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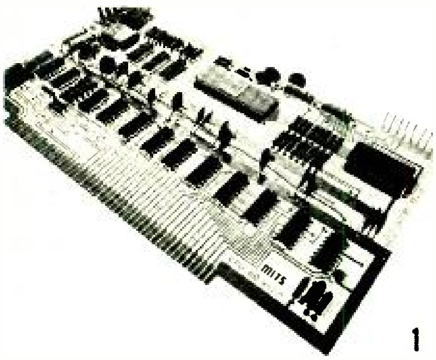
INSIDE the Altair Computer



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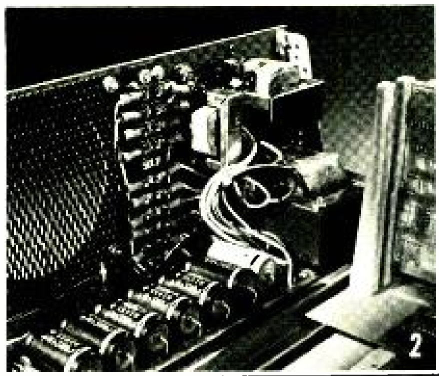

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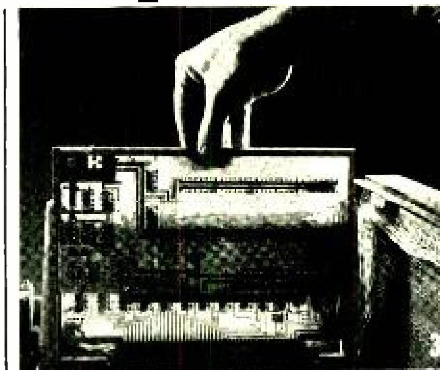

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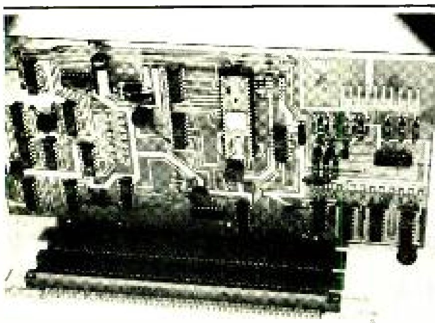

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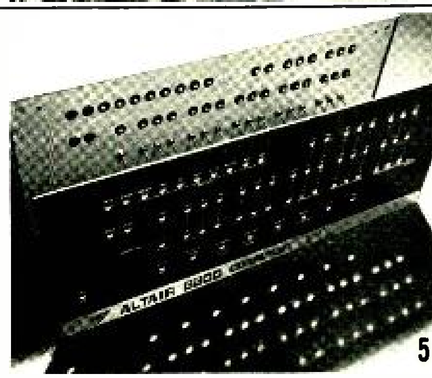

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6

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Editorial

THE VIDEODISC COMETH

After many false starts, manufacturers seem to be closing in on marketing of videodisc playback systems for consumers. Should it materialize, we'll all be winners when you consider that one could own a copy of the latest motion picture for the price of two theatre admissions plus babysitter fee. It would likely cost less to have a videodisc of a set of golf lessons, step-by-step TV cooking recipes, guitar lessons, still pictures of priceless paintings in your living room, and so on. Doubtlessly, some enterprising dealers will spring up to rent and exchange programs for even lower costs.

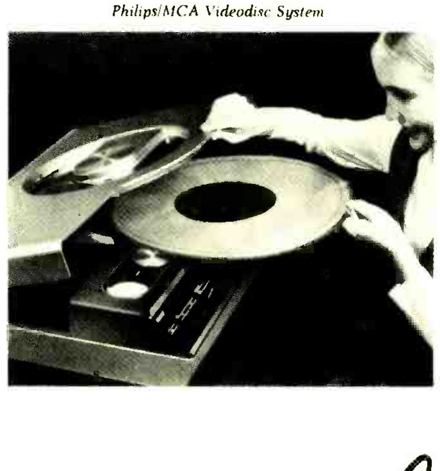
Naturally, there are a host of competing systems, including: Philips/MCA, with an optical laser sensor; Zenith (in collaboration with France's CSF Thomas), with a similar though incompatible system; Teldec (Germany's Telefunken and Britain's Decca), with a diamond-in-a-groove mechanical approach; RCA's capacitive pickup; Bogen-Rabe's magnetic system; and I/O Metrics' optical-photo system.

Playing a simple disc to produce color or B&W motion pictures with synchronized sound on a conventional TV receiver is a most appealing concept. You can view and listen to what you want when you want to. What's more, it has great potential for relatively low cost and fast access time (two challenges not yet met by video*tape*). So I was attracted to the first videodisc drumbeat in the East today—a presentation by Philips/MCA. I wasn't disappointed.

The Philips/MCA machine looks like a sleek waffle maker. One simply connects wires to a TV set's antenna terminals, positions what appears to be an aluminum-coated polyethelene LP disc on a turntable, closes the top, and presses a "play" button. The program appears on your TV screen—in beautiful color. Other pushbuttons control slow motion, frame freeze, reverse, and frame selection (with digital index readout on the screen). Two discrete audio channels with a 20-kHz top end are available, plus a technological opportunity for 4-channel sound. Turntable speed is 1800 rpm. With no physical contact between the optical pickup and the disc, the disc doesn't "wear out." Videodisc programs will retail for $2 to $10, depending on program content and length. (Each disc has an uninterrupted 30-minute play time at present.) Anticipated videodisc player price is $500 and target date for market entry is the fall of '76.

Gone is MCA's pre-merger entry of an optical laser system that used a floppy disc and a top-mounted pickup, giving way to Philips' 0.2 mm-thick rigid disc and bottom-mounted sensor. Philips, in turn, secures MCA's vast programming resources (Universal Pictures, for example), while MCA also garners Magnavox's manufacturing and sales resources. (Philips owns 84% of Magnavox.) So Philips/MCA is a videodisc power to be reckoned with! And since some Zenith TV consoles and videodiscs were displayed, I'd speculate that Zenith will be a Philips/MCA licensee.

Philips/MCA Videodisc System



Will Philips/MCA win all the videodisc marbles? I think not. Judging from the past, there will probably be two or three *incompatible* systems. Perhaps they will all vie for the same broad mass market. Or maybe, one will eventually dominate the affluent, adult market, while others will capture the remaining market with lower-priced systems.

In any event, I believe that videodiscs will be the next truly big family-entertainment product in the United States, though still a few years away. All the ingredients are there.

Art Salsberg

Royce

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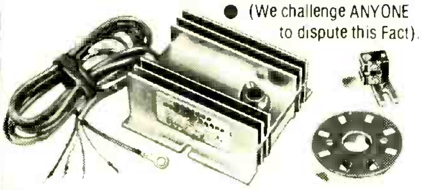
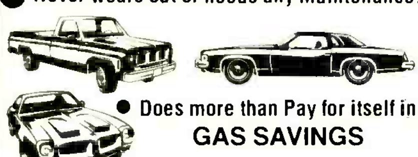


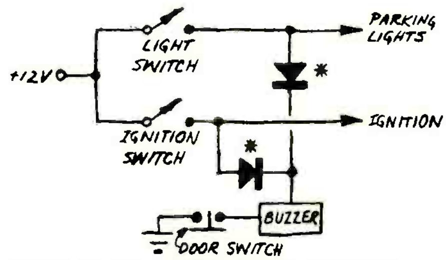


Letters

NO-KEY IGNITION TURN-ON

Anyone who incorporates Mr. Reckling's "Auto Lights Warning Buzzer" (Tips & Techniques, March 1975) in his vehicle will be in for a real surprise when he tries to switch off the engine with the lights on. Examination of the circuit indicates that, with the diode connected as shown, the ignition switch will be bypassed by the light switch through the added diode. This circuit will allow the engine to be started without using an ignition key.

The way to obtain a properly operating



circuit is to use two diodes in an OR-gate arrangement as shown in my schematic.

DUBY D. TODD
Grissom AFB, IN

UNIVERSAL DIGITAL PROBE

Reference was made to a 72720 dual differential comparator integrated circuit in "Build a Universal Digital Probe" (February 1975). The question is, what dealer handles this particular IC? I've searched through a number of catalogs and manuals and have had no success in locating this item. Can you help?

B. R. RAYFORD
Hayward, CA

In the article on the Universal Digital Probe, the foil pattern was said to be "actual size." It looks to me as if it is twice up.

JAMES E. BRONSON
Manchester, N.H.

The 72720 dual comparator is a new IC from Texas Instruments, available from any authorized TI dealer. However, if you are having trouble locating this IC locally, you can substitute the 1458 (available from many dealers; see the back of PE) or any other dual comparator IC. Just make certain that you make the necessary pin changes.

The foil pattern for the probe was printed twice up for clarity, but was mistakenly called actual size.

MORE ELECTRONIC ORGANS

I have just finished reading your article titled "How to Choose Electronic Organs" (March 1975). Some of the advances the author writes about had their beginnings with the Hammond Organ. One example is the reverberation unit that other organ manufacturers buy from Hammond. The author writes about LSI, but no connection with the subject is given to Hammond. The Hammond Organ is total LSI.

JERRY ORSONI
Eau Claire, WI

We have also been recently reminded that Miner Industries, Inc. manufactures and markets home entertainment products. Three of its subsidiaries make electronic organs: Opsonar Organ Corp. (which makes the Optigan); Estey Organ Co.; and Magnus Music Corp.

ANOTHER EM KEYBOARD SUPPLIER

In "How To Select EM Keyboards and Controllers" (July 1974), you closed with the request for information on sources for professional but inexpensive keyboards. In response to this request, I would like to recommend Synectic Music Systems, P.O. Box 30531, Seattle, WA 98103 as such a source. This company offers a variety of keyboards, all of which are usable in electronic music. Prices start at about $1.00/key.

WILLIAM REED
Seattle, WA

HOBBY SCENE SCHEMATICS

In the Transistor Tester circuit shown in the March 1975 Hobby Scene, I believe that the npn and pnp LED's are transposed. *LED1* should be pnp, while *LED2* should be for npn indication.

DEAN ISLER
Blocksburg, S.C.

The Mobile CB Power Supply featured in the April 1975 Hobby Scene column will not work as shown. The addition of a connection between the anode of the bottom diode and negative plate of the lower filter capacitor and the negative output terminal will make the power supply operational.

ERIC R. BEAN
Elkhart, IN

TEMPLATES NO SOLUTION

I have a suggestion that can help you improve the service you offer your readers. Why not print templates of the printed circuit layouts for the projects that appear in POPULAR ELECTRONICS and sell them at or near cost? The templates could be stamped on plastic sheets so that they could be placed on copper-clad board and slightly heated with a lamp to make them lie flat.

TOM PAGE
Batesville, AR

We've been asked this question a number of times in the past. Templates are impractical. They are prohibitively expen-

sive. More important, they are increasingly impractical as a given pc guide becomes more complex. The only type of practical template for a multi-IC guide with many closely spaced conductors and hole centers that must be critically placed would be a silk screen, which is too costly.

CONVERTING GMT TO LOCAL TIME

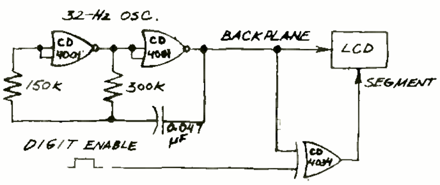
I noticed in "Shortwave Newscasts in English" (March 1975) that the times given are in Greenwich Mean Time (GMT). My question is, where can I get information on how to convert from the GMT schedule given to my local time?

JESSE L. ROSS
Fort Worth, TX

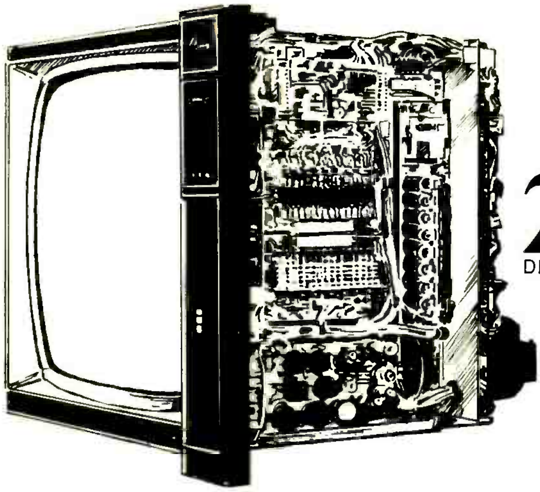
There's a simple rule for converting from GMT to your local time. When the U.S. is on Standard Time the Eastern, Central, Mountain, and Pacific Time Zones are 5, 6, 7, and 8 hours behind GMT, respectively, which means that you subtract 5, 6, 7, or 8 from the listed GMT, depending on your time zone, to obtain local time. (For Daylight Savings Time, the figures are 4, 5, 6, 7 hours, respectively.) Then convert from 24-hour time to 12-hour time. If the GMT is 2300, for example, your time in Fort Worth during Standard Time would be 2300 − 600 = 1700 or 5:00 pm.

Out of Tune

In "Getting to Know the Liquid Crystal Display" (April 1975), the schematic shown in Fig. 4 was incorrect. The corrected schematic is shown below. Also, to clarify understanding the theory behind LCD's, CMOS is preferred over TTL for driving the display because the output switches between the supply voltage and ground (instead of from about 4.7 volts and about 0.6 volt, as in TTL). This minimizes the undesirable effects of dc offset voltages.



In "Build a Muscle Feedback Monitor," (May 1975, p 39), on the component layout, two resistors were labelled *R22*. The one connected to terminals 4 and 8 of *IC4* should have been *R24*.



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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.

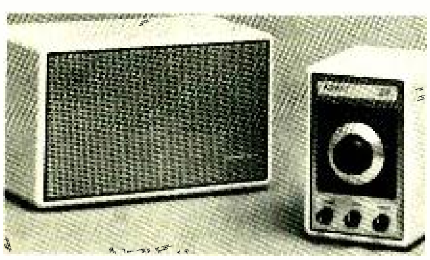
LARSEN MAGNETIC ANTENNA MOUNT

Using a new type of permanent magnet to achieve maximum magnetic pull, Larsen Antenna's mobile mount, available in five different models, will accommodate all popular types of mobile antennas. The units come with 12 feet of RG58/AU coax and plug. Just screw the antenna to the base and place the base on any flat surface (vehicle roof, fender, trunk) and run the coax to the equipment. The magnet is guaranteed permanent, according to the company, and will stay put at any highway speed.

CIRCLE NO. 70 ON READER SERVICE CARD

ADVENT FM RADIO

A compact monophonic FM receiver, Model 400, is being introduced by the Advent Corporation. The radio consists of two compact white molded cabinets, one containing the tuner/amplifier, and the other

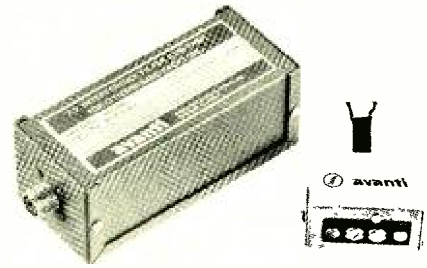


housing an acoustic-suspension speaker system. A 40-foot speaker cable connects the two units. The receiver has volume, bass and treble controls and a vernier tuning dial, as well as an output jack for tape recording and an input jack for playing a high-level source through the system. The receiver was designed to have good sensitivity and front-end overload characteristics. Its i-f stages (incorporating two IC's) are said to produce high selectivity and ease of tuning. The speaker driver, in conjunction with an LCR shaping filter, is said to provide good bass and treble response as well as satisfying tonal balance. The receiver section measures 6⅝" H × 6" D × 4½" W (16.8 × 15.2 × 11.4 cm), and the speaker enclosure measures 11" W × 6⅝" H × 6" D (27.9 × 16.8 × 15.2 cm).

CIRCLE NO. 71 ON READER SERVICE CARD

AVANTI TVI FILTERS

Avanti Research and Development introduces two filters for TVI problems associated with CB operations. The first filter is a low-pass unit for installation in the



coaxial feedline between transceiver and antenna. Any spurious high-frequency signals (harmonics) emitted from the transceiver will not be allowed to pass to the antenna. The second filter is a high-pass unit which should be installed at the TV receiver's antenna terminals. This filter is useful in curing those TVI problems caused by receiver overload and not by harmonic radiation. It lets TV signals through, but blocks the interfering 27-MHz CB signals. The high-pass filter is designed for use with 300-ohm feedlines, and the low-pass filter is to be used with 52-ohm coax.

CIRCLE NO. 72 ON READER SERVICE CARD

MOTOROLA TONE/FREQ. METER

Motorola's new Model SLN-6401A tone/frequency meter allows radio technicians to make high-accuracy measurements on low-frequency tones in two-way radios. This autoranging unit incorporates a phase-lock/frequency multiplier technique that is said to resolve to 0.002 Hz in only one second. Because of this ultra-fast counting speed, it is possible to read tones transmitted on two-way radio channels by reading them directly from the recovered audio of a receiver or communications service monitor. In the auto mode, the unit automatically provides maximum resolution of the six-digit display; in manual mode, a pushbutton selects a coarser resolution with increased counting speed. The unit also functions as a standard frequency counter over the range of 20 Hz to 2 MHz. Address: Motorola Communications and Electronics, Inc., 1301 E. Algonquin Rd., Schaumburg, IL 60172.

BOMAN AUTO CASSETTE PLAYER/RADIO

The Boman Astrosonix Model BM-1335 stereo cassette player/AM-FM radio is an in-dash unit with adjustable control shafts

(5⅛" to $6\frac{9}{32}$" or 13 to 16 cm) for easy mounting. The player/radio has tone, volume, balance, and tuning controls, as well as pushbuttons for FM/AM, Stereo, Eject, Fast-Forward, and Rewind. Indicator lights are provided for FM, AM, Stereo, and Tape End. FM sensitivity is claimed to be 6 μV and stereo separation 30 dB. Wow and flutter is said to be under 0.4% and tape separation 35 dB, frequency response is 80-10,000 Hz, and power output is 8.4 watts rms/channel into 4 ohms at 1% distortion. The Model BM-1335 weighs 4.5 lbs (2 kg) and measures 7⅛" W × 6½" D × 2⅛" H (17.8 × 16.5 × 5.4 cm). $184.95.

CIRCLE NO. 73 ON READER SERVICE CARD

STANTON MAGNETIC SUSPENSION TURNTABLE

The new 33⅓ and 45 rpm Stanton Model 8004-II manual turntable uses a Gyropoise™ magnetic suspension system in which the 12-inch platter makes no physical contact with its 24-pole synchronous motor's structure. Other features include belt drive, Unipoise™ single-point tonearm suspension, anti-skate control for all types of styli, stylus-force slide (0.4 grams), viscous-damped cueing control, and low-

capacitance cables. Wow and flutter is claimed to be less than 0.7% weighted and weighted rumble better than 60 dB down. The Model 8004-II comes with a walnut veneer base, dust cover, and a Stanton calibrated 681EEE cartridge. The turntable measures 14¾" × 13" × 7" (37.5 × 33 × 17.8 cm) and weighs 12 lbs (5.4 kg). $199.95. A 4-channel version, Model 8004-IV, is priced at $224.95.

CIRCLE NO. 74 ON READER SERVICE CARD

SONY PARABOLIC REFLECTOR

Superscope has added the Model PBR-400 portable parabolic reflector to its line of Sony recording equipment. It is designed to pick up high-quality sound from a distance and, depending on climatic conditions and surroundings, has an effective recording range of up to several hundred yards. According to the company, the PBR-400 will improve the sound sensitivity of most omnidirectional mikes 10 to 20 dB over rated sensitivity. Weighing under 3 pounds, the unit is hand operable but comes with a stand adapter for tripod use, a mike stand adapter, carrying case with shoulder strap, and internal accessory pouch. $79.95

CIRCLE NO. 75 ON READER SERVICE CARD

CORVUS 24-HOUR GMT DIGITAL CLOCK

Designed for amateur radio operators, the ac-powered Corvus Zulu 10 is a solid-state digital clock with a 24-hour display of time (GMT) and a 10-minute station indentification alarm/timer. It features a single MOS IC and LED display. The Zulu 10 is housed in a miniature 2½-inch plastic case with all switches and controls hidden from view. The case is silver color and chrome with a full-face red lens for wide-angle viewing. The 10-minute timer is reset by turning the clock upside-down with a "flick of the wrist." $39.95. Corvus Corp. 13030 Branch View Lane, Dallas, Texas 75234.

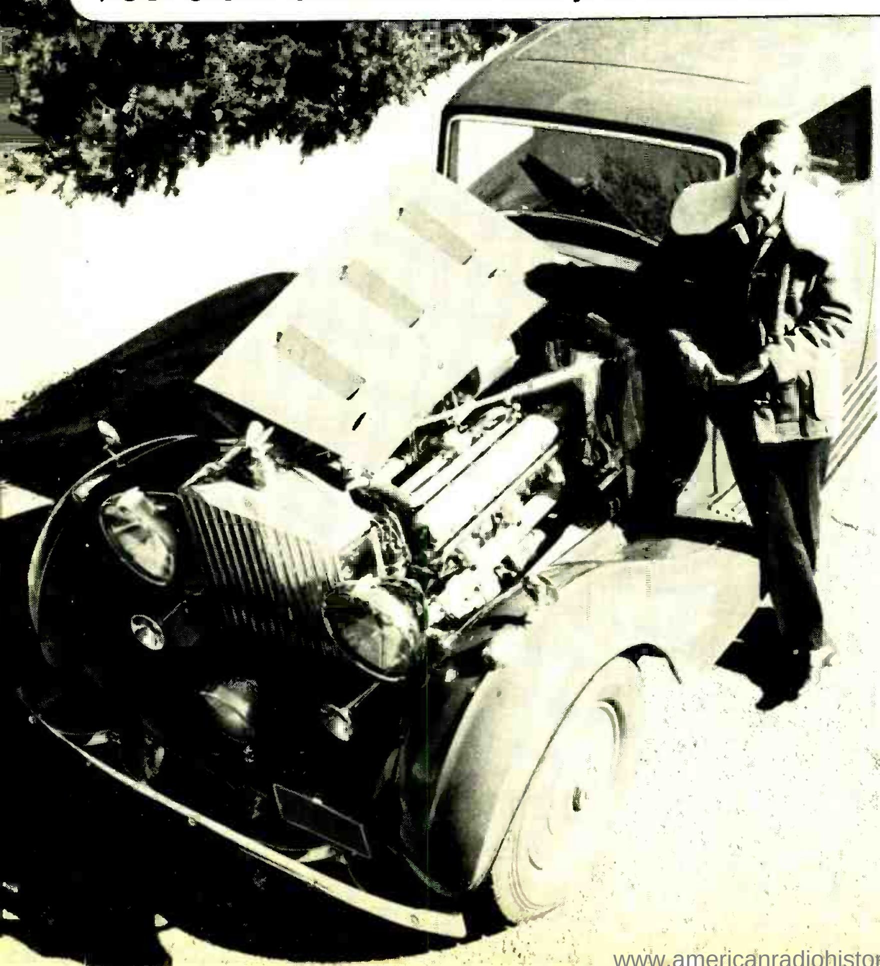
HICKOK 10-MHZ DUAL/TRACE SCOPE

The Hickok Model 512 Dual-Trace Oscilloscope uses a 5-inch CRT, has a claimed bandwidth of dc to 10 MHz (ac or dc coupled), normal or auto triggering, and 1-megohm input impedance shunted by 30 pF. Vertical sensitivity can be varied from 5 mV/cm to 50 V/cm (uncalibrated), or from 10 mV/cm to 50 V/cm (with 3% accuracy) in 12 calibrated steps. Sweep rate is variable from 0.1 μs/cm to 1 s/cm (uncalibrated), and from 0.5 μs/cm to 0.2 s/cm (with 5% accuracy) in 18 calibrated steps. The Model 512 can display either signal A or B alone, simultaneously, or alternately, as well as chopped (100 kHz) A and B, A plus B, or A minus B. A Z-axis (blanking) feature is also included. For TV work, trigger coupling can be chosen from among TV Field (Vertical), TV Line (Horizontal), VITS Field 1, and VITS Field 2. Among accessories included are two combination 10:1/direct probes, viewing hood and overlay for TV Field, VITS, and Vectorscope work. Front-panel controls are color coded. The 512 weighs 17 lbs (7.7 kg), and measures 17"D × 10½"W × 10"H (43.2 × 26.7 × 25.4 cm). $675.

CIRCLE NO. 77 ON READER SERVICE CARD

ECD DIGITAL CAPACITANCE METER

The new Model 100 Digital Capacitance Meter by ECD has a 3½-digit display and autoranging. The hand-held, battery-powered meter measures values over a

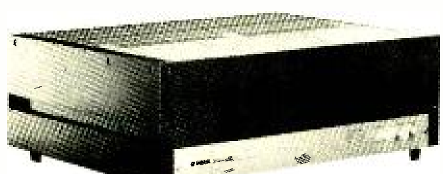


wide dynamic range—from 200 pF to 200,000 µF in 10 automatically selected ranges. Mounted test clips are useful for measuring small capacitors, and a pair of test leads is provided for large electrolytics. Measurement is accomplished by pushing a single pushbutton. An offset control is included to cancel out stray lead or clip capacitances. The display consists of a 0.6-inch high, 3½-digit LCD and four LED's to indicate units. Accuracy is claimed to be 0.1% to 200 µF, and 1% from 200 to 200,000 µF, over a temperature range of 59°F to 95°F (15°C to 35°C). Measurement time is said to be less than ½-second for values up to 200 µF, and increases to 5 seconds for 200,000 µF. The meter measures 5.9"W × 3.2"H × 2.3"D (15 × 8 × 5.7 cm) and weighs 15 oz (425 g). $289.00.

CIRCLE NO. 78 ON READER SERVICE CARD

YAMAHA FET POWER AMPLIFIER

The Yamaha Model B-1 basic stereo amplifier uses recently developed high-power FET's in output stages, as well as FET drivers. Rated output is 150 watts rms/channel (both channels driven into 8 ohms, 20-20,000 Hz) with THD and IM each 0.1% at rated power. Hum and noise level is reported to be −110 dB, input sensitivity is



0.775 V into 50 kilohms, and speaker load impedance is 4 to 16 ohms. A separate control unit, Model UC-1, is also available to provide switching and control functions for the power amplifier. The control unit features two peak-reading meters calibrated in both watts and dB, rumble filter, switch and level controls for five speaker pairs, separate overload warning indicators, and a thermal overload indicator.

CIRCLE NO. 79 ON READER SERVICE CARD

RUSSOUND AUDIO CONTROL

Russound's MP-2 multi-play audio control can serve as a miniature control center for an entire hi-fi system and provide switching capability for one or two signal sources. It allows outputs to be fed to one, two, three, or four pairs of stereo speakers. Each of the four stereo output channels has its own instant-impedance "L" pad volume control and any assortment of speaker efficiencies and impedance ratings may be combined in the MP-2 without overloading the amplifier's output stage. The walnut vinyl cabinet measures $8^{1}/_{16}$" W x 3⅞" D x $3^{1}/_{16}$" H (20 x 10 x 8 cm). $69.95

CIRCLE NO. 80 ON READER SERVICE CARD

DATA PRECISION MULTIFUNCTION COUNTER

A 7-digit, 100-MHz counter/timer, Data Precision's Model 5740, is designed to measure frequency, period, period average, elapsed time and total events. It features LED displays (about ½-inch high), and measures frequency from 5 Hz to 100 MHz, single period (sine wave) time from 1 microsecond to 0.2 sec., period average with 1 nanosecond resolution to 99,999.99 µsec, event counting from 0 to 99,999.99 and time interval from 0 to 99,999.99 seconds. Sensitivity is 10 mV to 20 MHz, rising linearly to 50 mV at 100 MHz. The instrument also has a front-panel trigger level control, a 20/1 attenuator, and an input impedance of 1 megohm shunted by 25 pF. Four separate gate times (10 sec, 1 sec, 0.1 sec, and 0.01 sec) are selected from the front panel. The unit can also count and resolve random pulses. Measurement capability can be extended to ± 250 V. Options include remote start/stop for time and events, a 50-ohm input termination, and BCD interface and logic control. The 5740 measures 9½"W × 7¾"D × 3½"H (21.6 × 18.5 × 8.9 cm) and weighs 5 lbs (2.27 kg). $295.00.

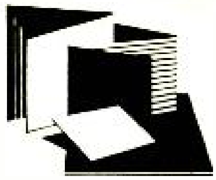
CIRCLE NO. 81 ON READER SERVICE CARD

DIP MARKER STRIP LABELS

A new line of press-on marker labels from the Vector Electronic Co. identifies DIP socket pins and circuit board hole locations on tenth-tenth Micro-Vectorboard. The 14-pin DIP markers, Model MS-9, have double sequential number lines from 1 to 7 on one side and from 8 to 14 on the other. Similar strips (Model MS-10) for 16-pin DIP sockets and IC's are also available. The circuit board markers also come in pairs of single line strips, numbered 1 through and 8 through 14 for 14-pin DIP's (MS-9A) and numbered 1 to 8 and 9 to 16 for 16-pin DIP's (MS-10A). MS-9 and MS-10 marker strips are priced at $1.98 per package of 36. MS-9A and MS-10A are $2.45 each per 36 pairs. Vector Electronic Company, Inc., 12460 Gladstone Ave., Sylmar, CA. 91342.

LED VU/S METER

A new VU meter, the Model M-241 by Pulse Dynamics Manufacturing Corp. uses seven LEDs to monitor signal levels from −15 to +3 VU in 3-dB steps. LED VU meters have no mechanical inertia and therefore no overshoot. The M241 is also available as an S meter. In both cases, the meter is offered with either vertical or horizontal scales. When a 0.775V rms sine wave is applied across the input, the Model M-241 indicates 0 VU. This calibration level is adjustable over ±10% range. The meter is reported to have a flat response over the audio range. A degree of slow decay is built-in to allow easy viewing of signal peaks. Power required is 12-15 V dc at 30 mA. P.D.M.C., Dept. 29, Colchester, IL 62326.



New Literature

CONTINENTAL BREADBOARDING CATALOG

A 16-page short-form catalog, "Spring 1975 Edition New Breadboarding Prototest Devices," has been released by Continental Specialties Corp. This illustrated catalog shows all the current breadboard Prototest equipment produced by the firm, including its new Logic Monitor. Other items described include QT sockets and bus strips, and a line of Proto Boards (one model has a built-in short-proof 5-volt, 1-amp regulated supply), and the Proto-Clip for power-on signal tracing. A special section is devoted to typical applications and answers frequently asked questions about breadboarding. Address: Continental Specialties Corp., Box 1942, New Haven, CT 06509.

TELEX HEADPHONE CATALOG

Telex Communications' 8-page catalog covers its expanded line of Broadcast/Communications headphones and accessories. Among equipment described are the Cameraman's series headsets, the Sportscaster with "push-to-cough" switch, the IC-10 headset intercom, the 1325 series broadcast stereo headphones, and the 1320 series communications headsets. Also included are general-purpose headphones, pillow speakers, and connecting cables. Address: Telex Communications, Inc., Broadcast/Industrial Sales Dept., 9600 Aldrich Ave. South, Minneapolis, MN 55420.

SHURE PROFESSIONAL PRODUCTS CATALOG

Shure Brothers' line of Professional Products is presented in a 24-page catalog. Among items covered are: unidirectional condenser, dynamic, cardiod and bi-directional ribbon microphones; omnidirectional and utility dynamic microphones; lavalier and miniature microphones, mixers, feedback controllers, and stereo preamplifiers. Also described are microphone accessories, including mounts, connectors, series transformers, windscreens, stands, attenuators, power supplies and component carrying cases. Shure's line of "stereo dynetic®" phono cartridges are included, as well as tone arms, test records, and a stylus force gauge. Address: Shure Brothers, Professional Products, 222 Hartrey Ave., Evanston, IL 60204.

CAR STEREO BOOKLET

RCA's 14-page booklet presents features and facts about its newly broadened line of car stereo players and speakers. Entitled "Come Drive With Us," this convenient pocket-sized brochure includes illustrations and technical specifications. It covers under-dash 8-track units, an in-dash AM/stereo FM/8-track unit, an automatic cassette player, and FM converter. A variety of accessory items, such as speakers and key-lock mounting brackets are also described. Address: RCA Parts and Accessories, Box 100, Deptford, NJ 08096.

SPEAKERLAB CATALOG

Speakerlab's 29-page catalog describes its loudspeaker system kits and components. The company's kitted systems, which range from two-driver, two-way bookshelf systems to four-driver, three-way systems, include grille cloth, frame, and instructions. The catalog also includes a summary of design and construction techniques. Address: Speakerlab, 5500 35th NE, Seattle, WA 98105.

EICO TEST INSTRUMENTS CATALOG

Eico Electronic Instrument offers a condensed version catalog featuring its line of kit and wired test instruments. These include: oscilloscopes, VTVMs, VOMs, tube and transistor testers, power supplies, probes, and auto testers. The six-page booklet carries product descriptions and illustrations. Address: Eico Electronic Instrument Co., 283 Malta St., Brooklyn, NY 11207.

BURGLAR/FIRE ALARM CATALOG

The Silmar Electronics' 1975 Spring catalog contains new alarms, accessories, and components, as well as other items in its line. The 12-page catalog also features illustrated and diagrammed installation instructions. Address: Silmar Electronics, 133 S.W. 57th Ave., Miami, FL 33144.

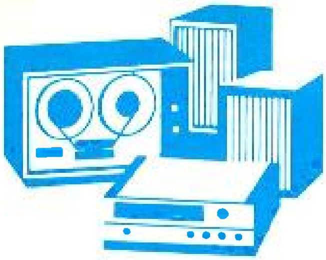
SOLID-STATE SWITCH SELECTION GUIDE

A 12-page product sheet describing two families of solid-state switches and a variety of actuating magnets is offered by Micro Switch. Product Sheet SR/SS/MG describes features and applications of the SR 5SS and 6SS series of Hall-effect sensors, which can interface directly with many electronic circuits. A detailed description of calibrated Hall elements helps users select the correct solid-state switch. The product sheet includes selection guides, sample gauss calibration curve diagrams for current sinking and sourcing, simple linear output and differential linear output circuits, mounting dimensions, a review of analog magnetic field sensors, and a description of seven special magnets. Address: Micro Switch, 11 W. Spring St., Freeport, IL 61032.

Coming Up In The July

Popular Electronics

Blackout Emergency Light
Programming Read-Only Memories
Hear Apollo/Soyuz Transmissions
What's New in Marine Radiotelephone



Stereo Scene

By Ralph Hodges

NON-TECHNICAL DEMONSTRATION RECORDS

THERE have never been so many demonstration records available from audio-equipment manufacturers as there are today. In fact, this brief overview will ignore, for now, non-music test records. (By my arbitrary definition, a demo record is a software package intended either to show off or trip up an audio system's ability to handle music that's reasonably listenable.)

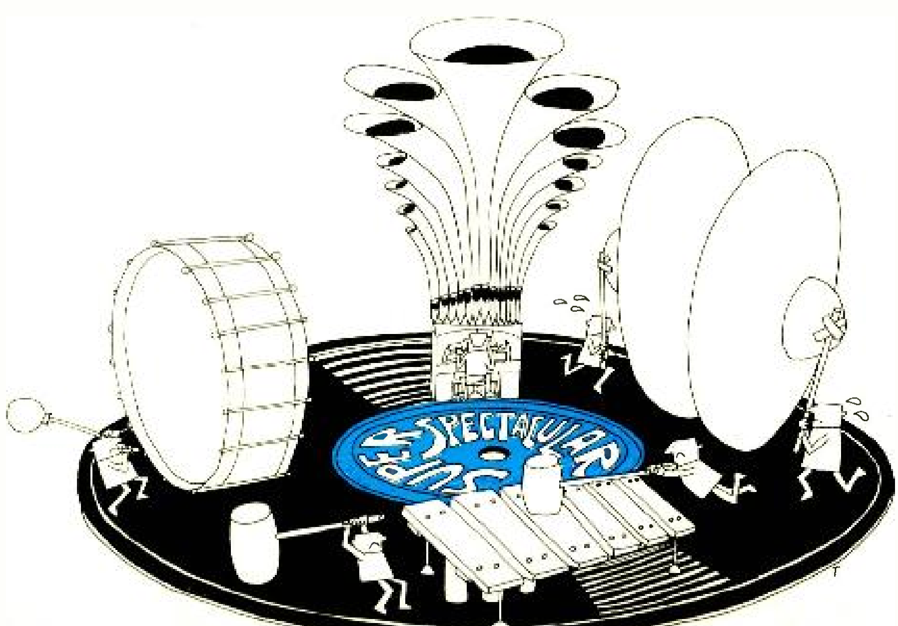
Many of these demo discs are furnished with ample instructions on what to listen for, so my specific remarks are merely supplementary. Even skilled listeners find it hard to judge the accuracy of reproduced sound without an absolute standard of reference—such as the live performance—for comparison. Lacking this, I find it helpful to concentrate on technical details of the performance. Is the string sound controlled in articulation and especially in tone, which is something professional musicians strive for? Are the unisons in unison and is there good sense of ensemble, shape, and smoothness? These are real musical values, as well as tip-offs to the stridency, raggedness, and feeling of "coming apart" that characterize flawed reproduction.

"Sessions." This JBL album was evidently put out to create a little excitement over the company's extensive connections with the professional sound industry. (JBL builds studio monitor speaker systems among other professional products.) This two-record set, while not exactly "listening for pleasure" fare, contains a lot that is potentially instructive. One disc traces the progress of a pop recording and mixing session, demonstrating such techniques as overdubbing, equalization, artificial reverberation, and the general symbiotic relationship between technician and artist in modern recording. The other disc is devoted to speaker evaluation under two categories: speaker "definition" and "coloration."

The session disc is most valuable for its excellent introduction to studio practice. Those of you with scopes will be interested to see that most instruments and vocals are mixed in mono. Only when an echo chamber is used to process the vocal track does the characteristic "fried-egg" stereo trace appear on an X-Y scope display. The very last cut on the record, introduced by the narrator as a tribute to music, is to this listener a striking example of what happens when studio equalization gets completely out of hand. Scope owners should note the considerable asymmetry of the musical waveform on this cut. Apparently some heavy waveform peak limiting has been used to introduce outlandish amounts of distortion—the type commonly associated with unbalanced amplifier-output stages.

The speaker-evaluation disc offers great riches. The terms "definition" and "coloration" are not really strictly defined (nor can they be, since the two factors are so closely interrelated), but some of the tests should prove uniquely useful. For example, a cut well into Side One features a close-miked female vocalist with very prominent speech sibilants. This is a fine demonstration of how a good, clean recording of this sort should sound. Loud sibilants have a tendency to unglue even the finest systems, especially phono cartridges and preamplifiers. Properly recorded, they have a delicate quality that suggests the soft passage of breath over the palate and teeth. When troubles occur, sibilant sounds thicken or rasp. Since the recorded levels on the disc are moderate, a phono cartridge has a fighting chance of tracking the cut properly, allowing you to hear how the rest of your system copes with this kind of signal.

Then there's the plucked acoustic bass on Side Two—just about the best test I've come across to pinpoint rattling objects in the listening room (Venetian blinds, bric-a-brac on shaky shelves, flimsy lampshades, brass spittoons, etc.). Often these furnishings chime or buzz only at the loudest moments of musical hysteria, when there is so much sonic stimulus around that they get mistaken for speaker problems or amplifier clipping. But this very strong solo bass line, ranging over the full register of the instrument, will give them away instantly as the culprits they are. (It should be pointed out that this and other bass material on the record will almost certainly bring out any acous-

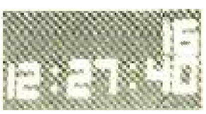


Now Heathkit digital-design Color TV comes in two screen sizes

21" diagonal 599^{95}* less cab.

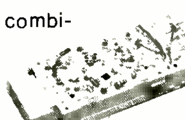
25" diagonal 669^{95}* less cab.

Now you can enjoy what Popular Electronics editors call "the color TV of the future" in either of two sizes, the original GR-2000 with 25" picture tube or the new GR-2050 with 21" tube. They have identical technology and features...just choose the picture size you prefer.



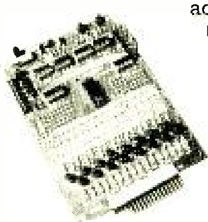
On-screen electronic digital channel numbers — big, bright, and easiest to read.

On-screen electronic digital clock time—low cost insurance against missed programs.



Silent, electronic, touch-tuning, thanks to the combination VHF-UHF varactor tuner. No knobs to turn, no contacts to clean, no noisy turrets, no humming motors, nothing to wear out. Just touch a button to tune.

Programmable Digital Counter/Channel Selector — a computer-like programming board for you to pre-program any 16 stations, UHF or VHF, or both, in any order, even repeating if you choose, so there is never any need to have unused channels again. When activated by touching the tune button or remote control, the counter silently sweeps up or down through the 16 programmed channels; release the button and the selected channel is locked in. And you can change the programming any time you wish, such as when new stations come on the air, or you move to a new locality...just slide out the Service drawer and re-program.



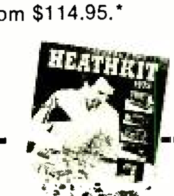
Exclusive Heathkit fixed ten-section LC bandpass filter — does away with critically adjusted traps yet eliminates adjacent-channel and in-channel carrier beats to give you truly superior color reception in multiple-transmitter urban areas or where multi-channel cable service is available. And it will never need periodic instrument alignment — it's adjusted and sealed at the factory so you have better pictures longer.

100% solid-state — more ICs than any other set in the world — 33 in all with remote control and clock — for greater reliability, less interference, truer colors, more precise tints, improved sensitivity, and better picture interlace for remarkable definition. Both sizes of picture tubes are black (negative) matrix types with full illuminated dots and black "surround" for brighter, more vivid pictures.

Easier to build, easier to service. Built-in digital-design dot generator, check-out meter, and easy-access adjustments for service you can do yourself. Modular circuit boards, wiring harnesses, and fewer chassis-mounted parts make it easier to build this color TV of the future.

Optional remote control, $89.95.* Cabinets from $114.95.*

See the complete line of Heathkit Color TVs and 350 other easy-to-build kits in this FREE Catalog.



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CL-567

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Units of Schlumberger Products Corporation
Retail prices slightly higher.

ARIZ.: Phoenix; CALIF.: Anaheim, El Cerrito, Los Angeles, Pomona, Redwood City, San Diego (La Mesa), Woodland Hills; COLO.: Denver; CONN.: Hartford (Avon); FLA.: Miami (Hialeah), Tampa; GA.: Atlanta; ILL.: Chicago, Downers Grove; IND.: Indianapolis; KANSAS: Kansas City (Mission); KY.: Louisville; LA.: New Orleans (Kenner); MD.: Baltimore, Rockville; MASS.: Boston (Wellesley); MICH.: Detroit; MINN.: Minneapolis (Hopkins); MO.: St. Louis (Bridgeton); NEB.: Omaha; N.J.: Fair Lawn; N.Y.: Buffalo (Amherst), New York City, Jericho (L.I.), Rochester, White Plains; OHIO: Cincinnati (Woodlawn), Cleveland, Columbus, Toledo; PA.: Philadelphia, Pittsburgh; R.I.: Providence (Warwick); TEXAS: Dallas, Houston; VA.: Norfolk (Va. Beach); WASH.: Seattle; WIS.: Milwaukee.

CIRCLE NO. 5 ON READER SERVICE CARD

Just think how much in demand you would be if you could prevent a TV station from going off the air by repairing a transmitter . . . keep a whole assembly line moving by fixing automated production controls . . . prevent a bank, an airline, or your government from making serious mistakes by servicing a computer.

Today, whole industries depend on Electronics. When breakdowns or emergencies occur, someone has got to move in, take over, and keep things running. That calls for one of a new breed of technicians — The Troubleshooters.

The troubleshooters have many names. In radio or TV, they're the Broadcast Engineers. In other industries, their titles may be Technical Representative or Customer Engineer.

What do you need to break into the ranks of The Troubleshooters? You might think you need a college degree, but you don't. What you need is know-how — the kind a good service technician has — only lots more.

Learn at Home . . . In Your Spare Time

As one of The Troubleshooters, you'll have to be ready to tackle a wide variety of electronic problems. You may not be able to dismantle what you're working on — so you must be able to take it apart "in your head." You'll have to know enough Electronics to understand the engineering specs, read the wiring diagrams, and calculate how the circuits should test at any given point.

Surprisingly, you'll find that you can learn the tech skills you have to know without setting foot in a classroom . . . without giving up your present job and its steady income.

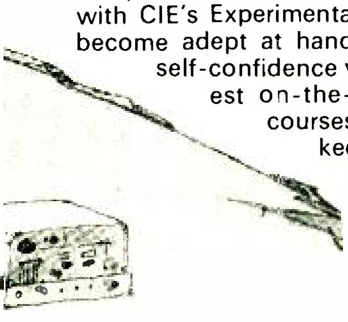
For more than 40 years, CIE — Cleveland Institute of Electronics has **specialized** in teaching Electronics at home. We've developed independent home-study techniques that make it possible for you to learn Career Electronics even if you have had no previous electronics experience. Our Auto-Programmed® Lessons help you build a thorough knowledge of Electronics just as you would build a wall . . . building block by building block . . . moving ahead at your own pace, in your spare time, until you have reached your goal.

You mail your lesson exams to CIE where our Instruction Department checks your thinking, grades your work and refers any questions to the instructor best suited by experience to help you. That way, you benefit from the combined knowledge of the entire specialized CIE instruction staff.

Exams received any weekday before noon will be graded and mailed back to you the same day. Then you can review the CIE staff comments while the work is still fresh in your memory.

You learn by doing

With CIE you can learn by doing . . . two ways: with your head and with your hands. In some CIE courses, you learn by doing "hands on" projects with actual components to solve "real world" problems . . . working with CIE's Experimental Electronics Laboratory. You'll become adept at handling components, pick up the self-confidence you'll need to handle the toughest on-the-job challenges. In other CIE courses, you'll go on to build . . . and keep . . . a big screen, solid-state color TV. After assembling the set, you'll learn the troubleshooting techniques of a TV technician with emphasis on digital electronics. The "learn by doing" method is so effective, some leading companies use CIE courses to train their own employees.



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PE-83

tic resonance in the listening room, so don't hasten to blame your speakers for any grotesque exaggerations of certain notes until you've experimented further with their placement.)

I question one test on the record that I can't get to work for me. It consists of a solo violin passage that is progressively limited in high-frequency response from a maximum of about 20,000 Hz down to 10,000 Hz. The narrator implies that no difference will be heard with a 15,000-Hz cutoff, but that losses below that frequency should be audible. I must confess that even with this violin's wealth of alley-cat overtones *and* using the very fine electrostatic headset that I finally resorted to, I could hear no significant difference—even when the bandwidth was limited to 10,000 Hz. Ordinarily, this wouldn't surprise me, since the overtones of the violin are very weak above 10,000 Hz. But I'm naturally uncomfortable when I don't hear something that I'm told is there. I suppose it's possible that a system introducing significant amounts of intermodulation distortion would "pass" this test in the prescribed way, but at the moment I'm completely in the dark.

Some final things I might mention: a few people have said they find this record strangely lacking in upper-mid-range and sometimes high-frequency energy, and I agree for certain cuts. The narrator's voice is also excessively "heavy" during much of the album, and not all of the instruments sound entirely natural to someone accustomed to hearing them from more than an inch or two away. However, "Sessions" is a very interesting record and could provide a genuine education in many ways.

(Available through JBL dealers or from James B. Lansing Sound, Technical Information Dept., 3249 Casitas Ave., Los Angeles, CA 90039. Price: $2.)

Acoustic Research Demo Record. The first of a projected series, this disc is almost exclusively classical, recorded for the most part by the Ensayo group in Spain. It is truly a high-fidelity production right down to the pressing, which in my copy is superior. Except for a Britten excerpt for string orchestra, the emphasis is on small instrumental groups and solos: a little Stravinsky, some Mozart, Kodaly, Spanish classics, and the first section from the now-familiar Bach *D Minor Toccata and Fugue*. The latter is the only selection that disappoints. A hoary old contribution from the Everest catalog, it sounds a little technically dated, and my best efforts have not been enough to get it to sound as clean as the liner notes suggest it should.

Particularly interesting is an excerpt from *Iberia* by Isaac Albeniz. This is one of the most difficult passages to reproduce well that I've encountered in a long time. Mercilessly exposed with virtually no reverberation, the upper register of the solo piano is pounded in a series of full-force chords and runs that offer a drastic test of cartridge tracking ability. On this material you *will* be able to hear audible differences between pickups. I tried several (and several phono preamplifiers as well) with widely differing results. As far as I can tell, the recording is clean and undistorted, but it will take an exceptionally good system to make it sound so.

Other attractions include the violin of Side One, Band Two, which is typically high, bright, and forward without ever being shrill; the magnificent solo cello of the Kodaly; the guitar of Manitas de Plata (if you've never heard the recordings the Connoisseur Society made of this celebrated Flamenco guitarist, don't wait another moment), and the jazz quartet on Side Two. Despite a little groove echo, this cut is as perfect an evocation of close-up jazz in a natural acoustic environment as I've ever heard. A pity that the music is a string of clichés.

(Available from Acoustic Research, 10 American Drive, Norwood, MA 02062. Price: $4.98.)

Motional Feedback Demo Record. No, this is not an invitation to modern dance. It is Philips' commemoration of the RH 532 speaker system, which employs electronic feedback techniques to "correct" speaker errors at the amplifier.

The disc's two sides are divided into light classical and light pop selections. Philips, which is of course one of the world's finer record companies as well as an equipment manufacturer, has evolved its own approach to recorded sound. This seems to consist of rather close miking, a heavy admixture of reverberation, and robust bass. I wouldn't call the end result entirely natural, but it is certainly virile. The first classical selection, from Liszt's *Danse Macabre*, illustrates this well. Another cut you might take note of is *Tuxedo Junction* on the opposite side, a rare insight into the artifice behind art. Listen to the way the back-up brass, recorded with a very "dry" sound on the left channel, is tamed with a wash of reverberation on the right. I'll bet you a pair of RH 532 speakers that this touch is courtesy of the control room rather than the natural acoustics of the recording site, but I think it comes off well. Technically, the record is well executed, and gives you a concentrated introduction to a recording philosophy that is distinctly unAmerican at the present time.

(Available from Philips Audio/Video Systems Corp., Video Division, 1 Philips Parkway, Montvale, NJ 07645. Price: $5.75.)

"Odyssey." This Altec-produced record draws on ten A & M releases to provide a selection of mostly MOR (middle-of-the-road) rock material. It's pleasant enough, though rarely profound. Apropos its technical merits, I am moved to comment on the state of recordings from the big California studios and their derivatives elsewhere. Many of them specialize in a peculiarly remote, reverberationless sound (incidentally, this also applies to much of the JBL album's content). Rarely do they go for the lush and the rich-sounding, with occasional exceptions in the bass line and for some vocal tracks. Undoubtedly they get the results they want, but the appeal of the sound may not be universal.

As one example, take the typical cymbal sound on the Altec and JBL records—effervescent but a bit bodiless, distant, and "tizzy." Compare it with the jazz cut on the AR record, or even with some of the Philips selections, where the instrument rings out with a genuine brassy clang and impact. Many modern recording outfits mike the percussion in a section of the studio that is very dead acoustically. This helps to keep the drum sound from leaking into the microphones for other instruments. Whether it also "eats up" the cymbal is not for me to speculate on. But I do wish I had the records from which these selections were taken to see if their sonics differ.

Another aspect of multi-track recording that I'm increasingly aware of might be called "dynamic perspective." In the studio, a typical pop artist tends to hammer away in pretty vigorous style. If the producer feels he should be quieter, he turns him down at the mixing console. Now if on the final version you hear a drummer who is obviously playing loud, but is being drowned out by the acoustic guitar, you (or your ear-brain mechanism) have to conclude that he's some distance away. Perhaps you can accept this until, for some special effect, the producer suddenly turns him up and he practically pops into your lap. There are a few such curiosities on the Altec record; for example, a tom-tom might jump forward for a few beats.

Notwithstanding, "Odyssey" is a competent job. The pressing may not be quite immaculate, and my copy has a slightly off-center spindle hole that troubles (with wow) the piano that's prominent on a few cuts. But I plan to listen to it again, for pleasure.

(Available from Altec Lansing Marketing Services, 1515 S. Manchester Ave., Anaheim, CA 92803. Price: $1.25.)

Home-Made with Teac. I wish I could get recording results like this in *my* living room. But anyway, according to the record, the sounds heard were indeed captured in a domestic setting, with audiophile equipment. The (pop) group featured is the "Hello People," who sing, play, and talk about their affection for the Teac 3340, the rather expensive tape deck with four-channel multi-track capabilities that was ostensibly used to make the recording. The presentation abounds in humor and plausibility, however, and there's much to interest the home recordist as well as one who wants to learn about studio techniques. The sound is generally quite good: upfront, alive, and with none of the dead-as-a-stick studio ambience.

(Available through Teac dealers. Price: $2.00.)

Bose Salutes the Sound of Mercury Records. Many audiophiles remember fondly the early Mercury "Living Presence" series of classical stereo recordings, some of which are now almost two decades old. They were high points of their era, although often prone to "overachievement" in recorded levels and creative equalization. Some of the better excerpts are presented in this Bose record, selected for their sonic interest, and intelligently remastered. All of them are orchestral, and none of them is less than exemplary, except for the brief excerpt from the Beethoven *Fifth Piano Concerto* with its strangely constipated piano sound.

I consider this material to be in the best tradition of symphonic recording—bright, spacious, impactful, and delicately detailed. There is some tape hiss, but surprisingly little for pre-Dolby days. The pressing is good, although on the several copies auditioned I've preferred the processing on Side One. If you yearn for the sounds of better days, the Bose record may be obtainable by hounding an obliging Bose dealer. Unfortunately, the company does not sell the disc direct to consumers.

The Real Thing. Among the most interesting demo records are those said to be made with no electronic doctoring whatsoever—no mixing beyond what is accomplished by microphone placement, no equalization, and usually no noise-reduction processing. Two discs now available from equipment manufacturers fall into this category.

Ambiphon Records, of which I wrote some months ago in connection with its remarkable four-channel tape recordings, has decided to broaden its market by issuing some disc records. The first is devoted to solo pianist Natalie Ryshna. (The record, incidentally, is not four-channel, although it could presumably be enhanced by playback through a matrix decoder.) Unhappily, this first offering is plagued with hiss, which was entirely absent on the tapes I heard. Apparently the noise crept in somewhere in the tape-to-disc transfer process or afterward, since it is present even between cuts. As for the piano sound itself, I think it is admirable, but not remarkable. That is, I have a few commercial piano recordings that I consider equally good. The four-channel *tapes* I heard were remarkable, however, adding a whole new dimension to the performance.

Ambiphon hopes to clear up the noise problem in the next production run, and this should add much to the record's impact. Distribution is through ESS (which is what qualifies the production as an equipment manufacturer's demo disc).

(For dealers carrying the record, write ESS Special Products, 9613 Oates Dr., Sacramento, CA 95827. Price: $11.75.)

Mark Levinson, a manufacturer of spare-no-pains audio electronics in Hamden, CT, has been live-recording for a number of years and is now up to Volume Three in his "Pure Acoustic Master Tape Reference Recording Series." I have Volume One—organ and choral selections performed in a rather intimate chapel setting. This material is remarkable for its wide, easy range, and particularly for the stability and scope of its stereo image. The latter is almost never as clear and palpable on commercial recordings in similar acoustic environments.

The acoustics are rather live, as the applause between selections demonstrates and, on my system, the sibilants from the chorus are prominent. This should raise the usual havoc with equipment that performs poorly in this area. But when all is well, the Levinson disc sounds real and untampered. I am told that the later volumes (piano and percussion, respectively), which I have not heard, are all-out attempts to capture the full dynamic range of the performances.

(Vols. One, Two, and Three are available from Mark Levinson, 55 Circular Ave., Hamden, CT 06514. Price: $10.50 each.) ◈

UPCOMING AUDIO SHOWS

October 10-12	**BALTIMORE HI-FI SHOW**	*Location to be determined*
October 31-November 3	**AUDIO ENGINEERING SOCIETY** (52nd Convention)	*Waldorf-Astoria Hotel, NYC*
November 6-10	**PHILADELPHIA HI-FI SHOW**	*Benjamin Franklin Hotel*
February 12-16, 1976	**DETROIT HI-FI SHOW**	*Cobo Hall*
March 12-14, 1976	**SAN DIEGO HI-FI SHOW**	*San Diego Community Concourse*

news HIGHLIGHTS

Bell Licenses Coupler

The Bell System has licensed Phone-Mate, Inc. to manufacture the new "Authorized Protective Connecting Module" for connection of Phonemate automatic telephone answerers to the System's telephone network. The coupling module allows an automatic answerer to be plugged into an ordinary four-prong telephone jack. Previously, subscribers who purchased their own answerers could attach these devices only through a Protective Connecting Arrangement, provided by Bell and requiring an installation charge and monthly rental fee. Under the new arrangement, answerers may be connected to the lines through the module into any extension jack.

CB and Amateur Radio Fees Reduced

As of March 1, 1975, the FCC fee for a CB license was reduced from $20 to $4; and for an amateur radio license, from $9 to $4.

Hi Fi Tape Training Console

A mini recording studio may soon appear in your local hi-fi emporium. The Creative Tape Center by TEAC, being introduced in 48 western hi-fi stores, will enable tape-machine owners to realize the creative potential they possess. The Center will teach mixdown techniques, overdubbing, basic mono and stereo techniques, and specialized effects like echo and sound-on-sound. The console uses TEAC two- and four-channel open-reel decks, a cassette deck with Dolby noise reduction, a mixing panel, three microphones and a mixer.

"Laserium" Concerts at Planetariums

Planetariums across the country have been the scene of "Laserium" concerts. They consist of projections of laser light in brilliant patterns in conformity with recorded music, which ranges through the works of Copeland, Strauss, Respighi, Billy Preston, Gustav Holst, and Emerson, Lake and Palmer, among others. The concerts, which last less than an hour, begin with the familiar sky scenes and then the laser light streaks and bobs over the dome in reds, greens, blues, and whites. The instrument that performs all this magic is a 1000-milliwatt laser projection system assembled by Laser Images, Inc. of Van Nuys, California. Although the basic program is fairly standardized, the keyboard operator can introduce variations of his own.

"NOAA" Now Official Radio Alert

The Executive Office of the President has officially selected the National Oceanic and Atmospheric Administration (NOAA) system as the sole government-operated radio system for communicating attack or weather disaster warnings direct to the public. There are 77 transmitter locations covering one-half of the U.S. population with the tone-alert service. National coverage is expected by the end of 1978, depending on Congressional appropriations. Acquisition and use of a home-warning receiver will be optional with each individual citizen.

According to the national Weather Service, additional cities that will start continuous weather broadcasts this spring are: Philadelphia; Buras and Morgan City, La.; Daytona Beach, Ft. Myers, Key West, Melbourne, and Tallahassee, Fla.; Port Lavaca, Tex.; Bay City, Ironwood, and Travis City, Mich.; Coos Bay and Newport, Ore.; Crescent City, Ft. Bragg, San Luis Obispo, Santa Barbara, and Santa Rosa, Calif.; Hoquiam, Port Angeles, Yakima, and Coachella, Wash.; Columbus, O.; Nashville, Tenn.; Rochester, N.Y., and Burlington, Vt.

WWV and WWVH Want Your Views

The Time and Frequency Division of the National Bureau of Standards is calling on users of its precise time and frequency stations, WWV and WWVH, for assistance in determining user demand. Last year, a 50-percent power output reduction was proposed by NBS for WWVH for the frequencies 5, 10, and 15 MHz. This action was postponed due to objections received from users of WWVH. Due to the government-wide efforts to reduce operating costs and conserve energy, the NBS is again soliciting users' views via a postage-paid questionnaire which is obtainable from Time and Frequency Service Section, NBS, Boulder, CO 80302.

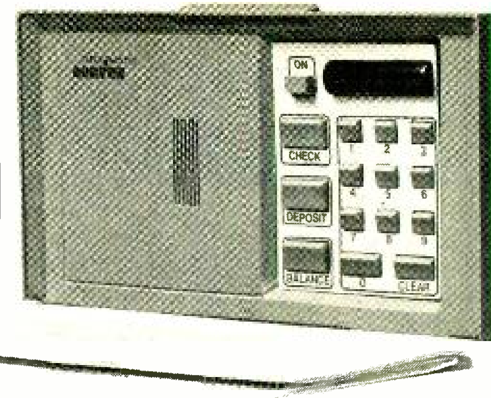
RCA Space Mountain at Walt Disney World

The latest attraction at Walt Disney World is the RCA Space Mountain—a further example of the fantastic effects that are achieved at the Park through the use of sophisticated electronics. A key feature of the Space Mountain is a thrill ride (similar to a roller coaster) that simulates a ride in space. Cars are shaped like rockets with phosphorescent side panels, and "g" forces and weightlessness are simulated by sharp dips and inclines. Many visual effects, such as strobe-light acceleration and fiery re-entry tunnels, meteor swarms and passing spacecraft, heighten the sensation of being in space.

According to Disney engineers, the ride is a good example of process control. A Data General Nova 2 minicomputer with 16K of memory space is used to oversee the operation of the ride. Data General I/0 interface circuitry links the computer to car-position sensors and electromechanical control devices. Magnetic reed switches detect car positions and pneumatic caliper brakes grip a fin beneath the car to slow it down. A back-up logic system composed of high-reliability telephone-type relays takes control of the ride in the event of computer or interface failure.

Another feature of the Space Mountain is the "Home of the Future." Here, animated figures controlled by DACS (Disney Animation Control System), are seen using small computer terminals for shopping, business and research; watching entertainment on wall-size televisions, etc.

Checkbook with a brain



Never make another checkbook error with America's first computerized banking center in a case.

The new CheckMaster is a checkbook holder with a built-in computer—a time-saving device that will keep you in perfect balance for every check you write, every day of the year.

YOUR BANK WILL LOVE YOU

If you're like most Americans, your checkbook is a disaster area. And your electronic calculator isn't helping much.

Now, there's a great new space-age product called the CheckMaster designed specifically to keep you in perfect balance, for every check you write, every day of the year. And it's actually easier to use than a calculator.

HERE'S HOW IT WORKS

Open your checkbook holder and turn on the built-in computer. Press the "Balance" key, and your bank balance is recalled on the display. The CheckMaster memory is so powerful that it never forgets your balance—even months after you last recall it.

Enter the amount of your check, and press the "Check" key. The check amount is automatically deducted from your balance, and your new balance is displayed—and all with just one key stroke.

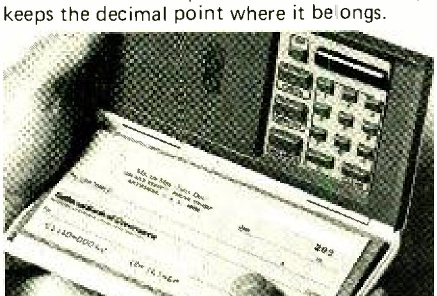
Or enter the amount of a deposit, and press the "Deposit" key. Your deposit is automatically added to your balance, and again, your new balance is displayed.

MANY EXTRA FEATURES

The CheckMaster does so much, so easily, and it's great fun to use. Here are seven reasons why:

1. Easily corrects mistakes If you enter the wrong digits, press the "Clear" key. Only your mistake will be cleared—never the balance.

2. Worry-free decimal Just enter the digits. The unit's dollar-position decimal always keeps the decimal point where it belongs.



3. Low battery signal The unit's penlight batteries will last one year with average use. A low battery signal on the display will indicate when it's time to replace them.

4. Overdraft alert CheckMaster will signal an overdrawn account plus show the overdraft amount and help you avoid the embarrassment of having a check accidentally bounce.

5. Safety switch If you forget to turn off your computer, don't worry. Whenever you close your case, your unit shuts off automatically.

6. Private viewing angle Don't worry about anyone seeing your balance. The red display can only be viewed by the user and registers up to $9,999.99 or any six digits.

7. Perfect size The CheckMaster's handsome tan and cream-colored case measures 7/8" x 3 5/8" x 6 3/4" and weighs only 8 ounces.

To find out your exact balance, even months after you've last recalled it, simply open your case and press the balance key. CheckMaster's memory never forgets. Designed for both men and women, CheckMaster holds any standard-sized personal checks, check register, credit cards and important papers.

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The American-made CheckMaster is manufactured for JS&A by Mostek Corporation, a leading consumer electronics manufacturer, and the first company to manufacture the pocket calculator integrated circuit. JS&A is the world's largest single source of electronic calculators, digital watches and other space-age products. We have decided to offer the CheckMaster directly to consumers, exclusively through the mail, for only $39.95 during our national introduction.

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Credit card buyers may call our national toll-free number or any of the local numbers listed below. Or you may send your check or money order for $42.45 per unit ($39.95 plus $2.50 postage, insurance and handling—Illinois residents add 5% sales tax) to the address shown below. But act quickly! See for yourself how easy it is to keep your checkbook in perfect balance every day of the year. Order your CheckMaster at no obligation today.

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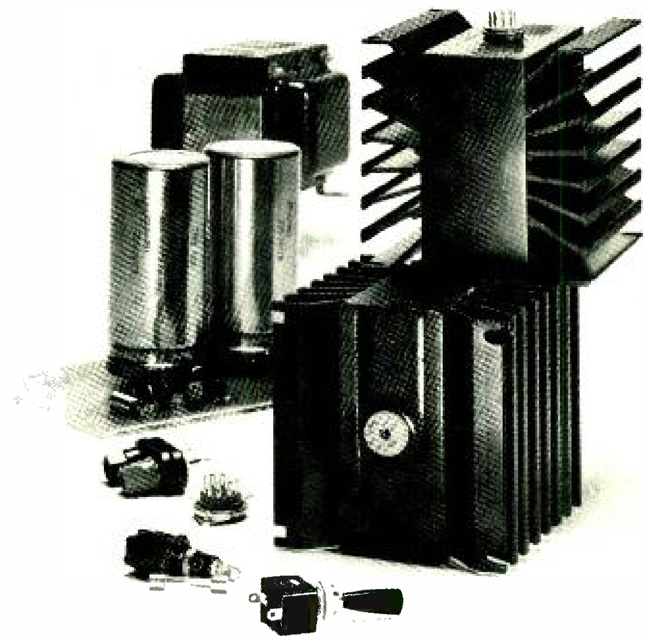
PE TESTED
CONSTRUCTION

The TITAN Modular Stereo Power Amplifier

Super op amps deliver high power, reduce construction time.



BY ROY HARVEY

TITAN is a high-performance high-power audio amplifier that is unusually easy to build because of the modular concept used in the circuit design. Power modules simply "plug in" to a socket.

The major parts of the complete stereo amplifier consist of two power modules, a power transformer, and one 8" × 4½" pc board to accommodate only a handful of components. With the unique power modules, the amplifier delivers a conservative 80 watts per channel. (Details on the modules, which eliminate considerable component mounting during assembly, are given in an accompanying box.)

Another interesting attribute of Titan is that you can choose your power output requirements—25 W, 50 W, or 80 W per channel—by specifying which power transformer to use.

The chassis measures approximately 13½"L × 8½"W × 6¾"H (34 × 22 × 17 cm) with the outboard-mounted power modules adding 4" to the length.

Circuit Operation. The schematic of one channel of the amplifier is shown in Fig. 1. The power module (*PM1*) is shown as an operational amplifier, since that is essentially how it functions. In this circuit, it is a noninverting amplifier (input connected to + terminal) with ac coupling at the input and direct coupling at the out-

AMPLIFIER SPECIFICATIONS

Power Output: 80 watts per channel (rms) into 8 ohms, both channels driven.
Harmonic Distortion: Better than 0.2% from 20 Hz to 20 kHz at rated power. Typically 0.05% at 1 kHz.
Intermodulation Distortion: 0.2% maximum into 8 ohms at rated power.
Power Bandwidth: 8 to 35 kHz ±1 dB at rated power.
Hum and Noise: 100 dB below 80 W into 8 ohms.
Input Sensitivity: 1.0 volts rms for full power.

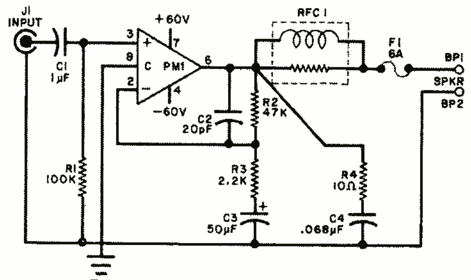


Fig. 1. The power module is a "super" 741 op amp that can deliver up to 100 watts across the audio range.

PARTS LIST

(Except where marked*, two of each are needed for stereo amplifier).

BP1,BP2—Five-way binding post (red and black
C1—1-μF, 100-V capacitor
C2—20-pF, 20-V disc capacitor
C3—50-μF, 20-V electrolytic capacitor
C4—0.068-μF, 100-V disc capacitor
C5,C6—7100-μF, 75-V electrolytic capacitor (Mallory CGS or similar)*
D1 to D4—200-V, 6-A rectifier (HEP-R0102 or similar)*
F1—6-A fast-blow fuse and holder
F2—4-A slow-blow fuse and holder*
J1—Phono connector
LED1—Any red LED*
PM1—IS741H150 power module (available only as noted below)
R1—100,000-ohm, ½-W resistor
R2—47,000-ohm, ½-W resistor
R3—2200-ohm, ½-W resistor
R4—10-ohm, 2-W resistor
R5—2700-ohm, 2-W resistor
RFC1—25 turns, #18 wire wound on a 10-ohm, 2-W resistor
S1—Spst switch
T1—72-V, CT, 4-A transformer**
Misc.—Suitable chassis, 9-pin socket (2), spacers, rubber grommet, shielded cable (6 in.), mounting hardware, line cord.

Note—The following are available from Integral Systems, 500 Waltham St., North Wilmington, MA 01887; pc board at $4.00; power transformer at $25.00**; power modules at $70 each; complete stereo kit including the above with chassis at $199.00.

**Select transformer on basis of desired power output (for heavy commercial use, don't exceed 50 W/ch.):

8-ohm Spkr.	*Trans. Sec.*
25 W/ch.	36 VCT, 5 A
50 W/ch.	56 VCT, 4 A
80 W/ch.	72 VCT, 4 A

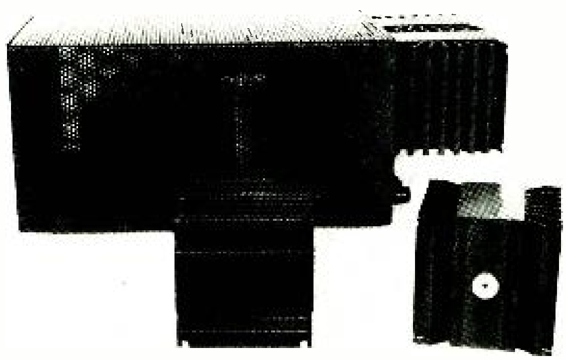


Photo shows assembled amplifier and two of the power modules.

put. Capacitor *C1* and resistor *R1* provide dc isolation from the source and a 100,000-ohm input impedance. Resistors *R2* and *R3* determine the gain of the amplifier, which is about 25. Thus, a 1½-volt rms input produces about 30 volts at the output, which is more than enough to provide 110 watts to an 8-ohm load (3.75 amperes).

Capacitor *C2* provides a rolloff of gain at high frequencies to prevent ringing and oscillation, while *C3* forces the op amp to act as a unity-gain voltage follower for dc signals. The latter lowers the output offset voltage.

The power supply (Fig. 2) is a heavy-duty, dual-polarity supply that uses a conventional bridge rectifier and filter system. Power-on indicator *LED1* is across the +60-volt supply.

Construction. The etching and drilling guide for a printed circuit board and a component layout are shown in Fig. 3. Also shown are the connections between the board and power modules, transformer, light, and terminals. In assembling the board, be sure to observe the polarities of the diodes and electrolytic capacitors.

Connections to the power modules are made through a vacuum-tube-type 9-pin socket. The modules also have four slots on the same side as the socket for mounting with machine hardware.

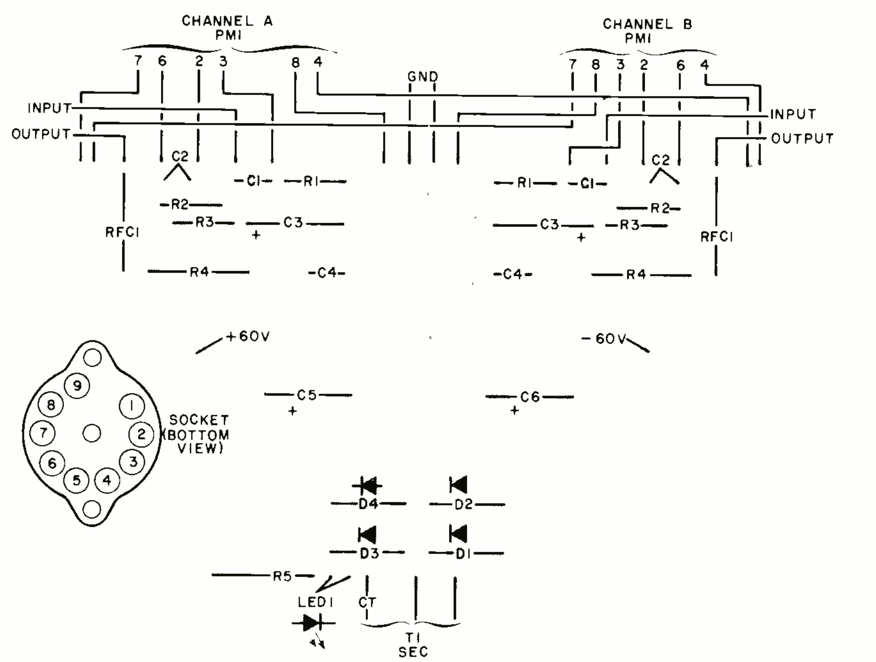
The photographs show the components of the prototype. Note that the power modules mount so that the heat-sink fins run vertically to provide "chimneys" for the heat.

The power modules do not have built into them protection circuits to guard against damage resulting from sustained short circuits across their outputs. Therefore, it is essential that the "hot" output lines be fused as shown in Fig. 1.

Use a red binding post for the "hot" speaker terminal on each channel and a black binding post for the common terminal. Mount the LED in a tight-fitting rubber grommet.

Use shielded audio cable for the two input lines going from the jacks to the amplifier assembly and #18 or heavier hookup wire for the power, output, and ground connections.

Operation. Before putting the power modules into their sockets, turn on the power and make sure that *LED1* is illuminated and that there is +60 volts



at pin 7 and −60 volts at pin 4 of each module socket. Then turn off the power and mount the modules.

(Note: *It is extremely important that the module pins and the socket be clean and free of oxide "scale" and that the "fit" between the two be tight to insure good electrical contact.*)

Connect an ac meter (30 volts) or an oscilloscope to each of the output terminals and apply a signal of less than 1 volt amplitude to the appropriate amplifier input. Note that the

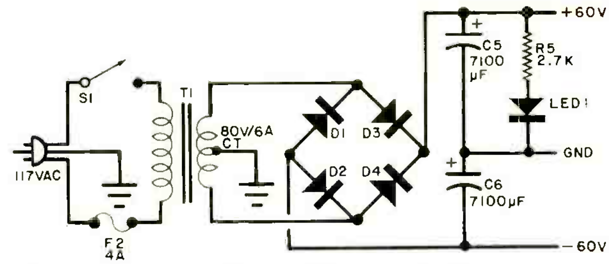


Fig. 2. Power supply can deliver up to 2 amperes and will suffice for a two-channel amplifier.

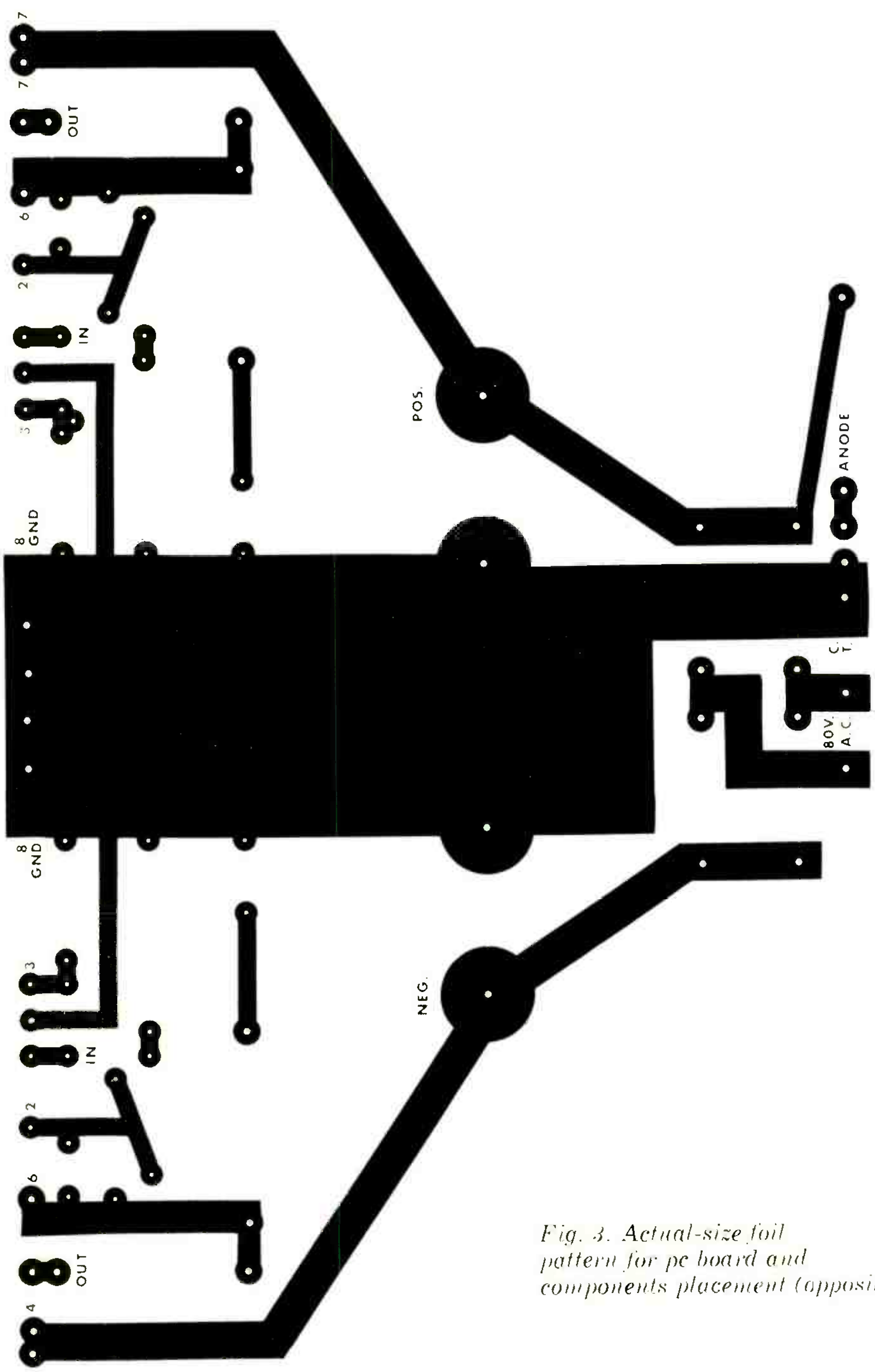
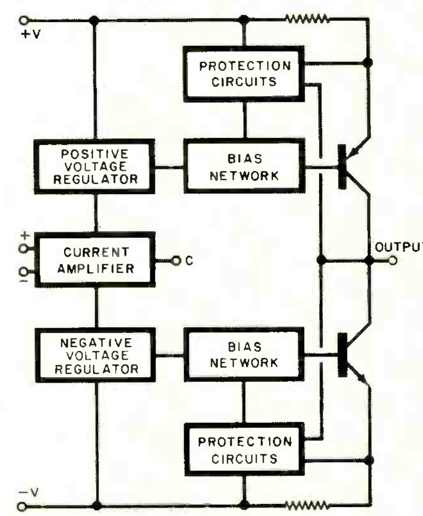


Fig. 3. Actual-size foil pattern for pc board and components placement (opposite).

ABOUT THE POWER MODULE



The Integral Systems 741H150 module (patent pending) is a cast hybrid structure with true differential inputs and full complementary output. The current amplifier sinks current through terminal C from either of the two voltage regulators depending on the instantaneous polarity of the signals at the positive and negative inputs. The regulators and bias circuits relay this information to the complementary output transistors.

Common-mode damping eliminates any tendency for the output devices to turn on simultaneously, as often happens in conventional amplifiers. Crossover bias current in the output stage is determined by the interplay of the damper and bias circuits. Thus, the collector output push-pull configuration, which has high gain but is unstable in many designs, is stabilized by the integral epoxy construction of the module and the resulting thermal equilibrium of the components.

The module also contains special circuitry to protect the output devices when operating conditions approach the danger point.

The 741H150 module performs as a conventional 741 op amp, except that it can deliver up to 10 amperes of current and can operate with supply voltages up to 120 volts.

output waveform is proper and that there is no large dc offset.

Turn off the power, connect 8-ohm speakers and a preamplifier to the Titan. Be sure the gain control in the preamplifier is turned down before turning on either the preamp or the Titan to avoid damaging the speakers. ◈

TITAN MODULAR STEREO AMPLIFIER
(A Hirsch-Houck Labs Report)

We tested the Titan amplifier with both channels driven into 8-ohm loads. (Since the amplifier is specifically not recommended for use with 4-ohm loads, 4-ohm-load laboratory instrument tests were not conducted.) The full rated power of 80 watts/channel was used as the maximum output power in all our tests, except that we briefly went to a higher power level to determine the amplifier's clipping level, which measured 120 watts/channel. It met all its claimed specifications.

At the 80-watt output power level, total harmonic distortion (THD) measured less than 0.02% between 20 and 600 Hz. It rose smoothly with increasing frequency to 0.17% at 20,000 Hz. Operation at half and one-tenth power did not significantly change the distortion characteristics, although the low-frequency distortion increased slightly, to a maximum of 0.04% at 20 Hz.

The 100-Hz THD decreased smoothly from 0.18% at 0.1 watt to between 0.03% and 0.04% at power outputs from 4 to 80 watts. Intermodulation (IM) distortion increased from about 0.025% at 0.1 watt to 0.1% at 5 watts output. At 80 watts out, it measured 0.13%.

A 0.34-volt input drove the Titan to a reference output of 10 watts. The output noise in a 25,000-Hz measurement bandwidth was 95 dB below the 10-watt level. Using the rated 80 watts/channel as a reference, the input sensitivity measured about 1 volt. The noise level was a very good −104 dB.

The frequency response of the amplifier within the audio band was down 0.4 dB at 20 Hz and 0.65 dB at 20,000 Hz. (It dropped to −3 dB between 5 and 10 Hz and at 50,000 Hz.) The square-wave rise time was 10 μs, and the amplifier was stable with a 2-μF load in parallel with 8 ohms.

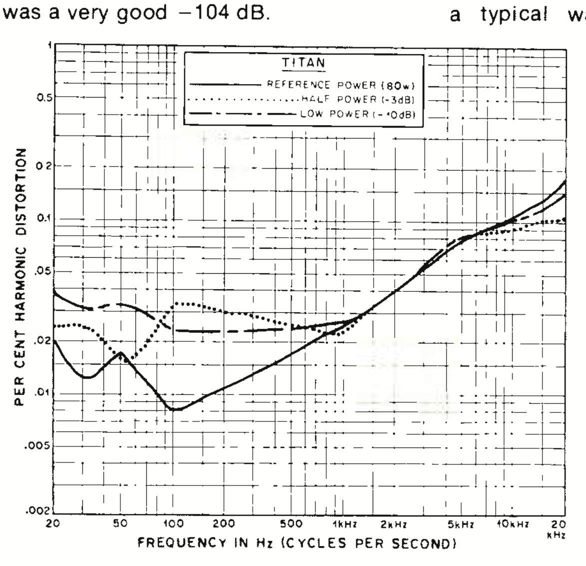
There were one or two cycles of damped ringing at about 30,000 Hz when we used the capacitive load.

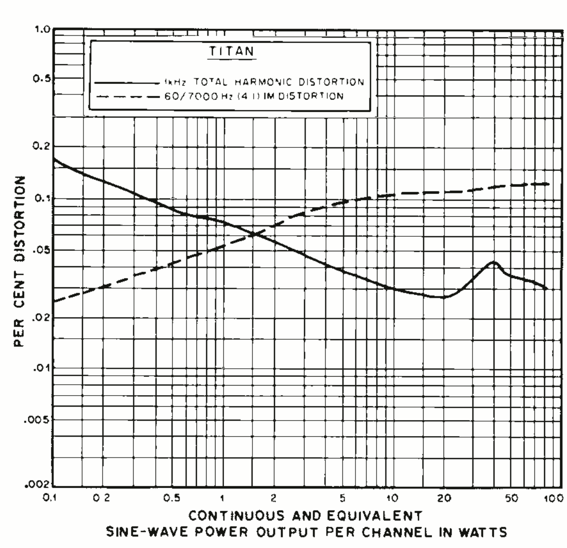
User Comment. During the course of testing the 80-watt/channel version of the Titan (we also tested a 100-watt/channel version), we blew out the power module. This, we believe, was caused by two conditions. First, we exceeded the recommended output power levels by a considerable margin. And dirt in the power module's socket plus an improper fit were possibly secondary causes. Cleaning the socket, plugging in a new module, and keeping the maximum output power levels reasonably near the maximum recommended avoided a repetition of this breakdown.

It is obvious from our lab test-bench report that the Titan amplifier is an excellent performer. Its measured performance, in fact, was excellent in *every* respect. Although the "music-power" rating has fallen into disfavor, the characteristics of the Titan do give it a very high music-power capability. In fact, the amplifier is able to deliver more than 120 watts/channel with very low distortion. If a typical waveform peak-to-average power ratio of at least 10 dB is assumed, the power modules can loaf along at a comfortable 10 to 12 watts average power, yet still be able to deliver 120 watts peak without distortion.

As with many high-power amplifiers, if the Titan is to be operated at high power levels or in an enclosed space, an external fan to remove excessive heat from the power module heat sinks should improve reliability. If you intend to operate the amplifier for heavy-duty use, we recommend that you go to a lower output power rating than the specified 80 watts/channel maximum, which one can do by choosing the proper power transformers (see parts list). This way, you will avoid overheating the modules.

The Titan was put through a worst-case operating situation by connecting it to an AR-LST 1, a 4-ohm speaker that has a very low impedance curve at the high-frequency end. Playing the amplifier for a few hours at high listening levels (average 87 dB in mono, about 90 dB in stereo) did not have any harmful effect on it, although the epoxy body did get pretty hot, as one would expect. So, clearly, the Titan can be used under any normal home-listening conditions, although aforementioned precautions should be followed, such as derating power, if one wishes to use it for a rock concert. Further, our project builder advised that it was the easiest power amplifier he had ever assembled, requiring less than an hour's time for assembly of the electronics.





TIMBRE & VOICING CIRCUITS FOR ELECTRONIC MUSIC

BY DON LANCASTER

Techniques for converting basic frequency references to elaborate musical notes.

THE majority of electronic musical instruments generate tonal frequency references in whatever waveform happens to be handy. To convert a sine, sawtooth, or square wave into varied and interesting musical sounds, the signal's time and frequency structure must be altered so that it simulates the sound of a traditional musical note or provides a new type of note or special effect.

To alter the time structure of the envelope of a tone (see "Keyers and VCA's," January and February 1975), a suitable waveform with the attack, fallback, sustain, decay, snubbing, and echo desired is combined with the required frequency reference. The envelope waveform is then multiplied by the frequency or tonal information to give the overall tone time shape desired.

But this is only half of the problem. A steady-sounding trumpet is very different from a steady-sounding clarinet, even when both instruments are sounding the same note and attack and time differences are ignored. The differences in sound between different types of musical instruments are called color or timbre. Circuits that alter timbre are called voicing circuits, filters, tracking filters, and voltage-controlled filters (vcf's). Only when suitable voicing is combined with a selected envelope does the final musical note result.

Elements of Tonal Color. Color differences between notes are obtained by the presence of harmonics, nonharmonic but related multiples of the basic pitch, multiple tones in chorus and warmth situations, and "extra" sources of noise (chiff, buzzes, random noise and variations, and other unrelated audio energy sources). By selecting the correct combination of these things, almost any desired timbre waveshape can be generated. Multiply the waveshape by an envelope, and the note can have any color you want.

Harmonics are the easiest with which to deal, but they are not by any means the whole story. If the zero-crossing points of a musical waveshape always occur at the same fixed fundamental frequency, that waveshape can be broken down into a fundamental-frequency sine wave and a series of harmonic sine waves of various phases through a mathematical process known as Fourier Analysis.

In Fig. 1 is shown how sine waves and their harmonics can be combined to build three basic musical waveforms, the square, sine, and sawtooth waves. Creating a new complex waveform is known as synthesis. While direct analysis and synthesis are often the best ways to find out what color you want and how to go about obtaining it, you rarely use direct synthesis to do the actual coloring process. This is because you can generate a square wave (for example) much easier with a digital flip-flop than by summing dozens of sine waves.

The undistorted sine wave has no

EMS "Synthi KS" Digital Sequencer Keyboard

harmonics present and is close to a flute-like tone. The square wave consists of diminishing odd harmonics only and produces a nominally hollow or "woody" sound like that associated with such woodwinds as the clarinet and stopped organ pipes. The sawtooth wave has all harmonics present in a uniformly decreasing series and produces a "bright" tone like that of a stringed instrument or, with bandpass modifications, a trumpet or other horn. Since everything needed is available in the sawtooth wave, it often represents a good "universal" waveform with which to work in electronic music because it is easy to use it to build a lot of realistic voices. Other basic waveforms can lead to voicing difficulties. The triangle waveform, for instance, does not have enough harmonic strength to be useful and the impulse has far too much strength.

The methods of getting back and forth between the basic waveforms are shown in Fig. 2. A sine or triangle becomes a square wave by heavily amplifying and then limiting it, but this can be done only to one sine wave at a time if intermodulation distortion is to be avoided. A sawtooth linearly becomes a square wave if minus one-half the second harmonic is summed with itself. This is called "outphasing," a technique that can handle many notes at once.

Getting from a square wave to a sawtooth wave can be accomplished by using a binary divider and a staircase generator. This particular approximation sounds much better than it looks. In a 16-step staircase, the first missing harmonic is the 16th, the next is the 32nd, and so on. Otherwise, the waveform is identical to a sawtooth.

Finally, to get from the more complex waveforms back to a sine wave, the fundamental can be sharply band-pass or low-pass filtered. A high Q needed for good second- and third-harmonic rejection directly conflicts with the need to handle many notes of different frequencies simultaneously. So either a tracking filter or fixed filters of only one-third—or at most one-half—an octave can be used.

Harmonics permit us to build many instrument imitations. Nonharmonic multiples can also be very important and are usually much more difficult to handle electronically. Nonharmonic multiples in the piano are "almost harmonics" caused by lateral stiffness of the strings, particularly on the low-frequency end. These almost-harmonics are called "partials" and get progressively sharper (higher in pitch) with harmonic number. For this reason, piano keyboards are not tuned to absolute pitch because, if they were, the nonharmonic partials of the low notes would sound out of tune with respect to the higher notes. Instead, piano keyboards are stretched while tuning to make the low notes flatter and the high notes sharper than they really are. The result is a warmer, fuller sound character.

Another feature of piano notes is that the hammer usually strikes three strings simultaneously. The strings are almost but not quite tuned in unison. This gives the characteristic warmth to a piano tone. It also explains why a chorus or an orchestra full of violins sounds richer than a single violin. Chorus and warmth effects can be introduced electronically by using several tone sources, differentially delaying ("Doppler modulating") one tone source, or using special-purpose tape delay units.

Yet another example of nonharmonic multiples are carillons and bells, which produce strong sequences of fifths (5:3 frequency) and others present in the characteristic cast-bell tone. Any other situation where you are intentionally generating chord sequences takes tonal groups related by something other than simple harmonics. It is often possible simply to use multiple combinations of notes already in hand.

The final noise effects—chiff, buzzes, etc.—are usually tacked on an as afterthought. In traditional musical instruments, they are inherent and unwanted byproducts or defects of the instrument's physical characteristics. Obvious examples are the wind noise in a pipe organ, steam in a calliope, resonance buzzes in a poorly designed or low-cost violin or guitar, sympathetic vibrations, etc. One time you do *not* tack on noise effects is when the note is predominantly filtered noise, such as that used for some percussion effects. In this case, the usual practice is to start with white or pink noise and filter it, the sharpness of the filtering determining how close you want to get to a well-defined fundamental tone. Small amounts of

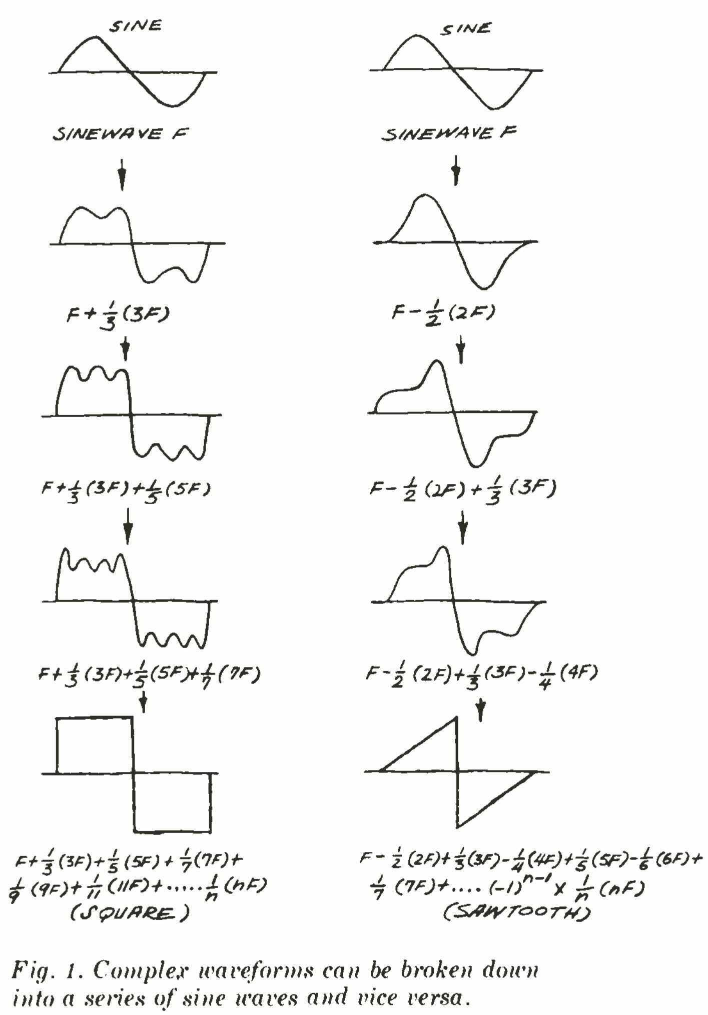


Fig. 1. Complex waveforms can be broken down into a series of sine waves and vice versa.

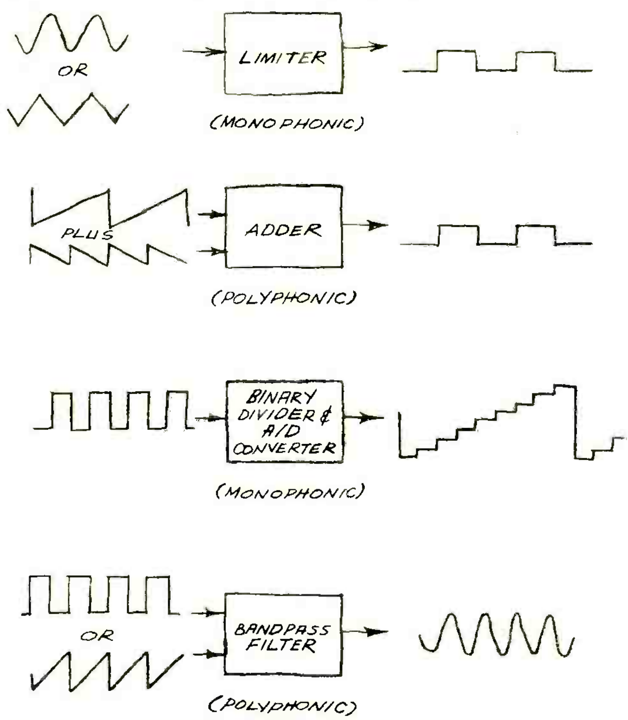


Fig. 2. Ways of transforming basic waveforms.

noise and frequency shifting can be introduced to slightly randomize or break up the exactitude of electronic pitch generation systems.

Harmonic Structure. Once you have decided what you want in harmonics, you have a second decision to make: whether you want identical harmonics on every note, changing harmonics as the notes change in frequency, or some combination of the two.

Musical instruments are basically some sort of acoustical bandpass filter. The horn on a trumpet is a pipe resonator. The guitar or violin is more or less a cavity resonator. These resonances are physical constants. Since they do not change, the harmonic structure of the notes passed through them evidently must change for notes of different frequencies. So, almost all traditional instruments introduce fixed-frequency filtering that alters the harmonic content from note to note. A fixed filter gives a variable harmonic content. If your primary goal is to imitate traditional instruments, fixed-frequency selective emphasis and de-emphasis of various frequency ranges is called for.

The sound once (and still) referred to as the "Hammond sound" is now called "synthesizer sound." Its characteristic is that all the notes have identical harmonic structures, evolving from the Hammond organ's electromechanical system in which synchronously rotated steel cams were used. As the cams rotated, each generated a series of harmonics that could be selectively added to a fundamental. All notes were treated identically and had identical harmonic structure. You can obtain the same effect in a synthesizer by using a tracking or voltage-controlled filter. Hence you need a moving or variable filter for a fixed harmonic structure.

Neither of the above techniques is "better" than the other. The one you use depends on what you are after. Traditional instrument synthesis will often sound phony if you use fixed harmonic structure. On the other hand, the fixed-harmonic-structure notes offer much in the way of flexibility and new sounds. (These two basic filter techniques are compared in Fig. 3.) One big advantage of a synthesizer is that you can handle both types quite easily.

Another reason for using variable or tracking filters is to let the harmonic content of the note change during the envelope time. In many musical instruments, higher harmonics decay faster than do the lower ones, while in the piano, sympathetic resonances may actually build up harmonics with time. These effects can often be obtained by adding an electrically variable filter to the output of the fixed formant filter, sliding the filter down as the note decays. A changing harmonic structure with envelope time, particularly with the decay cycle, is the key to realistic traditional instrument syn-

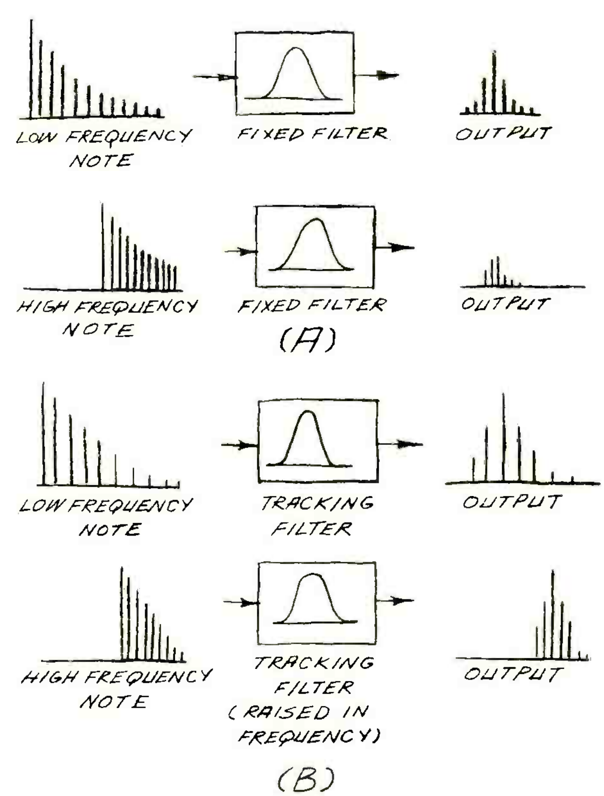


Fig. 3. Fixed filter (A) alters harmonic content from note to note. With tracking filter (B), output tone spectrum is independent of input.

thesis. It also provides many new possibilities for far-out sounds. (We will take a close look at what the traditional instruments need in harmonics and envelope in a future article in this series.)

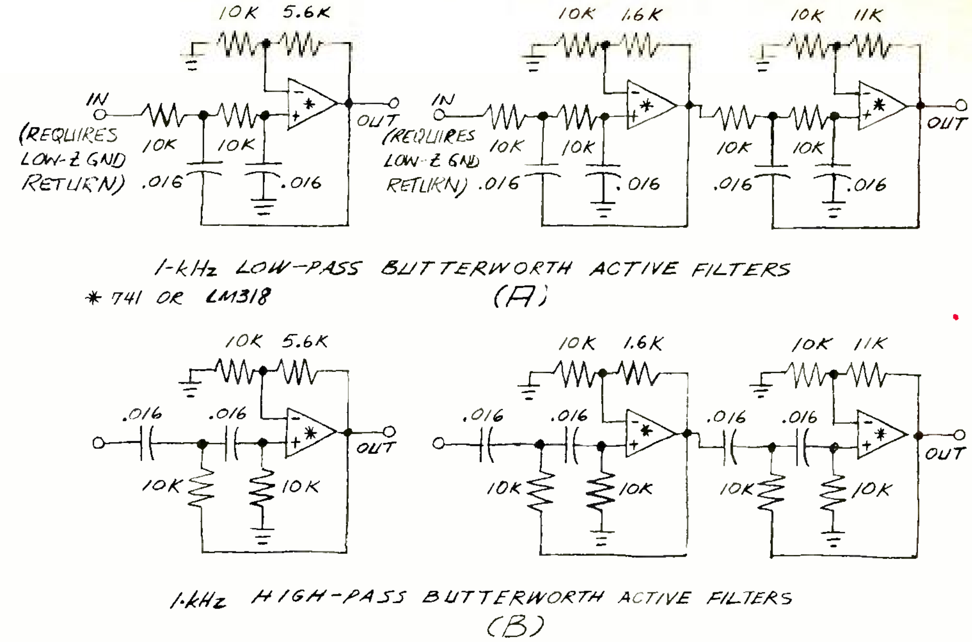


Fig. 4. Active filters on left have 12 dB/octave slopes. On right, are 24 dB/octave filters.

Voicing Techniques. As a general rule, there are four basic ways to electronically generate a suitable musical voice. Starting with a waveform or waveforms containing more harmonics in a different structure than are needed, filtering, or a "subtractive" method, can be used. Also called formant filtering, it is by far the most popular fixed-filter method used today in both electronic organ and synthesizer circuits.

An "additive" method can be used. Here, harmonically related sine waves are combined in the correct proportions to yield the desired note. While this approach was often used in older electromechanical organs, it is generally complex and difficult to program, and it is somewhat limited, requiring too many harmonics to achieve good synthesis. Too, if you are attempting to synthesize the sound of a traditional musical instrument, you must also provide for changing harmonic content with changing pitch.

A third approach is called the "nonlinear" method of voicing, where a fundamental frequency is run through a diode or other highly nonlinear component to generate harmonics. The harmonics are then filtered by the subtractive method. Some monophonic pedal circuits in home organs half-wave rectify a sine wave to get the strong second harmonic needed for diapason pipe synthesis. There are serious limitations to the nonlinear method. The input amplitudes may be critical if the nonlinear system is to generate the proper harmonic structure. Also, it is strictly a one-note-at-a-time monophonic technique; two notes fed into a nonlinear circuit at the same time will produce intolerable intermodulation distortion.

The fourth method of voicing is "replication." Here, the note wanted is generated directly in exactly the shape desired by starting with some sort of model or "replica" of the tone to be produced. For example, a binary-addressed read-only memory (ROM) could be followed by a digital-to-analog (D/A) converter. Stored in the ROM would be the exact wave shape desired. The faster the ROM is clocked or addressed, the higher the output pitch, but the shape would remain the same, as would the harmonic structure. The same thing could be done with a you-program-it computer lashup in which the timbre and envelope are simultaneously programmable. Important advantages of the replication technique are its tremendous flexibility and extreme simplicity, especially when new voices are to be added to the system. You can easily try a starting system with a binary counter, 7489 ROM, and MC1406 or MC1408 (both by Motorola) D/A converter. Cost is less than $10 for the system.

We might call "noise" technique a fifth basic approach to timbre generation, but it is really a form of subtractive filtering. Instead of removing or emphasizing harmonics of a fixed tone, various portions of a noise spec-

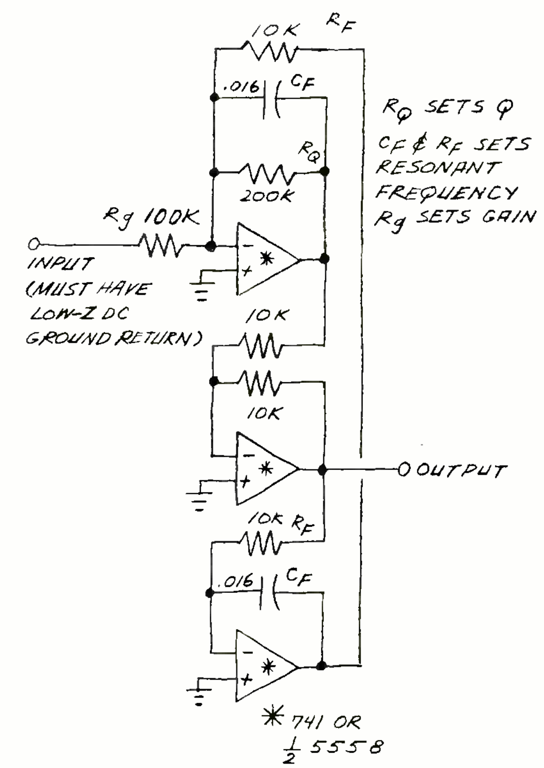


Fig. 5. Biquadratic bandpass filter set to 1 kHz resonance and Q = 20.

trum are emphasized or de-emphasized. Both are essentially subtractive filter techniques.

Filter Circuits. The subtractive filter technique is by far the most popular used in today's electronic music systems. Originally, fixed RC filters were used, with an expensive inductor or two thrown in only where absolutely necessary. This accounts for some of the rather poor instrument imitations produced by some older economy organs.

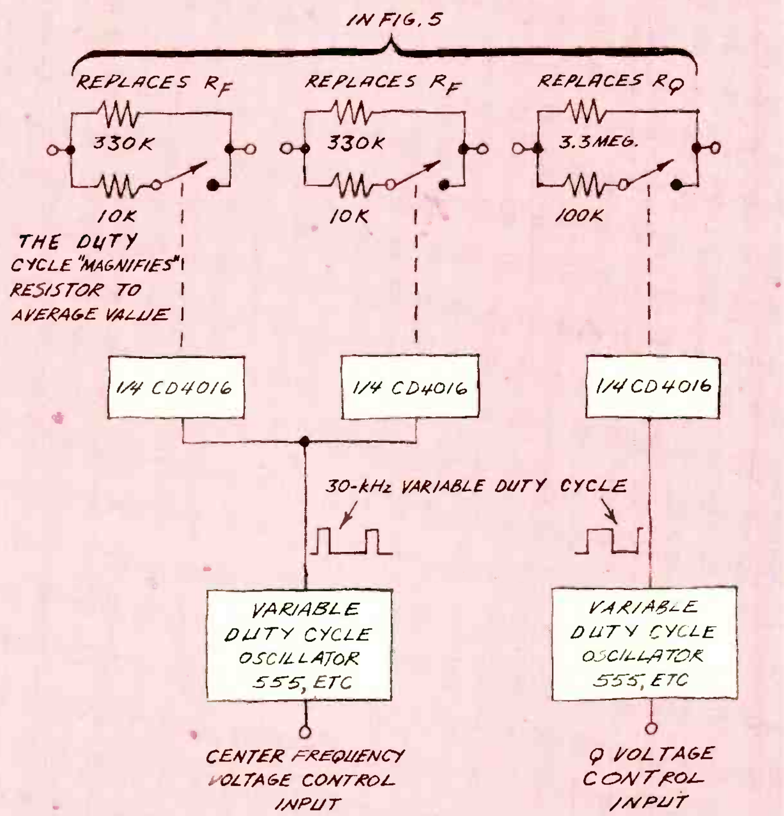
Today, we have a new approach: active filters. The active filter combines resistors, capacitors, and operational amplifiers (usually the inexpensive 741 op amp) to simulate exactly the type of filter you could normally build only with expensive, large, adjustable inductors.

Important advantages of active filters are their low cost and easy tuning and the total absence of loading problems. The last lets you combine and cascade sections in many arrangements without interaction. Better yet, is the ability of certain active-filter circuits to be electronically controllable to permit you to electronically shift the cutoff frequencies or bandwidths under voltage or digital-word control. This lets you move the filter from note to note or change the harmonic structure during the envelope time.

Pairs of high-pass and low-pass active Butterworth filters with 12- and 24-dB/octave slopes are shown in Fig. 4, while a single-pole active bandpass filter circuit is shown in Fig. 5. For higher frequencies and higher Q's, premium op amps like the National LM318 should be used to replace the 741 device, for which it is a direct pin-for-pin replacement.

To change the cutoff or resonance of the above filters, simply scale down the values of all the capacitors. For instance, doubling the capacitive values moves the 1000-Hz response of the figures down to 500 Hz. You can also scale down the resistor values, but you must keep all frequency-determining resistors and all capacitors identical in value.

The fixed active filter can be used for formant synthesis of traditional instruments, usually by starting with a sawtooth for most voices, except for some woodwinds that are better off with a square wave. Heavy sinewave filtering can be used for flute and piccolo and certain bland organ voices. ◈



CMOS switch is added to circuit in Fig. 5 to make a high-performance voltage-controlled bandpass filter.

ELECTRONIC TRACKING

How is it possible to vary *electronically* the cutoff frequency of an active filter? The answer is that anything that can change the value of a resistor under voltage control—such as a FET, incandescent lamp, or LED and photocell—will do the job. However, linearity, power, "insertedness," and cost might be objectionable. The CA3080 circuit on page 37 of the February 1975 issue provides good filter control.

Today, there is a new and easy way to build a tracking filter, working with the inexpensive CD4016 (RCA) or MC14016 (Motorola) CMOS integrated analog switch circuit. It works in an active-filter circuit that is basically an integrator, such as the low-pass versions in Fig. 4 and the bandpass circuit in Fig. 5. The details are shown in the circuit above.

The key to the process is to make a fixed resistor appear to be variable. If the value of a pair of fixed resistors can be electronically controlled, the same thing could be done as varying a dual potentiometer and automatically tracking any note you want. Better yet, if you want to, you can change parameters *during* the note's envelope, providing all sorts of synthesis possibilities.

The CD4106 is a quad analog switch that rapidly lets you turn a given resistor on and off. If you vary the off-to-on duty cycle, you can make the resistor look—on the average—like any resistance you want, from its actual value to infinity. The only requisite is that the switching be much faster than the highest frequency of interest so that the capacitors in the circuit average out the on/off switching into an essentially proportional resistance. In a 400-Hz bandpass filter, for example, an 8000-Hz *minimum* switching rate is recommended, with proportionately higer ultrasonic frequencies needed for higher cutoff frequencies.

The switches can be driven from an ultrasonic source of rectangular waves with a variable duty cycle. This is easily accomplished with CMOS logic. Alternatively, you can use the 555 or 8038 IC devices for initial tests, switching over to a voltage-controlled duty cycle modulator later on. (Incidentally, really good wide-range active bandpass filters that are stable and track have not been available at reasonable cost before. Both these techniques give you a wide open field for serious electronic music experiments.)

HOW TO DESIGN YOUR OWN POWER SUPPLIES

Following a step-by-step procedure, you can build a line-operated, professional power supply to your personal requirements.

BY JIM HUFFMAN

ALL active electronic projects and equipment require a power supply. The battery supply, of course, is convenient for low-power and portable applications. For the majority of applications, however, the ac, or line-operated, power supply is more practical for equipment which requires moderate or high power and where portability is unimportant.

This article tells you how to design line-operated power supplies. Our building-block approach starts off with the power transformer/rectifier/filter system that is basic to all line-operated supplies. Then we introduce voltage and current regulation and finish up with the error amplifier used in the power supplies found in the most sophisticated electronic equipment. You merely design your power supply to suit your needs.

From the Beginning. The schematic diagram of a very basic power supply is shown in Fig. 1. The power transformer steps down (or up for high-voltage supplies; in this article emphasis is on the low-voltage supply) the input voltage from the ac line to roughly the voltage needed for the project. The low voltage at the transformer's secondary then goes through a rectifier system, where it is converted to pulsating dc. The filter system then smooths out the pulsations to make the dc voltage at the supply's output more like the steady-state dc characteristic of batteries.

The choice of transformer depends mainly on the supply voltage and current demands of the project for which the power supply is designed. Let us assume that the circuit requires 12 volts at a maximum of 500 mA (0.5 A). A commonly available 12.6-V, 0.5-A transformer will do nicely. If you can't find a transformer with the exact ratings for your project, a higher secondary voltage and/or current rating will do. For the higher voltage rating, you will have to devise a dropping or regulating system to reduce the supply's output voltage to the proper level. Note that lower voltage and current ratings should never be used.

To insure safety in your projects, always design a fuse into the power supply. Determining the current rating of the fuse is simple. First, divide the line voltage by the transformer's secondary voltage. Divide the secondary current by the result. Then multiply your answer by 5 if you intend to use a slow-blow fuse (by 10 if you intend to use a fast-blow fuse). For convenience, you can round out the line voltage to 115 or 120 volts and drop fractions of a volt in secondary voltages.

Applying this procedure to our sample problem we get: 120 V/12 V = 10. Then, 500 mA/10 = 50 mA, which is the primary current. Finally 50 mA × 5 = 250 mA (1/4 A) for slow-blow or 50 mA × 10 = 500 mA (0.5 A) for the fast-blow fuses.

The three basic rectifier schemes used in single-phase power supplies are shown in Fig. 2. The half-wave rectifier is difficult to filter and should be used only in projects that have no critical circuitry. The full-wave and bridge rectifiers have twice the output ripple (120 pps in a 60-Hz setup) as the half-wave scheme and are easier to filter for projects in which critical circuits are used.

The full-wave rectifier scheme requires the use of a center-tapped transformer that can deliver twice the secondary voltage of a transformer used with a bridge rectifier to obtain the same output voltage. Its current rating, however, need be only half that required by the bridge-circuit transformer. The individual rectifiers in a bridge scheme must have peak inverse voltage (PIV) ratings of at least two times the rms voltage at the transformer, while the diodes in the full-wave and half-wave schemes must be rated at four times (minimum) the rms voltages at their transformer secondaries.

To design the filter system, first cal-

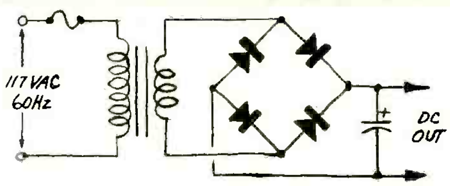


Fig. 1. Schematic of a basic power supply. The transformer steps the voltage down, the diodes rectify the voltage, and the capacitor smooths the output.

culate the power supply's load resistance by dividing the output voltage by the load current (12 V/0.5 A = 24 ohms). Then calculate the ripple period, or time constant, by finding the reciprocal of the ripple frequency (1/120 pps = 8.3 ms). Now, you can calculate the required filter capacitor value.

The value of the filter capacitor should be chosen to provide a time constant of at least three times the ripple period. In equation form, $C = 3TC/R = (3 \times 8.3\ ms)/24\ ohms = 1000\ \mu F$, which is the absolute minimum value you should consider practical. You would be better off going to a 5000-µF value.

The voltage rating of the capacitor is equally important. It must be greater than the *peak* secondary voltage. In our example, 12.6 V is an rms value. To convert it to peak, multiply by 1.414: 12.6 V rms × 1.414 = 18 V peak. A safe rating for the capacitor would, therefore, be 25 volts.

Further Considerations. The power supply we have just designed has an inherent problem: its short-term stability isn't very good. Without some form of regulation, the output voltage will vary with changes in load and even with changes in input voltage. While poor regulation might be acceptable for some applications, it can present problems in critical digital circuits, test equipment, and even audio gear.

The output voltage curves of a 12-volt power supply with 1 ohm of internal resistance are shown in Fig. 3. Notice that as the current drawn by the load increases toward 1 ampere, the output voltage decreases. The output drops 1 volt, leaving only 11 volts available. It is possible to obtain essentially the zero-resistance curve shown by electronically reversing the output curve in a voltage regulator.

In our design example, the actual no-load voltage depends mainly on the resistance of the transformer windings. The output could well be as high as 18 volts no load and drop to 16 volts under full load, a difference of 2 volts. This means that the internal resistance of the power supply must add up to that required to cause a 2-volt drop at the 500-mA full load. Using Ohm's law, R = E/I = 2V/500 mA = 4 ohms. The curves for the power supply with the 4-ohm internal resistance and with an additional 8 ohms used to yield a 12-volt output (from the no-load 18-volt maximum) are shown in Fig. 4.

If you use a transformer whose output voltage is higher than required by your project, you can either include or leave out the dropping resistor, depending on whether or not you plan to add a regulator to the circuit. Before you make this decision, however, carefully weigh the alternatives and study Fig. 4. The change in output from 18 volts no-load to a 500-mA full load is 2 volts, representing 11% regulation. The change in output voltage at 100 mA is 0.4 volt, and regulation is 2%—still not great but an improvement. So, a simple method of providing a degree of regulation is to draw only a small percentage of the available current from the power supply.

Another alternative is to "bleed" the supply by placing a load resistor permanently across the output of the supply so that the variations between no load and full load are kept to a minimum. Neither this nor the dropping resistor method provides much defense against line-voltage variations. The best alternative for this problem is to go to electronic voltage regulation.

Voltage Regulation. The reverse-biased diode is perhaps the simplest electronic voltage regulator around. Once it reaches its breakdown voltage, the diode will maintain the same voltage over a varying current range until the current reaches the point where the diode ultimately burns up. Except for burning up, this is exactly what the typical zener diode is designed to do. The point at which the zener diode breaks down is known as the "zener voltage" (same as regulator voltage).

Zener diodes are available in a wide variety of regulator voltages and powers. All current popular low voltages used in modern circuits are represented, as are most of the low- and medium-power ranges.

Designing a zener regulator into a power supply consists of calculating the resistance and power rating for the series resistor and determining the maximum amount of power the zener diode must be capable of handling in the circuit.

From the curves shown in Fig. 5, you can see that the zener regulation is good up to the point where the load current almost equals the zener current. Therefore, the current through the zener diode must be more than that required by the load. With a 0.5-ampere load current, the zener current would be best at five times this value, or 2.5 amperes. Using the power formula P = IE, at 12 volts, P = 2.5 A × 12 V = a whopping 30 watts. That's an expensive zener diode. Hence, it is practical to use zener diode regulation by itself only for low- and medium-current applications. For example, a 12-volt, 1-watt zener diode would operate with a zener current of 83.3 mA, providing reasonable regulation up to almost 83 mA as shown in Fig. 5.

In the case of our sample power supply, the voltage coming from the

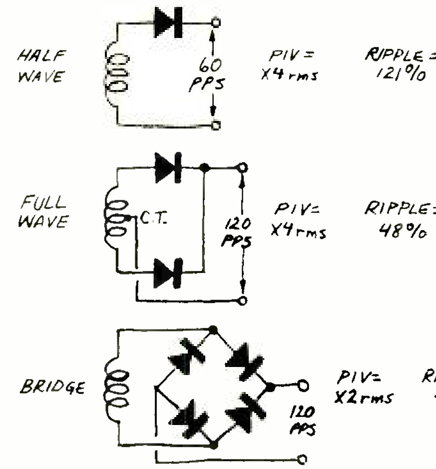


Fig. 2. Three types of single-phase rectifier circuits with some of their characteristics.

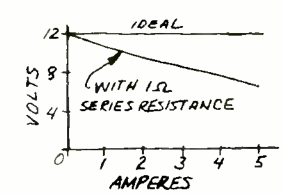


Fig. 3. Ideal output voltage occurs at all current levels. Actually, the voltage drops due to internal resistance of the power supply.

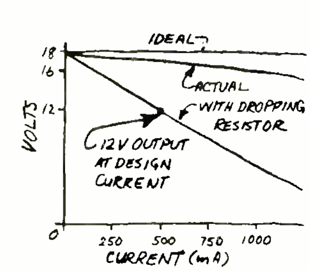


Fig. 4. Ideal and actual voltage output of ac/dc converter and filter as described in the text.

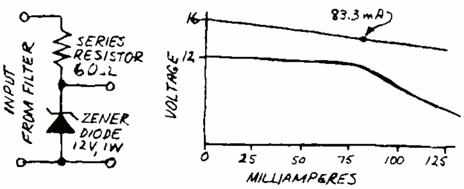


Fig. 5. Zener diode regulator is shown at left. The output is close to ideal (top) except when high current levels are reached.

rectifier bridge will be on the order of 17 volts. The zener diode will be regulating this at a 12-volt level, leaving a difference of 5 volts. So, we calculate the zener's series resistor value from R = E/I = 5 volts/83.3 mA = 60 ohms. The calculated 60 ohms, however, is a minimum value for the resistor; any higher voltage and the zener current could cause the zener diode to burn up. So, make certain you base your design calculations on the *maximum*

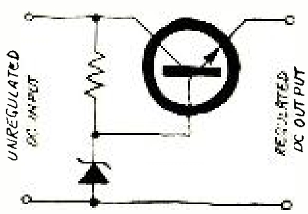


Fig. 6. Basic regulator circuit using a zener diode and emitter-follower pass transistor. This circuit provides current gain with no gain in voltage.

voltage drop that can be expected across the resistor. Then figure the power rating needed for the resistor from P = IE = 5 volts × 83 mA = 0.4 watt, which is the minimum rating; play it safe by using a 1-watt resistor.

The zener diode regulator is simple to design, but it is uneconomical in high-current power supplies. However, it can still be used—and most often is—as a low-current input to a current amplifier.

Pass Transistor Regulator. Using a zener diode as a reference regulator, the power supply's output regulation can be improved by employing an emitter-follower pass transistor to obtain current gain with no gain in voltage. The configuration of this circuit is shown in Fig. 6.

The zener regulator described above can't cope with the 500-mA demand assumed for our sample power supply. So, the pass transistor design is a natural for our purposes. First, however, we must know the biasing and power requirements for the transistor.

The current gain of the pass transistor determines the power rating of the zener diode, and vice versa. For example, a gain of 10 would permit the power supply to safely handle 833 mA of current, based on the calculations given above. The higher the β, then, the better; in fact, two transistors can be connected in a Darlington circuit configuration to multiply the gain of the pass transistor as in Fig. 7.

If the output coming from the unregulated power supply's filter is 16 volts and you want only 12 volts, the difference is 4 volts that must be dropped across the pass transistor. Since the maximum current from the supply will be 500 mA, the transistor must be rated at a minimum of 600 mA × 4 V = 2.4 watts. It is obvious, then, that most pass transistors require proper heat sinking for safe operation.

To determine the minimum base current for the transistor, divide the required load current by the transistor's β: $I_{Bmin} = I_{max}/\beta$ = 500 mA/10 = 50 mA. Multiplying this figure by 2 provides a margin of safety in the design; so, the zener diode used as the voltage reference need be rated at only 100 mA or 1.2 watts (P = IE = 100 mA × 12 V = 1.2 W). If you can't obtain a 1.2-watt zener diode, you have the option of using a pass transistor with a higher β. For example by going to a transistor with a β of 20, the base current would be only 25 mA, and doubling this yields 50 mA, requiring that the diode have a power rating of only 600 mW (0.6 watts).

By using the pass transistor, we reap another benefit—capacitance multiplication. The base capacitance is reflected to the emitter-collector circuit. We can bypass the zener diode with an electrolytic capacitor to make the emitter-follower pass transistor appear to the ripple as a capacitance equal to β times the value of the base capacitor. (Calculate the bypass capacitor from the formulas used earlier for calculating the filter's value.)

You can make the output of the supply variable by placing a potentiometer across the zener diode and feeding the base of the pass transistor with the variable output voltage from the pot. Bear in mind that for good regulation, the current through the pot should be at least several times the current required in the base of the pass transistor. The current through the zener diode should be a couple of times greater than the current through the potentiometer.

Error Amplifier Regulator. The pass-transistor scheme isn't without its shortcomings. For example, it does not efficiently combat output variations resulting from line voltage variations. You can improve the operation of your power supply by detecting the output variations and sending the inverse of the variations back to the pass transistor. Thus, you would have a supply that would in effect turn down the output voltage level when it attempted to rise, and vice versa, which is what the sense, or error, amplifier is designed to do.

The error amplifier can be a common-emitter amplifier stage, which gives an inverted output (Fig. 8). The error amplifier must operate only on voltages other than the regulated output potential. This can be done in a couple of ways, the most common

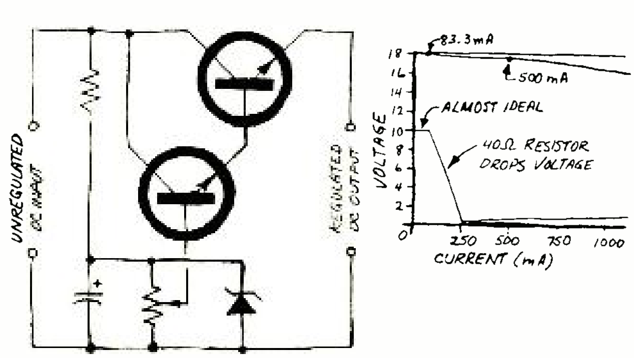


Fig. 7. Complete emitter-follower regulator. The second transistor lessens the requirements placed on the zener diode, and potentiometer is added to provide a variable output.

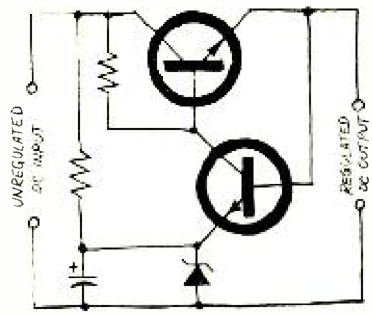


Fig. 8. Regulation using a sensing amplifier. The circuit component values are given in the text.

being the application of a voltage equal to the desired regulator output potential to the emitter of the error amplifier.

In the circuit shown in Fig. 8, the zener diode is the voltage reference. When the output voltage attempts to exceed the reference voltage, the stage conducts and reduces the output voltage. Regulation in this circuit is good for both load and line variations.

The calculations for the required drive current in the base circuit of the pass transistor and zener current remain as before. The value of the error amplifier's collector load resistor must be selected to give the desired base current for the pass transistor. In our design example, the difference between the desired 12-volt output and actual 16-volt level is 4 volts. At 4 volts, a 160-ohm resistor is needed to get 25 mA of base drive current, while an 80-ohm resistor would be needed to get 50 mA. A compromise might have to be struck if your calculations reveal that you need a non-standard resistor value. You might have to trade an exact 25-mA current if you can't find an 80-ohm resistor, but if you use a 100-ohm resistor, your compromise won't be great.

If you wish to make the power supply variable, you can vary the zener diode's output voltage as described earlier. You can also put a potentiometer in the base of the error amplifier to vary the. voltage supplied to it. The problem with the latter method is that you also divide the output voltage variations and reduce the sensitivity of the error amplifier.

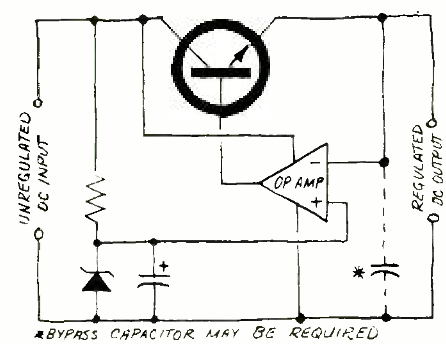


Fig. 9. Using an op amp as a sensing amplifier. High gain is an advantage of the op amp.

The sensitivity (or gain) of the error amplifier is important. In fact, the best system is one where the value of the collector resistor of the amplifier is relatively large so that gain can be high. In this manner, smaller variations in output voltage cause a larger reaction in the pass transistor circuit.

There are several possibilities for increasing stage gain. You can use a Darlington pair for the pass transistor system so that the collector resistor's value can be made larger. Another alternative is to use multiple-stage, high-gain amplifiers—inexpensive operational-amplifier (op amp) IC's.

IC Regulated Supply. The IC op amp makes an excellent regulator circuit. When used to feed a high-current pass transistor, it can regulate any load current. Using it as an error amplifier is very simple.

The non-inverting, or +, input of the op amp can be set to any desired reference level around which the power supply will regulate. The inverting, or −, input acts as an error amplifier. The signal at this input is inverted by the op amp and sent to the pass transistor. The advantage of applying inputs to both input lines of the op amp is that a much smaller current rating is required of the zener diode as a result of the IC's high gain.

Shown in Fig. 9 is an example of an op amp sensing system for an error amplifier. Designing the op amp into a power supply to serve as an error amplifier is easy. All you have to do is carefully adhere to the IC's ratings given on the specification sheet.

Current Limiting. The schematic of a "deluxe" power supply is shown in Fig. 10. This design has built into it a means for limiting the current to the load. To design current limiting into your power supply, you simply select the component values that will deliver the current to the load limited to the maximum safe current. ◈

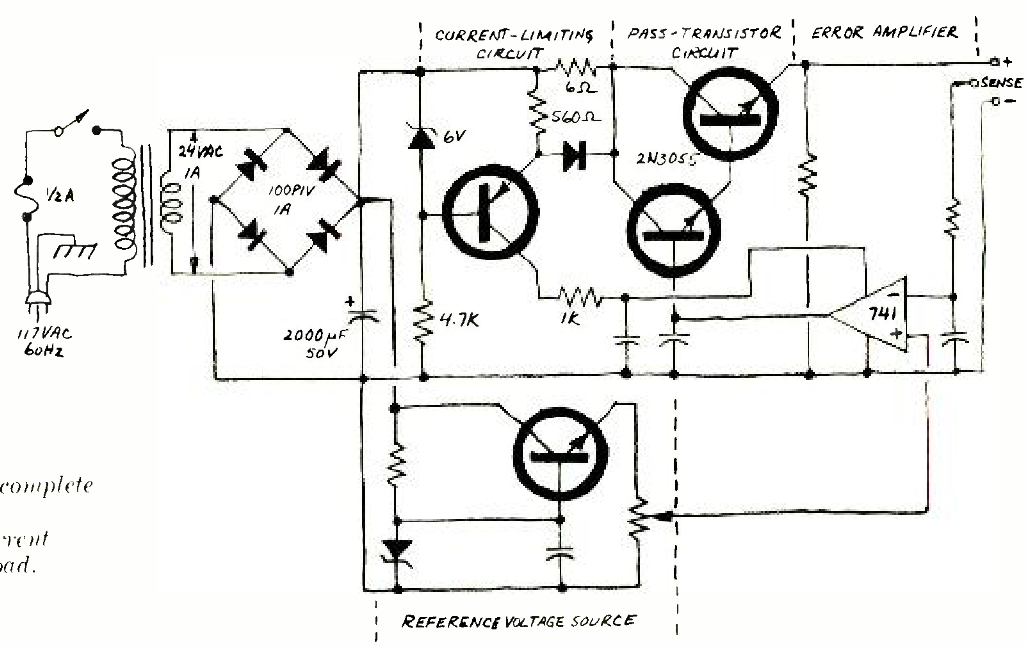


Fig. 10. Schematic of a complete "deluxe" power supply. This design includes current limiting to protect the load.

BUILD A

DIGITAL MARINE / AUTO TACHOMETER

BY MICHAEL D. HILKER

Measures rpm in thousands and hundreds for car or boat engine

THE analog meter movement, which has been the traditional display device for automotive and marine tachometers, suffers from two primary disadvantages. First, it is inherently inaccurate. More important, however, it requires the driver or boater to divert some of his attention away from navigating to interpret the meaning of the meter's pointer swing against its scale. In congested traffic, that attention is better given to watching other drivers.

The digital tachometer overcomes the two main disadvantages of the analog-meter tach. It can be made to indicate rpm with a high degree of accuracy. And, because it displays numbers that need no interpretation, instead of having to guess at an ambiguous pointer swing, you can give your whole attention to your driving.

The digital tachometer described in this article can be used with engines with two, three, four, six, eight, 12, or 16 cylinders that operate in the two- or the four-cycle mode. The TTL system derives its power from any 6- to 24-volt dc negative-ground automotive or marine electrical system. It employs a voltage regulator and an inexpensive 555 timer IC clocking oscillator time base.

About the Circuit. The schematic diagram of the auto/marine digital tach is shown in Fig. 1. It is basically a frequency counter that is modified for tachometer use. Only two decades of display are used, with *DIS1* indicating hundreds and *DIS2* indicating thousands of rpm. (Tens and units displays are not used because they would wander so fast that they would be distracting. In any event, two decades of display are sufficient for a tachometer.)

ENGINE TYPE		DISPLAY READOUT
Stroke/Cylinders		at 60 Hz (×100 rpm)
2/4	4/4	18
2/3	4/6	12
2/4	4/8	9
2/6	4/12	6
2/8	4/16	4*

*Halfway between 4 and 5

Because only thousands and hundreds of rpm displays are used, without the tens and units displays, the otherwise poor update of the frequency (between 6.6 Hz at 100 rpm and 659 Hz at 9900 rpm for a four-cycle, eight-cylinder engine) is improved by having the master clock count for only 150 ms. This provides a display update rate of approximately seven times per second.

Each display has its own 7490 decade counter (*IC5* and *IC8*), 7475 latch (*IC6* and *IC9*), and 7447 decoder/driver (*IC7* and *IC10*). The displays themselves can be incandescent or green or yellow common-anode LED-type 7-segment devices. (Note: *It is illegal to use red displays for anything but an emergency indicator in an automobile.*)

The master clock oscillator circuit (*IC3*) must be initially adjusted, according to the type of engine with

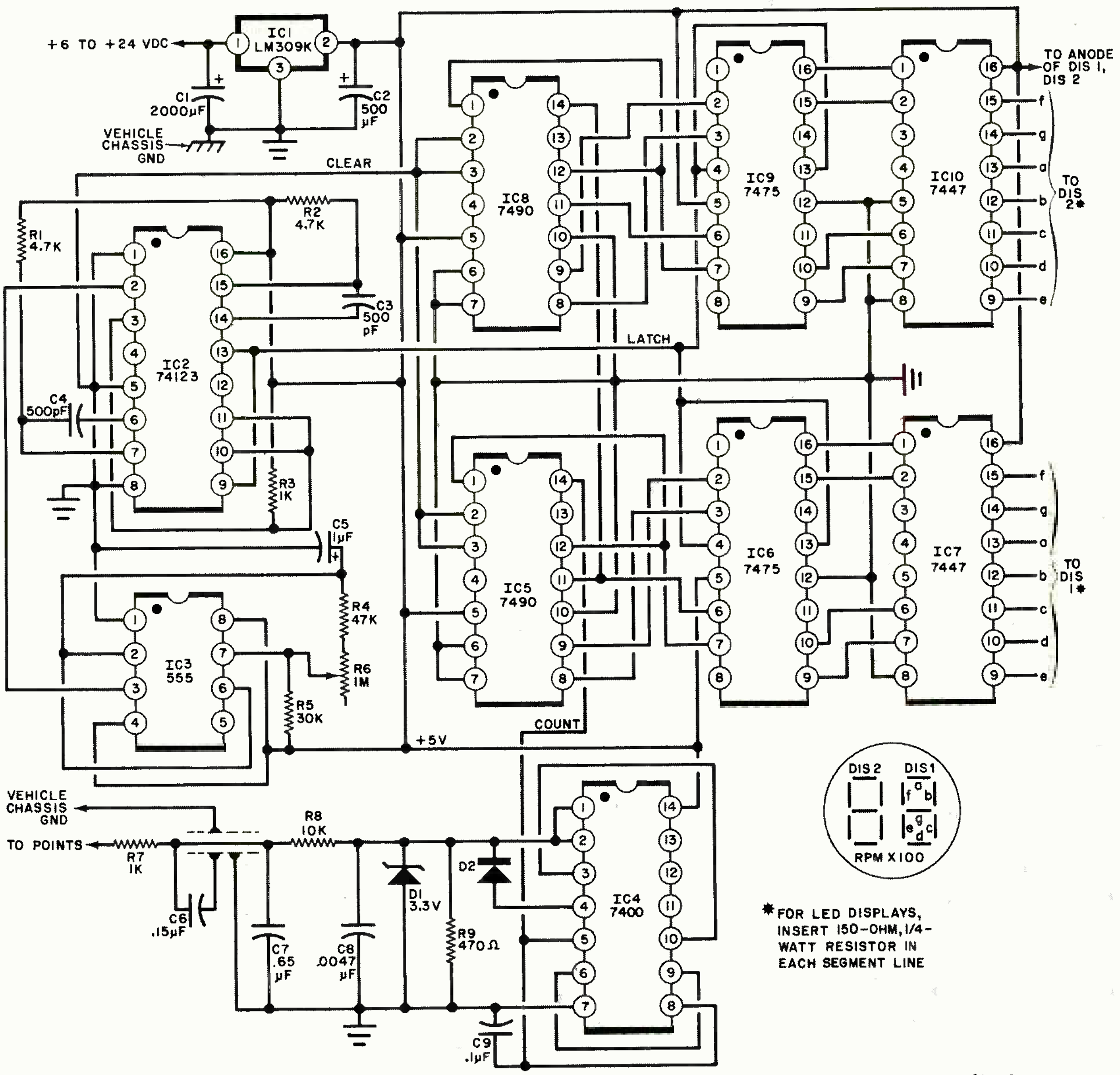


Fig. 1. The tachometer circuit is basically a frequency counter with two decades of display

PARTS LIST

C1—2000-μF, 30-volt electrolytic capacitor (voltage rating must be greater than actual input potential)
C2—500-μF, 10-volt electrolytic capacitor
C3, C4—500-pF tantalum disc capacitor
C5—1-μF, 10-volt electrolytic capacitor
C6—0.15-μF disc capacitor
C7—0.65-μF disc capacitor
C8—0.0047-μF disc capacitor
C9—0.1-μF disc capacitor
D1—3.3-volt, 500-mW zener diode (HEP-Z0206 or similar)
D2—1N4001 or similar silicon rectifier diode
DIS1, DIS2—7-segment display (see text)
IC1—LM309K 5-volt regulator
IC2—74123 integrated circuit
IC3—555 timer integrated circuit
IC4—7400 integrated circuit
IC5, IC8—7490 integrated circuit
IC6, IC9—7475 integrated circuit
IC7, IC10—7447 integrated circuit
R1,R2—4700-ohm, ½-watt resistor
R3, R7—1000-ohm, ½-watt resistor
R4—47,000-ohm, ½-watt resistor
R5—30,000-ohm, ½-watt resistor
R6—1-megohm potentiometer
R8—10,000-ohm, ½-watt resistor
R9—470-ohm, ½-watt resistor
Misc.—Printed circuit or perforated board and sockets for IC's and displays; suitable housing; heat sink for IC1 (Wakefield No. 680-12 or similar); dry-transfer lettering kit; filter for display; shielded cable; mounting hardware; hookup wire; solder; etc.

which the tach is to be used, before you can operate the tach properly. This, however, is the only calibration required of the system, via potentiometer *R6*. Once set, this adjustment need not be touched again unless you remove the tach and use it with a different type of engine. The number of pulses counted between each update is then equal to approximately 0.167 times the actual number of hertz and corresponds to the engine's rpm, which is displayed by *DIS1* and *DIS2*.

The 74123 dual retriggerable monostable multivibrator IC provides the clear pulses for decade counters *IC5* and *IC8* and latch pulses for latches *IC6* and *IC9*, keyed to the output of *IC3*. The 7400 quadruple dual-input NAND gates in *IC4* provide the gating required for proper operation of the tachometer.

Integrated circuit *IC1* is a 5-volt regulator. Potentials between +6 and

+24 volts dc applied to pin 1 of *IC1* result in a +5-volt regulated output.

Construction. The entire auto/marine digital tachometer can be assembled on two 4" × 3" (10.2 × 7.6-cm) pieces of epoxy-fiberglass (G-10) board that has holes pre-drilled on 0.1" (2.54-mm) centers. Use perforated board that has no copper on either side, sockets for the IC's and displays, a heat sink for *IC1*, and push-in solder clips for component mounting.

You can house the tach in any suitable enclosure, including a cylindrical plastic one that can sit on top of the dashboard, or mount the system in the dash panel in an unused instrument cutout. Don't forget to use *shielded* cable for the hookup between the engine's points and the tach's input.

Calibration & Use. Before you install the tach in your car or boat, it must be properly calibrated. For calibration purposes, you will need a low-

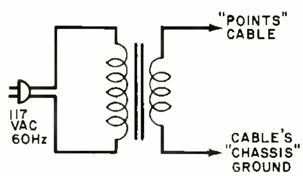


Fig. 2. Low-level 60-Hz source for calibrating tachometer.

level 60-Hz signal source. You can wire the circuit shown in Fig. 2 to obtain the low-level signal required. Wire the secondary of the 6.3-volt power transformer to the inner conductor (labeled "to points" in Fig. 1), via *R7*, and the shield of the tach's input cable.

Connect the lead from the tach labeled "+6 to +24 V dc" and the lead on the other side of *C1*, labeled "vehicle chassis ground," to the vehicle's electrical system or any other dc source capable of delivering about 1 ampere at the appropriate voltage.

Now, referring to the table, adjust *R6* for the proper display reading according to the type of engine with which the tach is to be used. The tach is now calibrated and need not be readjusted again unless it is to be used with a different type of engine.

You can now install the tach in your car or boat. After installing the tach, connect the various cables to the appropriate points in your vehicle's electrical system. Then the only thing left to do is use a dry-transfer lettering kit to label the legend "RPM × 100" on the display's filter. ◈

A Simple Method For Biasing TRANSISTORS

An easy step-by-step way to design stable amplifier stages using Ohm's law.

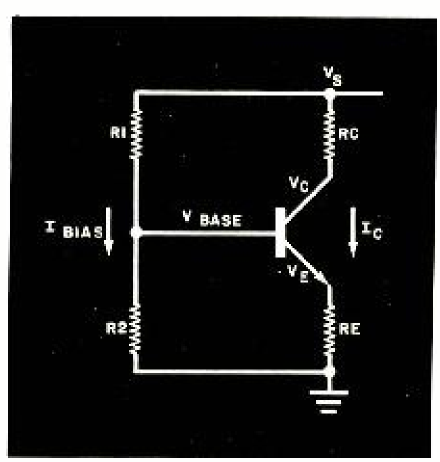
BY MYRON CHERRY

HERE is a simple way of determining the proper biasing of a bipolar transistor amplifier. It works for the majority of applications and has built-in protection against thermal runaway. All you need to know is the material of which the transistor is made (silicon or germanium) and Ohm's law.

First, there are some basic assumptions that can be made based on the superior quality of today's transistors. (1) Collector-to-base leakage current can be ignored. (2) The current gain (beta) is high enough that the base current can be ignored (or considered as a small part of the "bias" current). (3) Emitter current equals collector current. Based on these assumptions, we can use the simplified circuit model shown in the diagram.

The design of the bias circuit then consists of nine steps:

Step 1. Determine the collector current (same as the emitter current). Often this is determined by the load, or the test current given in the transistor specifications can be used. If the power supply is a battery, choose a small current for longer battery life. Typically, medium-signal transistors have a collector current of 1 to 10 mA.



For a small-signal transistor, it would be perhaps 0.1 mA.

Step 2. Determine the supply voltage. This is usually a standard value: 9, 12, or 24 volts depending on the battery or supply.

Step 3. We assume that the emitter voltage is to be 10% of the supply voltage so the emitter resistor is

$R_e = 0.1V_s/I_c$

The assumption for the emitter voltage provides thermal stability, allows for wide variations in beta and protects the emitter-base junction from a possible current overload.

Step 4. Calculate the base voltage. This depends on the semiconductor material, which determines the drop across the junction. For silicon, the drop is 0.7 V, and for germanium, it is 0.3 V. The base voltage is then the emitter voltage plus 0.7 or 0.3

Step 5. Assume that the "bias" current through *R1* and *R2* is 10% as much as the collector current. This is easier than considering that R_e times beta is in parallel with *R2*. In fact, we do not need to know beta if it is high enough because 10% or 20% variation in *R1* and *R2* would cause more change in bias current than the small base current in today's high-beta transistors. In fact, beta often varies from 100 to 300 for the same type of transistor.

Step 6. Calculate *R2* using base voltage and bias current.

$R2 = V_{base}/I_{bias} = V_{base}/0.1I_c$

Step 7. Calculate *R1*

$R1 = (V_s - V_{base})/I_{bias}$

Step 8. Choose collector voltage. Except for an emitter follower, the output signal is always taken from the collector. To avoid clipping, let $V_c = 0.5V_s$.

Step 9. Calculate R_c from I_c and V_c.

$R_c = V_c/I_c = 0.5V_s/I_c$.

◈

UNDERSTANDING THE UART

A DATA COMMUNICATION INTEGRATED CIRCUIT

Here are details about the UART to help you in using it in a data terminal.

BY ROGER L. SMITH

PERHAPS you have already heard about the universal asynchronous receiver/transmitter—commonly referred to by its acronym UART. If not, you soon will because UART may become an important part of data-handling systems in all areas of electronics where information must be routed from one location to another. In a UART, the transmitter converts parallel data bits into serial form for transmission over two-wire lines. The receiver section does the reverse operation.

You could use a UART with a video display to communicate with a computer or another type of display. Coupling it with suitable circuitry, you could use a UART to record ASCII data from a keyboard on a tape recorder. Use it with a modem (modulator/demodulator) and telephone coupler or Data Access Arrangement (DAA), and you could transmit data over telephone lines. UART's can also be used in centrally monitored burglar and fire alarms, intersection traffic control, and ecological data gathering. In fact, the applications in which UART's can be used are almost limitless. (See Fig. 1 for diagrams of typical applications for the device.)

General Information. In Fig. 2 are shown the transmitting section of one UART (left) and the receiving section of another UART (right), in logic diagram format. For these UART's to operate properly together, they must both be referenced to the same clock rate, which must be 16 times the desired line transmission rate. For example, if we communicate with a Teletype®, the bit transmission rate is 110 bits/ second. Therefore, the clock pulses delivered to pins 17 and 40 must be 110 × 16 = 1760 Hz. (The clocking signal can come from a crystal oscillator, but it is usually sufficient to use any stable oscillator that has an accuracy of 1% or better.

The UART has separate clock input pins for the receiver and transmitter sections so that receiving rates can be different from transmitting rates. For example, different rates might be used between terminals and from a terminal to a computer. Here, the transmission rate would be increased, to perhaps 1200 baud. (A baud is generally defined as a bit per second.) For another example, when the data comes from a manual keyboard, a rate of 150 baud should be adequate.

Before the UART can be operated, its internal registers and detectors must be cleared. This is usually accomplished automatically during power-up by pulsing reset pin 21 with a high (logic-1) pulse. You can do this with a resistor to ground and a capacitor to the +5-volt line.

Each half of the UART contains character-format mode control flip-flops that can be computer-controlled if the device is to be used with a computer. If the modes are to remain constant, the control pins can be hard-wired or connected to manual switches.

The controls that are available in a UART include:

I_{2SB} (pin 36)—transmitter stop bit control. A logic 0 causes one stop bit, and a logic 1 (+5 V) causes two stop bits to be transmitted.

I_{NP} (pin 35)—no-parity control. A logic 1 eliminates the parity bit from the transmitted data, disables the receiver parity check, and forces receiver parity error (0_{PE}) pin 13 to go to logic 0.

I_{PS} (pin 39)—parity select. A logic 0 inserts and checks odd parity, and a logic 1 inserts and checks even parity.

I_{NB1},I_{NB2} (pins 38, 37)—select character length of 5, 6, 7, or 8 bits/character.

I_{CS} (pin 34)—mode control strobe. A logic 1 enters the above controls into the holding register. This control can be hard-wired.

Once the control pins are either hard-wired or selected by computer, transmission can begin. Although the control pins serve both halves of the UART and both halves must operate in the same data format, they can be bussed in by the same lines that carry the data to be transmitted. The commands are then strobed into the holding flip-flops by pin 34; so, the computer can forget about them unless they must be changed.

Sending Data. Assuming all control pins have been selected, the transmission begins when a key is depressed. The ASCII, IBM Selectric®, Baudot, or other code appears at the UART's input pins (pins 26 through 33 if all eight bits are used). After a delay of 1 or 2 ms to allow the inputs to settle, a pulse must be sent to pin 23 (I_{DS}). This negative-going pulse is generated by

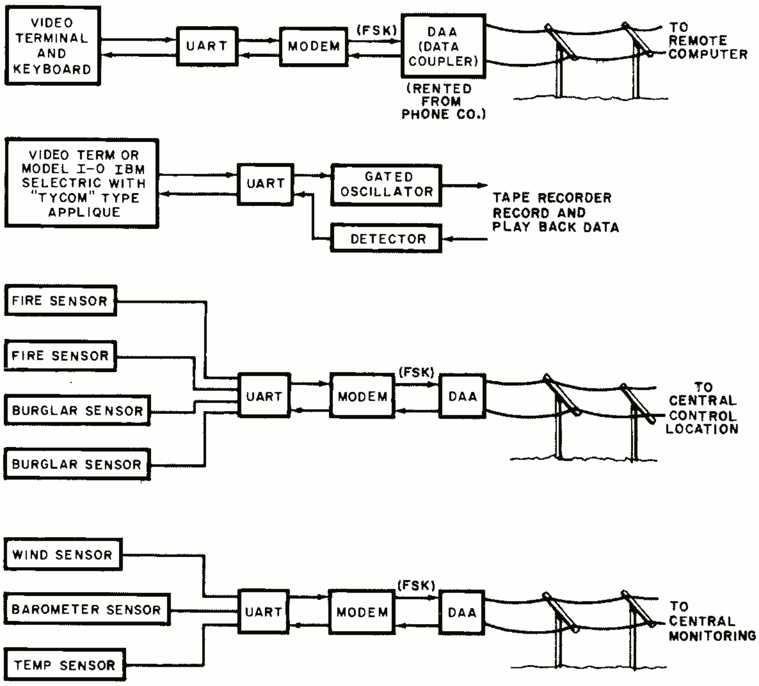


Fig. 1. Applications for UART include video systems, fire and burglar alarms, and weather monitoring.

logic on the keyboard. It enters the *data* into the input holding register. The transition of the pulse back to logic 1 causes a *start* bit to appear at serial output (0_{SO}) pin 25 after the next negative-going clock transition.

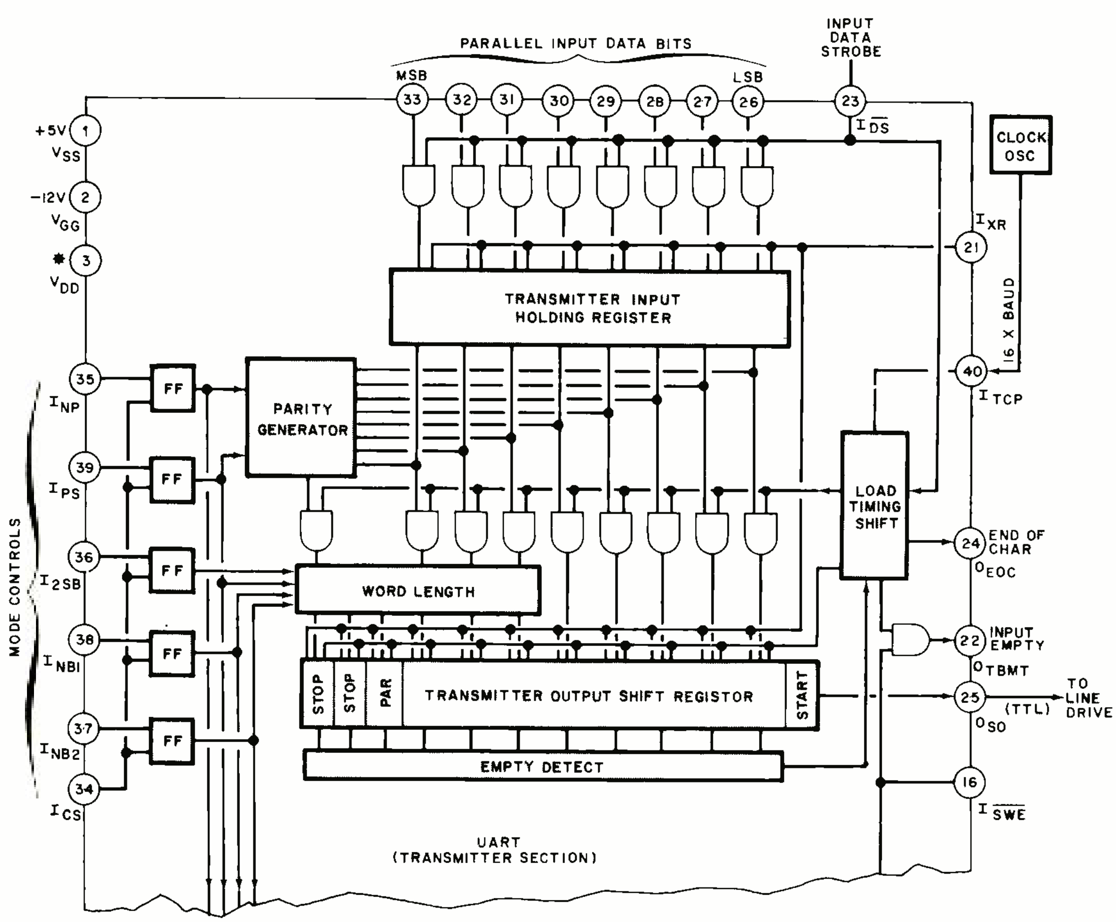
The UART is now transmitting the data out on pin 25 at a rate of one bit for every 16 clock pulses. The *start* bit is first, followed by the *data*, with the least-significant bit (LSB) first and the most-significant bit (MSB) last. This is followed by the *parity* and *stop* bits.

The UART executes the formatting commands as set up on the control pins. It then computes and adds the proper *parity* bit, if any. Just as it added a *start* bit preceding the *data*, it also adds one or two *stop* bits after the *data*. (The number of *stop* bits is determined by the logic level at pin 36.) If all possible bits were transmitted, they would number 12, including one *start*, eight *data*, one *parity*, and two *stop* bits. The minimum number transmitted can be seven: one *start*, five *data*, and one *stop* bits.

Since the transmitter section has an input holding register as well as an output shift register, it can receive a second keystroke input immediately following the first. If this should happen, both the holding and shift registers would be full and this would be indicated by a logic 0 on pin 22. This pin goes to logic 1 when the UART is ready to accept additional data (transmitter input holding register empty, 0_{TBMT}).

Normally, the output of the transmitter portion (pin 25) is boosted to the standard RS-232C interface levels to be sent to other devices. For example, the data could go to a modem to be

Fig. 2. At near right is the transmitting section of one UART. Receiving section of another UART is on opposite page.



converted to fsk (frequency-shift, or two-tone, keying). It can then go via either an acoustic coupler or a DAA to the phone line and some remote terminal or computer location where it is demodulated, converted to RS-232C and TTL levels, and then possibly to the receiver input of another UART.

Receiving Data. The TTL input level on pin 20 of the UART is normally logic 1, and the receiving section monitors this pin for any transition to logic 0. When a logic 0 transition occurs, a counter is started, clocked by the input on pin 17 at a 16 times baud rate.

When the counter reaches 8, which should be the center of the incoming bit, the UART again checks the level at pin 20 to ascertain that it is still at logic 0. If it is, a valid *start* bit has been received, and the UART begins to count in increments of 16 clock pulses to go from center to center of the incoming bit "cells." (Some designs check the input during all of the first 8 counts after a transition to logic 0. Whichever the case, noise spikes are not likely to cause false starts.)

Each time the counter reaches 16, the center of a bit cell has been reached and a *shift* pulse is applied to the input register. In this manner, all *data* bits are loaded into the shift register (LSB first), followed by *parity* and *stop* bits. Since the character length command was previously set up on pins 37 and 38, internal gating insures that the incoming signal word ends up all the way to the right.

The UART's error-detection circuits check the incoming data according to the previously selected controls. The *data* bits and *parity* bits are tallied and must be odd or even, as selected on pin 39 (logic 0 is odd, and logic 1 is even). If there is a parity error, the flag flip-flop (to pin 13) is set by going to logic 1. The center of the cell that follows the *parity* bit is tested to see that it is a logic 1. This is the *stop* bit; if it is not present, the framing error flag flip-flop (to pin 14) is set to logic 1.

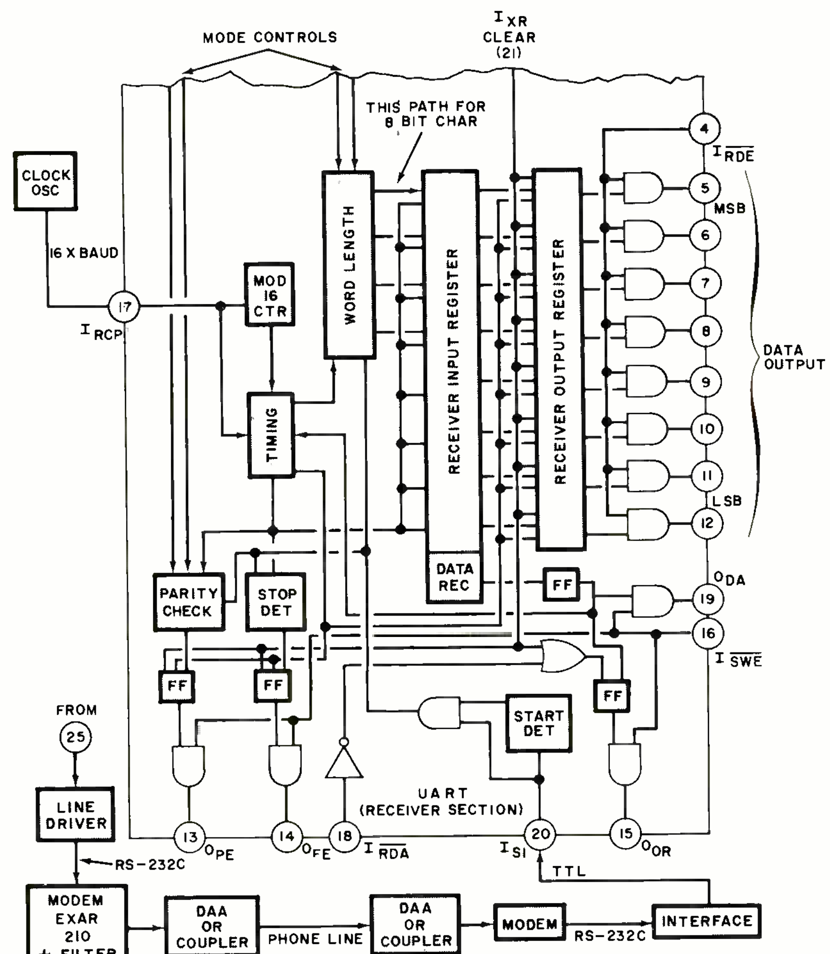
After the incoming serial data has completely shifted down, a "register-full" condition is detected and the data is transferred in parallel to the output holding register. The "data-available" flag flip-flop, whose output is pin 19, is set, indicating that a character has been received and is ready to be strobed out.

The status bits (parity error on pin 13, data available on pin 19, transmitter input holding register empty on pin 22, framing error on pin 14, and receiver overrun on pin 15) are enabled when pin 16 is at logic 0. Pin 16 is usually hard-wired to ground, except in cases where several UART's are serviced on a common bus. In these cases, each UART is queried by applying a ground pulse to pin 16 of successive UART's. If a data-available condition is detected on pin 19, the processor can read out the data by applying a logic 0 to received data-enable pin 4 of the UART.

Once data is available (as indicated by a logic 1 on pin 19), it must be removed before the next character is shifted all the way into the first register, because new data is written over the old. External circuitry must also clear the data-available flip-flop by applying a logic-0 pulse to reset data available pin 18. If this is not done, the overrun flag flip-flop (pin 15) will be set.

In Conclusion. As you can see, the UART could be termed a microprocessor in many respects. Its processing is specialized, dedicated to only the handling of data. Consequently, the UART is "transparent" to the data, since the data is not altered logically in passing through it. What goes into the UART is what comes out.

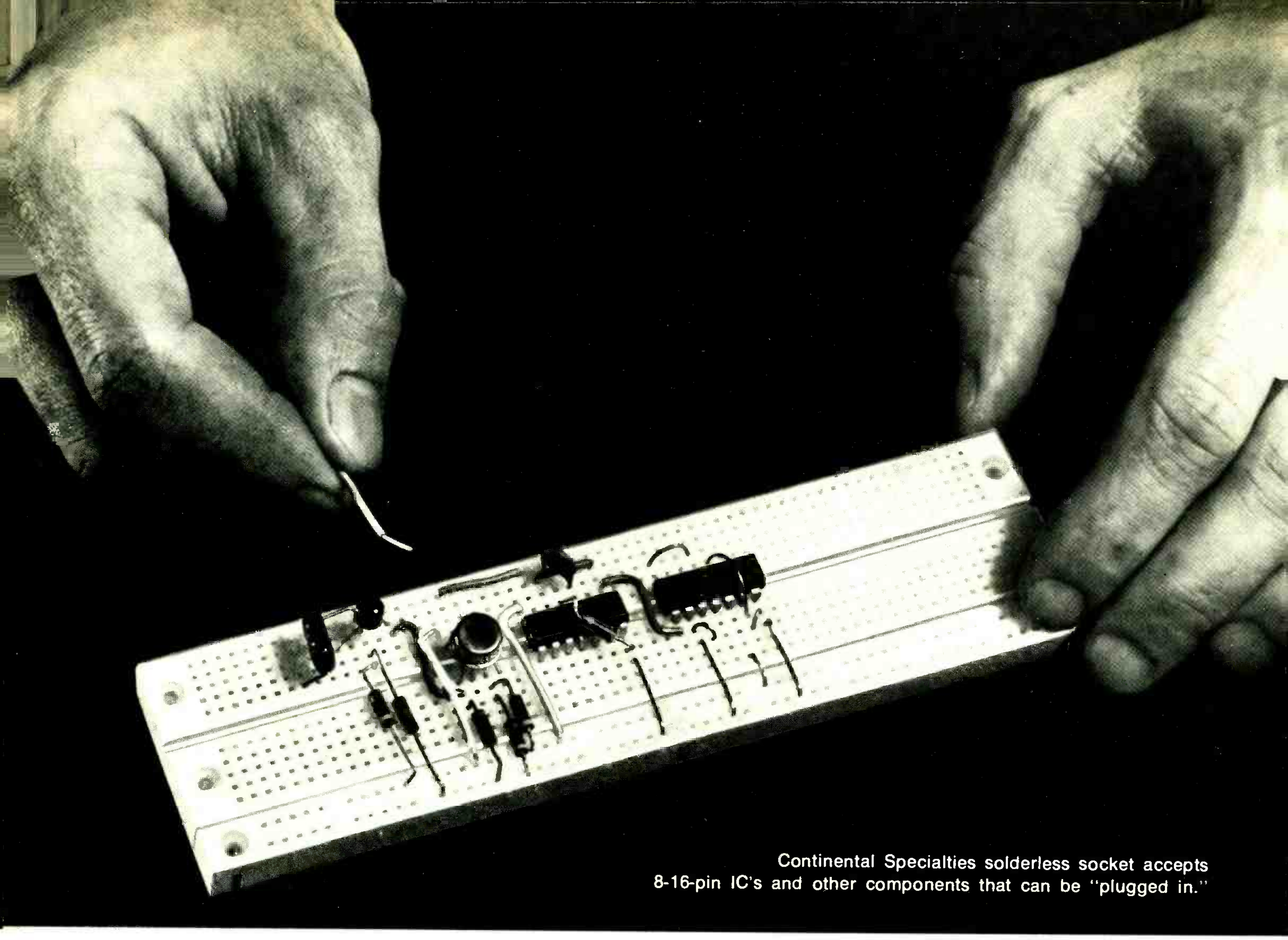
Considering the number of standard logic gates and register IC's it replaces, you can readily see that the UART is one of the best buys available at its current price of $10 to $15. ◈



UART MANUFACTURERS

Following is a list of the manufacturers currently making UART's. The numbers in parentheses are the manufacturers' catalog designations.

American Micro-Systems, 3800 Homestead Rd., Santa Clara, CA 95051 (S1757, S1883)
General Instrument, Box 600, Hicksville, NY 11802 (AY-5-1013A)
Intel, 3060 Bowers Ave., Santa Clara, CA 95051 (8201)
Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086 (2536)
SMC Microsystems, 35 Marcus Blvd., Hauppauge, NY 11787 (COM 2017, COM 2502)
Texas Instruments, Box 5012, Dallas, TX 75222 (TMS 6010NC, TMS 6012)
Western Digital, 19242 Red Hill Ave., Newport Beach, CA 92663 (TR1402, TR1602)



Continental Specialties solderless socket accepts 8-16-pin IC's and other components that can be "plugged in."

Getting Started with Op Amps

A solderless socket, a handful of parts, and you are ready to experiment with these versatile devices.

BY SOL D. PRENSKY

MANY hobbyists have avoided experimenting with op amps because they haven't had an easy means of breadboarding circuits with the multi-pin IC packages. Fortunately, a new concept that overcomes the breadboarding obstacle has been developed—the multi-receptacle solderless socket.

The socket is available in a number of different sizes, ranging from a one-IC block to a large block that can accommodate a half dozen IC's and their associated components with room to spare. All solderless sockets, regardless of size, are made in the same manner. Each consists of two sets of five series-connected receptacles in each row, with block size determining the number of rows in a given socket. The smallest socket has eight rows and can accommodate IC's with up to 16 pins. The receptacles are housed in a tough molded plastic block. Access to the receptacles is provided through a hole "matrix" in the block.

Running the length of the block, midway between the pairs of contacts, is a shallow groove. The IC must be inserted so that it straddles the groove, leaving four receptacle holes unoccupied for component hookups to each IC pin. Interconnections are made with lengths of #20 or #22 solid hookup wire and components with lead diameters averaging the same size as those found on ¼-watt resistors and disc capacitors. (You can use ½-watt resistors, but the larger diameter of their leads will require additional insertion force.)

One or more of the solderless sock-

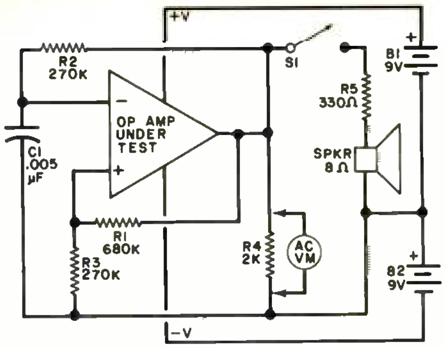


Fig. 1. Simple op amp tester has meter and audio outputs.

ets can be mounted on a sheet of perforated board. Connections to external devices—such as power supply, input and output connectors, meters, etc.—can be made via spring clips or binding posts that can be "plugged" into the holes in the perf board. Mount a rubber foot at each corner of the board, and you're in business.

Once you have an appropriate breadboarding system, experimenting with op amps becomes a simple matter. The op amps we selected for the following experiments are the types 709 and 741, both of which are low cost and widely available. These IC's are available in a number of different packages. The box shows the package configurations and pin designations.

Op-Amp Testing. The first experiment to try with your op amp is shown schematically in Fig. 1. This is an op-amp test circuit, a multivibrator arrangement where the IC acts as a free-running oscillator that produces a square-wave output.

The "quality" of the op amp is quickly determined by monitoring the output voltage, preferably peak-to-peak with a high-impedance voltmeter, or at a correspondingly lower average ac level with a 5000-ohms/volt VOM. The output voltage across the 2000-ohm load should be at least two-thirds of the ±9-volt supply (at least 12 volts peak-to-peak).

When *S1* is closed, an audible tone should be heard from the speaker, and the measured potential should drop to about 6 volts p-p. Bear in mind that the average meter indication with a VOM will be about half the peak-to-peak value. The oscillator frequency is determined by the *R2-C1* time constant. If you change the value of either (or both) component, the frequency will change accordingly.

This test circuit can handle many different types of op amps. In addition to the internally compensated op amps, of which the 741 is an example, the tester will also work with externally compensated op amps without circuit changes because the use of a compensating capacitor is not necessary in this setup. The LM107, 741, MC1556, CA3100S, and HEP-6052P are examples of internally compensated op amps, while the LM101A, NE531, 709, 748, and HEP6053P are examples of externally compensated op amps.

Because the dual in-line package (DIP) IC's have two parallel rows of leads, they are easy to insert into the solderless socket. If you have round metal-can op amps, you can form the leads into the correct in-line configuration with the aid of long-nose pliers; work carefully. Fig. 2 illustrates how the circuit is breadboarded.

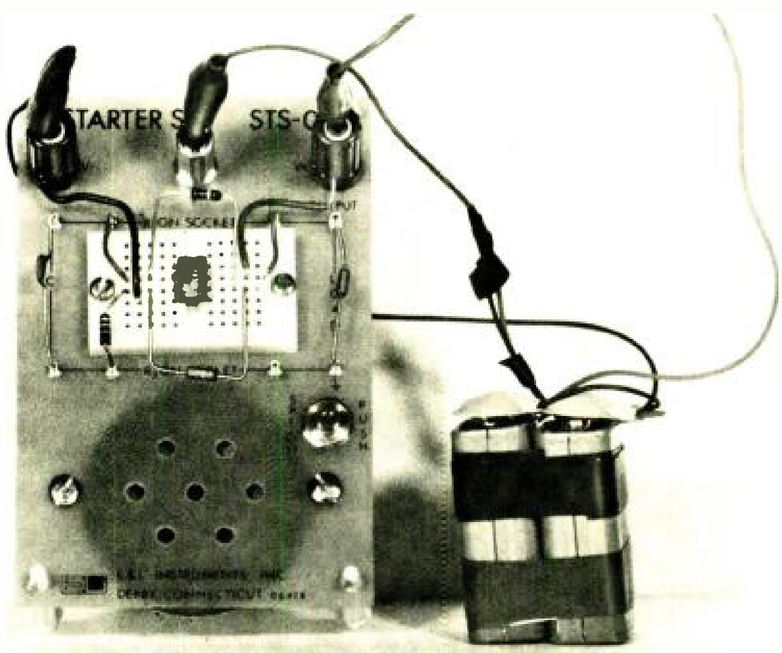


Fig. 2. Commercially available "starter kit" from E&L Instruments illustrates breadboarding of the test circuit in Fig. 1.

LED Experiment. The light-emitting diode, or LED, is a natural companion for the op amp. The LED requires only about 1.6 volts at 20 mA for proper operation, which is well within the output capabilities of the op amp.

The circuit shown in Fig. 3 uses an op amp to pulse a LED at a visible rate. This circuit can also be used as a clocking oscillator for digital circuits so that countdown action can easily be followed.

The basic circuit in Fig. 3 is similar

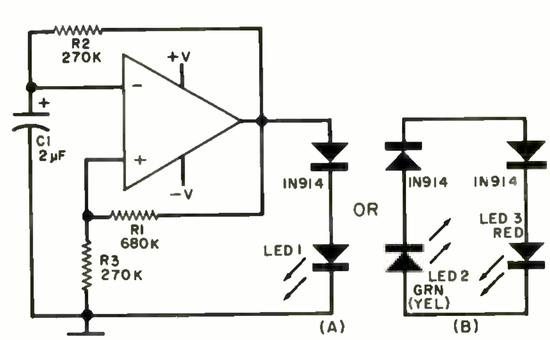


Fig. 3. A 1-Hz op amp oscillator can drive either a single LED on the positive-going cycles, or a pair of LED's alternately.

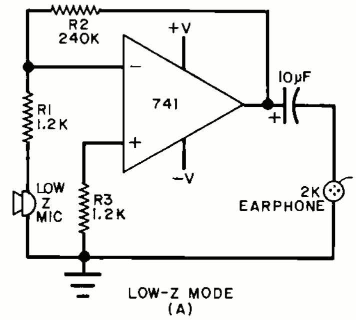
to that shown in Fig. 1, except that the value of *C1* has been greatly increased to slow down the repetition rate to about 1 Hz (1 pps). Display circuit A shows the addition of a conventional silicon diode and a LED (any color) that will pulse on with each positive-going portion of the oscillation pulse. The variation shown in circuit B employs two differently colored LED's. Arranged with silicon diodes, the LED's pulse on and off in step with the op amp's oscillator signal. (Note: some of the older type green and yellow LED's require more drive current than do red LED's, which means that they might not glow as brightly. If you use the newer GaP green or yellow LED's, you will encounter no difficulty in glow light level.) The two-color circuit can also serve as a polarity indicator for other circuits, if you assume the red LED to be on for one polarity and the green LED on for the other polarity.

Microphone Amplifier. The basic simplicity of op-amp amplification is shown in Fig. 4. The two modes—low- and high-input impedance—correspond to the two differential op-amp input connections. In using a single-ended input for a microphone, you have a choice of using either the inverting (−) or non-inverting (+) input. In either case, the closed-loop gain is substantially the same and is determined by the ratio of *R1* to *R2*.

The choice of input is determined by the greatly differing input impedances for each connection. In circuit A, the input impedance is approximately the same as the value selected for *R1*. Hence, for this mode, you can make the input impedance any reasonably low value (by selecting the proper value for *R1*) and determine the required gain by selecting the appropriate value for *R2*. In circuit A, the gain is $R2/R1 = 240{,}000/1200 = 200$ or 46 dB.

If you need a high-impedance input, in the range of hundreds of megohms, feed the input signal to the non-inverting (+) input as shown in circuit B. If you wish to use a crystal or ceramic microphone in this mode, you must shunt it by about 1 megohm to provide a dc path for the bias on the + input. The load in both circuits is a 2000-ohm earphone because of the limited ability of the op amp to supply substantial output current.

At these high gains, the 741 op amp will cover only the speech frequencies. For extended bandwidth, you will



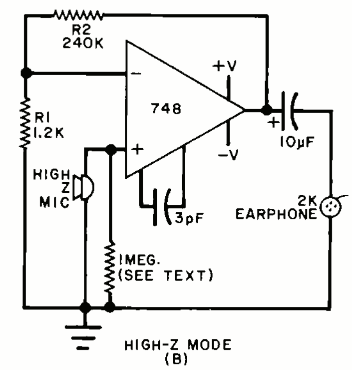


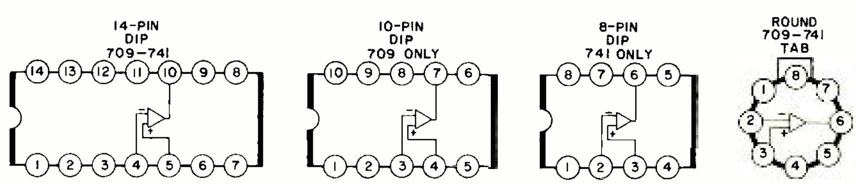
Fig. 4. Low-impedance microphone can be used with circuit (A) and a high-impedance unit with (B). Since 741 is frequency-limited, a 748 (externally compensated) can be used to extend the range.

have to use an externally compensated 748 op amp in place of the 741. For loudspeaker operation, replace the earphone with an equivalent value fixed resistor and use this signal to drive an audio amplifier.

If you want to make a simple audio mixer for two or more signal sources (microphones, turntables, tape recorders, receivers, etc.), use a separate *R1* for each source in the Fig. 4A circuit in a summing mode.

In Conclusion. There are an almost unlimited number of relatively simple op-amp experiments you can perform, many of which have been published in these pages in the past. Most such experiments can be assembled and tested for educational purposes or modified as the experiment progresses. They can be taken apart and reassembled in only a few seconds using the solderless-socket breadboard approach.

While in this article we have stressed the use of the solderless socket as a breadboarding system for linear (op-amp) circuits, this does not preclude their use in digital IC experiments and projects. Using one of the largest sockets, you can breadboard a complete logic system in only minutes. ◈



PIN ARRANGEMENTS

Following is a table of pin designations and the various package configurations for the popular 709 and 741 op amp IC's shown above.

Pin No.	14-Pin DIP 709	14-Pin DIP 741	10-Pin DIP 709	8-Pin DIP 741	Round Package 709	Round Package 741
1	NC	NC	NC	Offset Null	Input Comp	Offset Null
2	NC	NC	Input Comp	−Input	−Input	−Input
3	Input Comp	Offset Null	−Input	+Input	+Input	+Input
4	−Input	−Input	+Input	−V	−V	−V
5	+Input	+Input	−V	Offset Null	Output Comp	Offset Null
6	−V	−V	Output Comp	Output	Output	Output
7	NC	NC	Output	+V	+V	+V
8	NC	NC	+V	NC	Input Comp	NC
9	Output Comp	Offset Null	Input Comp			
10	Output	Output	NC			
11	+V	+V				
12	Input Comp	NC				
13	NC	NC				
14	NC	NC				

Note: NC = No Connection

The 10-pin configuration is a flat pack that cannot be used with solderless sockets. It is shown only to illustrate all packages used with IC op amps.

ACTIVE FILTER SHARPENS CW RECEPTION

Outboard op-amp circuit has a selectivity better than 100 Hz!

BY JOHN E. PORTUNE
WB6ZCT

ONE of the greatest assets a receiver can have is sharp selectivity, as anyone who has tried to copy CW on a crowded band can attest. Very selective receivers, using multiple conversion and ceramic or crystal filters, are priced beyond the reach of many amateurs. But, a simple outboard audio filter can change the picture. With it, an inexpensive receiver can become a razor-sharp CW rig without internal modifications.

The active filter described here can be connected to any receiver and provides a 6-dB selectivity of less than 100 Hz. That's an impressive figure for a circuit that costs less than $15.

About the Circuit. The use of audio filters to enhance CW reception is not new. However, until recently, sharply selective audio filters required impractically large inductors and capacitors. Op-amp technology has made these passive filters obsolete.

The heart of the filter is a 741 operational amplifier connected as shown in Fig. 1. The gain of the amplifier, V_o/V_i, (also called A_f), is determined by the following equation: $V_o/V_i = A_f = A_o\ (R_f/R1)$, where A_o is some fixed value. It is evident, therefore, that the larger R_f is with respect to *R1*, the greater the gain of the amplifier. We will take advantage of this property in designing the active filter.

Now, let's look at the schematic diagram of the filter, Fig. 2. In place of the fixed feedback resistor, R_f, the op amp, *IC1*, uses an R-C network, composed of *R1, R2, R3, C1, C2* and *C3*. One of the properties of the network is that at its center frequency, f_c, its impedance is a maximum. This is so because at this frequency the currents in the upper and lower arms are equal in magnitude and opposite in phase. The currents cancel each other out, so no resulting current flows through the feedback loop (which is the same as saying that R_f is infinite). The op amp's gain at f_c is very large. At other frequencies, however, this phase relationship is not a completely canceling one, so the effective R_f (and the op-amp's gain) is lower.

In other words, the gain of the op amp is very large at the center frequency, but drops off very quickly on either side. Fig. 3 shows the frequency response of *IC1*. For the values given for the filter, the center frequency is 750 Hz. If another CW note is preferred, these values will have to be changed. For example, if an f_c of 1200 Hz is desired, *R1* and *R2* are changed to 2200 ohms. *R3* would become 180 ohms. Capacitance values remain the same.

The receiver audio output is coupled to the active filter by the cable attached to *PL1*, which is plugged into the receiver's speaker jack. *R4*, a 10-ohm, 2-watt resistor absorbs most of the audio output. A fraction of the audio passes through *R5* and appears across the non-inverting input of *IC1*, and the audio component at f_c receives a great deal of amplification, as outlined above. The inverting input of *IC1* is loaded to insure stable operation. Since the output of *IC1* is not large enough to drive a speaker, another stage of audio amplification is

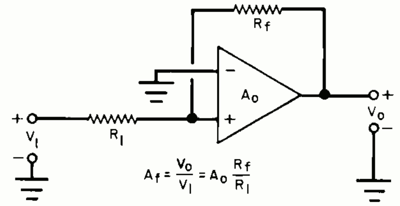


Fig. 1. Basic op amp circuit. Voltage gain depends on the amount of feedback.

included (*IC2*). A common one-watt IC audio amplifier is used for this purpose. This output level is sufficient to drive almost any communications speaker or pair of headphones, plugged into jack *J1*.

The op amp requires a bi-polar power supply. Since the audio module requires +9 volts, we decided to use a ±9-volt supply for both IC's. This can be obtained from a small full-wave zener-regulated power supply (Fig. 4). Alternatively, two 9-volt transistor batteries can be used, but you might find that they will run down rather quickly. Unless portable operation is desired, it's best to use the line-powered supply suggested.

Construction. Component layout and cabinet mounting are not critical. The circuit may be built on a pc board or a piece of perf board. Etching and drilling and component placement guides are shown in Fig. 5. An etched pre-drilled board is also available (see parts list). Be sure to use shielded cable from filter switch *S1* to the board to avoid excessive hum. Also, use an *insulated* phone jack for *J1* to avoid shorting out the power supply.

While 5% resistors and common disc capacitors are specified for the filter network (*R1*, *R2*, *R3*, *C1*, *C2*, *C3*), better results will be obtained using thin-film precision resistors and mica, glass, or polystyrene capacitors.

The active filter can be mounted either in a small utility box or, because of its small size, directly inside the receiver or speaker enclosure. One note of caution—if you are mounting the filter inside the receiver, try not to position it too close to the receiver power supply. Otherwise, you might encounter hum problems.

Using the Active Filter. While the active filter is very easy to use, it may take a little practice before you can realize its advantages. Turn on the receiver and the filter power supply, but leave filter switch, *S1*, in the FILTER OUT position. Tune around the band until you hear a CW station that you want to copy. Carefully tune the signal in until its note corresponds to the center frequency you have chosen. (It might be helpful to listen to this note on an audio signal generator a few times so that you will recognize it.) When the signal's note sounds like that of f_o, switch *S1* to the FILTER IN position. You should immediately note a drop in all QRM and most QRN. If the desired signal's level drops considerably, you have not centered it in the filter's passband. Try again! Don't touch the receiver's audio gain control once the filter is in the signal chain, because distortion might rise considerably. Instead, tune in the signal for maximum volume.

Since the passband of the active filter is so narrow, it is very difficult to tune around the band with *S1* in the FILTER IN position. Furthermore, it will not be possible to zero-beat a signal or listen to AM or SSB transmissions

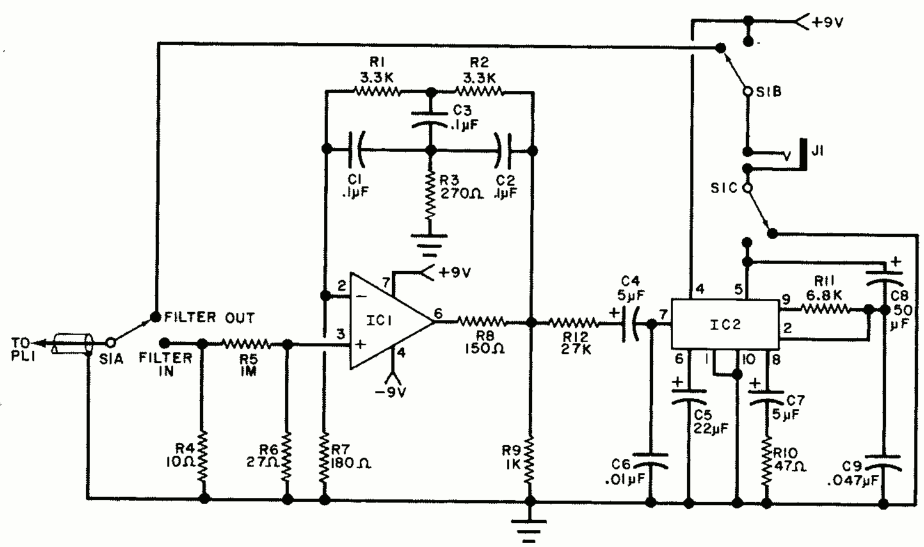


Fig. 2. Schematic for the active filter. The twin-T network determines the center frequency of the filter. When applied to any receiver, it will sharpen and improve CW reception.

PARTS LIST

C1,C2,C3—0.1-µF, 50-volt disc ceramic capacitor
C4,C7—5-µF, 15-volt electrolytic capacitor
C5—22-µF, 15-volt electrolytic capacitor
C6—0.01-µF disc capacitor
C8—50-µF, 15-volt electrolytic capacitor
C9—0.047-µF, 50-volt disc ceramic capacitor
IC1—741C op amp
IC2—1-watt IC audio module (Radio Shack 276-016 or equiv.)
J1—Open-circuit insulated phone jack
PL1—Phone plug
R1,R2—3300-ohm, ½-W 5% resistor
R3—270-ohm, ½-W 5% resistor
R4—10-ohm, 2-W resistor
R5—1 megohm resistor
R6—27-ohm resistor
R7—180-ohm resistor
R8—150-ohm resistor
R9—1000-ohm resistor
R10—47-ohm resistor
R11—6800-ohm resistor
R12—27,000-ohm resistor
All resistors ½-watt, 10% unless otherwise specified.
S1—3pdt switch
Misc: Perf or pc board, shielded audio cable, utility box, wire, solder, hardware, etc. An etched, pre-drilled pc board is available from P.O. Box 15, Hawthorne, CA 90250, $3.95, postpaid.

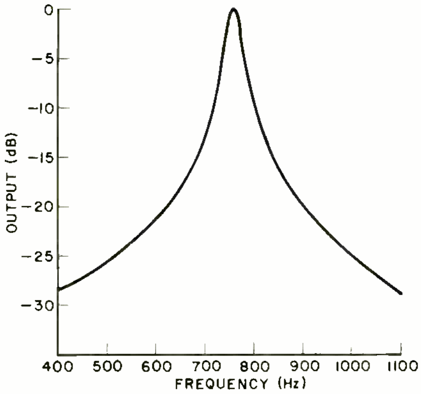


Fig. 3 Frequency response of IC1. Bandpass is less than 100 Hz.

while using the filter. However, it is possible to design a filter with a 2- or 3-kHz passband for phone use. Several filters, each with a different f_o, would have to be connected in parallel. Their outputs would then be combined by an op amp acting as a summer. Such a filter would have skirts as steep as the active filter we have described. Why not think about it? Op amps are very versatile and can make the job of sorting out signals on the crowded ham bands an easy one. QRM *can* become (for the most part) a thing of the past! ◈

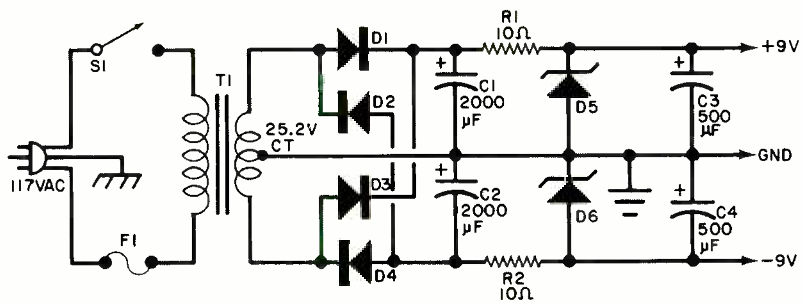


Fig. 4. Power supply for the filter. Bipolar supply features zener regulation.

PARTS LIST

C1,C2—2000-µF, 15-volt electrolytic capacitor
C3,C4—500-µF, 15-volt electrolytic capacitor
D1 to D4—1-A, 50-PIV diode (HEP R0050 or equiv.)
D5,D6—9.1-volt, 5-watt zener diode (HEP Z2513 or equiv.)
F1—¼-A fuse
R1,R2—10-ohm, 10-W resistor
S1—Spst switch
T1—25.2-volt CT transformer (Stancor P-8180 or equiv.)
Misc: Terminal strips, line cord, fuse holder, wire, solder, hardware, etc.

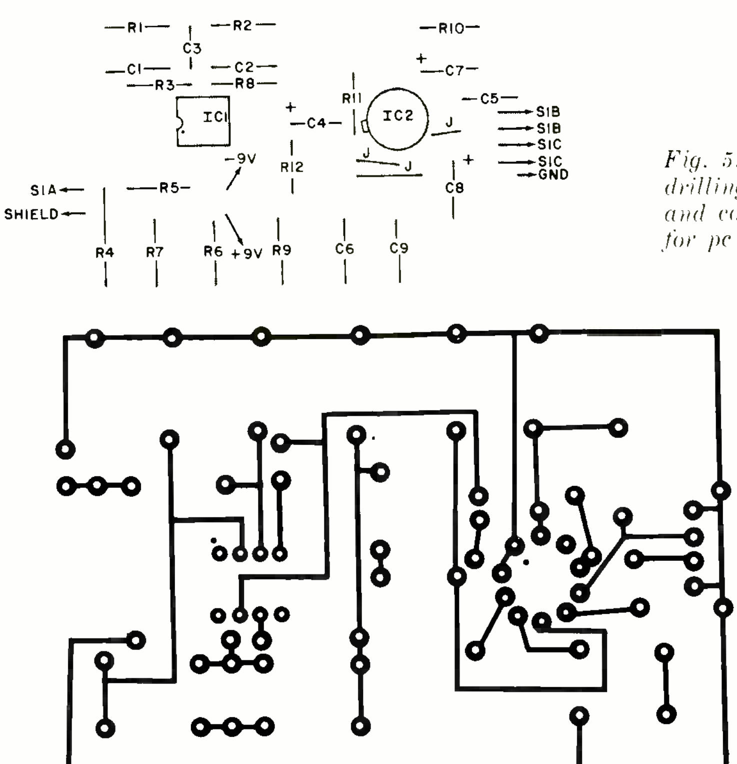


Fig. 5. Etching and drilling guide (below) and component placement for pc board (left).

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Product Test Reports

ABOUT THIS MONTH'S HI-FI TEST REPORTS

In this month's audio test reports, we're examining two products that are off the mainstream path in hi-fi—a dynamic noise-reduction unit and 4-channel headphones. Rounding out the audio section is a complete report on a good-quality, moderately priced open-reel tape recorder.

A handful of ingenious techniques have been devised to reduce noise, principally hiss, in audio systems. Burwen Laboratories' new DNF-1201, a consumer version of its professional equipment, is unusual since it materially reduces hiss with little or no effect on program content.

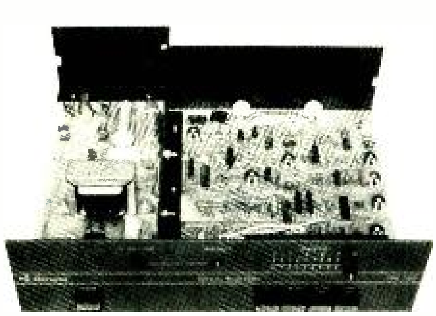
The Fixler-designed TEL-101F 4-channel headphones manufactured by Telephonics are substantially different in design from other quadraphonic headphones. They come close to achieving the seemingly impossible result of a 360° response through a pair of phones.

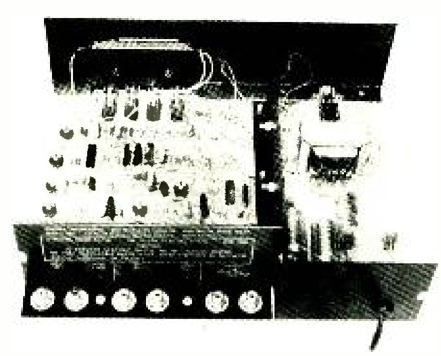
Cassette decks have virtually driven low-priced open-reel stereo tape recorders out of the marketplace, leaving open-reel tape buffs a choice of expensive or very expensive decks. So, we're pleased to report on the Sony TC-645 open-reel stereo tape deck that is competitively priced with the finer cassette recorders.

—Julian D. Hirsch

BURWEN MODEL DNF 1201 DYNAMIC NOISE FILTER

Signal-processing accessory removes last vestiges of hiss.





The bandwidth of a dynamic filter (a type of noise reduction system) is controlled by the characteristics of the audio signal passing through it. Ideally, the control should substantially reduce noise without loss of audible program bandwidth. To accomplish this, the filter's bandwidth must follow the changes in program level and frequency distribution, with careful attention given to how rapidly it responds to the changes in the program material.

If the response is too fast, a burst of noise can be introduced by a short transient, such as a record tick or pop. A slow response will dull the impact of the transient and can audibly reduce high-frequency response. (Most dynamic noise filters for the consumer market have proved to be unsuccessful because of their transient response deficiencies.)

Now, Burwen Laboratories, designers of very sophisticated and expensive professional noise reduction devices, is marketing a consumer-type dynamic noise filter. Although its Model DNF 1201 is less refined in its performance than the company's professional noise filters, it is an effective means for combating noise—and it sells for only a small fraction of the cost of professional units. Retail price is $299.95.

General Description. As with most signal-processing accessories, the noise-filter is best installed in an audio system through its tape monitoring circuit. The filter's 50,000-ohm input and 50-ohm output impedances are designed for just this type of hookup.

One of five pushbutton switches on the front panel is for controlling power. The remaining pushbuttons are for switching in and out the filter's operating modes. The OUT switch bypasses the filter altogether. The active operating modes include PHONO, PHONO 78, and TAPE/FM. The last, with its fast attack, provides the most effective noise reduction in most cases. PHONO is similar but with a slower attack time to reduce the effect of record ticks and scratches. PHONO 78 is slower still, providing more drastic hiss reduction.

Another mode, most effective with program material like piano music, can be engaged by leaving all buttons out (off). This provides the bandwidth characteristics of TAPE/FM with a slow attack time.

The filter has a slide-type SENSITIVITY control that can be adjusted to provide the optimum compromise between noise reduction and subjective loss of high-frequency response. A red LED comes on when the filter is in the SUPPRESSION mode, while a green LED comes on in the WIDEBAND mode (when the signal has effectively removed the filter from the system).

Burwen's specifications for the Model DNF 1201 include: 10 to 30,000 Hz ±0.5 dB frequency response; response down 3 dB at 500 Hz, after which it falls off at a rate of 9 dB/octave at maximum effectiveness; between 6 and 14 dB of hiss reduction; 0.77-volt (0 dBm) nominal input signal level; less than 100 µV output noise between 20 and 20,000 Hz; 0.2% maximum harmonic distortion with 3-volt input and maximum sensitivity between 20 and 10,000 Hz. Normally, the filter's cutoff frequency varies continuously and smoothly between 500 Hz and 30,000 Hz according to the program requirements.

The filter measures 11 3⁄8"W × 8 7⁄8"D × 3 3⁄4"H (29 × 23 × 10 cm).

Laboratory Measurements. Because dynamic measurements are almost impossible to make from outside the filter, our lab tests were performed on a steady-state basis. The filter's dynamic characteristics were judged subjectively.

The WIDEBAND frequency response was ±0.5 dB from 20 to 20,000 Hz. The output noise measured 130 μV (78 dB below 1 volt). In the SUPPRESSION mode, the noise was 80 μV (−82 dB). In short, it was far below the noise level that normally exists at the point where the filter is connected into an audio system.

The filter's output clipped at a surprisingly high 9.2 volts. At a 3-volt output at 1000 Hz, THD was 0.013% on WIDEBAND and 1.5% in the SUPPRESSION mode, where the output was down to 2 volts. At 100 Hz, THD was 0.009% on WIDEBAND and 0.022% on SUPPRESSION. (The 100-Hz frequency is well below the "knee" of the filter curve, so the output remained at 3 volts in both modes.) In practical terms, the distortion produced by the dynamic filter is negligible.

The gain of the filter system is adjustable from zero (off) to a 4.5-dB maximum. (Screwdriver controls are provided for adjusting the gain.) For our tests, the gain was set at unity.

After a number of unsuccessful attempts to measure the filter's characteristics with simple external signals, we plotted the transition frequency between the WIDEBAND and SUPPRESSION modes as a function of signal level. We established a 3-volt output as a 0-dB reference level and set the SENSITIVITY control to maximum.

At inputs of from 0 to −80 dB, we varied the frequency until the red and green LED's glowed with equal intensity, indicating that the filter was beginning to go into action. At 0 dB, this took place at 50 Hz, revealing that high-level signals at very low frequencies would open the filter completely. (They would also mask the hiss.) At lower signal levels, the transition frequency moved upward so that the filter "gate" could be opened by −30-dB signals at 600 Hz, −60-dB signals at 5500 Hz, and even −80-dB signals at 10,000 Hz.

It might appear that the usual −60-dB program hiss level would open the filter and allow the noise to pass through. Under the test conditions, this would be the case. But in normal use, the SENSITIVITY control would be set much lower so that the hiss would be suppressed, while any listenable program level would be able to open up the filter.

User Comment. To use the noise filter effectively, it is necessary to adjust the SENSITIVITY control for the actual program level and requirements of the particular program. In this respect, the Burwen filter differs from some other noise reduction schemes that are calibrated only once.

Adjusting the SENSITIVITY control is an extremely simple operation, though. Starting with a maximum setting, the control is adjusted until the green LED's come on when a signal is present and the red LED's come on when there is no signal. The noise level drops steadily as the control is adjusted. If it is set too low, the high frequencies will be noticeably attenuated. In almost every case, we found it possible to obtain worthwhile noise reduction without detectable loss of highs.

We would rate the subjective noise reduction of the filter as being comparable to the Dolby B system. It has the advantage that prerecorded programs are not needed and the disadvantage that its action can occasionally be detected.

In common with every dynamic filter system that does not use encoded material, the effectiveness of the Burwen filter depends on the transient nature of the program and its background noise level. In severe cases (such as a solo piano against a relatively high background noise level), it is often necessary to sacrifice either bandwidth or noise reduction to avoid hearing a "swish" as the filter's bandwidth opens on the attack of the piano note. On other types of program material, there can occasionally be a hardly detectable trace of dulling on the high-frequency transients when an otherwise satisfactory level of noise reduction is used. Subjectively, the full frequency range appears to be present at all times.

We found the filter to be especially useful for removing the last vestige of hiss from Dolby-encoded programs. It is easy to adjust the filter to eliminate the already attenuated hiss left by the Dolby system, with no effect on the program material.

The filter's response time is *extremely fast*. Even a single low-level bell or triangle note, or a record pop, is sufficient to open the filter's bandwidth, especially in the TAPE/FM mode. The PHONO 78 mode is much slower and relatively immune to transient record noise, but its noise and bandwidth reduction are too drastic to be used with modern records and tapes.

In our judgment, the Burwen Model DNF 1201 is a most effective dynamic noise filter. Under most conditions, it does a highly effective job of unobtrusively reducing or even eliminating background hiss.

TELEPHONICS MODEL TEL-101F 4-CHANNEL HEADPHONES

Quadraphonic phone produces fascinating effects.

HIRSCH-HOUCK LAB REPORT

Simultaneous with the development and evolution of 4-channel sound for the home, there has been a concerted effort to develop quadraphonic headphones. The objective has been (and still is) to make the phones recreate the same spatial effect produced by a good 4-channel speaker system setup. Until recently, however, quadraphonic phones have failed to produce a truly convincing 4-channel effect.

Jon Fixler, a pioneer of 4-channel matrix encoding and decoding, designed the unusual Telephonics Model TEL-101F quadraphonic phones reviewed here. Price is $59.95. At the same time, we also evaluated the performance of the Model TEL-101A "Quadramate" passive synthesizer accessory that derives the rear channels from stereo programs. It sells for $26.95.

General Description. As with all

4-channel phones, the Model TEL-101F has relatively bulky earcups that extend ahead of and behind the wearer's ears. Each cup contains two dynamic drivers. But instead of positioning the drivers in the usual locations in front of and behind the ears, the front driver faces to the rear and the rear driver faces to the front.

The combined outputs from the drivers couple to the ears through a single opening located midway between the drivers. A gently curved foam-rubber pad cushions the phones against the sides of the head. In combination with internal foam padding, this helps to produce the desired frequency response from the phones.

In spite of their bulk, the phones were surprisingly light in weight, weighing less than 19 ounces (0.54 kg). With this weight distributed over a large area by the ear pads, the phones were exceptionally comfortable to wear, even for extended periods of listening.

The phones come with an integral 10′ (3-m) long cord that is not coiled. The cord is fitted with separate three-circuit plugs for the front and rear channels. A control knob located under the left earcup provides a means for adjusting the separation between the two front channels.

The impedance of the phones is compatible with amplifier outputs rated at from 4 to 100 ohms. The phones can handle 400-mW/channel of continuous power.

The Quadramate accessory is housed in a compact plastic case that measures 4¼″L × 2½″H × 1⅛″D (10.8 × 6.4 × 2.9 cm). It comes with an integral 6′ (2-m) cord fitted with a standard stereo phone plug. Two phone jacks at the end of the box opposite where the cord enters are for the front and rear plugs of the TEL-101F phones.

Two slide-type controls on the box are marked FOCUS and PERSPECTIVE, and a slide switch has positions for 2 CH and 4 CH. The adjustment procedure for the accessory requires that the amplifier's balance control be set for full left-channel output with both slide controls at their right limits. The PERSPECTIVE control must then be moved until the sound appears to come from behind the listener's left ear. Then the balance control on the amplifier can be set to its normal position, while the FOCUS control can be set as desired for the optimum 4-channel effect.

Laboratory Measurements. We measured the frequency response of the phones as we would with an ordinary set of stereo headphones. The phones (either front or rear sections, which we measured separately) were driven through a 100-ohm resistance from a power amplifier, to simulate normal operation, at a constant 3-volt level.

The two sections had essentially similar frequency-response and output levels. As with most phones measured on a coupler, the TEL-101F's produced an irregular response curve, with a definite drop-off below 500 and beyond 10,000 Hz. Their efficiency was moderate, with a 3-volt input producing sound pressure levels between 95 and 105 dB.

When measuring one earcup at a time, the QUADRABLEND control on the left earcup had the effect of reducing the front channel output by about 15 dB at its fully blended setting. However, when listening to the phones in a normal manner, the only effect was to gradually move the sound toward the center of the listener's head as it was blended.

The impedance of each earcup was a fairly constant 80 or 100 ohms over most of the audio range. The front driver had a slightly lower impedance than the rear driver, possibly due to loading by the QUADRABLEND control's resistance. A well-damped resonance increased the impedance by about 20% at 130 to 140 Hz.

We repeated these measurements with the phones connected to the synthesizer accessory. With the controls on the accessory set to their right limits, the response was essentially unaffected by the accessory. However, the impedance rose to 250 ohms. When we set the switch to 2 CH, the output level dropped 13 dB and the impedance doubled to 500 ohms. In the 4 CH mode, the output level through the accessory was about 6 dB less than when the phones were used by themselves. Our tests of the Model TEL-101A accessory were limited to listening.

User Comment. We did not expect our laboratory measurements to give any clues to the effectiveness of the Fixler system in a listening situation. They were just to reveal the basic properties of the TEL-101F as a headphone system. Judging from the response curves we obtained, always a risky business, we would have expected the sound to be lacking in bass but generally well balanced over the frequency spectrum. In listening tests, however, the subjective bass was much better than the curves would suggest.

We used the phones with a 4-channel receiver, using SQ and QS matrixed records, CD-4 discrete discs, and stereo FM broadcasts. With matrixed sources, the sound was full, with a suggestion of rear-channel presence, but little identifiable directionality. This was to be expected, since the decoder in the receiver used lacked logic assistance and did not incorporate Variomatrix circuitry.

With CD-4 discs, whose directionality through speaker systems was unmistakable, the phones produced some fascinating effects. The rear channels were definitely to the rear, while the front channels appeared more or less centered to the left and right of the wearer's head. It was as though a 4-channel speaker setup was arranged with the front speakers on a line with the listener and the rear speakers to his rear. On some records with "gimmicked" effects, in which sounds moved through a 360° circle, the effect was very nearly as good with the phones as it was through speakers. In fact, it was positively dazzling at times.

The phones are not among the most efficient we have tested and are even less so when used with the Quadramate accessory. This, combined with their high impedance, prevents these phones from being used with most tape decks or preamplifiers that are equipped with phone outputs. We found that most amplifiers rated at 15 watts/channel or more produced very comfortable listening levels, although low-powered receivers had to be operated at high volume settings.

Do not make the mistake of thinking that 4-channel sound heard through these headphones, as good as they are, is the equal of what you can get with speaker systems. Even stereo phones do not sound like stereo speakers. The same limitations apply—even more so—in the case of four channels. The reason is that phones cannot provide the time delays inherent in listening to normally spaced speakers. With CD-4 and other discrete 4-channel program sources, however, these phones come remarkably close to simulating the effect of a quadraphonic sound field.

The Quadramate accessory appears

to be a passive "ambience-recovery" system that synthesizes the rear-channel signals from ordinary stereo programs. We found that it gave about the same subjective results with most stereo programs that the unaided phones did with matrixed discs played through a basic matrix decoder, with a strong sense of ambience and occasional hints of solid directionality.

The FOCUS control had a very slight effect that is difficult to define. On the other hand, the PERSPECTIVE control unmistakably shifted the sound around to behind the left ear during the adjustment procedure.

The purpose of the 2 CH mode eludes us, since it drastically cut the volume level and gave the sound a sometimes "constricted" character.

In conclusion, we feel that the TEL-101F phones and TEL-101A accessory make a remarkably good 4-channel listening team when used with a moderate- to high-power amplifier or receiver.

SONY MODEL TC-645 OPEN-REEL TAPE DECK

Four-track stereo deck boasts wide dynamic range.

HIRSCH-HOUCK LABS REPORT

According to Superscope, which distributes the Sony Model TC-645 stereo tape deck, the unit was designed for "ambitious home recordists." To back this up, the deck features: three tape heads (Sony's own "F&F" ferrite and ferrite design); three motors in a solenoid-controlled transport; separate recording bias and equalization switching for a variety of tape formulations; and a four-track record/playback format.

The recorder's microphone and line inputs have separate concentric gain controls. Furthermore, the inputs can be mixed through facilities built into the recorder. A single control is provided for adjusting the output levels of both channels simultaneously. The transport has a two-speed—3¾ ips (9.5 cm/s) and 7½ ips (19 cm/s)—mechanism.

The recorder measures 14⅞"H × 14⅝"W × 8⅞"D (37.8 × 37 × 22.5 cm) and weighs only about 41 pounds (19 kg). It retails for $549.95.

General Description. The transport's solenoid control levers latch mechanically. This permits the deck to be set up in advance for unattended recording and turned on by an external timer connected between the recorder and ac line. The tape tensioning arm shuts off the transport and disengages the pinch roller when the tape runs out.

The supply and take-up hubs accept reels up to 7" (17.8 cm) in diameter. A four-digit index counter is located at the top of the transport between the hubs.

The tape follows a straight-line path from one reel to the other. It is not necessary to remove the tape head cover to load the tape or clean the heads, but the removal of two thumbscrews makes removing the cover a simple operation.

On the scales of the illuminated meters are red lights that come on whenever either or both channels are in the record mode. If only one channel is in record only the appropriate meter's light comes on.

Separate pushbutton-switch L and R RECORD interlocks are provided. A second pair of pushbuttons is used for connecting the L and R LINE outputs to either the SOURCE or the TAPE playback program. A third pair of switches is for selecting HIGH or LOW bias and NORMAL or SPECIAL equalization for different tape formulations.

The five transport control levers are for record, rewind, stop, forward, and fast forward. Below the levers are the jack for 8-ohm stereo headphones, the LINE OUT level control, and the pushbutton power switch. The microphone input jacks are located below the meters, while the LINE input and output jacks are located on the rear apron, together with a single unswitched ac accessory outlet. A patch cable is supplied with the recorder for interconnecting the LINE outputs and inputs for making SOUND-ON-SOUND or ECHO recordings through the microphone inputs.

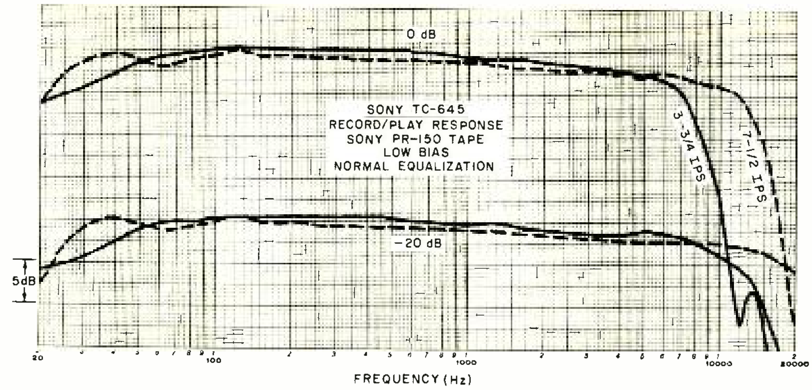
Laboratory Measurements. We tested the deck with PR-150 and high-performance SLH-180 tapes, both from Sony, using the bias and equalization settings recommended in the instruction manual that accompanied the recorder. The playback frequency response, measured with Ampex test tapes, was quite similar at both speeds. There was a slight rise below 200 Hz to about +3 dB at 50 Hz. The response was flat within ±0.5 dB from 500 Hz to the upper limits of the tapes, which were 7500 and 15,000 Hz at 3¾ ips and 7½ ips, respectively.

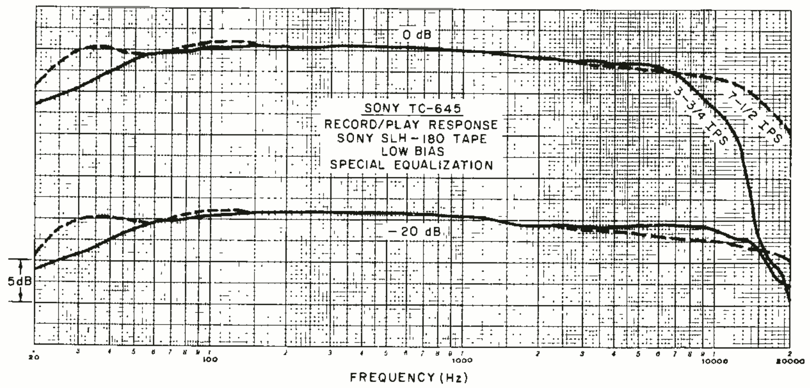
With Sony SLH-180 tape, using LOW bias and SPECIAL equalization, the overall record/playback response at a −20-dB level was ±3 dB from 25 to 16,000 Hz at 3¾ ips and between 20 and 23,000 Hz at 7½ ips. A more "standard" tape, Sony's PR-150, operated with LOW bias and NORMAL equalization yielded a ±3-dB response of 25 to 11,500 Hz at 3¾ ips and 22 to just beyond 20,000 Hz at 7½ ips.

Other characteristics of the deck were measured with the SLH-180 tape. The input for a 0-dB recording level was 40 mV on LINE and 0.125 mV on MIC. The playback output was 0.82 volt. The MIC inputs overloaded at 76 mV—a safe level for most applications and purposes.

At a 0-dB recording level, the playback distortion at 1000 Hz was a very low 0.6% at 7½ ips and 0.82% at 3¾ ips. A 200-nanoweber/meter test tape played back with a 0-dB meter reading.

To reach the reference 3% THD, the recording level had to be increased to +10 dB at 7½ ips and to +8 dB at 3¾ ips. The playback noise levels at these speeds, referred to the 3% THD signal level, were −61.8 and −58.5 dB, respectively. These were unweighted readings. Applying IEC A weighting to correlate with the audibility of the noise, these figures improved to −71.3 and −67.5 dB, truly excellent for any tape recorder. Through the microphone inputs at maximum gain, the noise increased by 10 dB. But at more "normal" settings, the added noise was much less.





The wow was unmeasurable, being less than 0.02% residual of the test tape. Unweighted rms flutter, the NAB standard, measured 0.09% at 7½ ips and 0.11% at 3¾ ips. The operating speeds were slightly fast, by about 1% at 3¾ ips and 0.5% at 7½ ips. In fast forward or rewind 66 seconds were required to pass an 1800′ (550-m) reel of tape from one reel to the other.

User Comment. This was a very simple, straightforward deck to operate. The levers moved smoothly and positively. It was almost as though they controlled the transport directly through an extraordinarily light pressure linkage. The tape handling was smooth, and shuttling back and forth with the fast speed levers, we found it impossible to spill the tape under any conditions we could devise—including interrupting the power during fast winding.

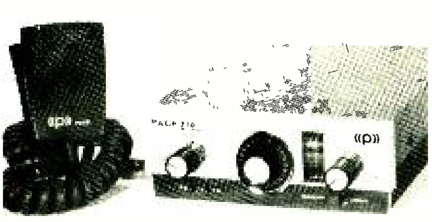
The considerable "headroom" above the 0-dB meter readings before tape saturation sets in makes recording a relatively uncritical procedure. As Sony points out, the maximum recording level can be allowed to reach 0 dB with little chance of overdriving the tape on program peaks. For "live" recording, a maximum meter indication of −3 to −5 dB is recommended.

When we recorded FM interstation hiss, at 0 dB, and compared the playback to the original, there was virtually no difference in sound between the two at 7½ ips. Only a trace of dulling of the very highest frequencies appeared at 3¾ ips. This is a severe test of tape recorder dynamic range. Few recorders at any price could pass this test as well as did the Model TC-645. Combined with very low noise levels, this gives the recorder a dynamic range well in excess of what most home recordists—even "ambitious" ones—will ever require.

CIRCLE NO. 67 ON READER SERVICE CARD

PACE MODEL 2300 MOBILE CB TRANSCEIVER

AM rig uses crystal-controlled frequency synthesis.



CRYSTAL-CONTROLLED frequency synthesis is used in the Pace Model 2300 mobile CB transceiver to provide full 23-channel Class-D AM coverage. As a result, the unit incorporates only 14 crystals. Included with the transceiver at its $219.95 retail price are a detachable microphone and mobile mounting hardware. A theft preventive feature is provision for use of a padlock at a snap-on mounting clamp.

In addition to the usual volume control, there is also an adjustable squelch control on the transceiver. PA operation is available through a jack for an external speaker. There is a second output jack for receiver use.

A DISTANCE/LOCAL switch allows the receiver gain to be reduced by about 15 dB when set to the latter position to cope with possible adverse effects from very strong local signals. The received signal strength registers in S units on an edgewise-mounted panel meter. The transmitter operates at full legal power, and full modulation is easy to maintain.

The transceiver is designed to operate from negative- or positive-ground dc sources capable of delivering 10 to 16 volts. A line filter is included in the negative leg of the supply, and reverse-polarity protection is incorporated into the system to protect it from electrical damage. Where necessary, zener diodes are used to provide voltage regulation.

The transceiver measures 8.4″D × 6.9″W × 2.6″H (21.3 × 17.5 × 6.6 cm) and weighs 5.5 pounds (2.5 kg).

The Receiver. The receiver section employs a double-conversion design. The first i-f is 7966 to 8006 kHz, obtained by heterodyning the incoming CB signal with one of six crystal oscillator signals from the synthesizer in the 35.221- to 34.971-MHz range. The result is converted to the 455-kHz second i-f using one of four crystals in the 8421- to 8461-kHz range.

Selectivity at the second i-f is obtained via six tuned circuits in a bandpass configuration. This setup, along with the a-f system, resulted in an overall 6-dB response of from 350 to 2300 Hz and a 10-kHz adjacent-channel rejection of nominally 50 dB.

The diode-protected input amplifier provided a 0.4-μV sensitivity for 10 dB (S + N)/N at 30% modulation with a 1000-Hz signal. The image rejection measured 50 dB, while other spurious responses were down by a minimum of 40 dB.

An amplified agc system controls the r-f, mixer and first i-f stages, while the resulting changes in the r-f amplifier's collector current controls an amplified squelch. The threshold of the squelching action was adjustable for signals ranging from 0.25 to 50 µV. The agc held the a-f output to within 9 dB with an 80-dB r-f input change (at 1 to 10,000 µV). The meter registered S9 with a 100-µV input signal.

The full-time noise limiter is a series-gate affair. The a-f chain consists of four cascaded stages in a single-ended arrangement that delivered slightly more than 2 watts of power into a 3.2-ohm speaker (1 watt into an 8-ohm speaker) with 10% distortion at 1000 Hz. The a-f section also doubles as the modulating system for the transmitter.

The Transmitter. During transmit, the carrier signal is obtained by combining, in the mixer stage, one of the nominal 35-MHz synthesizer frequencies with one of four frequencies in the 7966- to 8006-kHz range. The difference frequency is extracted for the on-channel signal that is then applied to the driver and the power amplifier stages, both of which are collector modulated. Harmonic filtering and matching to a 50-ohm load is accomplished with a triple-section output network. A relay is used for antenna transfer.

We measured a 4-watt power output when the transmitter was powered by a 13.8-volt dc source. Using a 1000-Hz tone, full modulation with a sine wave was obtained at 9% distortion. With a 6-dB increase in microphone input signal level, clipping set in, resulting in 14% distortion. Using EIA's standard test tone of 2500 Hz, the measured adjacent-channel splatter was down 45 and 30 dB, respectively, under the above modulating conditions. However, with dynamic operation under voice conditions, the splatter held to better than 50 dB down.

The overall response of the transmitter/modulator system at the 6-dB points was nominally from 250 to 4000 Hz.

User Comment. Aside from providing good performance, the Model 2300 transceiver presented a clean utilitarian appearance in its simulated wood-grain metal cabinet. The illuminated edgewise-mounted meter glows a soft white, except in transmit when it glows red.

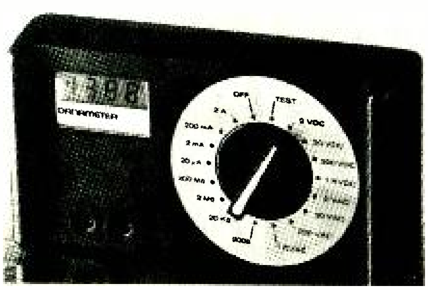
The rig's squelch operation was exceptionally smooth without "plopping" when it came into action. The threshold was stable with varying vehicular-motor speeds. The anl's operation was also good. It held noise pulses down to the equivalent of near 1 μV. The audio reproduction from received signals was good coming from a 6" × 2" loudspeaker located along the left side of the cabinet.

The transmitter's microphone gain is fixed so that, along with the transmitting characteristics, full modulation could be maintained with normal voice levels, while heavy overmodulation and adverse splatter were held down even when the voice was raised to a shout directly into the microphone. For PA operation, the volume control serves as the microphone gain control. (The microphone must be plugged into its jack to make the transceiver's built-in speaker operative.)

CIRCLE NO. 68 ON READER SERVICE CARD

DANA LABORATORIES "DANAMETER" DMM

3½-digit battery-powered multimeter has liquid-crystal display.



DIGITAL multimeters usually employ either high-current LED or high-voltage gas-discharge-type displays. A notable departure from this tradition is Dana Laboratories' "Danameter," a full-function digital multimeter that employs an extremely low-current liquid-crystal display. Teaming the LCD with even lower power MOS devices has resulted in very long life from ordinary replacement-type batteries in a DMM circuit that measures ac and dc voltages, direct current, and resistance.

The Danameter is housed in a virtually unbreakable Cycolac-T plastic case. A carrying handle that doubles as a tilt stand for the DMM folds away when not needed.

The DMM measures 7¼"W × 3¾"H × 2¼"D (18.4 × 9.6 × 5.7 cm) and weighs a scant 1 lb. (0.45 kg). It retails for $199.95.

Technical Details. The DMM's readout system consists of a 3½-digit field-effect liquid crystal display. The display forms ½" (12.7-mm) high black numerals against a very pale colored background to provide maximum visibility and contrast.

The instrument is designed to measure dc voltages of from 2 V to 1000 V full-scale in four ranges. Resolution is 1 mV on the 2 V position of the function/range switch. Input resistance on all dc voltage ranges is 10 megohms. (Polarity is automatically indicated in the display. Positive voltages generate a + sign, while negative voltages generate a − sign in the display.)

There are also four ranges set aside for ac voltage measurements. In this mode, the measurement range is from 1 mV to 700 V over a frequency range of from 45 Hz to 10,000 Hz. The input impedance is 2 megohms.

The DMM measures dc (but not ac) current in four ranges, from as low as 10 nA to as high as 2 A. This function is protected by a fuse for up to 250 V at the test inputs. Finally, there are four resistance ranges that provide a measuring capability of from 100 milliohms to 199.9 megohms.

The instrument can accept overloads of up to 250 volts dc or rms on all resistance and current ranges, 250 V dc or 1000 V peak ac on all ac voltage ranges, and 1000 V dc or peak ac on all dc voltage ranges. (The overload indication on the display is OL.)

Because of the instrument's very low power requirements, a single 9-volt transistor battery should power the Danameter for about a year. A position is provided on the function/range switch for testing the battery.

Several optional accessories are available for use with the Danameter. These include a pair of probes for 5- and 50-kV ranges, an r-f probe that can be used to 200 MHz, an ac current shunt that enables ac current measurements to one ampere, a carrying case, and a multiple-tip test-lead set for various applications.

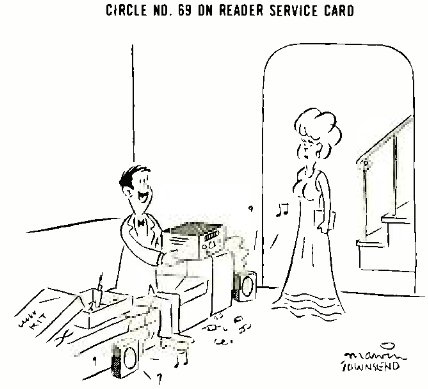
User Report. We checked out the Danameter in our usual manner. The dc voltage ranges were tested with the aid of a laboratory standard voltage source, while the resistance ranges were tested out with a number of high-tolerance precision resistors. The instrument displayed readings that were well within its published specifications.

Because Dana claims that the Danameter is housed in a "virtually unbreakable" plastic case, and being well aware of the rigors to which field service gear is put, we "field tested" the DMM by dropping it from a height of 1 meter onto a hardwood floor. Physical examination revealed no damage to the case, LCD, or function/range switch. To verify that the DMM was undamaged electrically, we again subjected it to the specification tests. There was no electrical damage.

Despite the fact that the LCD readout does not glow (like a LED or gas tube), and has no source of illumination, the large display is easy to read, even from a few feet away on the bench. But, since this power-saving system depends on ambient light for its brightness, it cannot be easily read in dimly lit areas.

With 3½ decades of display and high-accuracy measurement capability, the Danameter makes an excellent bench DMM. Its high impedance input gives it fine solid-state capability in a small package. Additionally, the battery-powered instrument's small size, light weight, and ruggedized construction make it an ideal portable test meter in all but very poorly lighted situations. ◈

CIRCLE NO. 69 ON READER SERVICE CARD



"While I was waiting, I assembled this stereo kit I picked up on the way over."

Solid State

By Lou Garner

THE VOLTAGE COMPARATOR

SUITABLE for use in a variety of applications in logic, control and instrumentation equipment, voltage comparators are available from most large semiconductor manufacturers as well as a number of the smaller specialty firms. In its basic form, the voltage comparator is essentially a modified differential amplifier with two stable output states, responding when an applied input voltage crosses a pre-established threshold level.

Typical of currently available voltage comparators, the "111 family" consists of three standard types offered in a variety of packages by at least two major suppliers, RCA's Solid State Division (Somerville, NJ 08876) and the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051). The RCA types are identified as the CA111, CA211 and CA311, while the corresponding

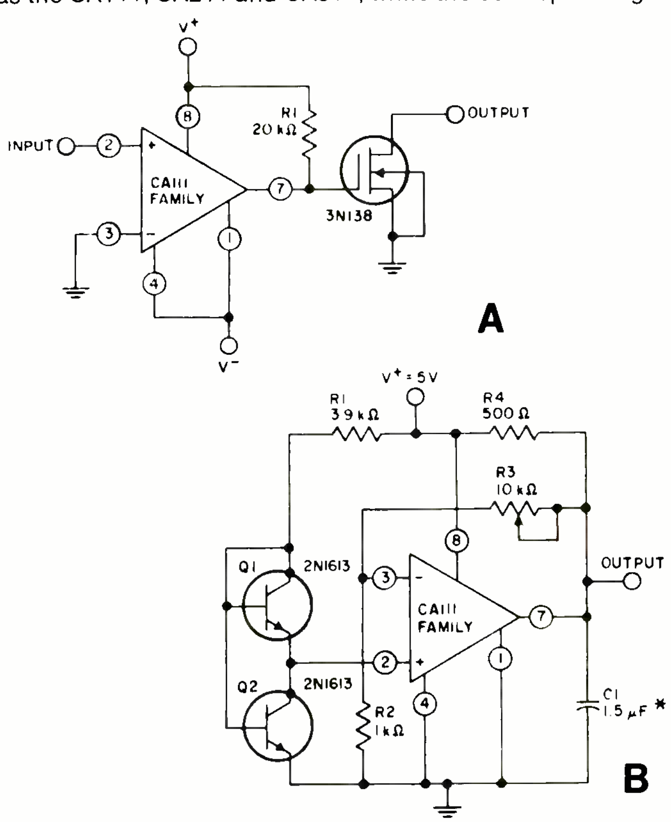


Fig. 1. Type 111 comparator in a zero-crossing detector (A), and an adjustable reference supply (B).

National Semiconductor devices are designated the LM111H, LM211H and LM311H, respectively. All three types are fabricated using monolithic silicon chips. The basic "111" circuit comprises 24 transistors, two zener diodes, and 19 resistors.

The 111 family devices can be operated on dual power supplies of up to ±15 volts or on single dc supplies down to 5 volts. They can drive lamps or relays, and can switch voltages up to 50 volts (40 volts for the 311) at currents of up to 50 mA. The three devices in the family are similar as far as maximum ratings, general specifications, and applications are concerned, differing primarily in their ambient operating temperature ratings and, in the case of the 311, in maximum input offset and bias current specifications. In all three devices, both the inputs and outputs can be isolated from system ground, permitting the output to drive loads referenced to ground, the negative supply, or the positive supply. Their common response time is specified at 200 ns.

Both the RCA and equivalent National Semiconductor devices are supplied in 8-lead TO-5 style case with identical terminal connections. In addition, National Semiconductor offers both the 111 and 211 devices in 10-lead flat packages and 14-lead DIPs, with the 311 offered in a special 8-pin DIP as well. National Semiconductor identifies its TO-5 packaged devices with an "H" suffix, its flat packages with an "F" suffix, its 14-pin DIP with a "D" suffix, and its special 8-pin DIP with an "N" suffix.

Extremely versatile, voltage comparators may be used in a broad range of circuit applications, both individually and in conjunction with other IC's and discrete devices. Because of their versatility, these devices are ideal for many hobbyist and experimenter projects.

A simple zero-crossing detector suitable for use in switching, control, and instrument applications is given in Fig. 1(A). Here, the voltage comparator is used to drive a MOSFET which, in turn, serves as the output switching element.

The low-voltage adjustable reference supply circuit shown in Fig. 1(B) utilizes two npn transistors, *Q1* and *Q2*, in conjunction with the basic voltage comparator. Potentiometer *R3* serves as the output level control. As indicated, output filter capacitor *C1* should be a solid tantalum-type electrolytic.

Two 100-kHz signal sources are illustrated in Fig. 2—a free-running multivibrator featuring a square-wave output signal at (A) and a crystal-controlled oscillator at (B). Each requires but a single IC and is designed to operate on a single-ended 5-volt dc source. The multivibrator may be used as a clock source in counters and timers or even as part of a secondary frequency standard.

Finally, a type 111 voltage comparator is teamed with a 101A op amp and discrete devices in the 10-Hz to 10-kHz voltage-controlled oscillator (VCO) circuit given in Fig. 3. Supplying both triangular and square-wave output signals simultaneously, this circuit could be used as part of a function generator or an electronic musical instrument. A

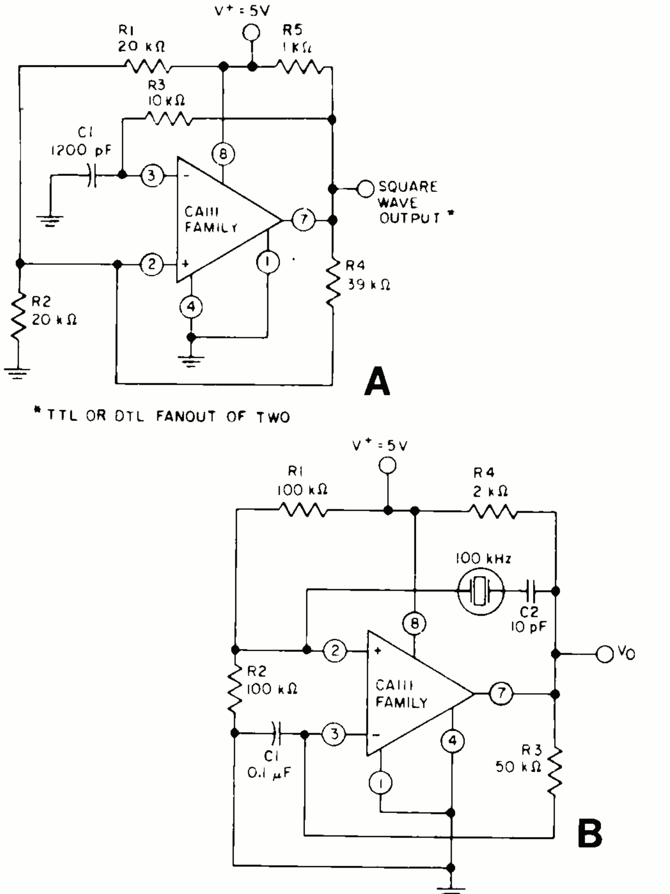


Fig. 2. A 100-kHz free-running multivibrator (A), and 100-kHz crystal-controlled oscillator (B).

dual 15-volt dc power supply is required for circuit operation. In practice, the circuit's instantaneous operating frequency is determined by its input control voltage (from 5 mV to 5 V), while its maximum frequency is established by feedback capacitor *C1*. Potentiometer *R8* serves as a semi-fixed symmetry control and is adjusted for a symmetrical square-wave output when the minimum (5 mV) control voltage is applied to the input terminal.

The three circuits we've examined are but a small sampling of those described in manufacturers' published literature. Among the other circuits found in both RCA and National Semiconductor publications are a *digital transmission isolator, solenoid driver, precision squarer, strobed relay driver, precision photodiode comparator, magnetic transducer detector*, both *positive and negative peak detectors*, and *switching power amplifiers*, all of which further illustrate the voltage comparator's amazing versatility.

Readers' Circuits. John M. King (1194 Idylberry Road, San Rafael, CA 94903), who submitted the low-light indicator circuit featured in last September's column, has come up with another winner. As his previous circuit, John developed the project to solve a problem encounterd by his son, who received a slot car racing set for Christmas. After a while, John and his son found that the 45-ohm rheostat speed controllers supplied with the set were far from satisfactory. If the cars were operated at slow speeds, they would tend to stall with even minor load increases, such as a slope or increased friction on some track sections. If additional power were supplied to pull up an incline, the cars would tend to speed up and crash off the track on the downhill side. John's solution, illustrated in Fig. 4, was a voltage-regulated dc power supply with both a continuous "speed" control and a "top speed" fixed adjustment.

Referring to the schematic diagram, line voltage is stepped down by *T1*, rectified by a full-wave bridge rectifier (*RECT.*), and filtered by capacitor *C1*. A commercial 3-terminal voltage regulator, *IC1*, establishes a constant output voltage. The regulator, in turn, is supplied with a variable control voltage pedestal by a voltage-divider consisting of speed control *R2*, top-speed adjustment *R3*, fixed resistor *R4*, and reference dc voltage obtained from zener diode *D1*. Capacitor *C2* provides filtering

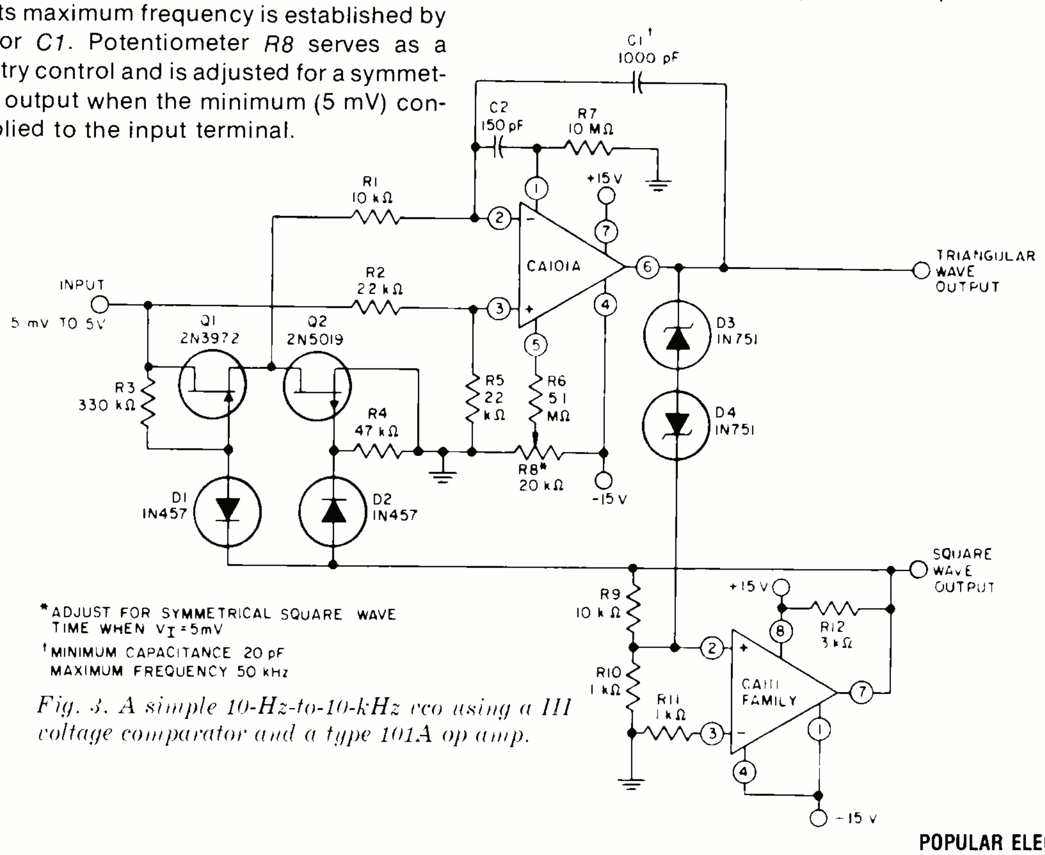


Fig. 3. A simple 10-Hz-to-10-kHz vco using a 111 voltage comparator and a type 101A op amp.

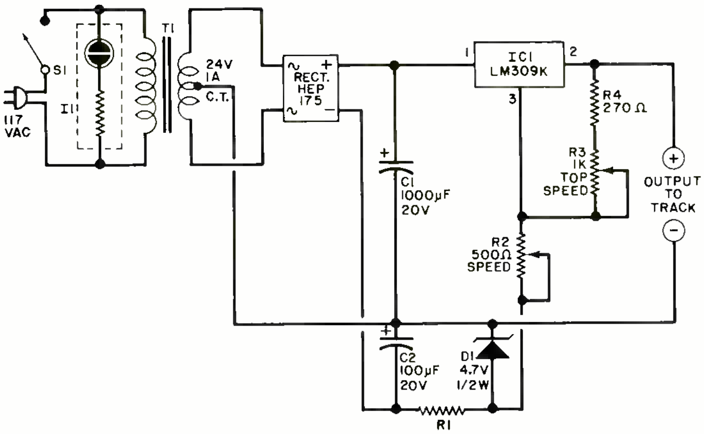


Fig. 4. Speed control circuit for slot cars and HO model trains as submitted by a reader.

for the reference voltage while series resistor *R1* limits the zener's current.

John used standard, readily available components in assembling his model. Power switch *S1* is a spst rotary type mounted on the 500-ohm speed-control potentiometer, *R2*. A 115-volt neon-type lamp assembly (with integral dropping resistor) serves as pilot lamp *I1*.

Since layout and lead dress are not critical, conventional construction techniques may be used for assembling the project. John built his original model in a 4"×5"×3" aluminum box, using the box itself as a heat sink for the voltage-regulator IC. With relatively few components needed, he used point-to-point wiring, providing a terminal strip to support the smaller parts.

With a maximum output of from 4.5 to 12 volts dc (depending on *R3's* setting) at approximately 1 A, the controller can be used with HO gauge model trains as well as slot cars. Separate controllers are needed, naturally, for each car in multi-car set-ups or for each train layout.

Anticipating that some builders might wish to use the power supply for other than model train or slot car control applications, John checked the circuit's overall performance. He measured a ripple of 25 mV at 10 volts output with a drain of 1 A, and found that the ripple could be reduced to less than 1 mV by adding a 50-μF capacitor between the negative output terminal and pin 3 on the regulator IC. The ripple at full output is somewhat higher, but the output voltage change is less than 2% from zero to full load.

Suggested by reader John Hornibrook (Box 1165, Silver City, NM 88061), the circuit shown in Fig. 5 might be called a *seeing aid* for the blind. Basically a light-controlled oscillator, the circuit provides an audible signal which changes in pitch with different light levels, thus permitting a user to "scan" the area in his immediate vicinity for changes in light contrast. John indicates that little practice is required for the user to detect objects in his immediate path, such as trees, telephone poles, other persons, walls, and so on, and thus to avoid collisions.

Except for photocell *PC1*, the circuit is a conventional collector-coupled multivibrator. The circuit's frequency will vary as *PC1's* instantaneous resistance varies and this, in turn, depends upon the amount of light falling on the photocell's sensitive area. Base resistor *R2* is made adjustable to permit the user to pre-adjust the circuit's frequency to a comfortable tone under average light conditions. The circuit's output signal, generated across emitter resistors

R4 and *R5*, is coupled to an external earphone through jack *J1*.

The circuit can be wired on perf board sized to fit and mounted on spacers inside a metal box or similar case small enough to be held conveniently in one's hand. The inside of the box should be blackened and all cracks covered with tape to make it light-tight. A lens should be provided to focus incoming light on the photocell. This is cemented behind a small (3/16") hole drilled in one end of the case, with the photocell mounted in the lens's focal plane. The photocell is modified by covering with opaque black tape, except for a 1/16" vertical slit on its face. John used a 1" diameter lens with a 3" focal length, but other small lenses may be used if the photocell is positioned at the proper focal point.

To use the completed instrument, plug a moderate impedance earphone into jack *J1*. Switch on and adjust *R2* for a pleasing tone with the lens pointed towards an open area. Next, move the unit back and forth to "scan" the area. As the instrument is moved past objects of varying contrast, there should be a change in the pitch of the audio signal. The instrument's effective sensitivity will depend on one's hearing acuity, on the degree of light contrast between detected objects and background lighting, and, to some extent, on *R2's* adjustment, as well as upon the degree of skill acquired through practice.

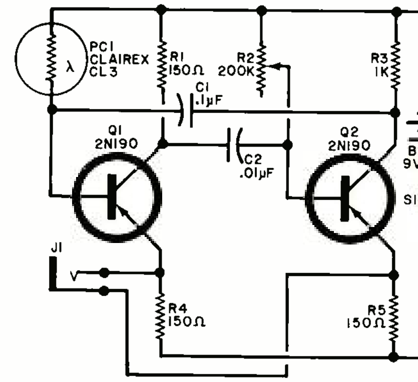
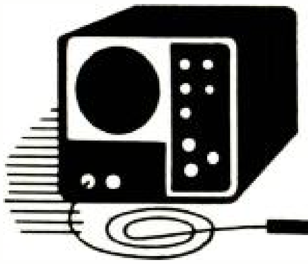


Fig. 5. Audible signal varies with different light levels.

Device/Product News. A new LED digit driver specifically designed for use in digital clocks and desk-top calculators has been introduced by *National Semiconductor Corp*. Identified as the DS8863, the new IC contains eight independent channels, each capable of sinking up to 500 mA. Intended for use in display systems employing LED's in the common-cathode multiplexed configuration, the device can be used with displays up to 0.6 inch high and even with digits made up of individual lamps. Featuring high-gain Darlington circuits and requiring a maximum input drive of only 2 mA, the DS8863 interfaces directly with MOS clock and calculator circuits.

If you're using round case TO-5 type IC's, but have a breadboard or circuit layout designed for DIP's, you'll want to check into a series of inexpensive mounting pads now available from *Bivar, Inc.* (1617 Edinger Ave., Santa Ana, CA 92705). Molded of high-strength plastic, these handy components have funnel-shaped, self-aligning entry holes which will accept devices with circular patterned leads, forming the leads into a DIP pattern at exit. Posts on the top and feet on the bottom of the pads provide extra lead exposure for heat dissipation and permit easy probe insertion for circuit tests. Three color-coded versions of the mounting pads are currently available: an 8-lead blue pad, Part No. 808-187, a 10-lead red pad, Part No. 810-187, and a 12-lead white pad, Part No. 812-187. All three versions are priced at \$9.05 per hundred in quantities of 100 to 499, dropping to \$36.25 per thousand in quantities above 10,000.

Thinking about assembling a digital watch? There's good news from the West Coast—a new low-voltage CMOS IC chip which contains all of the LSI circuitry required to make a digital watch is now available from *Siliconix, Inc.* (2201 Laurelwood Road, Santa Clara, CA 95054). In addition to the chip, type DF111, all that is required for watch assembly are a 32.768-kHz crystal, a battery, a LED display with drivers, and three switches, plus, of course, a case and hardware. Options are provided for sensors to indicate low-battery conditions and ambient light level. Functional down to 2.2 volts typical, the chip's nominal voltage range is 2.7 to 3.4 volts, supplied by two silver-oxide cells. The DF111 provides for a multiplexed four-digit, seven-segment LED display which will indicate days (date), hours, minutes, and seconds. Days, hours, and minutes may be set independently, and seconds may be synchronized from another time source. Optional displays are 12 or 24 hours, and an AM indicator is available with the 12-hour option. ◈



Test Equipment Scene

By Leslie Solomon

GROUNDING

WHEN you use test equipment, you probably connect a signal across the input and an oscilloscope across the output of the circuit under test and watch the scope's CRT screen. What you may not realize is that in many cases what you see is not what the device under test is really capable of doing. In fact, what you might be looking at is what the test equipment and the device under test is *adding* to the input signal (exclusive of distortion products).

What accounts for this strange phenomenon? The name of the culprit is "ground." The way many of us handle this ground in performing tests is simple. We merely connect one ground point to another, using some convenient wire or test leads. It is the lack of understanding the meaning of "ground" that causes a lot of grief at the testbench.

What is Ground? Since all electrical measurements are relative, a voltage or signal must be compared to a reference—usually zero or ground. When we refer to ground, ground is literally what we mean, since the local potential of the planet Earth was chosen as our arbitrary zero reference.

There are many ways of connecting to this zero reference, each with its good and bad points. Many people swear by a metal rod driven into the soil. But the rod must be driven deep enough to contact a low-resistance layer, or the rod and surrounding soil must be kept moist to maintain a low earth resistance. Just driving a rod into the ground is not enough. As a general rule, the deeper the rod is driven into the earth, the better.

The second and perhaps best approach to achieving a good earth ground is to use a *cold*-water pipe as the ground connection. In almost all cases, this pipe makes intimate contact with the surrounding soil over a large area because it must lie below the local frost line. At such a depth, chances are good that the pipe will lie in a layer of low-resistance soil.

Contact with the cold-water pipe can be made with a brazed, soldered, or clamped-on connector. There may be a problem here. Although most cold-water pipes are metal, there may be plastic joints or even sections of plastic pipe. Plastic is not a conductor. If such is the case, you can bridge over the non-conductors—assuming you have access to them—with heavy-duty wire braid, making good electrical connections on both sides of the non-conductive break.

The idea of using the wall socket's junction box as a ground should be discarded. True, in some areas of the country, metal armored cable is prevalent. The armor is usually connected to the metal junction box and to earth ground at some point. Unfortunately, there are many places where plastic-insulated power lines are the norm; although in such a system the third (green) conductor is supposed to be at ground potential, there is always the possibility that it is not.

Do not use the so-called "grounded" side of the ac power line as a ground. Because it is not a perfect conductor, there will be an unwanted signal generated across the wire resistance. Besides, if you happen to use the wrong side of the line, it could prove disastrous.

If you occasionally use the metal finger stop on your telephone dial as a ground, that's not a good idea, either. The phone company frowns on this practice. But more importantly, circulating currents may exist in such a hookup.

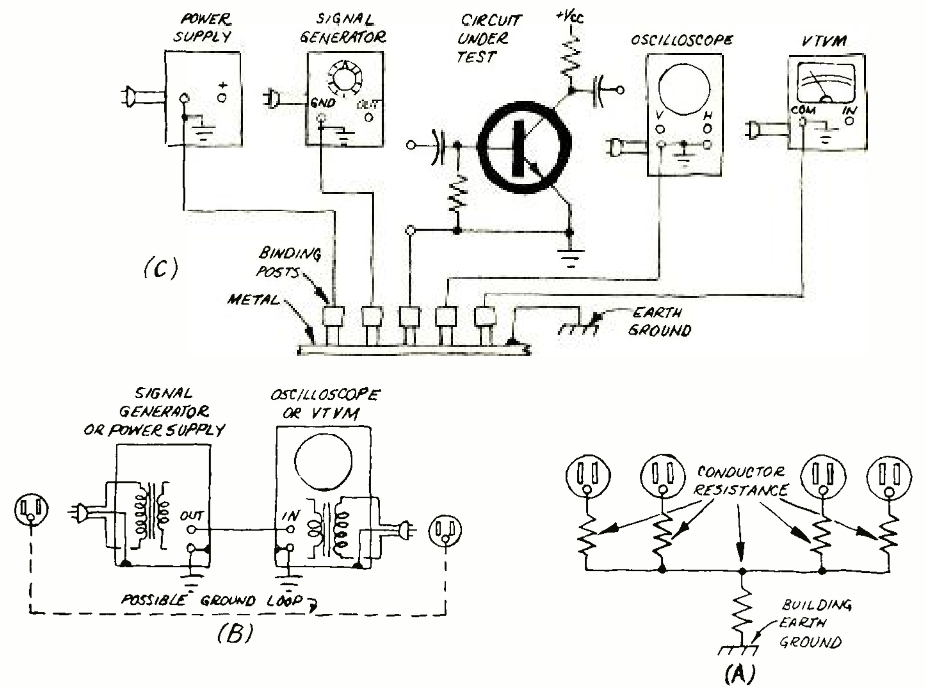
Origins of Unwanted Signals. Now, let us take a look at the origins of those unwanted signals. Sketch A shows a typical three-conductor power feed. Because the wire used is not a perfect conductor, differences in potential can and often do exist between two points of a grounding system if any current flows in the system.

The sketch illustrates the phantom wire resistance that forms the common signal point. Note that any instrument plugged into the three-wire outlet is essentially coupled to all other outlets via an interlocking set of phantom resistors.

If you connect a couple of line-powered test instruments as shown in

In using the ungrounded adapter, there is a potential danger if the "hot" power line within the instrument touches the metal chassis. So, before using this approach, make certain that all internal wiring is sound.

In multi-instrument setups, there may be more than one ground connection, creating more than one ground loop. Any one of these loops can introduce a problem. Since shielded cables are often used to in-



How grounding problems originate. (A) shows how differences in wire resistances create potential differences. (B) shows ground loop in building power line which introduces a false signal. At (C) is a typical test-bench setup with 2-wire plugs to eliminate loops.

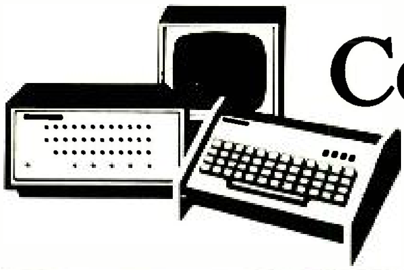
sketch B, a ground loop can occur. The metal chassis of both instruments are grounded via the third (green) wire of the receptacle. In some cases, there may be some real capacitors between the ac line and chassis. In all cases, there is the phantom capacitance across the power transformer. Hence, if any current is flowing within the building's power-line "ground," this signal will be "felt" by the measuring system, which will introduce a false signal into the measurement loop.

To break the ground loop and remove false signals, the third wire at one of the instrument power plugs must be broken. (Use a three-wire to two-wire adapter.) As a result, the system is grounded at only one point and, since the ground loop is now broken, false signals produced by ground currents are eliminated.

terconnect a system, especially in audio, all shields should be connected together and then tied to ground at the same point used by the measurement system.

A typical bench setup is shown in sketch C, where two-wire power plugs are used to eliminate the possibility of ground loops. In general, if more than one point in a system must be connected to ground, the ground connections must be made only at the same point where the input is grounded.

There are two excellent books that deal with the subject of grounding when working with test equipment. One is *Basic Electronic Instrument Handbook* by Clyde F. Coombs, Jr. (McGraw-Hill) and the other is *Guide to Electronic Measurements and Laboratory Practice* by Stanley Wolf (Prentice-Hall). ◈



Computer Bits

By Jerry Ogdin

A NEW BREED OF HOBBYISTS

FOR many years, the thought of having one's own digital computer was only a dream because they could cost anywhere from $100,000 to several million.

But in the late 1960's, Digital Equipment Corp. announced its $24,000 PDP-8, raising hopes of forward thinkers for that elusive home computer. With the 1970 introduction of the microprocessor IC (CPU-on-a-chip), representing the "heart" of a full-blown digital computer in a single IC package, they knew it was just a matter of time before prices dropped.

Not content to wait, amateur computer users banded together during the early '70s to share ideas and equipment. In fact, many of the successful applications of microprocessors on the market today owe their origination to these hardy souls, who experimented with building personal computers.

The breakthrough in low-cost microprocessors occurred just before Christmas 1974, when the January 1975 issue of POPULAR ELECTRONICS reached readers with the first relatively inexpensive unit—about $400 in kit form—that competed in performance with much costlier commercial units. The aftermath is heartwarming to electronics hobbyists—CPU prices are plummeting, and at least one major manufacturer drastically cut the price of its microprocessor.

People interested in computers fall into three major groups: (1) Strong background in "hardware," the physical electronics equipment; weak in "software," the instruction programs needed to make the computer perform some useful task. (2) Strong background in "software," weak in "hardware." (3) Interested amateurs who have no experience in either sector, but find the world of computers an exciting challenge they'd like to tackle.

So it's not surprising to learn that small hobbyist groups are springing up all over the country, where competent and enthusiastic programmers who cannot read a wiring or logic diagram share ideas with electronic engineers and technicians who work with computers daily, but still find the mysteries of software virtually a black art. For example, a recent letter addressed to POPULAR ELECTRONICS from Hal Singer (hardware editor) and Steve Diamond (software editor), Cabrillo Computer Center, 4350 Constellation Road, Lompoc, CA 93436, stated that they represent a user group of 300 hobbyists actively constructing microcomputers, and would like to encourage participation in their group by persons planning to build the *Altair 8800* computer that debuted in POPULAR ELECTRONICS' January 1975 issue. The group published four newsletters, which can be received by sending a self-addressed manila envelope with 50¢ stamp to the address above.

What's a Computer? A computer is a deceptively simple kind of device if you look at it from a "black box" viewpoint, not trying to understand all the electronic "innards."

All computers are fundamentally alike from the largest to the smallest. And the humblest of computers can perform the same work as a huge computer can, except that it takes more time to do it! With a suitable program (software) in its memory, a computer can be a game player, a home accounting machine, or an environmental controller; and in many cases, it can be all of these things at the same time.

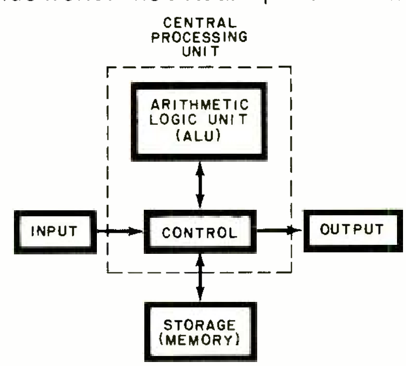
No matter how large or small, a computer must have five basic elements, as illustrated.

1. The Arithmetic Logic Unit (ALU) performs additions, subtractions, and all the other arithmetic and logical operations on the input data (something on the order of a super calculator). It is the features of the ALU that determine the ultimate potential power of the computer.

2. The Control portion orchestrates the movement of data and instructions from one part of the computer to another by taking the operational instructions that were inserted (programmed) into the memory and using these to perform some function to change the input data to output data.

3. The Memory (more properly called Storage, but the two words are used interchangeably) is used to hold operational instructions for the computer, and store intermediate results, commonly used tables, and other pertinent data.

4. The Input Circuit allows the computer to accept data from the outside world. The actual input can come



Five basic parts of any computer.

from a single sensor, a two-wire system, or a complex network of things to be monitored. Anything that can be converted into computer-acceptable data can be used as the input.

5. The Output Circuit delivers the data generated by the computer to some form of device that does the appropriate work. Without output capabilities, the computer serves no useful purpose.

The ALU and Control circuits are often combined and called a Central Processing Unit (CPU). Years ago, the CPU was awesome—a few feet high, a couple of feet deep, and several feet long. With the advent of large-scale integration (LSI), a complex CPU can now be contained within a single integrated circuit having 40 or less pins. Interestingly, there are now over 25 microprocessors to choose from, if you elect to build your own computer.

All of the current microprocessors have been described in a publication called "The New Logic Notebook," issued monthly. Its premier issue included a "Microprocessor Scorecard" that summarizes the major features of all known CPU's (since publi-

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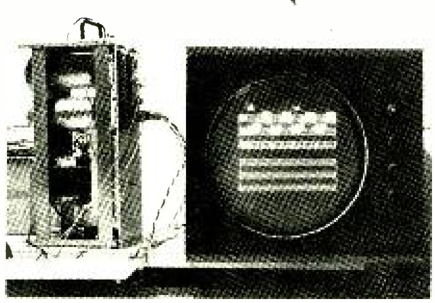
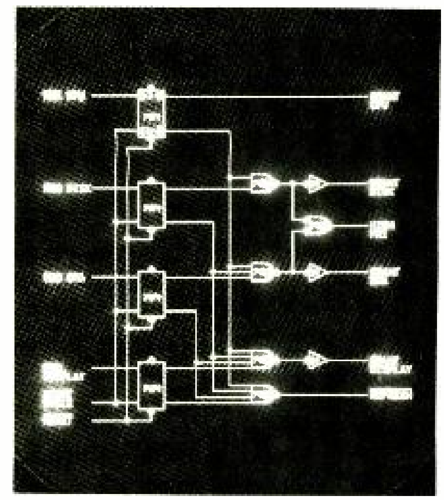
cation, General Instrument introduced its CP1600, a 16-bit address chip). To obtain a free copy of the scorecard, write directly to Microcomputer Technique, Inc., 11227 Handlebar Road, Reston, VA 22091, enclosing a 9″ × 12″ self-addressed, stamped (10¢) envelope.

The Biggest Problem. It is not overly difficult nor expensive to build your own computer. The major problem that plagues hobbyists (and the computer industry as well), is an inexpensive and useful input/output device such as a terminal.

The first reaction is usually to suggest using a teletypewriter such as Teletype Corp.'s 33ASR. However, this means connecting a $1200 device to a $400 computer—hardly a desirable match from the point of view of cost. There are, to be sure, some inexpensive teleprinters on the surplus market, and many hobbyists have adapted them to computer use. However, there is still a major problem—this equipment is bulky, noisy, and slow.





Graphics terminal (above left), designed by Hal Chamberlain, can draw pictures of music scores or logic diagrams, as at right.

The second reaction to the problem is almost always to consider using a TV set as the output display device and an inexpensive keyboard as the input medium. Connecting a keyboard to a computer is easy, of course, but driving a TV set with the output is a difficult task. At present, estimates run to a few hundred dollars to make this type of TV data display. (A couple of low-cost "computer terminals" are currently being advertised, but we have no experience with them to date.)

One solution to this problem has been the design of a graphics terminal by Hal Chamberlain, writing in "The Computer Hobbyist,' Box 295, Cary, NC 27511. This terminal is controlled from an Intel 8008 microprocessor with as little as 1024 (eight bit) bytes of memory. In addition to alphanumerics, it is also capable of drawing pictures (for example: chessboards, music manuscripts and logic diagrams). When combined with a low-cost keyboard for the input device, this display can serve as the primary output device for a small computer.

Sharing. The sharing of hardware and software ideas depends upon common agreement as to symbols and media. Electronic circuits all conform to standardized schematic symbol rules. However, computer programs are usually too complicated to be so simply described. It is common, therefore, for programmers to share and exchange programs.

If you obtain a useful program from a friend, you'll often be faced with the problem of transcribing it into computer form through a keyboard. Not only is that time-consuming, but it is error-prone. As one expects, most computer centers exchange programs on magnetic tape, but the tape transports cost upwards of $5,000. Users of mini-computers tend to use punched paper tape from a Teletypewriter, but few hobbyists will have a paper tape reader.

So what is the poor computer hobbyist to do? A neat, inexpensive solution will be offered in this column next time around. ◈

Editor's Note. It is hoped that this quarterly column will serve as a clearing house for computer hobbyist groups and others with interests in the field. If you are a member of such a group, or want to be, write to Computer Bits, Popular Electronics, 1 Park Ave., New York, NY 10016.

Taming Static Electricity

By John. F. Frye, W9EGV

THROUGH the open door of the service department, Mac watched Matilda typing in the outer office. She did not hear Barney, Mac's assistant, come in from the bright freezing weather outside. He quietly removed his snow boots and stealthily walked across the floor, sliding his feet on the carpet, until he was standing directly behind the absorbed girl. He slowly reached out a forefinger towards the nape of her neck, and she suddenly let out a shriek scattering the papers she was holding. Barney beat a hasty retreat to the service department with Matilda in hot pursuit.

"Let me kill him," Matilda begged, trying to dodge around Mac and get at Barney. "He stuck me with a pin."

"I did not," Barney denied, grinning down maddeningly. "I didn't even touch you."

Static Electricity Is To Blame. "He's right. I saw the whole thing," Mac said. "He gave you a shock with static electricity, and that gives me an excuse to continue a discussion of several months ago. Then we talked about the *uses* of static electricity for such things as smoke precipitation, ore separation, spray painting, and flocking. These are examples of static electricity on its good behavior—which it usually isn't! Most of the time it's causing shocks, unruly hair, clinging clothes, lightning strokes, and explosions; or it's fouling up printing and manufacturing processes or destroying IC's and transistors. Astronomy has been called the wise child of a foolish mother, astrology. In the same way, static electricity might be called the mischievous, annoying parent of a hardworking son, current electricity, which provides us with light, heat, telecommunication, and power. So now let's talk about how we can take the mischief out of static electricity."

"Amen!" Matilda said soulfully, rubbing the back of her neck.

"You both know from your high school physics or our previous discussion that, when certain substances are placed in firm contact and then separated, electrons transfer from atoms of one substance to atoms of the other. Atoms which lose electrons become positively charged ions, or cations; those gaining an electron become negatively charged ions, or anions. Both a potential difference and an electrostatic attraction develop between the separated, oppositely charged surfaces. In fact, if only one electron in 100,000 atoms of a surface is exchanged, that surface is very strongly charged. The substances vary widely, but one or both is usually a poor conductor. Some combinations are: glass and silk, wool and hard rubber, paper and a printing press roll, a fabric belt and a steel pulley, a rubber tire and the pavement, a cold dry stream of particle-bearing air and an airplane wing."

"Or the soles of a pair of size eleven clodhoppers sliding across a nylon carpet," Matilda injected tartly, glowering at Barney's feet.

"Electrostatic attraction is what makes your hair follow the comb on a snappy winter day such as this," Mac hastened to continue. "The passage of the comb leaves one type of charge on the hair and the opposite on the comb. But since the individual hairs have similar charges, they repel each other after the comb is taken away leaving you with a Phyllis Diller coiffure. Dampening the hair provides a conductive path for the charges to leak off the ends and permits you to comb it down.

"Here we have one rule for the control of static electricity problems: *provide a comparatively low resistance path for the charge to leak off as fast as it accumulates on a nonconductor or on the surface of an insulated conductor*. I say 'comparatively low resistance path' because a resistance as high as one megohm will ordinarily be adequate for preventing a potential buildup. When the relative humidity is raised above 70%, most insulators become conductive enough, either through absorption or hygroscopic action, to allow a static charge to leak away as fast as it is formed. Where static electricity causes the adhesion or repulsion of sheets of paper, layers of cloth, fibers, etc., humidifying the atmosphere has proved to be a solution in some industrial applications. Unfortunately, this sometimes brings on new problems with both materials and personnel.

"There is another way we can put moisture to work as a conducting path. That is by loading a plastic with a 'detergent' hygroscopic material or by spraying this material on a fabric or rug. This material will attract and hold water molecules forming a conductive path that prevents static buildup. Tomorrow, Matilda, I'll spray that rug out there with *Anti-Shock Spray*, marketed by Bigelow-Sanford, Inc., Greenville, S.C. Then you should be safe from Barney's shocking behavior until the humidity takes over in the summer."

"Then high relative humidity doesn't prevent the 'generation' of static electricity; it simply interferes with the accumulation of a charge high enough to be noticed," Barney observed. "Incidentally, how high a stored charge is 'high enough' to cause trouble?"

"Consider what happens in explosions of gases and vapors ignited by electrostatically produced sparks. The ability of such a spark to produce ignition depends on its energy, which is some fraction of the total stored energy. In a nonconductor, in which the charges are tightly bound, this fraction is low because only a small area can contribute to the spark; but with a conductor, through which charges move easily, the total charge contributes to the effect. That's why sparks between two nonconductors generating a charge seldom produce hydrocarbon gas explosions directly, but they induce charges in nearby conductors which are quite capable of producing such explosions.

"Stored energy is a function of both voltage and capacity. It can be calculated from the formula: $E = \frac{1}{2} CV^2 \times 10^{-9}$; where E is the energy in millijoules, or thousandths of a watt-second; C is the capacity, related to the surface area, in picofarads; and V is the potential across the spark gap in volts. It has been found that about 0.25 millijoules of stored energy is required for ignition of optimum mixtures of air and saturated hydrocarbon gases and vapors. Sparks arising from potential differences of less than 1500 volts are unlikely to be hazardous in these mixtures because of the short gap and the heat loss at the terminals. Plugging these minima into the formula, you come up with 222 pF., which is slightly less than the capacitance of a large man. As the voltage goes up, the minimum capacity goes down. The spark from Barney's finger to your neck, Matilda, was at least ¼ inch long, which indicates his body had a charge of around 20,000 volts. At that voltage, a capacitance of only 1¼ pF., or about that of a 20-penny nail, could store enough energy to ignite gasoline fumes. Incidentally, remember when we used to see gasoline trucks dragging metal chains to ground static buildup? We don't see that any longer because it didn't work well. Now they bond the metal tank of the delivery truck to the ground tank before gasoline is pumped into or out of the truck tank.

"Electrostatic voltages far below the 1500-volt level can do expensive damage to the equipment we use here. Some MOSFET's will be permanently damaged if as little as 30 volts is applied across the thin oxide region from gate to source. If your body is charged, just touching a lead can destroy such a device. Safe handling of many IC's and transistors requires that everything coming in contact with them be devoid of static charges, which is another way of saying everything should be grounded."

Special Products. "Custom Materials, Inc., Chelmsford, Mass., manufactures a special electrically conductive plastic product called VELOSTAT[R] just for this purpose. The conductivity is inherent and not dependent on moisture attraction, as is the case with many other 'antistatic' materials. When workbench, stool seat, and floor mat are covered with Velostat; when the worker is wearing Velostat boots, apron, or gloves; and when all these Velostat items are bonded to each other and to ground with Velostat ribbon; there's no opportunity for damaging electrostatic charges to accumulate.

"Now, let's consider some other ways of eliminating static charges.

"The shape of a conductor has

much to do with the distribution of a charge on its surface. The mutually repelling action of like charges concentrates the charge on the portion with the least radius of curvature. On a needle point, where the radius is near zero, the charge can be so concentrated that it ionizes the air at the point and is absorbed in the process. The discharge in such a case starts at a much lower voltage than would be the case if the conductor did not have a sharp point. Static-discharging 'wicks' bolted to the trailing edges of airplane wings are often made of frayed copper braid to take advantage of this ability of small diameter points to dissipate a charge.

"If a series of needle-pointed conductors is fastened to a metal bar so as to form a 'comb' and this is mounted close to a fabric belt being electrostatically charged by running over a metal pulley, the belt charge will induce an opposite charge in the comb. An ionized path between the belt and the needle points then dissipates the charge as rapidly as it forms. This works equally well with paper passing over rollers.

"A battery of such combs can be made to ionize the air by placing a high voltage on them. Then a fan blowing this conducting ionized air across any area where troublesome static charges may form will bleed off the charge to some nearby grounded object it can accumulate."

"What's this picture of a handheld device that looks like a ray gun?" Barney asked.

"That's a picture of Custom Material's instrument for measuring the potential of static electric charges from a safe distance. Here's a diagram of how it works. The meter, which is essentially at ground potential, is handheld at distance, d, from the charged object. A potential difference V, develops between the object and the gun tip setting up an electric field, E, directly proportional to V and inversely proportional to d. An opening in the gun barrel is covered with a wire screen; and directly behind the screen and to the side is a small sample of radioactive tritium emitting beta rays or electrons toward the screen. Electron-bombarded air molecules are ionized to form a thin layer on which the electric field of the static charge impinges. Since a field exerts a force on a charge, the ionized air molecules move forward or backward, depending on the polarity of the charge, the amount of movement being related to the intensity of the charge.

Custom Materials' Model CMI-7777M Static Meter

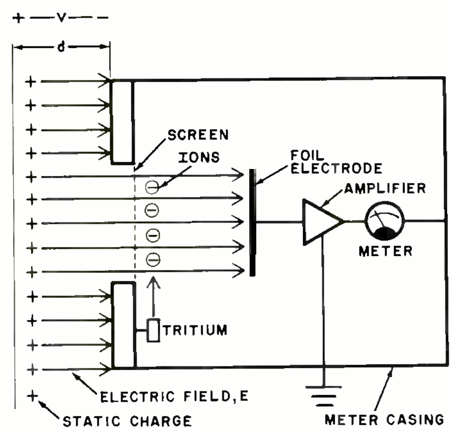
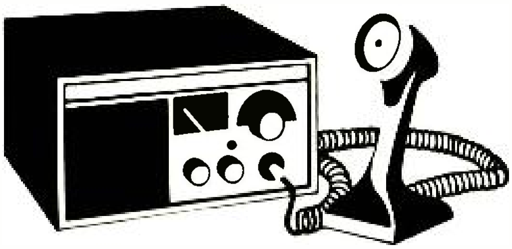


Diagram shows how meter to measure static buildup works.

"A metal electrode behind the layer of ionized air is connected to a sensitive FET amplifier and the current produced by the movement of the charged air molecules is displayed on a meter on the back of the gun. By holding the gun tip at distances of 2", 6", and 12" from the charged object and using a 3-position mechanical range selector, nine full-scale values covering a range of 500 to 200,000 volts are achieved.

"Now, we've got to knock it off and start earning a buck, although we've barely scratched the surface of the fascinating subject. We've talked before about lightning, the really big show of static electricity. Sometime, maybe we will discuss precautionary measures used in operating rooms, around explosives, in dusty locations, on helicopters, etc. ◈



CB Scene

By Len Buckwalter, K1ODH

HANDLING THE VSWR PROBLEM

A WHILE AGO I attended a meeting of microwave engineers. Up front, a speaker slashed the blackboard with a piece of chalk and said, "You've got to get rid of the *vizz war*!"

On another occasion, I heard an avionics technician, wriggling out of the fuselage of a light plane, exclaim triumphantly, "We just got rid of the *vizz war*!"

Of course, vizz war is not the latest skirmish to be debated at the United Nations. It's the way the "in crowd" pronounces VSWR, voltage standing wave ratio, sometimes called just plain SWR.

Most of the time, VSWR is as interesting to contemplate as a bubble surfacing in a pool of lava. It rarely intrudes if a CB system is comprised of standard components, in which a transceiver with a 50-ohm output impedance is connected to a 50-ohm transmission line that's hooked up to a 50-ohm antenna. There's a perfect match all around and r-f power flows smoothly from one to the other. But no marriage is forever perfect, as an escalating vizz war will indicate. Gradually, the coaxial jacket cracks, corrosion creeps into conductors and connectors, wires short out, a cold solder joint develops ohmic resistance, rust prevents a lug from making firm contact with ground or a base mount becomes isolated from a car's sheet metal. More dramatically, a heavy ice storm can cause radials to fall off, or a 200-pound bird comes to roost on your antenna. Any one of these troubles will draft you into fighting the vizz war.

Measurements. Since manufacturers appear to sell more SWR meters (also called "reflectometers") than any other CB accessory, they're worth a close look. Measuring an antenna's SWR (with a reflectometer) is a clever tactic, because troubleshooting an antenna system with other instruments would require the resources of a NASA laboratory. You can put an r-f wattmeter on the transceiver output, but all it reveals is how much power is being delivered to the coaxial cable. Finding out if that power is being efficiently radiated by the antenna is another matter.

Ohm's Law doesn't really help because most operators lack the gear needed to measure the parameters of an antenna system operating at 27 MHz. For example, if your rig puts out 4 watts into a 50-ohm load, Ohm's Law says that the antenna current would be 300 milliamperes (mA). But an r-f ammeter that could accurately read 300 mA is priced beyond the means of many CBers. So unless you have access to fancy r-f instrumentation, a low-cost SWR meter is the most practical way to monitor impedance matches.

Since a transceiver should have its output circuitry factory-tuned for 50-ohm loads, one doesn't expect much of an SWR ripple where the transceiver meets the coaxial cable. The feedline itself should not produce a mismatch, because standard lines, such as RG58/U, display a constant 50-ohm impedance regardless of length when terminated with a 50-ohm load. If you suspect something's amiss in the transmitter tuning, connect an r-f wattmeter and a 50-ohm dummy load to the rig's output with short pieces of coax. The output should nudge close to the 4-watt limit of the FCC. Use the procedure in the manufacturer's instruction manual to peak the output to the legal limit. (Remember to keep away from the frequency-sensitive controls, as these can only be adjusted by a technician with a valid FCC Commercial license. If in doubt, check with a tech.)

The happiest situation occurs when all the power delivered to the feedline is coupled to the antenna and radiated into space. In this ideal system, an r-f voltmeter placed across the transmission line, as shown in Fig. 1, will indicate a constant voltage anywhere along its length. With nary a voltage ripple, the line is said to be "flat." But the ravages of time and the elements eventually disturb this placid relationship.

The result is graphically shown in Fig. 2. Instead of accepting and radiating all the r-f power, the antenna bounces back part of the signal into the feedline. Two waves now travel on the line: a forward wave and a reflected one. The reflected wave opposes and cancels a portion of the forward wave, setting up a standing voltage wave. The r-f voltmeter will reveal this. Let's assume that voltmeter *M1* is put across the line at the point of maximum voltage (also called a loop or antinode) and reads a potential difference of 200 volts. The second voltmeter, *M2*, is placed across the line at the point of minimum voltage (called a node) and reads 100 volts. The standing wave ratio or SWR is then V_{max}/V_{min}, 200/100, or 2 (also expressed as 2:1 or "two-to-one"). If the two voltage extremes were 400 and 40 V, the SWR would be 10.

CSWR. We've been measuring voltage along the transmission line, but the same relationships hold for cur-

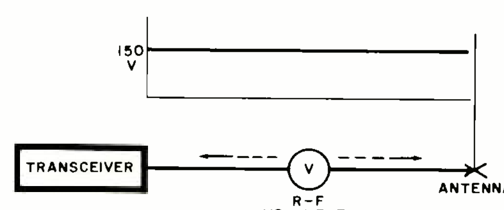


Fig. 1. In a perfectly matched system, the r-f voltage is constant all along the feedline.

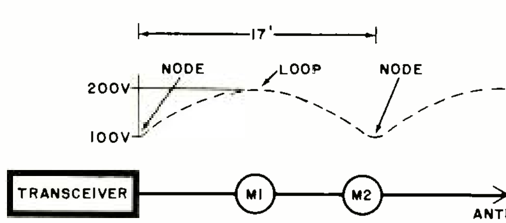


Fig. 2. When impedance mismatch occurs, standing wave appears on the transmission line. In the example shown here, the SWR is 2.

rent distribution. Current standing wave ratio is also meaningful. Incidentally, the loops (or nodes) in Fig. 2 are a half-wavelength apart from each other, or about 17 feet (approximately 5.5 m) at CB frequencies.

No practical system is perfect. An SWR of 1 occurs only in engineering textbooks. An acceptable ratio is 2 or less, but even at 2 the power loss is only 0.2 dB, or about 11%. That's much less than the 1-dB drop that occurs on a 50-foot (15-m) length of RG58/U from the transceiver to the roof. It's not worth trying to lower your SWR from 1.5 to 1.4, as power losses are small below 2 or 2.5. You should be wary, however, of an SWR of 3 because it usually means that something is drifting into the trouble area.

Losses due to high SWR pick up when it runs much above 3. At this value, about 25% of your power never makes it into the antenna. About half your r-f power is wasted when the SWR increases to 12. This is not as dramatic as it sounds. Losing half your power may seem like a lot, but that's only a 3-dB drop in signal strength (other things being equal) or about half an S unit.

SWR produces more serious effects than power loss. It can raise the voltage across the output circuitry to a critical value. Final transistors can blow out—as often happened in the early solid-state rigs. Today, however, engineers produce active devices with a high degree of SWR immunity. A high SWR can also heat up coaxial cables to the melting point, but this rarely happens at 4-watt CB power levels.

Besides keeping a watchful eye over your transceiver output stage, there's another advantage to monitoring the SWR of your system—it telegraphs the condition of your antenna system. While you sit comfortably at your operating position, you can judge how well your antenna is standing up to the hail and sleet storm raging outside. Any abrupt change in SWR warrants an inspection upstairs.

A typical SWR meter (Fig. 3) samples radiation traveling in two directions on a short piece of transmission line. Inside the cabinet, two "directional couplers" (short lengths of wire) run parallel to the line. A switch connects either pickup wire to a meter (through a diode rectifier, which converts the r-f signal to dc). When the switch is in the FORWARD position, the meter gives a relative indication of

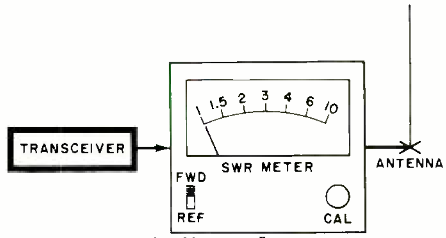


Fig. 3. An in-line reflectometer indicates the impedance match.

the strength of the wave traveling from the transmitter towards the antenna. You then adjust a calibrating pot to bring the needle to exactly full scale (using an unmodulated carrier). To read SWR, the switch is thrown to REFLECTED, which connects the meter to the other directional pickup. This samples the wave going back down the line from the antenna towards the transmitter. The meter indicates SWR directly, and some models are also calibrated in "Percent Reflected Power."

Many SWR meters have negligible insertion loss, so they can be left in-line for continuous monitoring. Others, however, have built-in dummy loads and no output jacks. These should be used only for peaking adjustments, as described above. Some models have limited power-handling capacities, but this is almost never a problem at CB power levels. Check the manufacturer's literature for details.

If your system's SWR reads suspiciously high after the antenna has been in service for a while, look for the trouble spots mentioned earlier. High SWR on a brand-new installation, might have some other cause. If you soldered coax connectors onto the cable yourself, doublecheck your work. When the coax was routed from the antenna to the rig, was it bent sharply? Did a nail or staple accidentally puncture the insulating jacket? If the antenna was positioned close to a large mass of metal, its feedpoint impedance might have been altered. At a base station, proximity to a large TV mast with a group of guy wires can cause this effect. Sheet-metal ducts, plumbing, metal flashing, or electrical cables can also create problems. Try to keep the antenna at least a half-wave (about 17 feet or 5.5 m) away from any large amount of metal.

Never try to reduce SWR by fiddling with transceiver controls. You might cause an apparent drop in SWR, but a better match is not obtained, merely a drop in transceiver output. Once the rig is optimized for 50-ohm loads, as described above, don't touch its innards anymore. ◈

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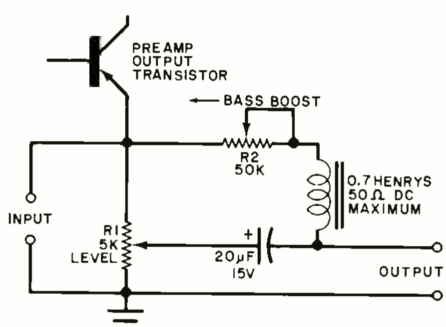
Hobby Scene

LOUDNESS CONTROL FOR AUDIO AMPS

Q. ***Could you explain the function of the Loudness control on many audio amplifiers? Is there an add-on circuit to realize this function?****—Edward Cheung, London, Ontario*

A. Loudness controls are incorporated into audio amplifiers because the ear has a nonlinear response. At low volume levels, we do not hear bass frequencies as well as the highs. Accordingly, the loudness control compensates by boosting the bass so that it sounds as loud as the treble material. The circuit shown here will function as a bass-boost or loudness control when placed between the preamplifier output and amplifier input. Set *R2*, a 50-k, linear-taper potentiometer for maximum resistance. Adjust *R1*, the level control, so that the program material sounds as loud as the original and adjust the treble control on the preamplifier for proper tone balance. Now the program level can be reduced to the desired listening level and *R2* adjusted for the same acoustical bass response. With *R2* set for maximum bass boost and *R1* for a −40-dB output, the frequency response will agree to within 2 dB of the 55-phon Fletcher-Munson curve. Inductor *L1* can be derived by using the yellow and green leads on the secondary of an Argonne AR-128 (Lafayette 33 F 85358) audio transformer.



AM RADIO ANTENNA TERMINALS

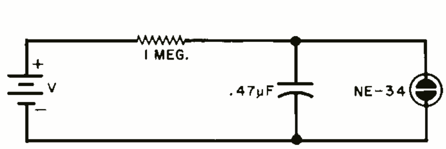
Q. ***I recently bought an old Silvertone radio at a garage sale. I am confused about the antenna terminals on the back of the set. There is a two-terminal strip and a ground lug underneath. One of the terminals is marked ANT and the lug is marked GND. I undersand what they signify, but the second terminal on the strip, marked DBL, mystifies me. What is the DBL terminal for?****—Todd Gillespie, Barrington, Ill.*

A. This configuration is often found on older BC and shortwave receivers. If an unbalanced antenna, such as a random-length, end-fed wire is used, it is connected to the ANT terminal. A wire should then be run from the GND terminal to a good earth ground (a cold water pipe is fine). If a balanced antenna, such as a center-fed dipole is used, one lead of the balanced feed-line (such as twinlead) should go to the ANT terminal, and the other lead to the DBL or *Doublet* (which is another name for a dipole) terminal. A good earth ground should be connected to the GND lug.

NEON BULB FLASHER

Q. ***I have an NE-34 neon light, and want to make a flasher circuit that will operate at about 2 Hz. Is there a simple way to do this?****—David Bellevue, Wilmington, DE.*

A. A high-voltage battery and a simple RC circuit can be combined with



your neon bulb to produce a flasher. The switching rate depends on the product of R and C, which in this case is about a half-second. The lamp will blink about twice each second. Use two NEDA 200, 67½-volt batteries in series as a voltage source.

Have a problem or question on circuitry, components, parts availability, etc? Send it to Hobby Scene, Popular Electronics, One Park Ave., New York, NY 10016. Though all letters can't be answered individually, those with wide interest will be published.

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42-14005	1N4005, 1Amp, 600PRV, Rec Diode	[illegible]
42-14006	1N4006, 1Amp, 800PRV, Rec Diode	[illegible]
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[illegible]	[illegible]	1.86

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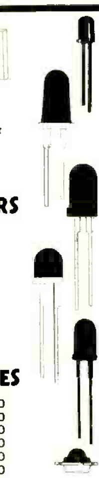

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7412N	.52
7413N	.65
7414N	1.80
7415N	.37
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7417N	.37
7420N	.17
7421N	.60
7422N	.27
7423N	.48
7425N	.34
7426N	.27
7427N	.31
7428N	.52
7430N	.20
7432N	.27
7433N	.62
7437N	.36
7438N	.35
7439N	.90
7440N	.16
7441N	.95
7442N	.78
7443N	.95
7444N	$1.05
7445N	1.04
7446N	1.10
7447N	1.00
7448N	1.00
7450N	.15
7451N	.20
7453N	.20
7454N	.26
7455N	.37
7460N	.25
7462N	.37
7464N	.37
7465N	.37
7470N	.30
7471N	.49
7472N	.33
7473N	.38
7474N	.35
7475N	.60
7476N	.45
7478N	.55
7480N	.60
7481N	1.19
7482N	.90
7483N	.80
7484N	3.02
7485N	2.50
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74115N	.92
74118N	1.51
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74132N	1.80
74136N	.92
74140N	2.50
74141N	1.19
74145N	1.08
74147N	2.90
74148N	2.20
74150N	.99
74151N	.84
74152N	1.50
74153N	1.05
74154N	1.48
74155N	1.08
74156N	1.18
74157N	1.18
74158N	1.44
74160N	1.50
74161N	1.28
74162N	1.50
74163N	1.48
74164N	1.70
74165N	1.78
74166N	1.50
74170N	2.60
74173N	1.55
74174N	1.20
74175N	1.60
74176N	1.30
74177N	1.50
74180N	1.05
74181N	3.20
74182N	.75
74184N	2.90
74185N	2.29
74188N	4.90
74190N	1.49
74191N	1.49
74192N	1.40
74193N	1.29
74194N	1.35
74195N	.80
74196N	1.90
74197N	.80
74198N	2.00
74199N	2.09
74200N	5.90
74221N	1.75
74251N	1.75
74278N	2.95
74279N	1.10
74293N	.95
74298N	2.55

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2601-21	11.40
2602B	8.00
2602-1B	8.00
2602-2B	8.00
MK4102P	11.40
7552-1CPE	8.00
7552-2CPE	8.00

74LS

74LS00	.58
74LS01	.58
74LS02	.58
74LS03	.58
74LS04	.63
74LS05	.63
74LS08	.58
74LS09	.58
74LS10	.58
74LS11	.58
74LS15	.58
74LS20	.58
74LS21	.58
74LS22	.58
74LS27	.64
74LS30	.58
74LS32	.64
74LS51	.58
74LS54	.58
74LS55	.58
74LS73	.92
74LS74	.92
74LS76	.92
74LS78	.92
74LS107	.92
74LS109	.92
74LS112	.92
74LS113	.92
74LS114	.92
74LS138	2.38
74LS139	2.38
74LS151	2.10
74LS153	2.38
74LS157	2.10
74LS158	2.40
74LS160	2.70
74LS161	2.70
74LS170	5.92
74LS174	3.02
74LS175	2.90
74LS181	3.72
74LS251	2.55
74LS253	3.05
74LS260	.58

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9301PC	1.20
9304PC	1.50
9306PC	6.90
9308PC	2.50
9309PC	1.60
9310PC	1.50
9311PC	2.30
9312PC	1.20
9314PC	1.30
9316PC	1.50
9318PC	2.30
9321PC	1.20
9322PC	1.30
9324PC	2.00
9328PC	2.50
9334PC	2.95
9338PC	3.30
9340PC	5.00
9341PC	4.10
9342PC	1.15
9360PC	1.75
9366PC	1.75

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74S02N	.80
74S03N	.75
74S04N	.75
74S08N	.80
74S10N	.75
74S11N	.65
74S20N	.80
74S30N	.80
74S32N	.80
74S40N	.80
74S51N	.80
74S64N	.80
74S74N	1.30
74S85N	6.10
74S86N	2.70
74S112N	2.20
74S113N	1.50
74S132N	3.60
74S133N	.90
74S138N	2.40
74S139N	2.40
74S140N	.90
74S151N	2.40
74S153N	2.40
74S157N	2.40
74S158N	2.40
74S160N	4.70
74S161N	4.70
74S174N	3.30
74S175N	3.30
74S181N	10.20
74S189N	5.10
74S194N	3.30
74S195N	3.30
74S251N	2.40
74S253N	2.40
74S257N	2.40
74S258N	2.40
74S260N	.90
74S280N	5.70

LOW POWER TTL

74L00N	.34
74L02N	.34
74L03N	.39
74L04N	.39
74L10N	.34
74L20N	.39
74L42N	1.62
74L51N	.34
74L73N	.74
74L74N	.89
74L90N	1.62
74L93N	1.74
74L95N	1.62
93L00	1.50
93L01	1.60
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93L09	1.80
93L10	2.80
93L11	4.20
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93L24	2.80
93L28	3.70
93L34	4.00
93L38	4.20
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93L41	6.50
93L60	3.00
93L66	2.70

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74H00N	.34
74H01N	.34
74H04N	.38
74H05N	.37
74H08N	.40
74H10N	.36
74H11N	.36
74H20N	.36
74H21N	.36
74H22N	.36
74H30N	.36
74H40N	.36
74H50N	.36
74H51N	.36
74H52N	.36
74H53N	.36
74H54N	.36
74H55N	.36
74H60N	.36
74H61N	.36
74H62N	.36
74H71N	.80
74H72N	.74
74H73N	.90
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74H76N	.90
74H101N	.80
74H102N	.80
74H103N	1.10
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LM354A	6-27	2.80	8	2.50
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TAA621A12	6-27	1.40	8	2.00
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75110N	2.20
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75138N	2.95
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LM301AN	1.10
LM301M	.90
LM301H	.90
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LM305H	1.05
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LM307H	.75
LM307M	.95
LM307N	1.50
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LM308M	1.20
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LM311D	1.90
LM311M	1.75
LM311N	2.00
LM312H	2.70
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LM339N	3.20
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LM320-5T	2.50
LM320-12K	2.90
LM320-12T	2.50
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LM340-06K	2.60
LM340-08K	2.60
LM340-12K	2.60
LM340-15K	2.60
LM340-18K	2.60
LM340-24K	2.60
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LM556CN	1.30
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1506	4.00
1507	4.00
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1702	33.00
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MM550H	5.90
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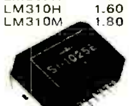
MM555H	5.60



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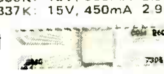

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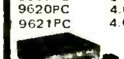

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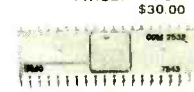

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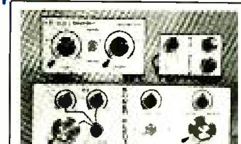

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2SA497	.55	2SB605	2 00	2SC681	2.50	2SC1383	.75
2SA505	65	2SB606	2.00	2SC684	2.10	2SC1393	.60
2SA562	.70	2SC15	.65	2SC687	2 50	2SC1409	2.75
2SA607	2.25	2SC24	.65	2SC696	2 35	2SC1410	2.75
2SA613	1.00	2SC32	.65	2SC710	70	2SC1450	1.00
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2SA647	2 75	2SC41	4.00	2SC712	.70	2SD30	.95
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2SA699	1.30	2SC154	3 75	2SC735	.70	2SD68	.70
2SA699A	2 00	2SC162	3.75	2SC739	70	2SD72	1.00
2SA705	55	2SC163	4 50	2SC756	1 50	2SD88	1.50
2SA714	2 50	2SC185	1 00	2SC774	1 75	2SD120	.85
2SA720	.70	2SC202	1.00	2SC775	2.00	2SD130	1 50
2SA733	.65	2SC206	1 00	2SC778	3.00	2SD141	2 25
2SB22	.65	2SC240	1 10	2SC783	1.00	2SD151	2.50
2SB54	70	2SC261	.65	2SC784	70	2SD170	2.00
2SB56	70	2SC291	.65	2SC785	1 00	2SD180	3 00
2SB77	.70	2SC320	75	2SC792	3.00	2SD198	2 50
2SB128	2 50	2SC352	75	2SC793	2.50	2SD201	2 50
2SB135	.95	2SC353	.75	2SC828	.75	2SD218	5.00
2SB152	4 50	2SC371	.70	2SC829	.75	2SD235	1.00
2SB172	55	2SC372	.70	2SC833	70	2SD261	.80
2SB173	55	2SC380	.70	2SC838	.70	2SD291	85
2SB175	55	2SC387	70	2SC839	.85	2SD292	.85
2SB178	1 00	2SC394	70	2SC930	65	2SD300	2.50
2SB186	60	2SC458	.70	2SC945	65	2SD315	.75
2SB187	60	2SC460	.70	2SC1010	.80	2SD318	.95
2SB235	1 95	2SC478	80	2SC1012	80	2SD341	95
2SB303	65	2SC482	1.75	2SC1013	1.50	2SD350	3.50
2SB324	1 00	2SC491	2.50	2SC1014	1.50	2SD352	80
2SB337	2 10	2SC495	.70	2SC1018	1.50	2SD389	.95
2SB364	65	2SC497	1.60	2SC1030	3 25	2SD390	.75
2SB365	.65	2SC515	80	2SC1051	2.50	2SD437	6.00
2SB367	1.60	2SC535	95	2SC1061	1.65	2SD458	.80
2SB370	1 10	2SC536	65	2SC1096	1.20	2SD1111	3.50
2SB379	65	2SC537	70	2SC1098	1 15	2SD1115	3.75
2SB380	70	2SC563	2.50	2SC1115	2.75	2SK19	2 25
2SB405	1 00	2SC564	70	2SC1166	70	2SK30	1.25
2SB407	2 10	2SC568	70	2SC1173	1.25	2SK40	1.60
2SB415	1 05	2SC582	85	2SC1213	75		
2SB461	1 25	2SC591	2 50	2SC1226	1.25		

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2N458A	To-3	4 1.00
2N538	Mt-36	3 1 00
2N1015	Mt-1	1 00
2N1725	To-61	2 1 50
2N2288	To-3	2 1 00
2N3054	To-66	5 1 00
2N3055	To-3	4 1 00
2N5002	To-59	3 2 00
2N5296 Tip31	To-220	7 1 00

OEM SPECIALS

	METAL	EPOXY		METAL	EPOXY
2N718	27	15	2N2222A	35	.22
2N918	55	25	2N2369	18	13
2N930	25	18	2N2484	75	35
2N1420	25	15	2N2904	50	20
2N1613	65	30	2N2905	50	20
2N1711	65	30	2N2905A	85	35
2N2218	50	22	2N2906	40	.20
2N2219	50	22	2N2907	40	20
2N2219A	75	30	2N3053	.20	16
2N2221	25	17	2N3251	75	35
2N2222	23	17	2N4036	75	35

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2SC773	.65
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2SC1678	5.75
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BU206	1700v	5 80
BU207	1300v	5 50
BU208	1500v	6 75
BU209	1700v	8 25
2SC1170	1100v	4 00
2SC1172B	1100v	4 50
2SC1308	1100v	5 00
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GE-X6 Cadmium sulfide Photocell	50
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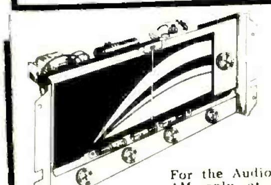

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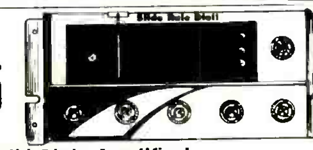

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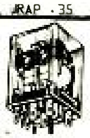

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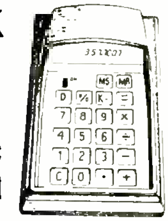

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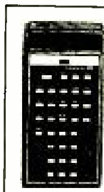

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7432	.27	74155	1.05
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7438	.35	74163	1.49
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7441	.95	74165	1.79
7442	.95	74173	1.55
7445	1.05	74175	1.80
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7448	1.10	74192	1.45
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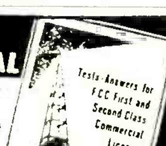

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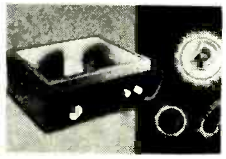

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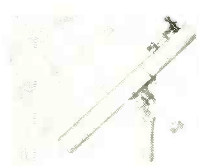

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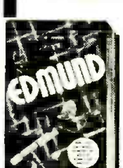

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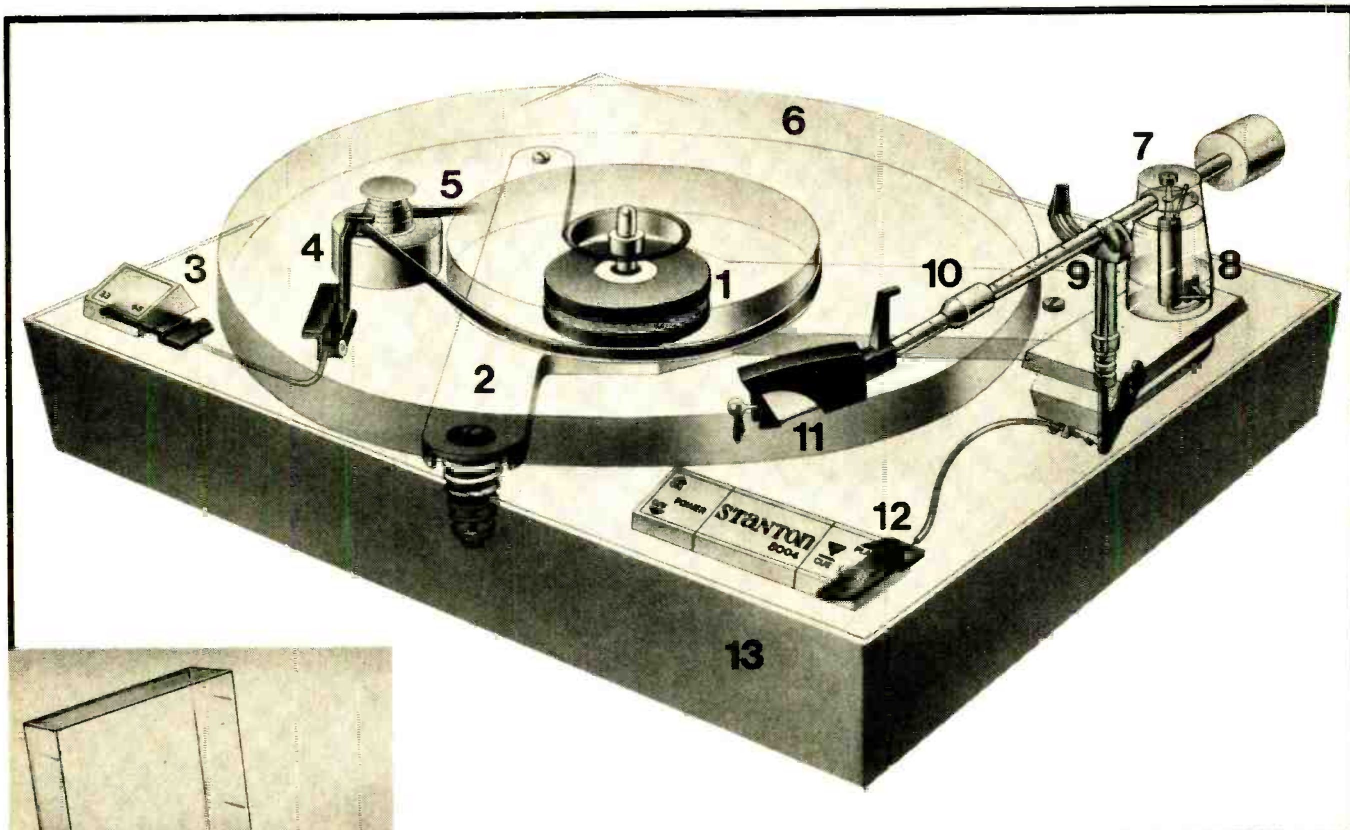

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