	.20	7496	.79	74184	1.90
7432	.23	74100	.98	74185	2.20
7437	.25	74105	.44	74187	5.75
7438	.25	74107	.37	74190	1.15
7440	.15	74121	.38	74191	1.25
7441	.89	74122	.38	74192	.95
7442	.59	74123	.65	74193	.85
7443	.73	74125	.54	74194	1.25
7444	.73	74126	.58	74195	.74
7445	.73	74132	.89	74916	1.25
7446	.81	74141	1.04	74197	.73
7447	.79	74145	1.04	74198	1.73
7448	.79	74150	.97	74199	1.69
7450	.17	74151	.79	74200	5.45

IC SOCKETS
Solder Tail - low profile

8 pin	$ .17	24 pin	.42
14 pin	.20	28 pin	.59
16 pin	.22	40 pin	.69
18 pin	.29		

Date sheets on request. Add 30¢ each if item is priced below $1.00 each.

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380-8	mDIP	1.09
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1 x 8K EROM

4 Digit Clock Kit
MM5312 and 4 NS71 .27" displays 12-24 hours, 50-60 Hz. One P.C. board accommodates clock, displays, and all necessary transistors, resistors, capacitors, diodes, 2 switches, complete instructions and schematics for assembly.
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MM5369 Divider mDIP $2.35
Crystal 3.58 MHZ color TV $1.50

CARBON FILM RESISTORS ±5%
ALL STANDARD VALUES
¼ OR ½ WATT

QTY.	PRICE (each)	PRICE (Minimum 10 per value)
0-10	$.10 ea	
10-100	$.10 ea	$.05 ea
100-1000		$.04 ea

METAL FILM RESISTORS
ALL STANDARD VALUES
± 1% ¼ WATT

QTY	PRICE EACH	PRICE MINIMUM 10 PER VALUE	PRICE MINIMUM 100 PER VALUE
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10 - 100	.20	$.15	
100 - 1000		.10	$.09
1000 -		.10	.08

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AY51013A **$6.95**

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8008 $16.95
8080A $16.95

TANTALUM CAPACITORS
Solid dipped +20%

.1 mfd	35V	$ .25	10 mfd	16V	$ .40
.33 mfd	35V	.25	10 mfd	25V	.45
1 mfd	35V	.25	15 mfd	10V	.40
2.2 mfd	20V	.25	15 mfd	20V	.45
2.2 mfd	35V	.30	22 mfd	16V	.45
3.3 mfd	35V	.30	33 mfd	10V	.40
4.7 mfd	16V	.30	47 mfd	6V	.40
6.8 mfd	6V	.30	56 mfd	6V	.45
6.8 mfd	50V	.40	150 mfd	15V	.50

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QUAD BI-LATERAL SWITCH

Carbon Film · 5%
1/4 WATT 04255
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2200 resistors 44 values supplied in a 15 drawer 60 compartment storage cabinet — table or wall mount Ready to use

RESISTOR KIT
~~$74.95~~ ea.
SHIPPING CHG $2.00

RESISTOR ASSORTMENT
50 RESISTORS PER VALUE

1.5	47	470	3.9K	33K	150K	1.0M	
3.3	68	680	4.7K	39K	220K	1.5M	
6.8	100	1.0K	6.8K	47K	330K	2.2M	
10	150	1.5K	10K	68K	470K	3.3M	
15	220	2.2K	15K	100K	680K	4.7M	
22	270	2.7K	22K				
36	330	3.3K	27K				

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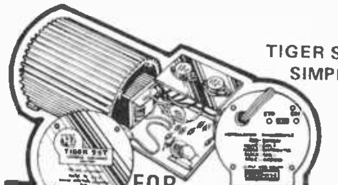

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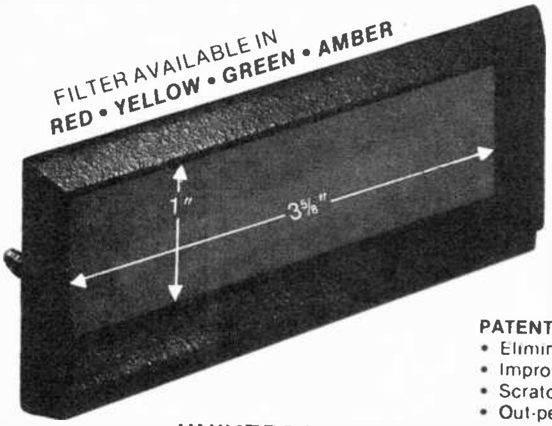

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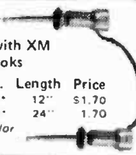

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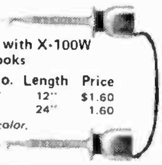

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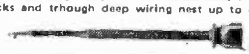

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.0022	1000	.14	.027	400	.15	.33	100	.30
.0027	1000	.14	.033	250	.15	.39	100	.33
.0033	1000	.14	.039	250	.15	.47	100	.36
.0039	630	.14	.047	250	.15	.56	100	.44
.0047	630	.14	.056	250	.15	.68	100	.47
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.22	35	.33	3.3	35	.42	15.0	35	1.32
.33	35	.33	4.7	35	.45	22.0	16	.45
.47	35	.33	6.8	16	.40	33.0	20	1.32
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1	25	.14	10	35	.22	33	50	.30	220	10	.23	470	16	.40
1	35	.15	10	50	.26	47	10	.17	220	16	.25	470	25	.45
1	50	.16	22	10	.15	47	16	.18	220	25	.35	470	35	.60
5	10	.13	22	16	.16	47	25	.24	220	35	.40	470	50	.80
5	16	.14	22	25	.21	47	35	.25	220	50	.50	1000	25	.65
5	25	.17	22	35	.23	47	50	.32	330	10	.30	1000	35	.80
5	35	.20	22	50	.28	100	10	.18	330	16	.33	1000	50	1.20
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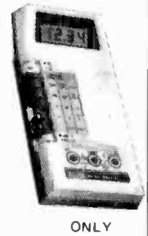

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2N929	.26	2N2925	.22	2N3711	.20	2N4142	18	2N4994	.30	2N5367	.50	2N6015	.68
2N930	.28	2N2926	.15	2N3721	.20	2N4143	18	2N5086	.30	2N5368	25	2N6027	.50
2N1132	.35	2N3019	.90	2N3724	.50	2N4220A	1.00	2N5087	.30	2N5369	26	2N6028	.60
2N1613	.32	2N3053	.36	2N3725	.52	2N4224	1.25	2N5088	.30	2N5370	28	2N6034	.92
2N1711	.34	2N3054	.90	2N3731	3.60	2N4228	.40	2N5089	.40	2N5373	.28	2N6035	1 00
2N1893	.36	2N3055	1.00	2N3740	1.20	2N4235	1.80	2N5109	1.90	2N5375	.28	2N6037	.92
2N2102	.40	2N3375	6.30	2N3741	1.50	2N4237	1.20	2N5131	.20	2N5383	.58	2N6076	20
2N2160	1.50	2N3391A	.25	2N3771	2.40	2N4238	1.30	2N5133	18	2N5397	2.50	2N6099	80
2N2218	.26	2N3392	.28	2N3772	2.50	2N4248	.22	2N5134	.20	2N5418	30	2N6101	1 06
2N2218A	.26	2N3393	.22	2N3773	3.90	2N4249	.18	2N5172	.20	2N5419	35	2N6103	1 10
2N2219	.26	2N3414	.20	2N3789	3 00	2N4250	24	2N5179	.50	2N5420	40	2N6121	66
2N2219A	.26	2N3416	.22	2N3819	40	2N4256	.20	2N5190	80	2N5447	30	2N6122	68
2N2221	.20	2N3417	.22	2N3823	70	2N4258	.32	2N5191	.80	2N5448	30	2N6123	.88
2N2221A	.25	2N3440	1 00	2N3859	22	2N4348	2.10	2N5194	.80	2N5449	.25	2N6124	.80
2N2222	.22	2N3442	1.80	2N3860	20	2N4395	1.30	2N5210	.15	2N5450	20	2N6125	68
2N2222A	.24	2N3553	1.80	2N3866	1 10	2N4400	.25	2N5219	.20	2N5451	25	2N6126	.88
2N2368	.30	2N3563	.15	2N3877A	29	2N4401	.25	2N5220	20	2N5457	.60	2N6218	64
2N2369	.26	2N3564	.16	2N3903	20	2N4402	30	2N5221	.20	2N5458	45	2N6219	.60
2N2369A	.26	2N3565	.18	2N3904	22	2N4403	.40	2N5223	.20	2N5484	60	2N6220	.58
2N2476	.60	2N3567	.19	2N3905	20	2N4409	.30	2N5225	.18	2N5490	70	2N6222	.30
2N2484	.30	2N3568	.30	2N3906	22	2N4416	.90	2N5227	.24	2N5777	.60	2N6223	30
2N2605	.50	2N3569	.18	2N3955	2.70	2N4425	.44	2N5232	.32	2N5778	55	2N6224	.32
2N2608	2.00	2N3638	.20	2N3957	1.50	2N4427	1.00	2N5232A	.25	2N5811	40	2N6225	34
2N2646	.70	2N3638A	.22	2N3958	1.60	2N4858	1.00	2N5249	.40	2N5817	40		
2N2647	.95	2N3642	.20	2N3962	.35	2N4898	1 10	2N5294	70	2N5818	40		
2N2713	.25	2N3643	.20	2N3970	1.20	2N4918	.60	2N5296	70	2N5819	45		
2N2904	.35	2N3645	.20	2N4032	.60	2N4919	60	2N5298	70	2N5822	58		

NEW from CSC

MAX-100 FREQ COUNTER
- 20 Hz to 100MHz
- 8 Digit Accuracy
- .6" LED Display

The max-100 is accurate enough for laboratory or field-service applications and priced low enough for educational or hobbyist use.

Frequency Characteristics Range: 20 Hz to 100 MHz (guaranteed); 110 MHz typical. Gatetime: 1 sec. providing 1 Hz resolution throughout freq. range. Accuracy: ± 1 count + Time Base error.
Input Characteristics Impedance: 1 MΩ shunted by 56 pf. Connector: phone jack. Coupling: AC Sine Wave. Sensitivity: 30 mVRMS; 10 Hz-50 MHz; 100 mVRMS, 50 MHz to 80 MHz; 300 mVRMS, 80 MHz and above. Maximum Input: 200 V Peak, 20 MHz-500Hz; 100V Peak, 500 Hz-1 KHz, 75 V Peak, 1 KHz-10 MHz; 50V Peak, 10 MHz and above.
Internal Time Base Characteristics Frequency: 3.579545MHz crystal oscillator. Setability: ± 3 ppm @ 25°C. Trimmer Adjustment: ± 4 ppm. Temperature Stability: Better than 0.2 ppm/°C. 0 to 50°C. Maximum Aging Rate: 10 ppm/year.

MAX-100 $134.95

OTHER CSC PRODUCTS

SOCKETS AND BUS STRIPS
Plug-in, wire, test, modify or expand without patch cords or solder. Snap together to form breadboard needed.

PN/Description	Term'ls	Price
QT59S Socket	118	$ 12.50
QT59B Bus	20	2.50
QT47S Socket	94	10.00
QT47B Bus	16	2.25
QT35S Socket	70	8.50
QT35B Bus	12	2.00
QT18S Socket	36	4.75
QT12S Socket	24	3.75
QT8S Socket	16	3.25
QT7S Socket	14	3.00

PROTO BOARDS AND EXPERMENTERS
Build and test circuits as fast as you think!

PB-6	$15.95
PB100	19.95
PB101	29.95
PB102	39.95
PB103	59.95
PB104	79.95
EX300	9.95
EX600	10.95

PROTO-CLIP

PC14	14-pin	$ 4.50
PC16	16-pin	4.75
PC24	24-pin	8.50
PC40	40-pin	13.75

JAPANESE TRANSISTORS

2SB405	.85	2SC1973	1.30
2SC536	2/1.20	2SC1974	3.00
2SC828	2/1.50	2SC1975	3.10
2SC829	2/1.50	2SC2034	3.40
2SC929	2/1.40	2SD72	1.00
2SC930	2/1.30	2SD313	1.10
2SC933	1.00	2SD325	1.25
2SC1226A	1.25	3SK49	2.75
2SC1359	.90		

PLESSEY SAMPLER 300 METALIZED CAPACITORS 18 DIFFERENT STD. VALUES $26.00

SAMS BOOKS

TTL COOKBOOK No.21035	$8.95
IC OP AMP COOKBOOK No.20969	$12.95
TV TYPEWRITER COOKBOOK No.21313	$9.95
C-MOS COOKBOOK No.21398	$9.95
TRANSISTOR SUBSTITUTION HANDBOOK, 15th Ed. No.21169	$4.50
TRANSISTOR SPEC. MANUAL, 7th Ed. No.21208	$5.95
SEMICONDUCTOR REPLACE. GUIDE No.21092	$3.95
BUILDING AND INSTALLING ELECTRONIC INTRUSION ALARMS No.20929	$4.50
UNDERSTANDING IC OP-AMPS No.20855	$3.95
HOW TO USE IC LOGIC ELEMENTS, 2nd Ed. No.21081	$4.50
UNDERSTANDING CMOS IC's No.21129	$4.95

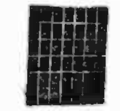
ZENER DIODES

½ WATT	V	PRICE	1 WATT	V	PRICE
IN5223B	2.7	.22	IN4728A	3.3	.44
IN5224B	2.8	.22	IN4729A	3.6	.44
IN5225B	3.0	.22	IN4730A	3.9	.44
IN5226B	3.3	.22	IN4731A	4.3	.44
IN5227B	3.6	.22	IN4732A	4.7	.44
IN5228B	3.9	.22	IN4733A	5.1	.44
IN5229B	4.3	.22	IN4734A	5.6	.44
IN5230B	4.7	.22	IN4735A	6.2	.44
IN5231B	5.1	.22	IN4736A	6.8	.44
IN5232B	5.6	.22	IN4737A	7.5	.44
IN5233B	6.0	.22	IN4738A	8.2	.44
IN5234B	6.2	.22	IN4739A	9.1	.44
IN5235B	6.8	.22	IN4740A	10	.44
IN5236B	7.5	.22	IN4741A	11	.44
IN5237B	8.2	.22	IN4742A	12	.44
IN5238B	8.7	.22	IN4743A	13	.44
IN5239B	9.1	.22	IN4744A	15	.44
IN5240B	10	.22	IN4745A	16	.44
IN5241B	11	.22	IN4746A	18	.44
IN5242B	12	.22	IN4747A	20	.44
IN5243B	13	.22	IN4748A	22	.44
IN5244B	14	.22	IN4749A	24	.44
IN5245B	15	.22	IN4750A	27	.44
IN5246B	16	.22	IN4751A	30	.44
IN5247B	17	.22	IN4752A	33	.44
IN5248B	18	.22	IN4753A	36	.44
IN5249B	19	.22	IN4754A	39	.44
IN5250B	20	.22	IN4755A	43	.44
IN5251B	22	.22	IN4756A	47	.44
IN5252B	24	.22	IN4757A	51	.44
IN5253B	25	.22	IN4758A	56	.44
IN5254B	27	.22	IN4759A	62	.44
IN5255B	28	.22	IN4760A	68	.44
IN5256B	30	.22	IN4761A	75	.44
IN5257B	33	.22			
IN5258B	36	.22			
IN5259B	39	.22			
IN5260B	43	.22			
IN5261B	47	.22			
IN5262B	51	.22			
IN5263B	56	.22			
IN5264B	60	.22			
IN5265B	62	.22			
IN5266B	68	.22			
IN5267B	75	.22			

DIODES

IN914	10/1.00
IN4002	10/1.00
IN4003	10/1.00
IN4004	10/1.00
IN4005	10/1.10
IN4006	10/1.20
IN4007	10/1.20

RESISTOR KITS 5% CARBON FILM RESISTORS



COMPLETE WITH STORAGE BIN

1/4 WATT KIT
42 Different Values (68Ω to 4.7 MΩ)
20 Each Value

1/2 WATT KIT
42 Different Values (68Ω to 4.7 MΩ)
20 Each Value

1/4W – $24.90 PER KIT
1/2W – $25.90 PER KIT

CARBON FILM RESISTORS (5%)
Only in Multiples of 100 pcs per value (ohms)
¼W . . . $1.69 per 100
½W . . . $1.79 per 100

10	100	1.0K	10K	100K	1.0M
11	110	1.1K	11K	110K	1.1M
12	120	1.2K	12K	120K	1.2M
13	130	1.3K	13K	130K	1.3M
15	150	1.5K	15K	150K	1.5M
16	160	1.6K	16K	160K	1.6M
18	180	1.8K	18K	180K	1.8M
20	200	2.0K	20K	200K	2.0M
22	220	2.2K	22K	220K	2.2M
24	240	2.4K	24K	240K	2.4M
27	270	2.7K	27K	270K	2.7M
30	300	3.0K	30K	300K	3.0M
33	330	3.3K	33K	330K	3.3M
36	360	3.6K	36K	360K	3.6M
39	390	3.9K	39K	390K	3.9M
43	430	4.3K	43K	430K	4.3M
47	470	4.7K	47K	470K	4.7M
51	510	5.1K	51K	510K	5.1M
56	560	5.6K	56K	560K	5.6M
62	620	6.2K	62K	620K	6.2M
68	680	6.8K	68K	680K	6.8M
75	750	7.5K	75K	750K	7.5M
82	820	8.2K	82K	820K	8.2M
91	910	9.1K	91K	910K	9.1M

RESISTOR ASSORTMENTS
Each assortment contains 5 pcs each of 10 different values. Values included are shown in (Ohms)
¼W,5% (50 pcs total)...$1.75 / ½W,5% (50 pcs total)...$1.85

Asst.1:	10, 12, 15, 18, 22, 27, 33, 39, 47, 56 ohm
Asst.2:	68, 82, 100, 120, 150, 180, 220, 270, 330, 390 ohm
Asst.3:	470, 560, 680, 820 ohm, 1K, 1.2K, 1.5K, 1.8K, 2.2K, 2.7K
Asst.4:	3.3K, 3.9K, 4.7K, 5.6K, 6.8K, 8.2K, 10K, 12K, 15K, 18K
Asst.5:	22K, 27K, 33K, 39K, 47K, 56K, 68K, 82K, 100K, 120K
Asst.6:	150K, 180K, 220K, 270K, 330K, 390K, 470K, 560K, 680K, 820K
Asst.7:	1M, 1.2M, 1.5M, 1.8M, 2.2M, 2.7M, 3.3M, 3.9M, 4.7M, 5.6M. (¼W Assortment No.7 doesn't include 5.6M)
Asst.8R:	(All seven assortments above) ¼W,5% 350 pcs total: $10.95 ½W,5% 350 pcs total: $11.55

HYBRID AUDIO POWER AMPLIFIERS

SanKen

- Multi-purpose linear amplifiers for comercial and industrial applicacations.
- Less than 0.5% harmonic distortion at full power level.
- 1/2 dB response from 20 to 100,000 Hz.
- Single or split (dual) power supply.
- Rugged, compact and lightweight packages.
- Built-in current limiting for SI-1050G and efficient heat radiating construction.

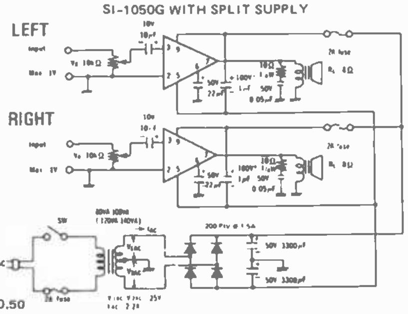
SANKEN Series SI-1000G amplifiers are self-contained power hybrid amplifiers designed for Hi-Fi, stereo, musical instruments, public address systems and other audio applications. The amplifiers have quasi-complementary class B output. The circuit employs flip-chip transistors with high reliability and passivated chip power transistors with excellent secondary breakdown strength. Built-in current limiting is provided for SI-1050G and all devices can be operated from a single or split power supply.

SI-1010G (10W output) . . . $ 6.90
SI-1020G (20W output) . . . $13.95
SI-1050G (50W output) . . . $26.80

Data Sheet with Application Notes — $0.50

TYPICAL CONNECTIONS

SI-1050G WITH SPLIT SUPPLY



MICROPROCESSOR CRYSTALS

FREQUENCY (MHz)	HOLDER	PART NUMBER	PRICE
1.00	HC33	CY1A	$8.55
2.00	HC33	CY2A	6.75
3.2768	HC33	CY3B	4.80
4.00	HC18	CY3A	4.80
4.434	HC18	CY4C	4.80
5.00	HC18	CY7A	4.80
5.068	HC18	CY5B	4.80
5.7143	HC18	CB5C	4.80
6.00	HC18	CY6B	4.80
10.00	HC18	CY12A	4.35
14.31818	HC18	CY14A	4.35
15.00	HC18	CY15A	4.35
18.00	HC18	CY19A	4.35
20.00	HC18	CY22A	7.20
23.684	HC18	CY23B	4.35
27.00	HC18	CY27A	4.35
32.00	HC18	CY30B	4.35

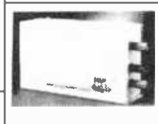
MICROPROCESSOR & SUPPORT CIRCUITS

P8080A	17.50	AM8238PC	8 20	MHD026CN	5 00
C8080A	19 50	C8251	14 30	MH0026CH	5 50
C1702A	13 40	C8255	13 50	P2101	2 90
C2708	33 50	P2405	9 90	P2101 1	4 20
P8212	4 10	2512K	4 30	P2102	1 70
P8214	8.95	2524V	4 00	P2102 1	3 45
P8216	3.90	2525V	2 40	P2111	3 70
AM8224PC	6.20	2533V	4 90	P2111 1	3 70
P8226	3 90	N8T26B	3 10	P2112	2 90
AM8228PC	8 20	N8T97	1 60	P2112 2	3 70

MOTOROLA'S EDUCATOR II MICROCOMPUTER HEP KIT

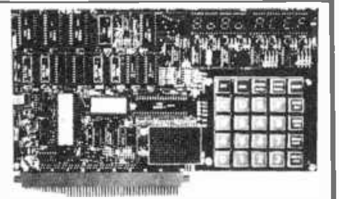
- Motorola M6800 Technology
- Test-as-you build in easy steps — normally one evening assembly
- Completely self contained with all parts, cabinet and instructional manual

Get started in the fascinating world of Micro Computers for only $169.95



EDUCATOR II POWER SUPPLY KIT

- 5 V @ 1.0 Amps
- Designed specifically for Educator II Microcomputer Kit
- Complete Kit — all parts, cabinet and construction manual $29.95



NEC TK-80 SINGLE BOARD MICROCOMPUTER FOR LEARNING 8080A MICROCOMPUTER SYSTEM

$395.00

- Single board microcomputer system.
- On board displays and keyboard.
- Powerful monitor program in factory coded ROM.
- Easy system operation.
- CMOS RAM battery back up capability.
- Provisions for audio cassette tape for external storage.
- System expandability.
- Battery operation capability.
- Instructive program examples for learning.
- Informative documentations.

7400N SERIES

7400N	16	7453N	.22	74145N	1 20	74221N	1 30
7401N	.20	7454N	.22	74147N	1 80	74247N	2.10
7402N	26	7459N	25	74148N	1.70	74251N	1 80
7403N	.26	7460N	22	74150N	1.50	74278N	3 40
7404N	.22	7470N	.48	74151N	1.10	74279N	1 10
7405N	23	7472N	44	74152N	1 10	74293N	.90
7406N	.36	7473N	42	74153N	1.10	74298N	1 40
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7411N	.27	7481N	1 60	74158N	1 30		
7412N	.38	7482N	1.40	74160N	1 20		
7413N	48	7483N	.82	74161N	1 70		
7414N	1 16	7484N	1 20	74162N	1.80		
7416N	.42	7485N	1 20	74163N	1.40		
7417N	.42	7486N	.44	74164N	1 40		
7420N	22	7489N	2 20	74165N	1 50		
7421N	.28	7490N	56	74166N	1.50		
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7437N	36	74105N	.90	74180N	1 10		
7438N	35	74107N	.42	75181N	3 10		
7439N	.36	74109N	56	74182N	1.00		
7440N	26	74110N	80	74184N	2.70		
7441N	.90	74111N	.80	74185N	2 90		
7442N	.66	74116N	1.90	74188N	2 90		
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		74136N	90	74198N	1 60		
		74141N	1 60	74199N	1.40		
		74143N	4.80	74200N	7 50		

74L'S

74LS00N	36	74LS90N	84	74LS258N	1 10
74LS01N	44	74LS92N	86	74LS260N	44
74LS02N	.32	74LS93N	86	74LS261N	1 90
74LS03N	32	74LS95N	1.00	74LS266N	72
74LS04N	.36	74LS96N	1.24	74LS273N	2 66
74LS05N	.33	74LS107N	46	74LS281N	7 60
74LS08N	36	74LS109N	46	74LS283N	2 00
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74LS10N	32	74LS113N	64	74LS293N	1 76
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74LS22N	44	74LS136N	74	74LS375N	82
74LS26N	33	74LS138N	99	74LS378N	1 60
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74LS33N	.56	74LS153N	.88		
74LS37N	.50	74LS155N	1.50		
74LS38N	.58	74LS157N	88		
74LS40N	44	74LS158N	99		
74LS42N	92	74LS160N	1 25		
74LS51N	44	74LS161N	1 25		
74LS54N	44	74LS162N	1 25		
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		74LS193N	1 21		
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		74LS195N	99		
		74LS196N	2 76		
		74LS197N	2 84		
		74LS221N	1 76		
		74LS241N	3 00		
		74LS251N	1 10		
		74LS253N	1 10		
		74LS257N	95		

74H

74H76	.42	74H01	.32
74H101	.42	74H04	32
74H102	42	74H05	32
74H103	.42	74H08	34
74H106	.48	74H10	.32
74H108	.48	74H11	32
		74H20	32
		74H21	32
		74H22	.32
		74H30	32
		74H40	.32
		74H50	32
		75H51	.32
		74H52	32
		74H53	.32
		74H54	32
		74H55	32
		74H60	.32
		74H61	32
		74H62	32
		74H72	54
		74H73	42
		74H74	1 02

74S

74S00	46	74S140	62
74S01	.76	74S151	1.80
74S02	.44	74S153	2 20
74S03	.44	74S154	2.10
74S04	.50	74S157	1.80
74S05	.50	74S158	1.80
74S08	44	74S160	3.60
74S09	.76	74S161	3.60
74S10	44	74S172	6 00
74S11	44	74S174	2 00
74S15	.44	74S175	2.00
74S20	.44	74S178	2.36
74S21	.76	74S179	2 36
74S22	.44	74S181	6.00
74S30	.60	74S182	2 36
74S32	50	74S189	3 20
74S37	56	74S194	2 00
74S40	.44	74S195	2 00
74S50	.76	74S196	2 66
74S51	.76	74S197	2.66
74S60	76	74S251	1.80
74S64	.44	74S253	1.92
74S65	.76	74S257	1 92
74S74	70	74S258	1.80
74S76	1 16	74S260	50
74S78	1.16	74S280	4.00
74S85	2.50	74S289	3 60
74S86	68		
74S112	68		
74S113	80		
74S114	2 08		
74S133	44		
74S134	.80		
74S138	1 76		
74S139	1 80		

74C00

74C00N	.38	74C89N	14 00
74C02N	.38	74C90N	1.36
74C04N	.38	74C93N	1.36
74C08N	.38	74C95N	1 80
74C10N	38	74C107N	1 90
74C14N	2.20	74C151N	3.82
74C30N	38	74C154N	5 70
74C32N	38	74C157N	3 42
74C42N	2 08	74C160N	2 04
74C48N	3 32	74C161N	2 04
74C73N	1 00	74C162N	2 04
74C74N	86	74C163N	2 04
74C76N	1 00	74C164N	1 80
74C83N	2.74	74C165N	1.80
74C85N	2.74	74C173N	1 66
74C86N	.98	74C174N	1 66
		74C175N	1 66
		74C192N	2.04
		74C193N	3 74
		74C221N	2 04
		74C901N	1 00
		74C902N	1.00
		74C903N	1 00
		74C904N	1 00
		74C906N	1 00
		74C907N	1.00
		74C914N	2 20
		74C922N	5 70
		74C925N	12 00
		74C926N	12.00
		80C95N	1.16
		80C97N	1 00

C – MOS

4000AE	15	4016AE	80
4001AE	26	4017AE	1 20
4002AE	26	4018AE	90
4004AE	1 34	4019AE	.54
4006AE	1 20	4020AE	1 40
4007AE	24	4021AE	1 40
4008AE	1 20	4022AE	1 20
4009AE	50	4023AE	30
4010AE	50	4024AE	90
4011AE	24	4025AE	26
4012AE	28	4026AE	2 50
4013AE	32	4027AE	60
4014AE	1 44	4028AE	80
4015AE	1 20	4029AE	1 50
		4030AE	48
		4033AE	2 00
		4035AE	1 00
		4040AE	1 50
		4042AE	1 00
		4043AE	90
		4044AE	90
		4046AE	2 80
		4047AE	2 50
		4048AE	1 43
		4049AE	58
		4050AE	58
		4051AE	1 50
		4052AE	1 50
		4053AE	1 50
		4055AE	1 50
		4056AE	1 50
		4060AE	1 50
		4066AE	88
		4068AE	44
		4069AE	44
		4070AE	[illegible]
		4071AE	[illegible]
		4072AE	[illegible]
		4073AE	[illegible]
		4075AE	[illegible]
		4076AE	1 2[illegible]
		4077AE	[illegible]
		4078AE	[illegible]
		4096AE	1 5[illegible]
		4507AE	1 2[illegible]
		4508AE	2 1[illegible]
		4510AE	1 5[illegible]
		4511AE	1 3[illegible]
		4512AE	1 3[illegible]
		4514AE	2 7[illegible]
		4515AE	2 7[illegible]
		4516AE	1 5[illegible]
		4518AE	1 5[illegible]
		4520AE	1 5[illegible]
		4521AE	1 2[illegible]
		4585AE	2 0[illegible]
		4901AE	[illegible]

NEW ANCRONA DISCOUNT POLICY FOR ALL 7400 SERIES TTL IC'S

BUY 10 PER TYPE . . . 5% DISCOUNT
BUY 25 PER TYPE . 10% DISCOUNT
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MN6040 C-MOS PLL

a single chip phase locked loop intended for use as a frequency synthesizer in CB transceivers and other communications equipment

$7.90

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LF355H	1 60
LF355N	1 10
LF355AH	22 50
LF356H	1 10
LF356AH	22 50
LF357H	1 60
LF357N	1 10
LF357AH	25 50

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LM101AH	3.50	LM302N	1.90	LM709CH	.75
LM101F	5.65	LM304H	1 50	LM710CH	.90
LM105H	4.90	LM305H	1 40	LM710CN	.90
LM105F	9.00	LM305AH	2.30	LM715H	9.00
LM106H	9 00	LM305N	1.50	LM715CH	2.90
LM107H	3.95	LM306H	6.80	LM175CD	6.40
LM108H	4 90	LM307H	.95	LM723CH	1.20
LM109K	8.00	LM307N	90	LM723CD	1 40
LM114	3 40	LM308H	1.50	LM723CN	.95
LM118H	14 50	LM308AH	6.30	LM725H	9 00
LM201H	98	LM308N(8)	1.50	LM725CH	4.80
LM201AH	3.00	LM309H	1 90	LM725CD	4.50
LM201AN	3.90	LM309K	1 90	LM733CH	1.70
LM202H	7.00	LM310H	3 30	LM733CD	1.90
LM205H	6.80	LM310D	3 80	LM733CN	1.80
LM206H	12.50	LM311D	4 20	LM741H	1.32
LM207H	3.50	LM311N(8)	1.30	LM741CH	.84
LM208H	6 00	LM311H	1.40	LM741CD	1.00
LM209H	5 00	LM312H	3 50	LM741CN(8)	.50
LM209K	5.40	LM316H	5.20	LM741CN	.50
LM210H	5 70	LM318H	3.50	LM747CH	2.60
LM211H	3.45	LM318N(8)	3.10	LM747CD	2.90
LM218H	9.50	LM319N	3 60	LM747CN	1.40
LM300H	1.50	LM324N	1 40	LM747D	4.90
LM300N	1.50	LM339N	1.40	LM748H	1.30
LM301AH	.90	LM380N	1 50	LM748CH	.90
LM301AN	90	LM381N	2 30	LM748CN(8)	.84
LM302H	3.40	LM555CN(8)	.90	LM748CN	.90
		LM556CN	1.20	LM1458CH	1.50
		LM709CN	.75	NE536T	3.30

DIP SOCKETS

LOW PROFILE, SOLDER, TIN

	1-24	25-49	50 UP
8 Pin	16	15	14
14 Pin	19	18	17
16 Pin	21	20	19
18 Pin	28	27	26
20 Pin	34	33	32
22 Pin	36	35	34
24 Pin	37	36	35
28 Pin	44	43	42
36 Pin	59	58	57
40 Pin	62	61	60

STANDARD SOLDER, TI

8 Pin	25	23	22
14 Pin	27	25	24
16 Pin	30	27	25
18 Pin	35	32	30
22 Pin	70	65	60
24 Pin	49	45	42
28 Pin	99	90	81
36 Pin	1 39	1 26	1 15
40 Pin	1 59	1 45	1 30

STANDARD, SOLDER, GOLD

8 Pin	30	27	24
14 Pin	35	32	29
16 Pin	38	35	32
18 Pin	52	47	43
22 Pin	70	63	57
24 Pin	70	63	57
28 Pin	1 10	1 00	90
36 Pin	1 75	1 40	1 26
40 Pin	1 75	1 59	1 45

WIREWRAP GOLD (Level No. 3)

10 Pin	45	41	37
14 Pin	39	38	37
16 Pin	43	42	41
18 Pin	75	68	62
24 Pin	1 05	95	85
28 Pin	1 40	1 25	1 10
36 Pin	1 59	1 45	1 30
40 Pin	1 75	1 55	1 40

MD4301 CMOS ALARM CIRCUIT IC $2.50

SANKEN HYBRID POWER OP-AMP — up to 50 w. (AC rms) power output — Built in current limiting — 1/2 dB response from DC to 100,000 Hz — Terminal for external feedback SI-1050 GS $33.80

WIRE WRAP TOOL WSU-30 $5.95
Strips, wraps and unwraps 30 ga. wire on standard wirewrapping pins. 50' roll wire, specify color red, blue, white or yellow $1.98

WIRE WRAP KIT WK-2 $11.95
Includes WSU-30 tool, 50 ft roll of 30 AWG wire and 50 ft roll of 30 AWG wire and 50 pcs ea of 1", 2", 3" and 4" lengths of prestripped wire. Specify color red, blue white or yellow.

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Designed for mobile radios, tape players, etc. Easy to use, High Gain — 53 dB (Closed Circuit). $3.90 ea.

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TO-220 VOLTAGE REGULATOR FROM FAIRCHILD

7805C	5V	7815C	15V
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7808C	8V	7824C	24V
7812C	12V		

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INTERSIL 8038 PRECISION WAVEFORM GENERATOR AND VCO

For simultaneous sine, square and triangular waveforms <.001 Hz to 1 MHz.

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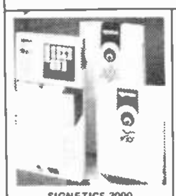

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1 ea N3001 Microprogram Control Unit
4 ea N3002 Central Processing Element
1 ea 74S182 Look Ahead Carry
3 ea 82S114 256 × 8 Prom
1 ea 8T31 Bi-directional I/O Port
2 ea 8T26A Quad Bus Transceiver
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This $299 Emulator Kit provides all that you need to run your 8080A system at bipolar speeds Includes PC board, all components and manual

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A fully assembled and tested F8 Microcomputer System It includes an F8 CPU, SMI, PSU (with Fairbug) and 1K byte RAM. This kit is supplied with F8 literature and a Programming Manual

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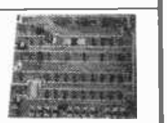

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9 95	KIM Math Subroutines
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$47.50

ACOUSTIC COUPLER

This coupler was manufactured by Novation, Inc., Tarzana, Ca. for use in Texas Instruments model 725 Electronic Terminal. It is compatible with Bell 103 and 113 data sets or the equivalent. The coupler operates asynchronously to a maximum speed of 300 baud in the full or half duplex mode. All signal outputs are compatible with TTL. Transmit freq. is 1270hz. for mark and 1070hz. for space. Receive freq. is 2225hz. for mark and 2025hz. for space. Unit requires ±12 volts and +5 volts for operation. Complete with schematic and all pertinent information fully reconditioned, calibrated and guaranteed.

RS232 to TTL to RS232 converter kit .... $4.50 (includes P.C. board and schematic)

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ACE Makes It Easy With Etch Powder. Etch 'em To Your Own Specifications.

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G-10 1/16" Unetched Copper Clad 1oz. 2-sided or 2 oz. 1-sided

SIZE	1	10	100
3"x6"	.50	2.50	19.95
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Solid Silver Plated 30 AWG Blue, Red, Yellow, Black, Green, or White.
100' Spool $2.50
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26 AWG Red or Black
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G.E. SC51B 15A 200V in press fit case. Ideal for color organs.
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10V 200ma P.C. mount 1 1/4"h x 1 3/8"w x 1 1/8" thick. PRI: 117V 10/$14.95 100/$99.50

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1392 turns 50mh 65ma
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PITTMAN 12 VDC MOTOR $1.95 each

The Pittman runs on as low as 2 volts, rated 12 volts 250 ma., 2.8 inch oz. torque at 5000RPM. 1 1/8"DIA X 2" long with 0.118" shaft. New, Guaranteed.
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1 bag of asst. colors in 3 10 ft. lengths. Ideal for any wiring project. approx. 100' $1.00

BISMUTH ALLOY

MELTS IN BOILING WATER 4oz. ingot $3.95 1lb. $9.95
FUN TO PLAY WITH!

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An assortment of precision components for calibration of test equipment.
Kit includes (10) assorted 1% capacitors, (10) assorted 0.01% resistors, and (1) temperature compensated zener reference diode. ONLY $6.95

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1¾" shaft 1" dia. base $.75/ea. 10 for $4.95

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7730 .3"char. RED common anode $1.50 4 for $5.95

NE-2H / A3C NEON BULB

100/$4.95 1000/$39.95

MOLEX I.C. PINS 100/$.98 1000/$6.95

6'2" POWER CORDS BLACK OR WHITE
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Bonds Rubber, Plastic, Metal in Seconds. Compare at $1.98 for 0.1oz. elsewhere. Comparable with Eastman 910. 1oz. Bottle $4.95

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135 MH per 1000 turns. 1"ID.x1 7/8"OD.x3/4"THK. p/n A-759135-2 $1.50 ea. 100 for $98.00

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SHEET OF 50 $1.00

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*Cuts the wire to length.
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Refillable spool
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on paper tape $25.00

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74C10–	.22	4012–	.22	4023–	.22	4042–	.78
74C193–	1.50	4013–	.40	4024–	.75	4046–	2.25
4001–	.22	4015–	.95	4025–	.22	4049–	.40
4002–	.22	4016–	.40	4027–	.40	4050–	.40
4006–	1.20	4017–	1.05	4028–	.88	4055–	1.50
4007–	.22	4018–	1.00	4029–	1.10	4066–	.80
4009–	.42	4019–	.25	4030–	.22	4071–	.27
4010–	.42	4020–	1.05	4033–	1.50	4076–	1.05
4011–	.22	4022–	.95	4035–	1.10		

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8 PIN – .22 24 PIN – .40
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MC6860 MODEM CHIP $9.95

Silicon Power Rectifiers

PRV	1A	3A	12A	50A	125A
100	.06	.14	.30	.80	3.70
200	.07	.20	.35	1.15	4.25
400	.09	.25	.50	1.40	6.50
600	.11	.30	.70	1.80	8.50
800	.15	.35	.90	2.30	10.50
1000	.20	.45	1.10	2.75	12.50

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7405–	.18	7472–	.29	74157–	.58
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7407–	.25	7474–	.29	74163–	.80
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7411–	.20	7483–	.62	74174–	.95
7412–	.20	7485–	.87	74175–	.82
7413–	.39	7486–	.30	74176	.75
7414–	.63	7489	1.85	74177–	.75
7416–	.25	7490–	.42	74180	.65
7417–	.25	7491–	.58	74181–	1.90
7420–	.14	7492–	.43	74190–	1.00
7425–	.25	7493–	.45	74191–	1.00
7426–	.22	7494–	.70	74192–	.83
7427–	.25	7495–	.65	74193–	.83
7430–	.14	7496	.65	74194–	.85
7432–	.25	74107–	.28	74195–	.52
7437–	.21	74121–	.33	74257	1.25
7438	.21	74123–	.65	74279	.87
7440–	.14	74125	.40	75324–	1.75
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7442	.40			75492	.65

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74LS09	.33	74LS151	.98	LM 319	.95
74LS10	.23	74LS153	.93	LM 324	1.05
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74LS21	.23	74LS161	1.02	LM 382	1.25
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74LS27	.27	74LS163	1.02	LM 553	2.50
74LS30	.23	74LS168	1.10	LM 555	.44
74LS32	.33	74LS169	1.10	LM 556	.85
74LS37	.37	74LS173	1.39		
74LS38	.37	74LS174	1.05	560	2.00
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74LS54	.23	74LS191	1.50	567	1.50
74LS74	.49	74LS192	1.75	703	.90
74LS90	.95	74LS193	1.75	709	.25
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100	.40	.70	1.30	.40	.50	1.20
200	.70	1.10	1.75	.60	.70	1.60
400	1.10	1.60	2.60	1.00	1.20	2.20
600	1.70	2.30	3.60		1.50	3.00

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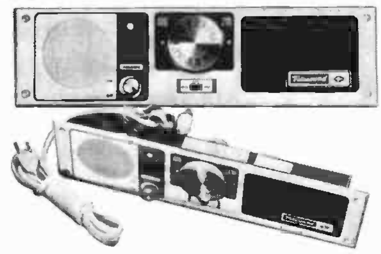

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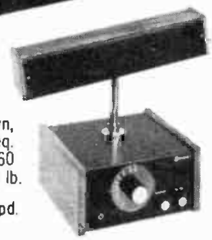

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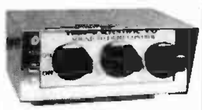

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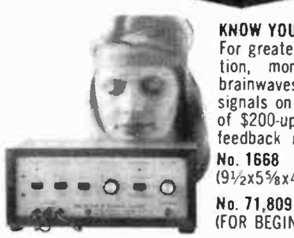

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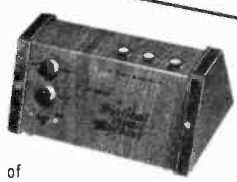

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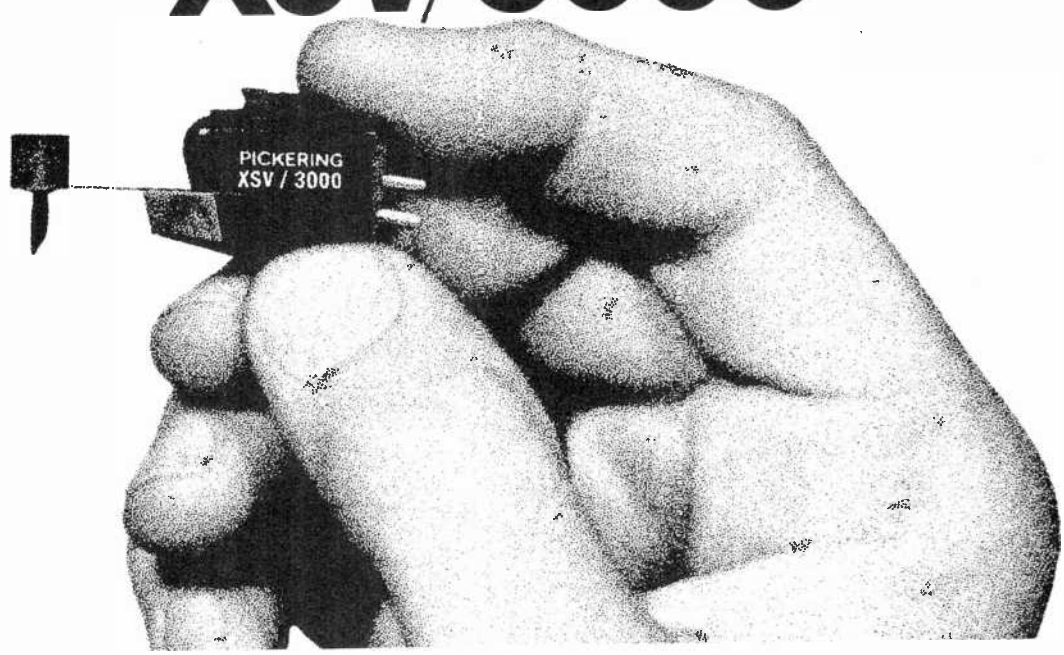

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