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Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE DECEMBER 1975 / 75c

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PLUS: 1975 ANNUAL CUMULATIVE ARTICLE INDEX

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DECEMBER 1975 VOLUME 8, NUMBER 6

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FEATURE ARTICLES

CONSTRUCTION ARTICLES

COLUMNS

PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

THE ART OF PROGNOSTICATION

The holiday season often induces editors to take a crack at predicting new developments for the coming year—sometimes even for the next decade. The short-range forecast is easier. I remember from my RCA days, for example, when we were developing MOSFET's for military surveillance equipment, that the next yield was to be aimed at hi-fi tuners. The latter didn't come to pass for almost two years, however, so I could have wrapped myself in the cloak of a remarkable prognosticator if I had predicted it at the time.

I look upon *long-range* forecasters such as Jules Verne and General David Sarnoff with considerable awe. They passed the true test of imagination and perception. For example, when H.G. Wells said in 1927 that radio stations would be talking to a phantom army of non-existent listeners, Sarnoff likened his remarks to the guffaws that greeted the possibility of a horseless carriage.

Considering long-range predictions further, I reviewed my May 1972 issue of the *Proceedings of the IRE*, which was celebrating its 50th anniversary with coverage of the past, present and future of electronics. For the latter, a host of engineering leaders was enlisted to present views on what electronics would be like in the year 2012. Here are some of the predictions made 13 years ago:

Peter Goldmark envisioned a moon-to-earth Citizens Radio Service in the millimeter band, high-power wristwatch transceivers, large "digital" color TV screens mounted flush with the wall, and a proposal in 2012 for a 120-megabit TV standard. *N. Rochester* "saw" an automatic computing machine handbook to store data and calculation procedures and execute problems. *Sir Noel Ashbridge* felt that binary digit techniques would lead to development of picture electronics and scanning would be discarded in favor of a bit-controlled element screen. *Yasujiro Niwa* believed that transmitted foreign languages would be converted automatically to the local language of the receiver. *Harry F. Olson* noted that a printed page would be converted to speech by a print reader and speech synthesizer. *George D. Watkins* visualized living-cell amplifiers, with a basic nutrient providing the power (such as an undersea repeater living off the water's micro-organisms). *Marvin Camras* foresaw a moneyless society, where all purchases would be charged directly to one's bank account through the use of magnetic credit cards. *Austin Bailey* estimated that there would be 13 million mobile telephones by 1980. *Benjamin B. Bauer* speculated that wireless transmission of multichannel information to special earphones would give people freedom of motion. *W.D. Lewis* envisioned electrical access to reference libraries.

And *E.A. Sack* conjectured that by 1980 AM stations would be playing the same 20 records 90% of the time, so one national station was proposed. He also said that the Communications Act of 2008 would have ended the existing spectrum shortage. All information would first be transmitted to Washington by surface mail for review, transmission priority would be determined by a review board, and redundant information would be mailed monthly on tape.

Well, why don't we all check this out here in 2012?

Art Salsberg

Best Wishes for a Joyous Holiday Season and a Happy New Year

Letters

ADDING FUNCTIONS TO CALCULATORS

I was very pleased to find "How to Add Functions to Simple Hand Calculators" in the September 1975 issue. I immediately added the extra functions as described in the article. —*David Thorn, Florissant, Mo.*

The description of how to use the constant function in the article could use some clarification. To multiply by the constant, it is necessary to clear and then press the constant key once. Then insert the numerals via the keyboard. For example, 2 × 2 = 4. To continue multiplying any other number by 2, enter the new number and then operate only the constant key. To divide, hit clear, press the constant key, enter the first number, hit ÷, the number you want as the constant divisor, and =. Thereafter, enter the new number and press the constant key. Otherwise, pressing the constant key successively will only result in multiplying or dividing the first entry by the same number ad infinitum. —*Robert Peel, Winston-Salem, N.C.*

PRO'S AND CON'S OF KARNAUGH MAPS

Just a quick note to let you know that I really enjoyed "Karnaugh Maps for Fast Digital Design" (September 1975). I hope to see more theory articles like this in the future. —*Lawrence Corrado, Manitowoc, Wisc.*

The Karnaugh map has been very useful in the past as a logic minimization tool, but is it necessary today? Recently, I programmed six 8223 PROM's, and all I had to do to solve a five-variable problem was simply to write the truth table into the PROM's. My truth table is implemented in just one chip, and there is nothing to minimize. — *Lawrence Marinaccio, Wampum, Pa.*

CB WAVE TRAP NOTE

The CB wave trap described in the July 1975 CB Scene was just what I was looking for to cure an interference problem. However, I noticed that no value was given for the home-brew coil. For those readers who would prefer to buy a ready-made coil, I have calculated the value needed: 1.5 μH. With L set at 1.5 μH, the trimmer capacitor should be adjusted so that its effective value is 23 pF. Stray capacitances might make it necessary to vary this setting slightly. Sufficient capacitance range should be obtainable from the 3-to-30-pF trimmer specified. (A 1.5-μH coil is available as Miller part No. 4604 or from Lafayette Radio Electronics as part No. 34-86644.) —*Donald M. Keller, Dillsburg, Pa.*

ULTRASONIC TRANSDUCER SOURCE

I had some difficulty locating a supplier of transducers for the ultrasonic relay in the "Phased-Locked Loop" article in the October 1975 issue. I finally located a source: Delta Electronics, Box 1, Lynn, MA 01903. The Stock No. P6000 transducer sells for $3 each or two for $5. —*L.H. Wels, Los Angeles, Calif.*

Out of Tune

"Experimenting with PLL's," (October 1975. Fig. 1: C1 goes between TR1 and the junction fo R1 and R2; R6 is 2700 ohms; R8 is 10,000 ohms. Fig. 2: the + side of C8 goes to pin 4 of IC1; the − side to ground. Fig. 3: R1 goes between pins 5 and 6 of IC1; R1 = 2200 ohms, R2 = 100,000 ohms, R3 = 180,000 ohms, R4 = 22,000 ohms, R5 = 330 ohms, R6 is the load resistance which must be over 150 ohms. Fig. 4: R13 = 100 ohms.

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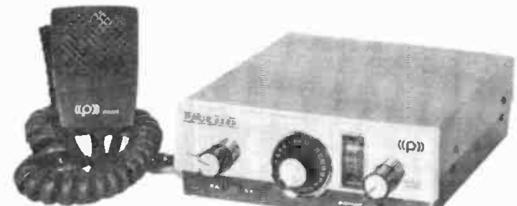
CHOOSE FROM THE MOST COMPLETE LINE OF CB RADIOS WITH TOP PERFORMANCE, CLASS, AND RUGGEDNESS. MOBILE. BASE. HAND-HELD.



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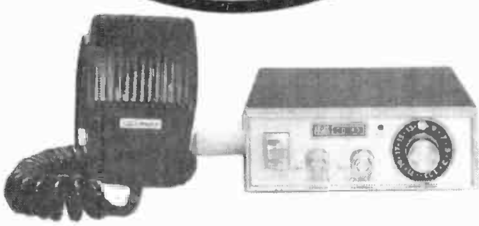

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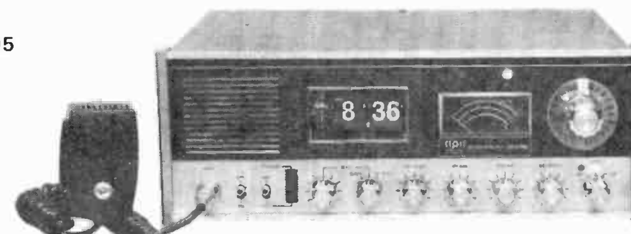

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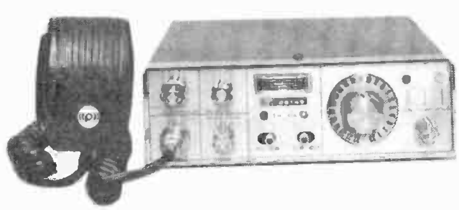


- **CB 145** — *Deluxe transceiver with two weather channels (WX-1 and WX-2)* $209.95

Other quality PACE CB transceivers such as, hand-helds, mobiles and base stations available at your local distributor. See him today for your "ULTRA-RELIABLE CB COMMUNICATIONS: PACE" Or write for details.

PATHCOM INC. PACE TWO-WAY RADIO PRODUCTS

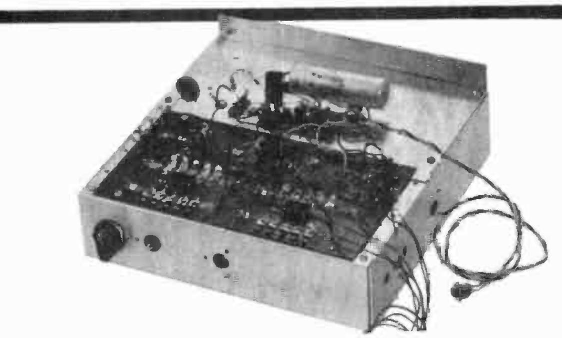
62

24049 S. Frampton Ave., Harbor City, CA. 90710,

Available in Canada from Superior Electronics Inc. Export (all other parts of the world): 2200 Shamus Dr., Westbury, N.Y. 11590.

good with 7 kits . . . $370

Or low monthly terms



A basic TV/Audio Servicing Course including 7 training kits for your experiments. You build your own solid-state radio, solid-state volt-ohmmeter, and experimental electronics lab. Includes 65 bite-size lessons (16 on color TV), 15 special reference texts with hundreds of servicing short cuts, tips on setting up your own business, etc. This completely up-to-date course covers black & white and color TV, FM multiplex receivers, public address systems, antennas, radios, tube, transistor and solid-state circuits.

better . . . with 11 kits and B/W TV . . . $465

Or low monthly terms

A complete course in B&W and Color TV Servicing, including 65 lessons (16 on color TV), 15 special reference texts and 11 training kits. Kits you build include your own solid-state radio, solid-state volt-ohmmeter, experimental electronics lab, plus a 12" diagonal solid-state black & white portable TV . . . to build and use. At each assembly stage, you learn the theory and the application of that theory in the trouble-shooting of typical solid-state TV sets.

better yet with 11 kits and 19" diag. Color TV . . . $795

Or low monthly terms

The course includes 53 lessons and reference texts plus kits and experiments to build a superb solid-state 19" diagonal color TV receiver . . . complete with rich woodgrain cabinet, and engineered specifically for training by NRI's own engineers and instructors. This handsome set was designed from the chassis up to give you a thorough understanding of circuitry and professional trouble-shooting techniques. You build your own solid-state volt-ohmmeter, and experimental electronics lab.

best . . . with 14 kits and 25" diagonal Color TV . . . $1,095

Or low monthly terms

The ultimate home training in Color TV/Audio servicing with 65 bite-sized lessons, 15 reference texts, and 14 training kits . . . including kits to build a 25" diagonal Color TV, complete with handsome woodgrain console cabinet; a wide band, solid-state, triggered sweep, service type 5" oscilloscope; TV pattern generator; digital multimeter, solid-state radio, and experimental electronics lab.

This Master course combines theory with practice in fascinating laboratory units. Unlike "hobby kits", the NRI color TV was designed with exclusive "discovery" stages for experimentation and learning. Building the set will give you the confidence and ability to service any color TV set on the market. And you'll have a magnificent set for years of trouble free performance.

Plus Advanced Pro Color . . . $645

Or low monthly terms

An advanced Color TV Servicing Course for experienced technicians, 18 color lessons, 5 new "Shop Manuals", and NRI 18" diagonal Color TV training kit are included.

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.

NAKAMICHI MICROPHONE SYSTEM

Nakamichi Research's Tri-Model Microphone System consists of three CM-300 electret condenser mikes, each of which comes with cardiod (CP-1) and omnidirectional (CP-2) capsules. Windscreens, connecting cables, batteries and swivel stand adapters complete the package. The CP-1 element has a rated frequency response of 30 to 18,000 Hz ±3.5 dB. The CP-2 claims a response of 30 to 15,000 Hz ±3.5 dB. Both units have a 200-ohm nominal impedance, and a weighted S/N of better than 50 dB. The system is packaged in a carrying case. Several options are available—a special pin-point (super-omni) capsule, CP-3, and a shotgun unit with windscreen CP-4. $300.

CIRCLE NO. 70 ON FREE INFORMATION CARD

LUX STEREO PREAMPLIFIER

Lux Audio's Luxman CL-350 Stereo Preamplifier offers six input pairs, including two sets of phono inputs, one with adjustable impedance from 30,000 to 100,000 ohms in three steps, and the other for use with moving-coil cartridges. Stereo microphone inputs are provided, each with an independent preamplifier. Three auxiliary high-level inputs are available, two of

which have rear-panel, variable-sensitivity controls. Independent negative-feedback tone controls are incorporated for each channel, with a choice of three turnover points each for bass and treble. High- and low-frequency filters provide a choice of two cutoff frequencies each. An internal control adjusts upper bass (150 to 300 Hz) response over a ±0.6-dB range to match speakers and room acoustics. A headphone jack has its own amplifier, and a rear-panel control matches headphone level to that from speakers. Claimed frequency response is 10 to 50,000 Hz (−1 dB), output is 1 V nominal (7 V maximum), THD is 0.02% at 2 V output, phono S/N is 63 dB at 1000 Hz, and S/N for AUX inputs is 80 dB. The front panel is smoked silver, and the cabinet has natural-wood finish. $495.00.

CIRCLE NO. 71 ON FREE INFORMATION CARD

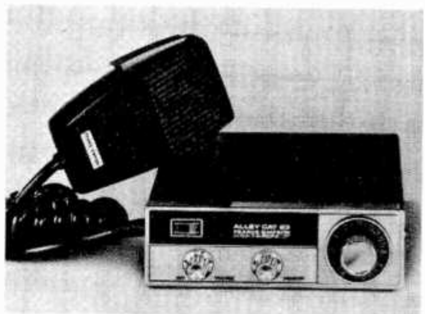
PAIA PORTABLE PRACTICE AMPLIFIER KIT

PAIA Electronic's new Pygmy is a battery-powered, portable amplifier (in kit form) for use with musical instruments. Power output is rated at 1.2 W rms. Other features include a built-in 5" (12.7-cm) acoustic suspension speaker, selectable headphone/line or low-level outputs, and a ½" (1.3-cm) plywood vinyl-covered case. Weighs 6 lb (2.7 kg). $39.95.

CIRCLE NO. 72 ON FREE INFORMATION CARD

PEARCE-SIMPSON MINI MOBILE TRANSCEIVER

Pearce-Simpson's new Alleycat 23 mobile transceiver is a compact all-channel unit with a dual-conversion superhet receiver. Other features are a ceramic filter, S/r-f



meter, anl, squelch, and a noise-cancelling mike. The dual meter glows amber on receive, red when transmitting, and bright red during modulation. Rated sensitivity is 0.5 μV for 10 dB S +N/N, and power output is 4 watts. The Alleycat 23 requires a 13.8-volt, positive or negative ground supply. It draws 0.28 A during squelched receive, 0.9 A unsquelched, and 1.3 A on transmit with maximum modulation. The black vinyl case measures 8⅛" D × 5" W × 1½" H (20.6 × 12.7 × 3.8 cm), and weighs 3.3 lb (1.5 kg). $119.95.

CIRCLE NO. 73 ON FREE INFORMATION CARD

ALTEC LANSING BOOKSHELF LOUDSPEAKER

The Model Three, part of Altec Lansing's new line of speakers, is a two-way bookshelf system. Program material below 1500 Hz is handled by a 10-inch (25.4-cm) high-efficiency woofer. Above the cross-over frequency, a 4-inch (10.2-cm) frame cone driver takes over. The vented cabinet is made of oiled natural oak, and its baffleboard is also finished. Black knit fabric forms the grille, and is mounted on a removable frame. $119.

CIRCLE NO. 74 ON FREE INFORMATION CARD

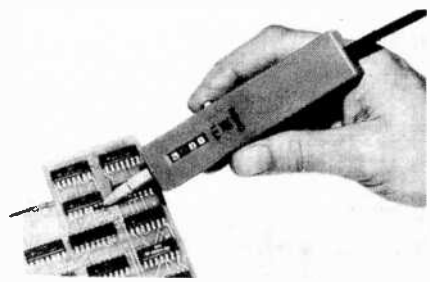
ELENCO CONVERGENCE GENERATOR

Elenco's new Model SG-200 convergence generator offers a choice of 10 different patterns, including full or gated rainbow color bars, 4 crosshatch and 4 dot patterns. The heart of the generator is a quartz crystal oscillator. Linearity of horizontal and vertical lines is said to be better than 0.1%. R-f carrier output is preset for channel 3, but can be easily changed for channels 2 through 5. The ac unit is housed in a die-cast aluminum case. Measures 5⅞" × 4½" × 1¾" (14.9 × 11.4 × 4.4 cm) and weighs 25 oz (710 g). $99.95

CIRCLE NO. 75 ON FREE INFORMATION CARD

ZI-TECH LOGIC PROBE

The Zi-Tech division of the Aikenwood Co. announces its new Logic Probe, Model LP-7000. It displays high and low logic levels and acts as a pulse counter for both



TTL and CMOS logic. Threshold levels are automatically adjusted when switching from one family to the other. By pressing a pushbutton, pulses as narrow as 50 ns are detected, counted and stored by a two-bit binary counter. Counting frequency is in excess of 10 MHz, according to the manufacturer. Rated input impedance is 2 megohms, and continuous overvoltage inputs of up to 250 V can be applied without damage, according to Zi-Tech. $110. Address: Zi-Tech Div., Aikenwood Co., 233 Forest Ave., Palo Alto, CA 94301.

"BIG MOMMA" MOBILE CB ANTENNA

Antenna Specialists' Model 419 "Big Momma" is designed for use on mobile homes, long-haul trucks, and other heavy vehicles. The antenna has a heavy-duty loading coil, and a stainless steel whip attached to an aluminum mast. A cast aluminum mounting bracket may be pivoted for either vertical or horizontal mirror frame installation. The mirror mount is terminated in an SO-239 standard coaxial jack. $29.95

CIRCLE NO. 76 ON FREE INFORMATION CARD

TEAC FM STEREO TUNER

The Model T-101, part of the Accuphase by Teac line, can be switched to give priority to either selectivity or low distortion, depending on the nature of the incoming signal. Among its other features are separate multipath, signal-strength, and center-

CIRCLE NO. 17 ON FREE INFORMATION CARD

tune meters; a dual-gate MOSFET front end, a buffered local oscillator, and a variable selectivity circuit employing lumped and piezoelectric filters. A PLL multiplex demodulator provides good channel separation. Spurious signal rejection is claimed to be 100 dB, and image rejection, 80 dB. The dial scale is 24.5 cm (10-in.) long, calibrated at 250-kHz intervals. Both fixed and variable level outputs are provided. $450.

CIRCLE NO. 77 ON FREE INFORMATION CARD

SIMPSON VOM

Simpson's Model 260-6XL supplements its 260™ family of VOM multimeters. Featured are additional range coverage, including two low-power ohms ranges, and shock- and drop-resistant construction. A total of thirty-three ranges is provided, and color-keyed meter scales facilitate measurements. The VOM can measure ac and dc volts from 0 to 1000 V, dc and ac current from 0 to 5 A, resistance (standard) on R × 1 to R × 10K ranges, and low-ohms on R × 1 and R × 10 ranges with a claimed maximum measuring power of 0.125 mW. Options include probes for high voltages and currents. $90.00

CIRCLE NO. 78 ON FREE INFORMATION CARD

FONEAIDS ANSWERING DEVICE

The Call Valet is a telephone record/answering adaptor introduced by Foneaids, a division of Eico. It can be used as an "announce only" unit utilizing only one cassette recorder, or as an answerer and recorder (for copying the caller's message) using two cassette recorders. $39.95.

CIRCLE NO. 79 ON FREE INFORMATION CARD

BLONDER-TONGUE ANTENNA ROTOR

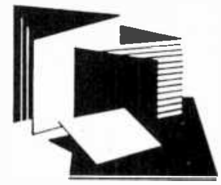
The Blonder-Tongue Laboratories Model SA-1000 antenna rotor is built into a one-piece aluminum housing, will handle masts up to 1½" (3.8 cm), and requires a cable having only two conductors. Its dc motor reaches full speed before the unit turns so that maximum torque can be achieved. Reliable operation is claimed over a temperature range of −40°F to 140°F (−40°C to 60°C). The control unit is housed in a high-impact polystyrene cabinet. Pressing a touch bar on the top of the unit causes rotation, which continues until the bar is released. LED's indicate direction of rotation and power application. The rotor turns at about one rpm. Lightning protection is provided, according to Blonder-Tongue.

CIRCLE NO. 80 ON FREE INFORMATION CARD

WELLER CORDLESS SOLDERING IRON

Weller's Model WC100 soldering iron features rechargeable NiCd batteries, low weight (5¾ oz, 163 g) and a contoured and balanced case. The tip achieves a temperature of 700°F (371.1°C) and can sustain it for about 15 minutes. It has a built-in work light and safety-lock switch. Three interchangeable tips are available. A plug-in overnight recharger is included.

CIRCLE NO. 82 ON FREE INFORMATION CARD



New Literature

RCA INSTRUMENTATION CATALOG

The 24-page 1975-6 Electronic Instrument Catalog from RCA highlights 58 instruments, providing specifications, photos, and applications information. Accessory items (probes, cables, etc.) are covered, and optional distributor prices are listed. New instruments include a pocket clamp tester, power-line monitor, a semiconductor tester, dual-trace adapter for triggered scopes, and a 75-ohm attenuator. The rest of the RCA line (signal, color-bar, and function generators, power supplies, sound-level meter, resistance boxes, etc.) is also described. Address: RCA Distributor and Special Products Division, Cherry Hill Office, Camden, NJ 08101.

ALLIED PURCHASING MANUAL

The 1976 Engineering Manual and Purchasing Guide (228 pages) from Allied Electronics covers wire, cable, solid-state devices, test equipment, timers, connectors, relays, tools, capacitors, resistors, etc. Unit and bulk prices are given for each entry. $1 postage and handling charges. Address: Allied Electronics, Dept. 76, 401 E. 8th St., Fort Worth, TX 76102.

MICROPROCESSOR BROCHURE

National Semiconductor's 16-bit "PACE" microprocessor is described in an illustrated brochure. The PACE (Processing and Control Element) chip contains control logic, four registers (accumulators), a ten-word stack and interrupt control circuitry. A color-mapped photograph of the chip, complete with call-outs, and a functional block diagram are included. Address: National Semiconductor Corp., Marketing Services Dept., 2900 Semiconductor Drive, Santa Clara, CA 95051.

HICKOK INSTRUMENT CATALOG

A new 16-page catalog, #75CBA, describes Hickok's full line of test instruments. Included are single- and dual-trace oscilloscopes, a digital multimeter, function generator, curve tracer, FET multimeters, semiconductor testers, color-bar generators, tube testers, a CRT tester/rejuvenator, and a sweep and marker alignment generator. Features, operating data, and specifications are given for each product. Address: Instrumentation and Controls Div., Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, OH 44114.

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Solid State

By Lou Garner

SOLID-STATE GIFT GIVING

IN KEEPING with the holiday spirit, in December, we have always offered solid-state gift ideas in this column. Sometimes they are commercial products, other times circuits for home-built toys and gifts. Over the years, the number and variety of solid-state products suitable for use as (or in) gifts have grown at almost an exponential rate. Within the memory of many readers, the selection was once limited to such items as a few transistor radio receivers, an audio preamp or two, and perhaps a few simple kits for the experimenter and hobbyist. Today, there's a whole galaxy of gifts from which to choose, in any price range to suit the special interests of the donees. There are digital electronic stop watches for the sports enthusiast, programmable electronically controlled appliances for the home, accessories for the hi-fi fan, special gear for the CB'er, simple calculators, and sophisticated computers. In fact, it would be close to impossible to find an electronic gift that doesn't use solid-state devices, at least in part.

At the low end of the price spectrum, new special-purpose devices make excellent "stocking stuffers" for your experimenter and hobbyist friends. Examples include National's LM3909 LED flasher, as discussed in my July and October columns, RCA's versatile CW3062 photo detector/power amplifier, and Exar's XR-2240, as described in the *Experimenter's Corner* last October. Be sure to include data sheets, or at least a pin layout and suggested circuits in the gift box.

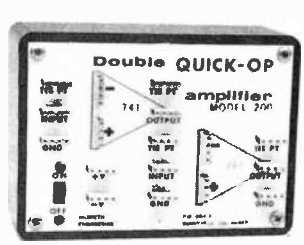
Your technician, practical engineer and hobbyist friends might also appreciate one of the new wire-wrap tools (and accessories) available from several distributors. These include manual tools, such as the one offered by Solid State Systems, and Cambion's XQ line of tools, wire, and IC sockets. These tools are generally designed for use on standard 0.025-inch square posts with #30 AWG wire, and make it possible for the experimenter to assemble solid-state projects using solderless wire-wrap techniques. A hybrid product developed by Vector Electronic Co. features heat-strippable insulated wire. (See this month's Product Test Reports.) The system combines the advantages of the wire-wrap and solder methods.

Should you wish to expand the basic gift, you might include a package or two of wire-wrap terminal posts, packs of #30 AWG insulated wire, and an 80-pin wire-wrap IC socket strip. For about fifteen dollars, in fact, you could furnish your friend all the basic wiring hardware needed to assemble a project using up to five 16-pin DIP IC's (or an equivalent combination of smaller devices). You might even want to pick up a tool and hardware for yourself—wire-wrapping can be almost as much fun as gift-wrapping!

For a few dollars more, as the expression goes, you can give your technically oriented friend a breadboarding kit. These vary from "barebone" to complete analog or digital workboards, including your power supplies, clocks, or function generators. The Quick-Op series from Hildreth Engineering Company and the Proto-Board and Design-Mate lines from Continental Specialties are representative of this type of product. Each Quick-Op consists of one or more standard op amps in a small plastic case, with functional terminals brought out to multi-position solderless connectors. Available models range from a single to a triple op amp version. Continental's Design Mate 1 will

The Corvus CheckMaster

Continental Specialties Design Mate 1



Hildreth Double Quick-Op

The new SX-737. So much for so little.

With its extraordinary engineering, advanced design concept and extreme flexibility, Pioneer's new SX-737 AM-FM stereo receiver offers a level of performance that can only be described as awesome.

Its exceptional FM reception is achieved through the use of phase lock loop circuitry, ceramic filters, and a dual-gate MOS FET. So it cleanly and clearly picks up stations that were once just numbers on the dial — without interference.

The SX-737 has more than enough power to satisfy your needs. It delivers 35 watts per channel, minimum continuous power, 20Hz—20kHz, maximum total harmonic distortion 0.5% at 8 ohms. And all of this power is smooth and stable with dual power supplies driving direct-coupled circuitry.

If you equate performance with versatility, you'll find the SX-737 unsurpassed in its price range.

It accommodates every listening interest with a complete range of connections for two pairs of speakers, turntable, tape decks (with tape-to-tape duplication), headphones and microphone. And it offers an exclusive Recording Selector that lets you record FM while listening to records, or vice versa.

All of this performance requires the proper controls to handle it. And the SX-737 gives you the kind of control mastery you deserve. Click-stop tone controls . . . high/low filters . . . loudness control . . . dual tuning meters . . . and FM muting.

The SX-737 is under $400* — including the cabinet. If, by chance, you're looking for even more power and additional features, the SX-838 is under $500*. Both deliver the awesome level of performance that is typical of Pioneer excellence.

U. S. Pioneer Electronics Corp., 75 Oxford Drive, Moonachie, New Jersey 07074. West: 13300 S. Estrella, Los Angeles, Calif. 90248 / Midwest: 1500 Greenleaf, Elk Grove Village, Ill. 60007 / Canada: S. H. Parker Co.

Specifications	SX-737	SX-838
FM Sensitivity	1.9 uV	1.8 uV
Selectivity	60 dB	80 dB
Capture Ratio	1.0 dB	1.0 dB
S/N Ratio	70 dB	70 dB
Power	35 Watts per channel, minimum continuous power, 20-20,000 Hz, with maximum total harmonic distortion 0.5% at 8 ohms.	50 Watts per channel, minimum continuous power, 20-20,000 Hz, with maximum total harmonic distortion 0.3% at 8 ohms.

*The value shown is for informational purposes only and includes a cabinet with walnut grained vinyl top and side panels. The actual resale price will be set by the individual Pioneer dealer at his option.

SX-838 AM-FM Stereo Receiver

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CIRCLE NO 1 ON FREE INFORMATION CARD

accept any discrete component or IC and connections are made with solid wire—no soldering. It has a built-in power supply. The Design Mate line also includes a function generator and an R/C bridge.

For experimenting with digital circuits, the E&L Instruments Digi-Designer provides power, clocking, and breadboarding facilities.

Not to be forgotten are the electronics laboratory breadboarding kits which can be used to build any number of different circuits. These include Heathkit's Junior Electronics Workshop, Radio Shack's 100-in-1 Electronic Project Kit, and Lafayette's 150-in-1 Electronic Experimenter's Kit. Kits from Eico and RCA also make excellent gifts for the budding electronics technician.

Tools and Test Equipment. Though they are not really solid-state, tools can always be used by the hobbyist who is experimenting with solid-state equipment. For example, Panavise's "Third Hand" series allows the builder to position a pc board at exactly the right angle for him to work on it without having to hold it himself.

The new cordless rechargeable soldering irons (Quick Charge from Wahl Clipper and the Model WC-100 from Weller-Excelite are two examples) make good gifts for the technician who does a lot of field work. They are also handy when working in tight areas (as on pc boards) where the cord can get in the way. Each of these has a variety of tips, quick heating and high tip temperature.

For serious experimenters, you might consider test instruments—digital multimeters, function generators, logic probes, power supplies, etc. Most of these are available in kit form as well as assembled instruments.

In the same price range, how about a microprocessor IC for advanced experimenters? There are the Intel 8080 and Motorola MC6800 to keep in mind here.

Commercial Products. On the other hand, if you want a gift for someone who is not interested in the technical side of electronics but already has a transistor radio (who doesn't?), a good choice of a moderately priced solid-state gift would be the Corvus CheckMaster™ electronic checkbook manufactured by the Mostek Corporation. At $39.95, it is available through many banks and by mail from the JS & A National Sales Group (4200 Dundee Road, Northbrook, IL. 60062). Wallet-sized, weighing only 8 ounces, and designed to hold a standard bank checkbook, this is essentially a special-purpose electronic calculator with a fixed decimal point and six-digit LED readout equipped with a cuirvilinear lens. Unlike the familiar 4-function calculator, the instrument cannot be used for multiplication and division, only addition and subtraction. But it has a nonvolatile memory circuit capable of storing data (such as the bank balance) for weeks or months, even with the main circuit power switched off.

Technically, the instrument's unique memory capability was achieved by using a PMOS static shift-register circuit which is clocked only during operations requiring memory access (as when adding to or subtracting from the balance). This permits the entire circuit to be turned off during the standby mode, with the sole exception of the 50 static loads in the memory itself. It can also be used in other applications where running totals, balances, and subtractions must be made.

(continued on page 26)

Gifts of Gab from Radio Shack

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Deluxe 2-Channel
Separate speaker and mike, battery tester, earphone jack. #21-111.
26.95

Budget 2-Channel
Beeper alert, push-pull audio. #21-122.
19.95

1-Channel
Volume control, superhet receiver. #21-121.
15.95

The Micro
Fits in a shirt pocket. #60-3019.
19.95 pair

The Standard
With lock-on talk switch. #60-3020.
7.95 each
14.95 pair

4-Way Base Station/AM Radio
Sends voice or code. Receives on 23 channels. #60-3028.
42.95

The Senior
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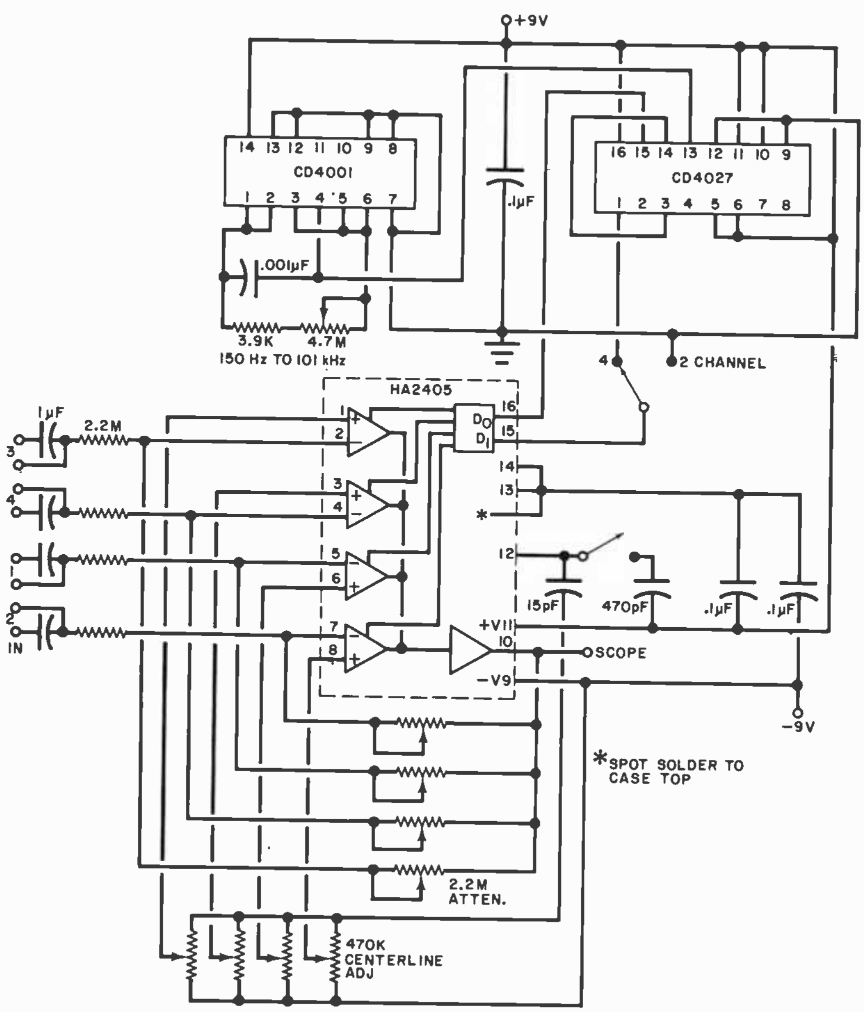
Perhaps the ultimate gift for that extra special someone is a digital electronic watch. As with calculators, these are available in a great variety of models and styles at retail prices ranging from less than forty dollars to the hundreds of dollars. Here, the price depends not only on technical features but on such factors as the style and material of the case and band (or strap) as well as upon the manufacturer's name and reputation. In general, little-known or house brands are less expensive than well-known standard brands offered by jewelry and better department stores, but service may be a problem with the former.

Aside from such considerations as style and exact model, which are matters of personal taste, there are two basic things to consider when choosing a digital watch: type of display and number of functions. Commercially available digital electronic watches generally use either LCD (liquid crystal display) or LED (light emitting diode) readouts. The former require less power, may display the readout continuously, and are easy to read under average ambient light conditions, including bright sunlight. Except for a few models which offer optional internal illumination, however, LCD watches are difficult to read at low light levels. LED watches, on the other hand, usually have a pushbutton operated display and can be read easily under all light conditions, including total darkness, although there is a tendency for the display to be "washed out" in direct sunlight. As far as the number of functions is concerned, these can range from a minimum of two (hours and minutes) to six or more (hours, minutes, seconds, year, month, day and date).

Reader's Circuit. A previous contributor to this column, Guy C. Sheatz (Box 39, Shippenville, PA 16254), has submitted another interesting and versatile circuit. As shown in the diagram, his newest design is a selectable 2/4 channel oscilloscope switch. Featuring only three IC's, the instrument is intended to be used between various signal sources and the vertical input terminals of a standard oscilloscope, permitting up to four channels of information to be viewed simultaneously.

Referring to the schematic diagram, the heart of the instrument is a Harris type HA-2405 four-channel programmable operational amplifier (available from industrial distributors for about $15 each). The basic switching signal is provided by a type CD4001 COS/MOS quad 2 input NOR gate connected as a relaxation oscillator in conjunction with a type CD4027 COS/MOS dual J-K master-slave flip-flop. Oscillator feedback is supplied through a 0.001-µF capacitor, while the switching rate (frequency) can be varied from approximately 150 Hz to over 100 kHz by means of a 4.7-megohm potentiometer. A spdt switch permits user selection of either 2- or 4-channel operation. Two inputs are provided for each channel in addition to the common ground terminal—one for direct coupling through a 2.2-megohm isolating resistor and a second for capacitive (ac) coupling through a 1-µF dc blocking capacitor. Individual channel attenuation is achieved by means of adjustable negative feedback, supplied through 2.2-megohm potentiometers connected between the overall amplifier's common output terminal and each input. Individual offset bias values for each amplifier, determined by 470,000-ohm potentiometers, provide channel centerline adjustment.

Other than the IC's, standard components are used throughout the design. Except for the linear potentiometers, all resistors are 1/4- or 1/2-watt types. The capacitors are low-voltage ceramics, although some builders may prefer to use higher voltage metallized plastic types as the input blocking capacitors for each amplifier channel. Operating power is supplied by a pair of conventional 9-volt transistor batteries. Neither circuit layout nor lead dress is overly critical and either pc or perf board construction techniques may be used when duplicating the design. Good wiring practice should be followed, of course, and the usual precautions observed when installing the MOS type devices. Guy suggests that a short lead be spot soldered (quickly!) to the top of the HA2405's case and connected to circuit ground to supply some shielding. If 4.7-megohm potentiometers are hard to find, gang two 2-megohm units and wire them in series. ◈



A selectable 2/4 channel oscilloscope switch.

Doing anything interesting after work?

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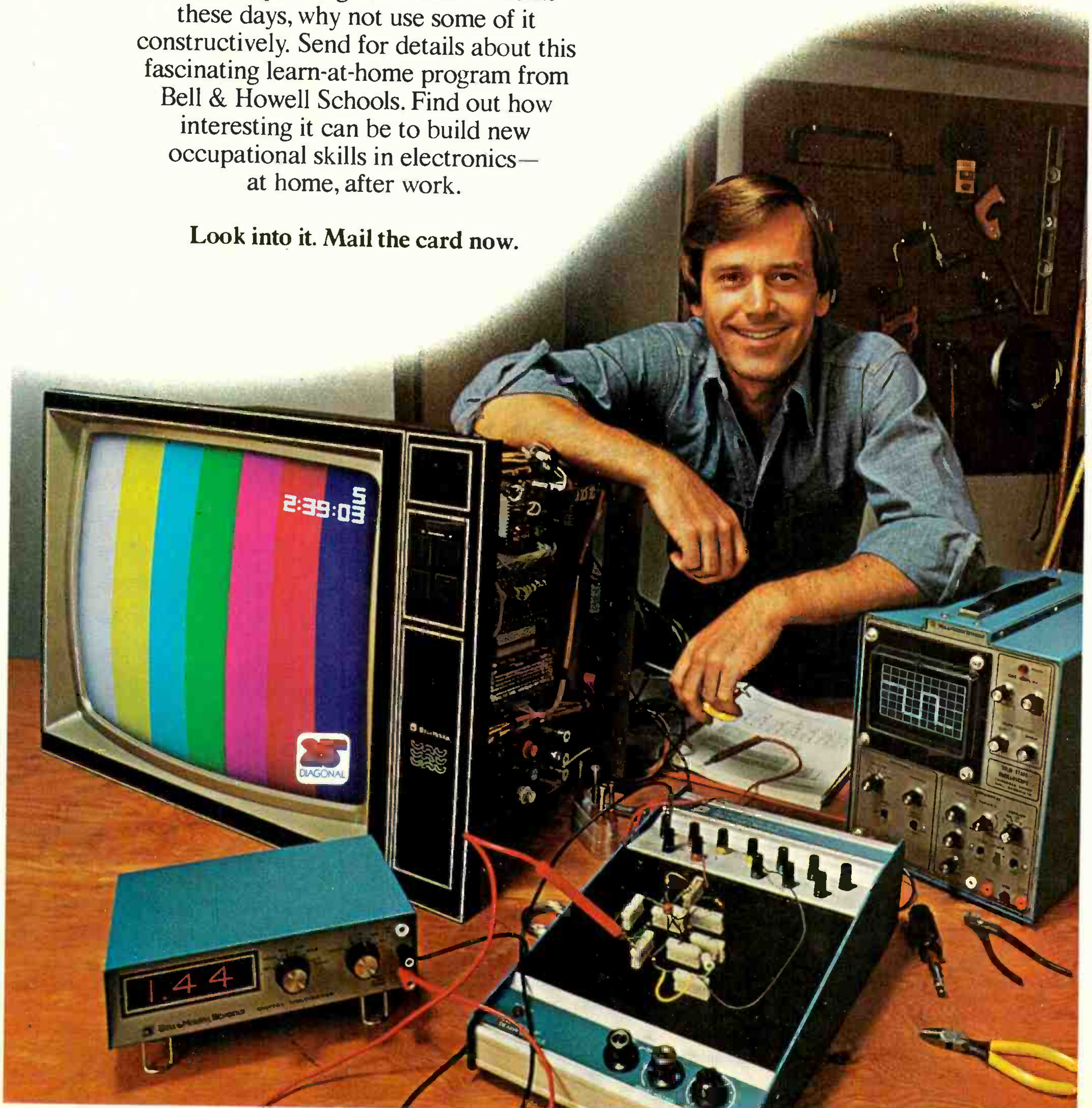

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Why this program is designed to make learning electronics especially interesting.

Electronics is a fascinating subject! But, let's face it, learning at home means you're on your own a good part of the time. There's no teacher to prod and coax you.

That's why we planned this learn-at-home program to hold your attention and make each principle you learn more vivid... easier to remember!

We'd like to think you'll rush home from work each evening—anxious to haul out your course materials and get down to business!

Let's talk about what we do to keep you interested.

For one thing, we don't just send you books.

Oh, books are important. In fact, this program includes a complete set of carefully prepared texts. And there's no way you can get along without them.

But if you decide to spend some of your time learning electronics at home, you're going to get a lot more than books. You're going to take your jacket off, roll up your sleeves and actually get your hands on modern electronic equipment. You're going to explore it... experiment with it... put it together yourself!

If that doesn't *already* sound like something pretty interesting to do after a day at work, take a closer look.

With the very first lesson, you get a Lab Starter Kit to help you grasp the basics.

If you're a complete beginner at electronics, this Kit will help you make a good start.

It's not complicated. Just a simple voltmeter and "breadboard" you use for basic experiments that help you understand the fundamentals. Now, you're ready to move on to something more advanced.

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One evening, when you get home from work, you'll find a large package waiting for you. When you open it, you'll find a set of electronic components.

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to start working with these components. Following the instruction manuals and course materials—and using the principles you've learned—you'll actually begin to build three modern test instruments. Once assembled, they make up a complete home electronics laboratory you'll use for testing, troubleshooting and circuit analyzing.

Use the design console... to set up and examine circuits. It's completely modular... no soldering!

Use the digital multimeter... to measure voltage, current and resistance. Read data in big, clear numbers—just like on a digital clock!

Use the solid-state "triggered sweep" oscilloscope... to analyze modern, "state-of-the-art" integrated circuits. Triggered sweep feature locks in signals for easier observation!

By now, you've spent many fascinating evenings at home learning electronics. And you're really making progress. In fact, you're ready to get into "state-of-the-art" integrated circuitry—even some applications of *digital* circuitry!

At this point, you start building a remarkable color TV.

As you build this 25" diagonal color TV, you investigate the digital circuitry that allows the automatic channel selector to go directly to preselected channels--as well as discovering the circuitry behind channel numbers and a digital clock that appear on the screen. You find out why the Black Matrix picture tube makes for such exceptional color clarity. You explore "state-of-the-art" integrated circuitry and the 100 percent solid-state chassis.

Once you've built this TV, you've rounded out your electronic training and gained new occupational skills.

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Since you're learning at home, on your own, we do everything possible to keep your progress trouble-free.

For example, since it's easier to grasp new ideas one at a time, we send you texts that break the subject of electronics into small segments. You can take your time to master each one before moving on to the next.

Special learning opportunities give you extra help and attention.

In case you do run into a problem or two, we're ready to give you more help and personal attention than you'd expect from most learn-at-home programs.

For example, many home study schools ask you to mail in your questions. Bell & Howell Schools gives you a toll-free number to call for answers you need right away.

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news HIGHLIGHTS

Robbie The Robot

Robbie, a robot built by Tom Clayton (an Australian servo-systems engineer), is a handy companion to have around the house. He can help make snacks of toast and percolated coffee, amuse children by playing logic games and answering questions, comfort a baby by singing a lullaby and rocking the cradle. Mr. Clayton built Robbie in his spare time from bits and pieces. His body is an old washing machine tub, his head is a cake tray, and his arms are automotive heating ducts. The robot is controlled by a home-made computer housed inside his body. In one of Robbie's legs is a tape recorder, while the other leg contains cables that run down to his base, in which electric motors and a storage battery are housed.

Robbie is mounted on wheels. Although his battery gives him freedom of movement, he is usually plugged into the ac line through an extension cord. Robbie has an electrical outlet on his base, which is activated by a spoken command. When a toaster is plugged in and he is asked to make toast, Robbie will allow current to flow without burning the toast. He can also control a percolator when asked, "Coffee, please." He can also control power flow to an electrical drill or similar tool by the commands, "power on," and, "power off." The tape recorder in his leg is loaded with answers to the questions he'll most likely be asked. The computer will search the tape for the most appropriate answer to a question. Robbie can also cut off the sound of TV commercials, make the acquaintance of strangers, play a version of the Chinese number game "NIM," and after a little "surgery," will be able to play a good game of chess.

Improved Regulation For Windmills

A newly developed regulator is expected to allow more output from automotive-type alternators driven by windmills. The Watchman, a solid-state device produced by Earle Engineering of Alpine, California, is said to prevent battery discharge during periods of no wind without using conventional speed-sensing switches. It also gives additional charging during periods of light wind from windmill inertia, according to Earle. Such a unit will increase the overall efficiency of a wind energy source, which is expected to play an increasing role in the overall energy picture.

Software Growth Predicted

Business Communications Co. reports that sales of software packages in the U.S. are estimated to increase from $500 million in 1974 (a 40% growth over 1973) to $1.3 billion in 1980). Some authorities are predicting a $2 billion expenditure for that year. During 1974, an estimated $10 billion was spent on in-house design and programming. This means that about 20 times as much money is spent on in-house system development than on buying or leasing software packages. The largest single type of package was in data management, with $100 million in sales. Software management, banking hardware management, and design management were next in order of sales.

Optoelectronic Market Study

The market research company, Frost & Sullivan, Inc., has compiled a 154-page report on the growth potential of LCD displays, LED's, gas-discharge devices, commercial lasers, opto-isolators, and light-sensing devices. Liquid crystals will grow from a $3.2 million market in 1974 to $230 million in 1982. Gas-discharge devices, pegged at $34 million in 1974 will peak out at $62 million in 1978 and drop to $29 million in 1982. LED's will grow from $103 million in '74 to $261 million in 1982. Electronic watch displays, which had a $4.2 million market in 1974, will triple in market dollar size by the end of 1975 and peak out by 1977 even though the digital watch market will continue to expand. Lasers will find more and more applications in "point of sale" scanning terminals, especially in supermarkets. Eventually, up to 140,000 checkout lanes may be equipped with scanners. The fibre-optics communications field will also expand, causing more production of necessary components—lasers, LED's, modulators, and photodetectors. This market is expected to grow from $2 million to $220 million in 1982.

"Unbreakable" CB Antenna

Russell Industries has developed an "unbreakable" replacement antenna for hand-held CB transceivers. Labelled the Duck-CB (and jokingly called the "Rubber Duckie"), the antenna measures 12 inches (30.5 cm), is continuously loaded, and clamps onto an existing antenna stub with one set screw.

New Batteries

Four thin, rectangular FLAT-PAK™ battery cartridges have been introduced by P.R. Mallory & Co. under the DURACELL™ label. These alkaline cartridges, containing 1.5-volt cells in series, are available in three- six- or nine-volt configurations. They are said to contain high energy density in a small physical package. For example, the 5K69™ battery is a 9-volt unit measuring slightly more than ⅓-inch thick, 1.9 inches long, and 2 inches wide (0.85 cm × 4.8 cm × 5.1 cm) and weighs 2.2 oz (56.8 g).

GE has announced development of a new NiCd sub-C cell combining high capacity with high discharge rate. The new 1.2-AH cell offers as much as 20% improvement in deliverable capacity over 1.0-AH edge-weld units at high discharge rates. A single cell weighs 1.5 oz (42.6 g) and has an internal impedance of 12 milliohms.

Special Altair®

MITS-MAS

Christmas Catalog

Lowest Price in the World!

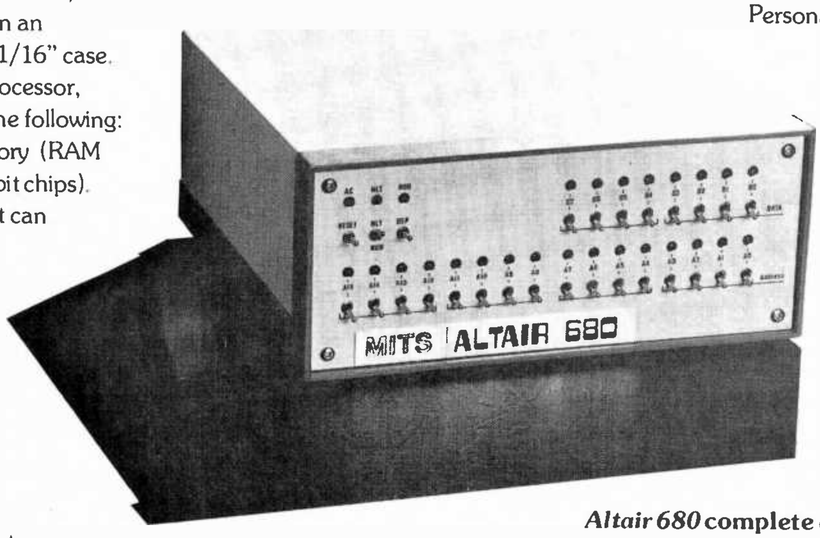
In January of 1975, MITS stunned the computer world with the announcement of the *Altair 8800* Computer that sells for $439 in kit form.

Today MITS is announcing the Altair 680.

The Altair 680, built around the revolutionary new 6800 microprocessor chip, is the lowest priced complete computer on the market. Until December 31, 1975, this computer will be sold in kit form for the amazing introductory price of $293! **(A savings of $52!)**

The Altair 680 comes with power supply, front panel control board, and CPU board inclosed in an 11" wide x 11" deep x 4 11/16" case. In addition to the 6800 processor, the CPU board contains the following:

1. 1024 words of memory (RAM 2102 type 1024 x 1-bit chips).
2. Built-in Interface that can be configured for RS232 or 20 mA Teletype loop or 60 mA Teletype.
3. Provisions for 1024 words of ROM or PROM.



The Altair 680 can be programmed from the front panel switches or it can be connected to a computer terminal (RS232) or a Teletype such as an ASR-33 or surplus five-level Baudott Teletype (under $100).

The Altair 680 can be utilized for many home, commercial or industrial applications or it can be used as a development system for *Altair 680* CPU boards. With a cycle time of 4 microseconds, 16-bit addressing, and the capability of directly addressing 65,000 words of memory and a virtually unlimited number of I/O devices, the *Altair 680* is a very versatile computer!

Altair 680 Software

Software for the *Altair 680* includes a monitor on PROM, assembler, debug, and editor. This software is available to *Altair 680* owners at a nominal cost.

Future software development will be influenced by customer demand and *may include BASIC on ROM*. MITS will sponsor lucrative software contests to encourage the rapid growth of the *Altair 680* software library. Programs in this library will be made available to all *Altair 680* owners at the cost of printing and mailing.

Contact factory for updated information and prices.

Altair Users Group

All *Altair 680* purchasers will receive a free one year membership to the Altair Users Group. This group is the largest of its kind in the world and includes thousands of *Altair 8800* and *680* users.

Members of the Altair Users Group are kept abreast of Altair developments through the monthly publication, ***Computer Notes.***

Altair 680 Documentation

The *Altair 680* kit comes with complete documentation including assembly manual, assembly hints manual, operation manual, and theory manual. Assembled units come with operation and theory manuals. Turnkey model and CPU boards also include documentation.

NOTE: ***Altair 680 manuals can be purchased separately. See back page of this catalog for prices.***

Delivery

Personal checks take 2-3 weeks to process while money orders and credit card purchases can be processed in 1-3 days. Delivery should be 30-60 days but this can vary according to order backlog. All orders are handled on a first come, first served basis.

Altair 680 Prices

***Altair 680* complete computer kit $293**
($345 after December 31, 1975)

***Altair 680* assembled and tested $420**

***Altair 680T* turnkey model (complete *Altair 680* except front panel control board) Kit Only $240**
($280 after December 31, 1975)

***Altair 680* CPU board (including pc board, 6800 microprocessor chip, 1024 word memory, 3 way interface and all remaining components except power supply) $180**
($195 after December 31, 1975)

***Altair 680* CPU board assembled and tested $275**

Option I/O socket kit (required when interfacing 680 to external devices) .... $ 29

Option cooling fan (required when expanding 680 internally) .... $ 16
($22 after December 31, 1975)

Option cooling fan installed .... $ 26

PROM kit (256 x 8-bit ultraviolet, erasable 1702 devices) .... $ 42

MITS
"Creative Electronics"

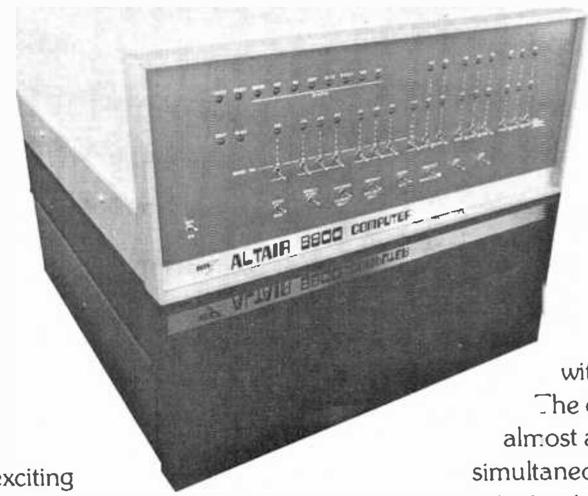
Prices, delivery and specifications subject to change.

"PROJECT BREAKTHROUGH!
World's First Minicomputer Kit To Rival Commercial Models . . . 'Altair 8800'"

headline on cover of *Popular Electronics*, January, 1975

The Altair 8800 from MITS is now one of the most successful computers ever delivered. Thousands of *Altair 8800's* have been sold and are in the field where they are being used for an infinite variety of industrial, business, science and home applications.

The *Altair 8800* is extensively supported by ongoing hardware and software development. *Altair 8800* interface and memory modules and *Altair peripherals* are inexpensively priced, yet among the highest quality in the business. Byte for byte, *Altair 8800* BASIC language software is the most powerful BASIC ever written.



Thanks to the success of the Altair 8800, building and programming computers has become one of the World's most exciting and fastest growing hobbies. Local Altair 8800 Users Clubs have been formed across the United States and in such far away places as England and Japan.

Thanks to clean, efficient design and accurate, easy to understand assembly instructions, the *Altair 8800* is an easy kit to assemble. As an *Altair 8800* kit builder, you will have the satisfaction of successfully building your own computer and you will learn about the internal structure of digital computers.

As the owner of an Altair 8800, you will be backed by the technical expertise of the MITS Customer Service Department. You will receive the latest update information, programming hints, technical advice and general computer information on a monthly basis through a free subscription to *Computer Notes*. You will be in contact with other *Altair 8800* owners through the *Altair Users Group* and you will have access to the extensive *Altair 8800 Software Library*.

No other computer on today's market can offer you as much support as the Altair 8800.

Christmas Special

For a limited time only, you can be the owner of an *Altair 8800* with a 1,024 word memory module for just $68 a month! See back page of this catalog for all the details.

Altair 8800 Features

Built around the most successful (and many say the most powerful) microprocessor chip ever [the Intel 8080], the *Altair 8800* is a variable word length computer with an 8-bit processor, 16-bit addressing and a maximum word size of 24-bits. It has 78 basic machine instructions with variances over 200 instructions. The *Altair 8800* can directly address 256 input and 256 output devices and up to 65,000 words of memory.

Up to 300 peripherals can be interfaced to the *Altair 8800* without any additional buffering. The custom designer can interface almost any number of imaginable devices simultaneously. All *Altair* peripherals are supplied with software handlers to make interfacing easy.

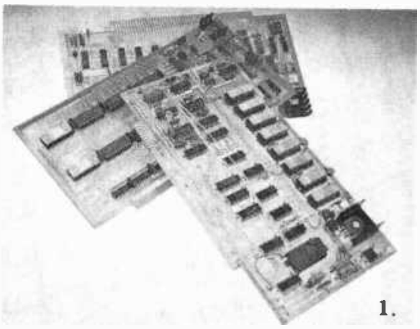
The *Altair 8800* includes the CPU board, front panel control board, power supply (enough to power any additional cards), and expander board (with room for 3 extra interface or memory modules) all inclosed in a handsome, aluminum case complete with sub-panel and dress panel. Up to 16 cards can be added inside the main case.

Altair 8800 Prices

Altair 8800 Computer kit (includes assembly hints, assembly, operator's, and theory manuals)	**$439**
Altair 8800 assembled	**$621**
Expander board (adds 4 slots)	**$ 16 kit**
assembled,	**$ 31**
Cooling fan	**$ 16 kit**
assembled,	**$ 20**

Altair Modules—

Custom Design Your Computer System to Meet Your Application *(and stay within your budget!)*



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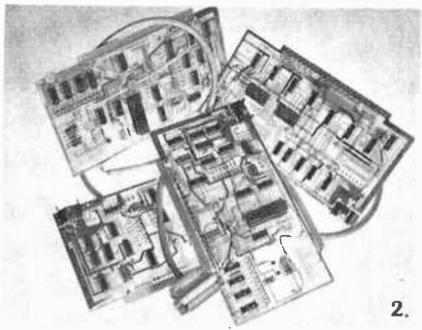

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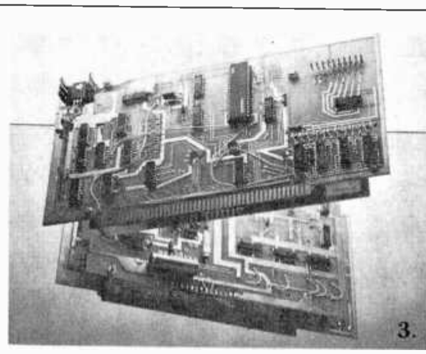

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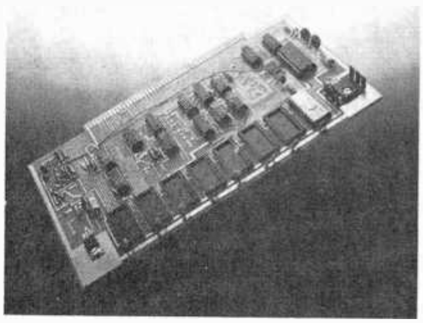
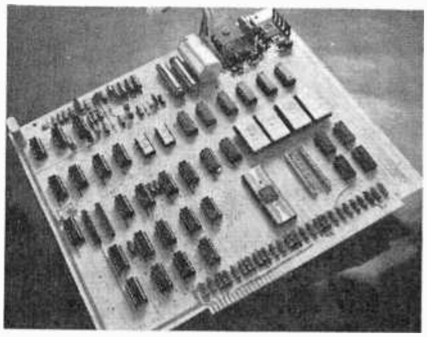
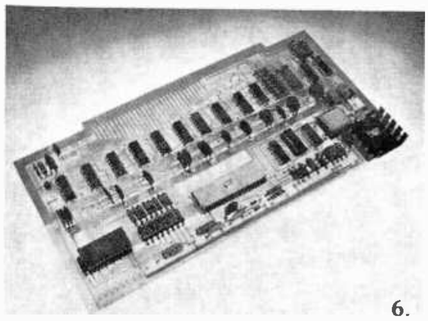






6.

1. Three 8800 memory modules. Three memory modules are now available for the *Altair 8800* and more are in the works. These modules include a 1K (1,024) word static card, a 2K (2,048) word static card, and a 4K (4,096) word dynamic card. Each of these modules is constructed with the finest components available and each contains memory protect features (prevents the computer from accidently writing over programs you want to save). The maximum access time of the static cards is 850 nanoseconds while access time for the dynamic card is 300 nanoseconds.

2. Four 8800 Interface Modules. Interface modules now available for the *Altair 8800* include three serial and one parallell I/O cards. The SIOA serial card is used to connect the *Altair 8800* to CRT's and other computer terminals that have industry standard RS232 asynchronous interconnect lines. It has divider logic to allow for presettable baud rates up to 19,200 baud (5-8 data bits).

The SIOB is the same as the SIOA except that all signals are TTL levels. This card is a general purpose serial interface that can be used to custom interface the *Altair 8800* to a wide variety of devices.

The SIOC is also the same as the other serial cards except it is used to interface the *Altair 8800* to conventional Teletypes and other asynchronous 20 mA current loop terminals. The SIOC is required to interface the *Altair* with ASR-33 Teletypes available from MITS.

The PIO parallel interface card is used for bidirectional transmission of bytes at speeds up to 25,000 bytes/second! It is a full TTL compatible input/output card with necessary handshake flags for conventional parallel interface. Both input and output data have their own 8-bit latch for buffering. Includes necessary logic to allow an adjacent channel to be a control channel. Most commonly used to interface the *Altair 8800* to SWTPC-TVT's or equivalent, custom A/D-D/A interfacing, computer to computer interfacing, and control applications.

3. Audio-Cassette Interface. This best-selling *Altair* module allows you to connect your *Altair 8800* to any tape recorder (medium quality cassette is adequate) for inexpensive mass storage. It works by modulating (changing) digital signals from the computer to audio signals for recording data and by demodulating the audio signal for playback. Consists of a special *Altair* modem board "piggy-backed" on an SIOB board. Requires one slot in the 8800.

4. 8800 PROM module. This PROM memory card is designed to hold up to 2K of PROM. Contact factory for price and other information. *Altair 8800* PROM Programmer to be announced soon.

5. 680 CPU board. The *Altair 680* CPU board is a complete computer on a board (less power supply). In addition to the 6800 CPU available from Motorola and AMI, the *Altair 680* CPU board comes with 1K of RAM memory (2102 type, 1024 x 1-bit chips), built-in I/O that can be configured for RS232 or 20 mA current loop or 60 mA current loop, and provisions for 1K of ROM or PROM. It measures 8¾" x 10¼".

6. 8800 CPU board. The heart of the *Altair 8800* is its CPU board. This double-sided board was designed around the powerful byte oriented, variable word length 8080 processor—a complete central processing unit on a single LSI chip using n-channel, silicon gate MOS technology. The CPU board also contains the *Altair* system clock—a standard TTL oscillator with a 2.000 MHz crystal as the feedback element.

Altair Module Prices:

1K static memory .... **$97 kit** and **$139 assembled**

2K static memory .... **$145 kit** and **$195 assembled**

4K dynamic memory .... **$264 kit** and **$338 assembled**

SIOA interface .... **$119 kit** and **$138 assembled**

SIOB and SIOC interface .... **$124 kit** and **$146 assembled**

PIO interface .... **$92 kit** and **$114 assembled**

Audio-cassette interface .... **$128 kit** and **$174 assembled**

680 CPU board kit .... **$180 kit**

[$195 after December 31, 1975]

680 CPU board, assembled **$275**

8800 CPU board .... **$310 kit** and **$360 assembled**

NOTE: ***Watch our advertisements for announcement of new Altair 8800 modules and Altair 680 modules.***

BASIC language was chosen for the Altair 8800 because it is the *easiest language to learn* and because it can be used for an *infinite number of applications*. Literally hundreds of thousands of BASIC programs have been written and are in the public domain. These programs include accounting programs, business programs, scientific programs, educational programs, game programs, engineering programs, and much more.

Altair BASIC is an *interactive language*. This means that you get immediate answers and you can use your Altair as a super programmable calculator as well as for writing complicated programs.

8K BASIC Features

Altair 8K BASIC leaves approximately 2K bytes in an 8K Altair for programming which can also be increased by deleting the math functions. This BASIC is the same as the 4K BASIC only with **4 additional statements** [ON ... GOTO, ON. . . .GOSUB, OUT, DEF], **1 additional command** [CONT] and **8 additional functions** [COS, LOG, EXP, TAN, ATN, INP, FRE, POS]. Other additional features include *multi-dimensioned arrays* for both strings and numbers, *AND, OR, NOT* operators that can be used in IF statements or forumlas, *strings* with a maximum length of 255 characters, *string concatenation (A$ = B$)* and the following string functions: *LEN, ASC, CHAR$, RIGHT$, LEFT$, MID$, STR$, and VAL.*

> *"I've seen and used other BASICs, but byte-for-byte, Altair is the most powerful BASIC I've seen. I'm particularly impressed with the n-dimensional arrays (and for strings too!), machine level I/O, and machine language 'function' features. The level of your documentation is, for me, though the high point. Sections for those who know nothing and sections for those who know a lot, plus sections that 'normal' people can read and understand."*
>
> **J. Scott Williams**
> **Bellingham, Washington**

Altair BASIC was written as efficiently as possible to allow for the *maximum number of features in the minimum amount of memory*. You can order one of three Altair BASICs: 4K BASIC-designed to run in an Altair 8800 with as little as 4K of memory, 8K BASIC, or EXTENDED BASIC (12K). Each of these BASICs allows you to have *multiple statements per line* (a memory saving feature), and each of them is capable of executing *700 floating point additions* per second!

The 8K BASIC and EXTENDED BASIC have *multi-dimensioned arrays* for both strings and numbers. This is particularly useful for applications requiring lists of names or numbers such as accounting programs, inventory programs, mailing lists, etc.

The 8K BASIC and EXTENDED BASIC also have an OUT and corresponding INP statement that allows you to use your Altair 8800 *control low speed devices* such as drill presses, lathes, stepping motors, model trains, model airplanes, alarms, heating systems, home entertainment systems, etc.

Altair BASIC comes with complete documentation including a copy of "*My Computer Likes Me When I Speak in BASIC*" by Bob Albrecht, a beginner's BASIC text.

Never before has such a powerful BASIC language been marketed at such low prices!

4K BASIC Features

Altair 4K BASIC leaves apporimxately 750 bytes in a 4K Altair for programming which can be increased by deleting the math functions. This powerful BASIC has **16 statements** [IF ... THEN, GOTO, GOSUB, RETURN, FOR, NEXT, READ, INPUT, END, DATA, LET, DIM, REM, RESTOR, PRINT, and STOP] in addition to 4 commands [LIST, RUN, CLEAR, SCRATCH] and **6 functions** [RND, SQR, SIN, ABS, INT and SGN]. Other features include: *direct execution* of any statement except INPUT; an "@" *symbol* that deletes a whole line and a "←" that deletes the last character; *two-character error code* and line number printed when error occurs; *Control C* which is used to interrupt a program; *maximum line number of 65,535*; and all results calculated to at least *six decimal digits of precision*.

EXTENDED BASIC

Altair EXTENDED BASIC is the same as 8K BASIC with the addition of *double precision arithmetic, PRINT USING* and *disk file I/O*. A minimum of 12K memory is required to support EXTENDED BASIC.

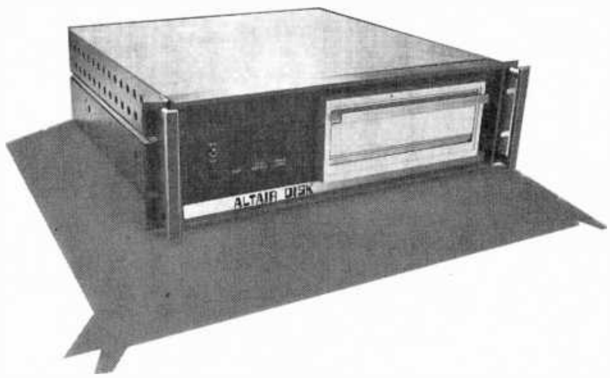
Other Altair 8800 software includes a Disk Operating System, assembler, text editor, and system monitor. Altair users also have access to the *Altair Library*, which contains a large number of useful programs.

SOFTWARE PRICES:

Altair 4K BASIC	**$150**
Purchasers of an Altair 8800, 4K of Altair memory, and an Altair I/O board	**$ 60**
Altair 8K BASIC	**$200**
Purchasers of an Altair 8800, 8K of Altair memory, and an Altair I/O board	**$ 75**
Altair Extended BASIC	**$350**
Purchasers of an Altair 8800, 12K of Altair memory, and an Altair I/O Board	**$150**
Altair PACKAGE ONE (assembler, text editor, system monitor)	**$175**
Purchasers of an Altair 8800, 8K of Altair memory, and an Altair I/O board	**$ 30**
Altair Disk Operating System	**$500**
Purchasers of an Altair 8800, 12K of Altair memory, Altair I/O and Altair Floppy Disk	**$150**

Note: *When ordering software, specify paper tape or cassette tape.*

Inexpensive, Sophisticated Mass Storage



The *Altair Disk* can store over 300,000 words of information on a floppy disk! It offers the advantage of nonvolatile memory (doesn't "forget" when power is turned off) and fast access to data (3/4 seconds—worst case). The data transfer rate of the *Altair Disk* to and from the computer is a whopping 250,000 bits per second.

The *Altair Disk* includes the disk controller, disk drive, one floppy disk and a software driver. The disk controller, which consists of two cards requiring two slots in the 8800, is capable of controlling up to 16 disk drives. It controls all mechanical functions of the disk, presents the disk status to the computer, and converts serial data to 8-bit parallel words and vice versa for rapid transfer.

The disk drive consists of a Pertec FD400 drive mounted in an *Altair* case including power supply, a buff/multiplexer board, and cooling fan. Its rotational speed is 360 rpm, track to track access time is 10 msec., average time to read or write is 400 msec., and disk life is over 1 million passes per track.

The floppy disk is hard sectored for 32 sectors per track (128 words per sector). There are 77 tracks on each disk. Extra floppy disks are available for $15 from MITS.

A Disk Operating System (software) with complete file structure and utilities for copying, deleting and sorting files is also available.

PRICES:

88-DCDD Altair Disk (includes disk controller, disk drive, one floppy disk and software driver)	**$1,480 kit**
	assembled, $1,980
88-DISK Altair Disk Drive only	**$1,180 kit**
	assembled, $1,600
Floppy disk	**$ 15**
Disk Operating System (if purchased separately)	**$ 500**
Purchasers of an Altair 8800, 12K of Altair memory, Altair I/O and Altair Disk (88-DCDD)	**$ 150**

Build Your Own Advanced Terminal!

The Comter II is easily the most advanced computer terminal kit on the market. It has its own internal memory of 256 characters which combines with a highly-readable, soft orange 32 character display to provide ease of operation and information retrieval.

Complete cursor control allows you to move data in and out of the display and operate the Comter II with the versatility of a CRT terminal. **Built-in audio-cassette interface allows you to store unlimited data from the computer and feed that information back into the computer.**

Other features include auto transmit which allows line-by-line transmission of data or program information to the computer from the Comter's memory. The Comter II has a *complete ASCII encoded keyboard* with TTY-33 format plus the addition of special function keys. Its total weight is just 15 lbs.

Flexible power requirements allow you to operate the computer at either 95-125V or 190-250V. The Comter II can be interfaced to any computer with an RS232 serial interface. Requires an SIOA board to be connected to the Altair 8800. No interface required to connect to the Altair 680.

PRICES:

Comter II kit with built-in audio cassette I/O	**$780**
Comter II assembled	**$920**

High Speed Printing at Low Cost!

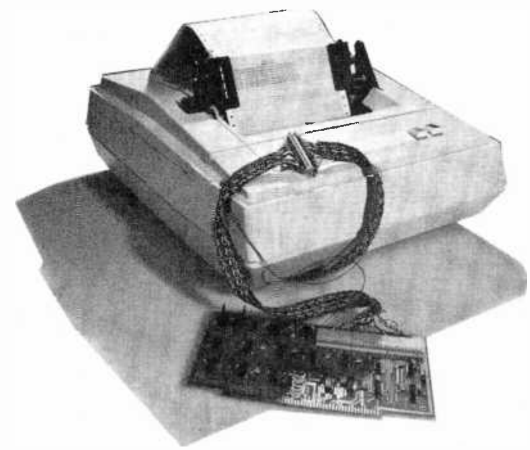
The *Altair 110 Line Printer* is a desktop line printer that produces 80 columns of 5 x 7 dot matrix characters at 100 characters per second x 70 lines per minute. The impact head prints bidirectionally on a 8½" roll paper* using a conventional teletype ribbon. The *Altair Line Printer* will print up to four copies of any item.

Maximum reliability is provided by a mechanism which contains no brakes, clutches, dampers or stepper motors. All control electronics including one-line buffer and self-test circuitry are contained on a single 5" x 15" printed circuit card. The Model 110 was expressly designed for the simplicity, reliability and extremely low cost required by current small-scale data handling systems and terminals.

Vibration and wear are minimized because the print head moves uniformly in both directions and pauses only at the end of each line. Opto-electronic sensing is used to accurately position each dot and permit characters to be printed on the fly.

The *Altair 110 Line Printer* comes with complete control electronics including a printer control card. Requires one slot in the *Altair 8800*.

**Pin-fed Optional.*



PRICES:

Altair Line Printer with controller card .... **$1,750 kit**
.... **assembled, $1,975**

Very Low Cost Terminal

The *Altair VLCT* is ideal for machine language programming. It converts a three digit octal code directly into an 8 digit binary code for transmission to the computer and then displays the binary output from the computer in a 3 digital octal format. This allows you to program in octal which is much easier than programming in binary. In addition, the VLCT is much more convenient to work with than using the front panel switches of the *Altair 8800*.

PRICES:

VLCT .... **$129 kit**
.... **assembled, $169**

NOTE: *PIO interface module is required to connect VLCT to Altair 8800.*

Teletype— *Most Versatile*

With a built-in paper tape reader and punch and hard copy output, this *ASR-33 Teletype* is perhaps the most versatile of all low cost input/output devices.

The *ASR-33 Teletype* prints 10 characters per second. It is a completely checked-out machine with standard 120 day warranty.

PRICE:

ASR-33 Teletype **$1,500**

NOTE: *SIOC interface module is required to connect Teletype to Altair 8800.*

Christmas Time Payment Plan

1K Altair for Just $68 a Month!

You can be the owner of an Altair 8800 with a 1,024 word memory module for *just $68 a month*. Each month (for 8 months) you send in your payment and we send you part of an Altair kit until you have the complete system. The advantages of the plan are *NO interest* or financing charge, *GUARANTEED price* based on today's price, and *free, immediate membership to the Altair Users Group* including subscription to Computer Notes.

Our terms are cash with order, BankAmericard, or Master Charge. If you send in an early payment, we will make an early shipment. By the same token, a late payment will result in a late shipment. (After 60 days past due, the balance of the deal is cancelled. All payments must be made within 10 months).

Total $544.00 (Retail price: Altair 8800 $439.00, Memory $97.00, Postage and Handling $8.00—total $544.00)

Altair Users Group Special

Each month the Altair Users Group sponsors a software contest and each month MITS gives away $130 in credit to the winners of this contest. At the end of the year, the author of the overall best program will receive $1000 in credit.

Membership to the Altair Users Group (the largest of its kind in the world) is free to Altair 8800 owners. However, even if you don't own an Altair, *you can be an associate member for one year at the special low price of $10 (regularly $30).*

As a member of the Altair Users Group, you will be kept informed of Altair developments, software contests, and general computer news through the monthly publication, Computer Notes. You will have access to the Altair Software Library and you can communicate to other Altair users throughout the world.

Note: These specials expire on January 30, 1976.

Altair Manuals

Altair 8800 Operators	$ 7.50
Altair 8800 Assembly	$ 9.00
Altair 8800 Theory, Schematics	$10.00
Altair 680 Operators	$ 7.50
Altair 680 Assembly	$ 7.50
Altair 680 Theory, Schematics	$10.00
BASIC Language Documentation	$10.00
Assembler, Monitor, Editor	$ 7.50
8800 4K Memory (includes Assembly, Theory & Schematics)	$ 5.00
8800 2K Memory	$ 5.00
8800 1K Memory	$ 5.00
8800 SIOA	$ 5.00
8800 SIOB	$ 5.00
8800 SIOC	$ 5.00
8800 PIO	$ 5.00
8800 ACR	$ 5.00
COMTER II Operators	$ 6.50
COMTER II Assembly	$10.00
COMTER II Theory, Schematics	$10.00
VLCT (Assembly, Operators, Theory)	$ 5.00
Altair Line Printer Interface	$ 5.00

Documentation Special One

Altair 8800 Operators, Assembly and Theory manuals plus BASIC Language manual (regularly $36.50). *Now just $15.00.*

Documentation Special Two

Altair 680 Operators, Assembly and Theory manuals. Regularly $25. *Now just $14.50.*

Documentation Special Three

BASIC Language manual, Package I (Assembler, Monitor, Editor), and BASIC language beginners text (My Computer Likes Me When I Speak BASIC by Bob Albrecht). Regularly $19.50. *Now just $12.50.*

MITS/6328 Linn NE/Albuquerque, NM 87108
505-265-7553 or 262-1951

Mail this special Altair Coupon Today!

☐ Enclosed is check for $________ ☐ BankAmericard #________ ☐ or Master Charge #________

☐ Altair 8800 ☐ Kit ☐ Assembled ☐ Fan ☐ Christmas Time Plan ☐ Expander Board

☐ Altair 680 ☐ Kit ☐ Assembled ☐ Fan ☐ I/O Sockets

☐ Teletype ☐ Line Printer ☐ Comter II ☐ VLCT ☐ Disk ☐ Disk Drive Only ☐ Disk Controller Only

☐ Memory Module ☐ I/O Module (list on separate sheet)

Postage & Handling: Add $8 for Altair 8800 or Altair 680 and $3 for any cards or peripherals if ordered separately. Teletype and Line Printer shipped by collect freight. Warranty: 90 days on parts for kits and 90 days on parts and labor for assembled units. Prices, specifications, and delivery subject to change.

☐ Documentation Special One ☐ Documentation Special Two ☐ Documentation Special Three

☐ Altair Users Group plus Computer Notes

☐ Please put me on your mailing list

BILL TO:

NAME________

ADDRESS________

CITY________

STATE & ZIP________

COMPANY (IF APPLICABLE)________

SHIP TO:

NAME________

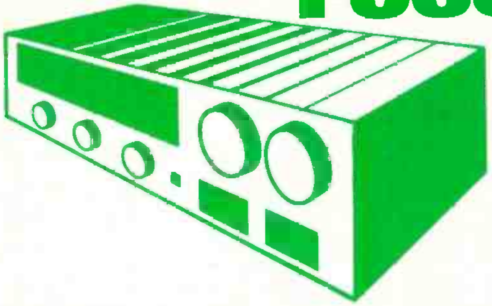
ADDRESS________

CITY________

STATE & ZIP________

☐ Please send Christmas Card to above address announcing gift and anticipated delivery.

MITS/6328 Linn NE/Albuquerque, NM 87108 505-265-7553 or 262-1951



FOCUS ON HI-FI

A HI-FI turntable isn't something you would ordinarily expect to see as a construction project in an electronics magazine, but here's a turntable system you *can* build yourself. It's chock full of electronics, and its direct-drive design is the apple of the audiophile's eye today. In addition, it features two remarkable innovations: an automatic pitch control and a direct-readout meter for checking speed accuracy.

BUILD A DIRECT-DRIVE TURNTABLE

FEATURES AUTOMATIC PITCH CONTROL AND METER-READOUT "STROBE".

BY GEORGE MEYERLE

Unlike turntable designs which use idler-rim drive or belt drive, the direct-drive turntable does not employ speed-reducing devices to rotate the platter. Consequently, there are no idler wheels to flatten or belts to fray and stretch over a period of time. The servo-controlled motor, operating directly at a precise speed of 33 1/3 or 45 rpm, connects directly to the platter. Such a slow rotational speed reduces vibration and rumble. At 33 1/3 rpm, the main rumble frequency is below 10 Hz. Direct drive also permits use of a single bearing, reducing wow, flutter and rumble caused by multiple bearings.

Using electronic circuitry to control a direct-drive motor produces a host of benefits. For example, speed accuracy is maintained even in the face of line frequency changes, which can occur from time to time. Moreover, you can adjust the pitch higher or lower. And should there be an unusually heavy force applied to the platter of this turntable while it's rotating — say, by a record-cleaning brush — you can quickly achieve precise speed by switching on the *automatic* pitch control.

About the Circuit. The turntable employs a direct-drive brushless dc motor that has one main sleeve bearing and

PARTS LIST

C1—4.7-μF, 10%, 10-volt electrolytic capacitor
C2—0.015-μF, 10%, 50-volt polyester film capacitor
C3—47-μF, 10%, 10-volt tantalum capacitor
C4—1-μF, 10%, 10-volt tantalum capacitor
C5,C6—330-μF, 10-volt electrolytic capacitor
C7,C9—220-μF, 35-volt electrolytic capacitor
C8—1000-μF, 35-volt electrolytic capacitor
C10—100-pF, 50-volt disc capacitor
C11—0.047-μF, 10%, 50-volt polyester film capacitor
C12—0.22-μF, 10%, 50-volt polyester film capacitor
D1 through D5,D8—1N4148 diode
D6,D7—100-volt, 1-ampere rectifier diode (1N4002 or similar)
IC1—MC1732CL integrated circuit (Motorola)
IC2, IC3—747 operational amplifier integrated circuit
J1,J2—Dual phono jack assembly
M1—Zero-center, ±75-μA meter movement
The following resistors are ¼-watt unless otherwise noted:
R1,R2,R3,R31—100,000 ohms, 10%, carbon film
R4—220,000 ohms, 10%, carbon film
R5,R6,R35—12,000 ohms, 10%, carbon film
R7—10,000 ohms, 2%, metal film
R8,R12,R16—300,000 ohms, 2%, metal film
R9,R11,R32,R33—330,000 ohms, 10%, carbon film
R10,R13—1200 ohms, 10%, carbon film
R14—1000 ohms, 2%, metal film
R15—22,000 ohms, 2%, metal film
R17—22,000 ohms, 10%, carbon film
R18,R22,R27—560 ohms, 10%, carbon film
R19—2400 ohms, 2%, metal film
R20—390 ohms, 2%, metal film
R28—10 ohms, 10%, carbon film
R29—680 ohms, 2%, metal film
R30—2700 ohms, 2%, metal film
R34—6200 ohms, 2%, metal film
R21,R26—10,000-ohm trimmer potentiometer
R23,R24—2500-ohm trimmer potentiometer
R25—39-ohm, 10%, 5-watt resistor
R36—2500-ohm, five-turn potentiometer
S1—3-pole, 3-position rotary switch
S2—Spst switch
T1—16-volt, 100-mA wall-plug transformer with line cord
Misc.—Direct-drive, brushless dc motor with integral circuit board assembly; printed circuit board for control circuit; motorboard; turntable base; control panel; acoustic-isolator springs (8); wire nuts (6); control knobs (3); 6-32 × 1" machine screws and nuts (3); No. 6 × ½" woodscrews (2); double-sided tape; hookup wire; solder; etc.

Note: The following items are available from Netronics Research & Development Ltd., 27 Eagle St., Spring Valley, NY 10977: Complete turntable kit, including all parts and Audio-Technica Model AT-100511 universal tonearm No. 450D for $159.95; complete kit less tonearm (motorboard minus tonearm holes) No. 350D for $99.95; dust cover for above No. 40-004 for $12.00; motor with cast platter and rubber mat No. 99-001 for $65.00; control circuit pc board No. 99-007 for $5.90; meter movement No. 99-004 for $6.50; wood base with motorboard (minus tonearm holes) No. 40-001 for $15.00; MODE switch (S1) No. 50-001 for $1.70; and AUTO PITCH CONTROL switch (S2) No. 99-004 for 90c. When ordering complete kit, add $2.50 for postage. New York state residents, please add sales tax.

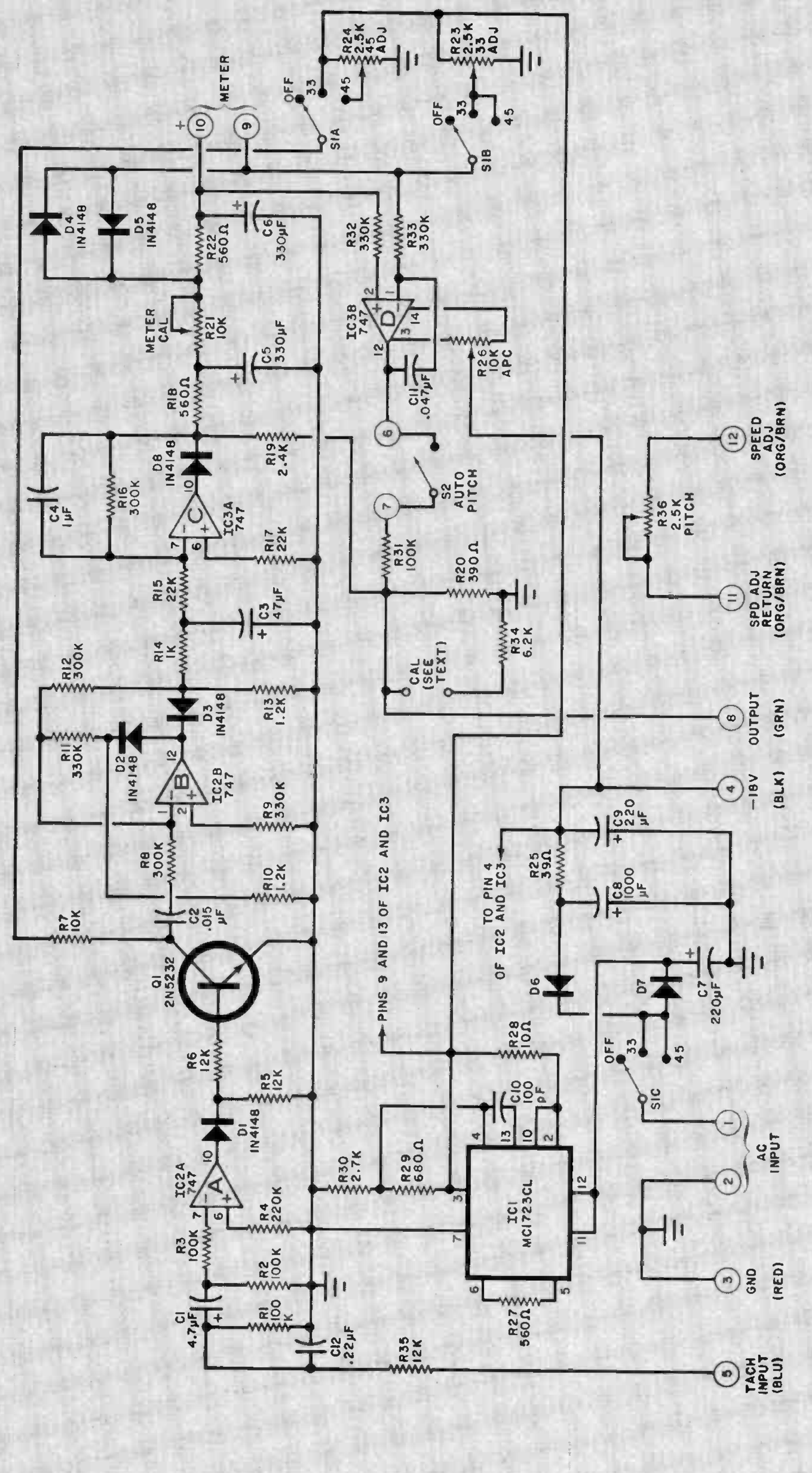


Fig. 1. The control circuit for the turntable motor. The tachometer signal is converted to square waves, differentiated and fed back to the motor. The oscillator and filter for the power supply are also located on the control board assembly.

a ball-type bottom bearing. A preassembled 11-transistor circuit board is housed inside the motor's case. It is connected to an external electronic control circuit board assembly via a color-coded cable system. The circuit assembly inside the motor housing contains all of the circuitry required to rotate the motor and provides a means by which the accuracy of the motor's speed can be monitored.

The motor's brushless action is accomplished by using a high-frequency oscillator, the output of which goes to a series of commutator coils that initiate and sustain motor rotation. A tachometer coil assembly generates a signal that is a function of the speed of the motor's rotor. This control signal is fed back to the speed control circuit to provide constant regulation.

The external control circuit is shown in Fig. 1. The tachometer signal from the motor goes to stage A (*IC2A*), which converts the pulses into square waves. The positive-going portions of the square waves go through *D1* and *Q1*. The circuit associated with stage B (*IC2B*) differentiates the square wave and, due to *D3*, passes the negative portions to *R14, C3, R15*, and *C4*, all of which are associated with the precision rectifier made up of stage C (*IC3A*). The output of stage C is, therefore, proportional to the speed of the motor. Independent of temperature or line voltage, this output is then coupled back to the motor control board through *R19*. Once the motor has been set to a desired speed, via *R36*, the electronic feedback system tracks to maintain this speed.

A zero-center meter movement is connected between the output of stage C and the rotor of 33 1/3-rpm potentiometer *R23*. When this potentiometer and PITCH potentiometer *R36* have been properly set, the direct-drive motor locks onto exactly 33 1/3 rpm and the meter's pointer remains at the zero-center index mark on its scale.

If for any reason, such as record loading or other sources of friction, the speed of the motor deviates from 33 1/3 rpm, the meter will begin to indicate off the zero mark. The meter itself is calibrated for a ±5% motor speed deviation range (both sides of the zero index mark). You can compensate for speed changes by operating the speed adjust potentiometer and recentering the meter's pointer. However, there is a far easier and faster way to accomplish the same end that makes this turntable different from other turntables.

Stage D in the control system is what sets this turntable apart. Note that op amp *IC3B* is connected as a differential amplifier directly across the meter terminals. Because this stage has a gain of about 20,000 and is operated wide open, a change of only a few millivolts at its input ports generates a maximum output. The change in millivolts will barely be revealed by the meter's pointer, which will remain virtually fixed at the zero mark.

If *S2* is closed (AUTO PITCH CONTROL ON), the output of stage D will be fed to the motor speed control board for instant use. The correction factor in this mode is so fast that it insures an almost perfect pitch. Even the slightest change in motor speed is immediately corrected automatically and the motor will rotate at a predetermined speed to keep the meter's pointer on zero center and the inputs to the differential amplifier will be exactly the same.

With automatic pitch control switch *S2* set to OFF (open), speed adjust potentiometer *R36* can be used to fine tune the turntable speed for exact pitch, slightly above or below 33 1/3 rpm, if there have been any slight frequency changes during the manufacturing stage between the original recording and the final retail disc. You can also tune a disc for your own instrument if you wish to play along with the music.

Note that only the rectifier/filter part of the power supply is on the control circuit board assembly. The 16-volt transformer plugs into a wall outlet and only the low ac voltage is routed to the turntable's electronics package. This insures a very low hum level to be picked up by the phono cartridge.

This turntable employs a second set of acoustic isolators that are resonant about 2 Hz below the resonant frequency of the main platter system. The result is excellent isolation from acoustic coupling sometimes experienced from loudspeakers.

Construction. The actual-size etching guide and components placement guide for the printed circuit board to be used in the turntable are shown in Fig. 2. Mount the components on the board exactly as shown, taking care to properly orient the electrolytic capacitors, diodes, transistor, and IC's. Use a low-wattage soldering iron with fine tip and apply only enough heat to assure good electrical and mechanical connections. Carefully inspect each solder connection for cold soldering and solder bridges between closely spaced conductors. When you are satisfied that the board is properly wired and soldered, temporarily set it aside.

The motorboard, which measures roughly 17" × 10" (43 × 25 cm), consists of two ¾" (1.9-cm) thicknesses of high-density particle board glued firmly together to form a monolithic sandwich. The upper layer of the sandwich has a 5" (12.7-cm) hole cut into it, while the lower layer has a 3½" (8.9-cm) hole centered within the hole in the upper layer. The motor drops into the motorboard through the top hole, its mounting flange resting on the lower layer's upper surface. Then three 6-32 × 1" machine screws and nuts anchor the motor into place. Mount the tonearm and its rest post in their respective locations on the right side of the motorboard. Slip the turntable platter onto the motor's spindle and check to make sure that it rotates without brushing against the motorboard.

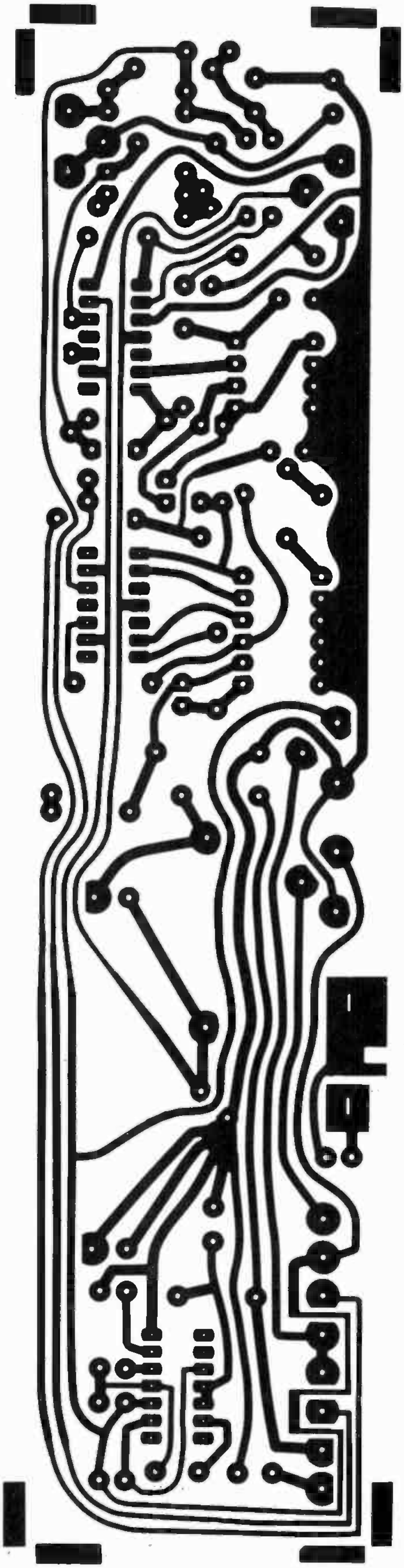
The base of the turntable must be large enough to accommodate the motorboard and leave enough room to house the control electronics package in front. It must also be deep enough to clear the motor or permit the rear end of the motor's housing to sit in a cutout in the bottom panel.

Use #6 woodscrews to mount tour isolation springs near the corners of the motorboard. Turn over the base and, in like manner, mount four more isolation springs near each corner of the base.

Mount the AUTO PITCH CONTROL (*S2*) at the left end of the control panel. Then, using double-sided tape, mount

SPECIFICATIONS

Wow	0.02% rms (weighted)
Flutter	0.04% rms (weighted)
Rumble	−60 dB RIAA/RRLL
Drift (APC on)	0.01%
APC accuracy	0.01%
Speed control	±5% (33 1/3 & 45 rpm)
Suspension	Dual resonant
Motorboard weight	5½ pounds (2.5 kg)
Platter	180 kg/cm² moment of inertia, non-ferrous
Pitch control	Five-turn, three-ball planetary potentiometer for precision accuracy



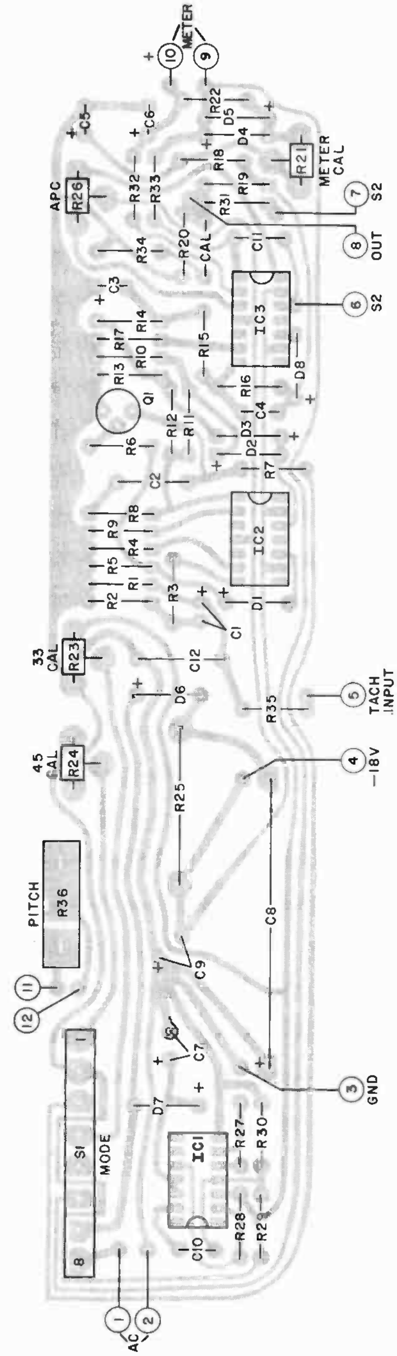


Fig. 2. Etching and drilling guide for the turntable is shown above. Component layout is above right.

the meter movement in a rectangular cutout in the control panel so that its scale is easy to read. This done, mount the control circuit board assembly to the panel via the PITCH control *(R36)* and MODE switch *(S1)*. Check to make sure that the adjustment slots of the 33 *(R23)*, 45 *(R24)*, and APC *(R26)* trimmer potentiometers line up with the holes in the control panel.

Referring back to Fig. 1 and Fig. 2, complete wiring the system. Do *not* solder the wires coming from the motor housing directly to the pc board pads. Instead, solder lengths of prepared hookup wire (preferably color coded for easy identification) to the board, twist together the free ends of the hookup wires and the appropriate motor wires, and screw onto each twisted connection a wire nut. Solder a 1" (2.54-cm) long piece of solid bare wire to the pads marked CAL on the circuit board. Then solder the leads from the outboard low-voltage transformer's output to the pads marked AC.

Next, connect and solder the cartridge leads coming

TEST RESULTS
A Hirsch-Houck Labs Report

The turntable performance was exactly what you would expect of a first-quality unit. Checks with a frequency counter confirmed that the indicated nominal speeds were exact, within the ±0.1% accuracy of our four-digit counter's display. The meter indications for vernier speed control were within 5% of full-scale and on the nose at the zero-center index mark. Line voltage variations had absolutely no effect on the speed of the turntable or meter indications.

The unweighted rms wow was 0.02%, essentially the residual of our test record and meter. The flutter measured 0.04%. The unweighted rumble was −31 dB, principally in the lateral plane. With RRLL audibility weighting, the rumble was −58 dB.

The turntable took a little longer to reach its final speed than do most turntables. We timed it at about 7 seconds to come up to 33 1/3 rpm and 11 seconds to come up to 45 rpm. With the AUTO PITCH CONTROL set to ON, the turntable required about 14 seconds to reach a locked-in condition at both speeds.

The turntable's unique double-suspension isolation system proved to be very effective in preventing acoustic feedback. We confirmed this when we made our standard test for isolation from the mounting surface, as a function of frequency. This was by far the best turntable we have tested in this manner. Its most sensitive point was at about 35 Hz—at least as good as the best turntable we previously tested. Its isolation at higher frequencies, where most acoustic feedback problems occur, was typically 20 to 40 dB better than other turntables.

User Comment. Without considering cost, our tests revealed that this turntable performs essentially on a par with other direct-drive, commercially made turntables. Its wow, flutter, and rumble are as good as most direct-drive turntables and better than most belt-driven units.

The turntable's speed stability was exceptionally good, with none of the warm-up drift that is typical of direct-drive or other electronically controlled turntables. This drift is usually small enough to be negligible, but in the case of this turntable it was undetectable. The range of the PITCH control is greater than average, and we especially like the APC system. It gives the user the rock-stable, accurate frequency of a synchronous motor with the advantage of being able to set the "synchronous" speed to one's own taste.

The chief drawback to the turntable was the long start-up time. On the other hand, the platter can be left running while changing records or stopped manually at any time. Hence, there is no need to shut the turntable off during a playing session. Because of the soft base suspension, one must be careful when operating the controls to avoid jarring the motorboard. But in normal operation, the tonearm's finger lift or cueing lever are the only active controls, and they pose no problems in this regard.

We did not perform tests on the Audio-Technica tonearm that was mounted on the turntable's motorboard. From past experience with it, we know that this is a smooth-handling tonearm that should be compatible with any good phono cartridge. The turntable can accommodate any separate tonearm, of course.

This turntable gives every audiophile the opportunity to own a truly state-of-the-art direct-drive disc player for a fraction of the usual cost by allowing him to wire the electronics and assembling the mechanical section.

out of the base of the tonearm assembly to the lugs on a two-phono-jack assembly and mount the jack assembly on the bottom of the turntable's base. Mount a phono cartridge in the tonearm's cartridge shell.

Setup and Use. Set the motorboard assembly into the base so that it rests on its isolation/support springs. Slip onto the motor's spindle the turntable platter and rubber mat. Place a bubble level on the platter to make sure that it is level.

Preset all potentiometers on the control board to their mid-positions. Plug the turntable's line cord into an ac outlet and set the MODE switch to 33 and the AUTO PITCH CONTROL switch to OFF. Illuminate the strobe pattern on the edge of the turntable platter with a fluorescent or neon light source. Adjust the 33 control on the bottom of the motor housing so that the second set (from the bottom) of strobe marks is approximately stationary. Then adjust the PITCH control until the pattern is exactly stable. Adjust the 33 CAL *(R23)* control so that the meter's pointer rests on the zero index on the scale.

Set the MODE switch to 45 and adjust the 45 CAL *(R24)* control until the bottom set of strobe marks on the platter are stationary. Put the MODE switch back in the 33 position and set the AUTO PITCH CONTROL to ON. Adjust the APC calibration control *(R26)* for a zero indication on the meter. Set the AUTO PITCH CONTROL to OFF.

Lightly twist together the two bare calibration wires on the circuit board. This will speed up the motor by 5%. Adjust METER CAL potentiometer *R21* (this pot is not acessible through a hole in the front panel) until the meter's pointer indicates exactly +5%. Untwist the calibration wires and orient them so that they do not touch each other or any part of the circuit.

(Note: The calibration procedure is best performed during the hours when commercial power demands are at their lowest, such as during a weekend. This will insure that the power-line frequency is at its closest to the ideal 60 Hz.)

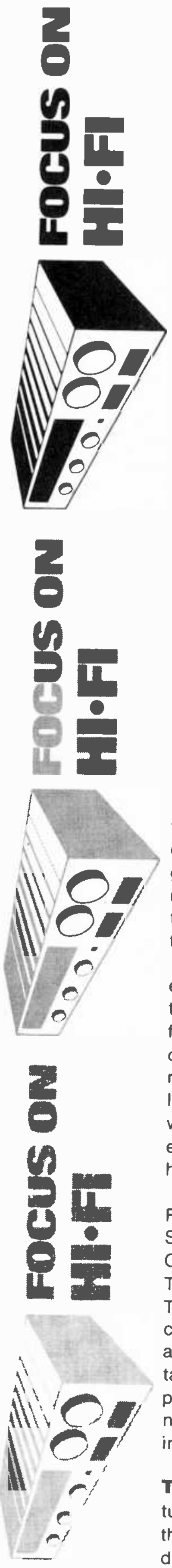
Turn off the power by setting the MODE switch to OFF and disconnect the power from the ac receptacle. Remove the turntable platter and mat. Then fit the control panel in place in the turntable's base and fasten it down with two No. 6 woodscrews. Reinstall the platter and mat and check again with the bubble level to make certain the turntable is level. If necessary, repeat the adjustment procedure from the point where you trim the PITCH control to obtain an exactly stable 33 1/3 rpm speed when viewing the strobe marks on the platter.

Put the turntable where you want it in your system and connect the feed cables between it and your audio amplifier. Check again to make sure the turntable is level. It is now ready to be used for playing discs.

Whenever you turn on the turntable from a cold start or switch from one speed to another, wait about 10 seconds for the speed to stabilize before lowering the tonearm onto the disc's surface. (Monitor the meter; when the pointer rests on the zero, or center, index, the turntable is operating at the proper speed.)

The most convenient way of operating the turntable is by leaving it in the automatic mode. In this mode, the speed of operation will be as close to perfect as your calibration can make it. When the turntable is operated on automatic, the assumption is that the disc was cut at an exact 33 1/3- or 45-rpm speed. If you find that the pitch appears to be off, however, you can set the AUTO PITCH CONTROL to OFF and bring it back on-pitch by adjusting the PITCH control. You can adjust for up to ±5% pitch error in this manner. ◈

(Editor's Note: The author is pursuing patent protection for concepts described in this article. However, readers may build it for personal use.)



HOW GOOD ARE FERRICHROME & OTHER NEW CASSETTE TAPES?

LAB TESTS EXPLORE PERFORMANCE OF LATEST "SUPER" TAPES.

BY JULIAN D. HIRSCH/Hirsch-Houck Laboratories

NEW CASSETTE tapes are introduced with almost clockwork regularity. Most are claimed to have significantly improved characteristics in such important areas as frequency response, noise, distortion, coating uniformity, etc. Some tapes, notably the "ferrichrome" types available from Sony and 3M (Scotch), require special recording bias and equalization to obtain their full potential. Most tapes, however, are designed to be compatible with the "normal" or "chrome" operating modes of any good cassette deck.

In past tests of cassette tapes, we used an Advent 201 deck to achieve uniformity of results for reference purposes. This deck has a single switch to set both bias and equalization for either "regular" ferric-oxide or chromium-dioxide tapes. In testing the new tapes, however, we used the Advent as well as a Nakamichi 500 deck which has separate three-position switches for independently setting bias and equalization. This permitted us to get a better overall picture of modern cassette performance. We would have liked to use other decks also, but the number of measurements required made this impractical.

Some inconsistent or difficult-to-explain results were expected from our tests, and we were not disappointed in this respect. However, we did find some significant differences between some tapes. Note, though, that many of the apparent differences between some tapes are a result of recorder characteristics. Quite possibly, the relative standing of the tapes in some performance areas would be different with other decks. Some of the differences are so clearly a function of the tapes themselves, however, that they leave little room for doubt.

The new tapes tested were: Capitol Music Tape, Fuji FX, Maxell UD-XL, Memorex MRX_2, Nakamichi EX, Scotch Low Noise/High Density (LN/HD); Scotch Chrome, Scotch Classic, Sony Ferrichrome (FeCr), and TDK SA (Super Avilyn). As a reference, we also included TDK SD, a familiar high-quality tape whose properties are compatible with the regular bias for which the Advent and other decks are specially set. The Scotch Chrome tape, which is similar to other CrO_2 tapes, was used primarily to establish a basis for comparison against the new TDK SA tape. The latter is a unique ferric-oxide tape intended to perform with CrO_2 bias and equalization.

Tape Details. One way to improve tape is to manufacture smaller ferric-oxide particles whose shape ideally is that of a rod about 10 times longer than it is wide. Particle distribution must be even throughout the binding material that anchors them to the plastic backing to reduce tape noise and output fluctuations and maximize the playback output level. It appears that all tape manufacturers have devoted considerable effort to achieving a uniform distribution of correctly formed and proportioned oxide particles.

High-frequency performance can be enhanced by "doping" the ferric-oxide with cobalt. Again, the problem of homogeneity exists, with "clumping" of the cobalt portion of the mix being undesirable. TDK and Maxell have attacked the problem with what appears to have been a similar approach, but by different techniques. According to TDK, the SA tape has a ferric-oxide base, with cobalt ions added to each fine oxide particle. This tape is unique among ferric-oxide tapes in requiring chrome bias and equalization and a 70-µs playback characteristic. (The back of the cassette even has the special notch that automatically switches some decks to the CrO_2 mode.) TDK states that the SA's characteristics are in some ways superior to those of CrO_2 tape.

Maxell's UD-XL tape is offered as a "very high performance ferric-oxide tape" that can operate with normal ferric-oxide bias. However, the slightly higher level offered on some decks with an EX, LN, etc., switch is preferable. It should be used with a 120-µs playback equalization. Maxell has developed a smaller magnetic particle coated with cobalt ferrite, which takes care of the clumping problem. Claimed for the UD-XL tape are a higher output level at all frequencies and a lower noise level when compared to conventional ferric-oxide tape.

The other ferric-oxide tapes—Capitol Music Tape, Memorex MRX_2, Nakamichi EX, and Scotch LN/HD—appear to offer an overall refinement in performance rather than any specific technological breakthroughs. They all lay claim to finely dispersed coatings, compatibility with normal bias and equalization, and the precise mechanical construction needed for a smoothly operating, jam-free cassette.

Two ferrichrome tapes (Sony FeCr and Scotch Classic) were included in our tests. Both have a layer of ferric oxide coated with a thin layer of chromium dioxide. The low and middle frequencies penetrate to the oxide layer that has superior characteristics in these ranges, while the surface coating brings the superiority of chromium dioxide into effect for the highest frequencies.

Operating at normal ferric-oxide bias settings (or the higher settings of decks designed for high-energy tapes), a ferrichrome tape can have a high-frequency response that surpasses conventional ferric-oxide and chromium-dioxide tapes. The catch is that special recording equalization is also required. On a standard recorder not designed for it, a ferrichrome tape has an exaggerated high-end response. Further complicating matters is the fact that the Sony and Scotch tapes are so different in their characteristics that they are not interchangeable. The Scotch tape has a thinner chrome layer and does not have as extreme a high-end boost as the

Sony tape. Hence, a Scotch tape performs best on a 3M Wollensak deck, and a Sony deck is needed for best performance from a Sony tape. (This situation is expected to change shortly and may have done so by the time this report is in print.)

The Tests. We used both the Advent Model 201 and Nakamichi Model 500 cassette decks throughout our testing. We tested: record/playback frequency response at 0- and −20-dB recording levels; IM distortion in playback from recordings made at 0, −5, and −10 dB; input level required at 1000 Hz to produce 3% THD on playback; playback output level from a 0-dB, 1000-Hz recording; output noise (IEC "A" weighted) referred to the playback output from a 0-dB, 1000-Hz recording; playback THD at 100, 1000, and 5000 Hz from recordings made at a constant input level corresponding to 0 dB at 1000 Hz; and playback output uniformity, including the effects of dropouts in the tape coating and mechanical friction in the cassette.

The last test was accomplished by recording a 10,000-Hz signal at −20 dB for about three minutes and playing it back into a slow-speed chart recorder with a fast pen response. The width of the trace, ideally a straight thin line, is an indicator of the uniformity of the tape coating. A cyclic variation in output level indicates a binding or eccentricity within the cassette. In all measurements, the 0-dB level was based on the decks' meter indications.

Whenever possible, we used the recommended bias/equalization switch settings. Obviously, the regular and CrO_2 positions of the Advent deck placed some of the high-energy ferric-oxide tapes, to say nothing of the ferrichrome tapes, at a disadvantage. We set out to discover how well a "super" tape performs when used in a machine for which it was not specifically designed. It soon became obvious that neither test deck could cope with the ferrichrome tapes using a single switch setting. Therefore, we settled for recording with regular or EX bias and equalization and playing back with the 70-μs CrO_2 equalization. This provided an "acceptable" frequency response, although we doubt that we were utilizing the full potential of either tape.

Interpreting the Data. After accumulating more than 30 frequency-response charts and hundreds of observations on various aspects of tape performance, we faced the difficult task of evaluating the data. Our hope that the degree of saturation at high frequencies revealed by the rolloff in response of the 0-dB record/playback curve would indicate the relative high-frequency energy capabilities of the tapes had to be discarded. It proved to be basically a property of the tape deck. In any event, the differences between the tapes were too small to be significant.

The differences between some of the tapes in our IM tests on one deck were so great that we began to doubt our instruments. However, the same measurements repeated on the other deck yielded totally different results—in degree, not kind. Although the tapes ranked in roughly the same order in both cases, the measured IM distortion levels reflected the internal operating conditions of the decks as much as they did the tape characteristics.

In our opinion, the four remaining parameters indicate real tape qualities. Although there were some differences between the two decks, we feel that they would generally apply to the tapes used in other good recorders. However, one must not attach too much importance to small differences between tapes, since they would not be warranted by our test conditions.

The dynamic range was separately tabulated for each tape deck. This is the decibel span between the maximum recording level, above the deck's own 0-dB meter reading, that corresponded to a 3% THD at 1000 Hz in playback and the weighted noise. It was taken from a section of tape exposed to the bias waveform but with no signal applied. Although much is made of the separate factors of maximum level and playback noise by the manufacturers, neither is sufficient to define the important dynamic-range parameter.

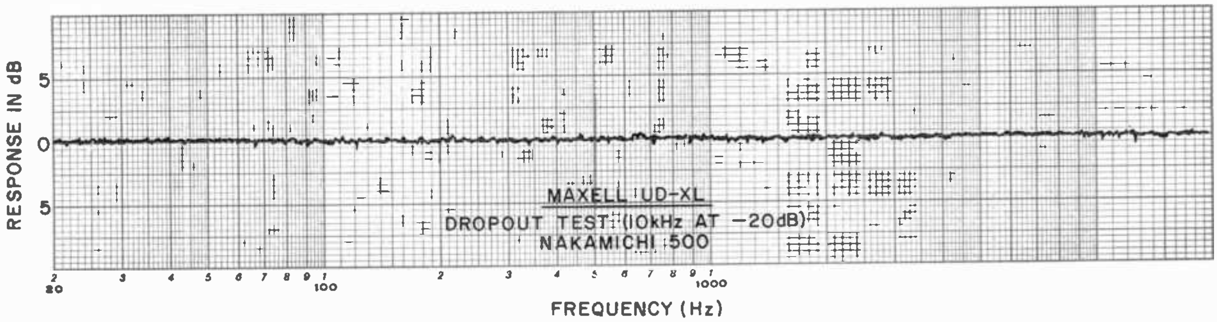
We divided the S/N measurement into 2-dB intervals, assigning each tape a numerical rating based on its own performance. The overall range of the actual S/N measurements was higher (better) on the Advent than on the Nakamichi deck. This tends to obscure the comparisons between tapes unless they are made on the basis of a single deck. Nevertheless, the tapes that ranked high on one deck generally did so on the other, even if the order was slightly different.

The maximum recording level for 3% THD on either machine reveals the midrange saturation capabilities of the tapes. This is dependent on the operating bias and equalization, but it gives a clue to how close one comes to saturation by recording up to the "zero" mark. The playback output from a 0-dB recording is an indicator of how much energy has been stored on the tape. All else being equal, a higher output implies a higher S/N.

The chart recorder's trace in the "dropout" test is one of the best guides we know to check the homogeneity of the tape coating. Although it does not necessarily correlate directly with audible effects, it seems obvious that, in this case at least, less is better than more. A "typical" chart obtained in this test is shown below.

The relative performance of the tapes with respect to the four parameters described is shown in the table. Remember that small differences are usually not significant and that comparisons should be made in each category only on the data obtained from one deck. If both decks suggest a similar ranking of the tapes, this gives a greater credibility to the rating, but the reverse is not necessarily true.

Other Cassette Features. There is more to a good cassette than the tape within it. All the makes represented in our tests have good-quality mechanical con-



Typical chart recording of dropout test—in this case for the Maxell UD-XL struction, and our experience with them has been uniformly satisfactory. Since we tested only one C-60 cassette of each tape type, no sweeping conclusions can be drawn regarding uniformity throughout production. However, we wouldn't expect any major departures from our findings.

The listing of test results in the table includes a column for case construction, which is nearly evenly divided between screw fastened and welded. If a case is well made, there is probably little difference between the types. Some people might prefer the screw-fastened case because it can be disassembled to permit reguiding and splicing of tapes. (A welded cassette cannot be opened without breaking the case.) However, as 3M points out in its novel cassette-splicing kit, disassembling a case is never recommended. If a tape is broken, it can be spliced from outside the case.

Of the cassettes tested, the Memorex MRX_2 and Maxell UD-XL had larger-than-normal windows for viewing the tape, the former spanning almost the full width of the cassette housing. TDK, Nakamichi, and Maxell have timing marks on their tape leaders. Nakamichi and Maxell tapes have marks that indicate five seconds remaining before the coated tape reaches the head and arrows that indicate the direction of tape motion. Nakamichi also marks the side, A or B, on the leader. TDK tapes have four seconds of leader, with timing marks at one-second intervals. The Maxell (and we suspect from the audible sound as it moves, the Nakamichi) has a special head-cleaning tape as a leader so that the heads are cleaned every time the leader passes over them.

Recordists who have run afoul of short-length cassettes that can cause the end of a half-hour broadcast to be lost will appreciate Sony's FeCr Plus 2 cassettes. They have a full 31 minutes of tape per side.

Summing Up. As stated earlier, it is possible that, by optimizing a recorder for each of the tapes, we would have eliminated many of the differences observed. But this isn't an option open to most users. Thus, the question of what a user can expect from each of the tapes on his particular deck still remains.

Every tape we tested is capable of making really good hi-fi recordings with any good deck. In most cases, especially when recording FM broadcasts, we doubt that anyone could tell which tape was being used. Our TDK SD control tape, once a "premium" tape, is now a "standard" tape of sorts. This says a lot for the continuing progress in tape performance. Except for its higher dropout level, the Scotch LN/HD tape was very similar to the TDK SD tape. (On the Advent deck, they were almost identical.)

In most respects, Memorex MRX_2 and Capitol Music tape measured not too differently from the TDK SD tape, which was in the middle in our tests. On the Advent deck, the Capitol tape ranked at the top in dynamic range and maximum recording level, but it was in the middle of the group on the Nakamichi deck. Strangely, Nakamichi EX tape was in the middle or slightly above in all characteristics, but never reached top position on either deck. In other words, it was a very fine tape among other very fine tapes.

As claimed, the Maxell UD-XL tape ranked close to the top in maximum recording and playback levels. Its dynamic range was also outstanding on the Advent deck, though average on the Nakamichi deck. Its dropout level was very low, ranking with the TDK SA and Sony FeCr tapes and better than all the other ferric oxide tapes except Fuji FX. In all our tests, the Fuji tape was so close to the Maxell UD-XL that we would not consider any differences to be significant.

Scotch Classic was something of a "maverick" in this group. Without optimum recorder adjustments, it saturated early, had a fairly low output level (lower than average S/N), and average dropout rating. Although most of the other tapes gave nearly identical frequency-response curves (on a given deck), the Classic had a strongly peaked high end on the Advent deck. On the Nakamichi deck, with EX bias, the peak was considerably tamed. This would not be a tape for use with decks that have only regular and CrO_2 bias and equalization, since it doesn't fit into either category. A possible exception might be an older deck with unexceptional highs, which might well become exceptional with this tape. Needless to say, on

TEST RESULTS

	Dynamic Range (dB)		Rec. Level at 3% THD 1 kHz[1]		Output from 0-dB Rec.		Dropout Ranking [2]	Case Seal [3]	Price ($)[4]	Comments
Recorder[5]	N	A	N	A	N	A	N			
Tape										
TDK SD	54-56	58-60	+2.3	+5.0	0.0	0.0	5	S	3.00	4-s timed leader
Scotch LN/HD	52-54	58-60	+1.5	+4.5	−1.3	−0.7	6	W	3.00	
Memorex MRX_2	58-60	58-60	+1.5	+5.0	+1.0	−0.7	5	W	2.30	Large window
Capitol Music Tape	56-58	62-64	+3.5	+6.5	0.0	+0.8	5	S	3.00	
Nakamichi EX	52-54	58-60	+1.5	+5.0	+0.7	0.0	3	S	3.70	5-s timed leader, head cleaner
Maxell UD-XL	56-58	60-62	+2.0	+6.5	+2.2	+0.7	2	S	4.89	5-s leader, head cleaner, large window
Fuji FX	56-58	60-62	+2.0	+6.0	+2.3	+0.6	2	S	3.50	
Scotch Classic	52-54	58-60	−1.0	+2.0	0.0	+0.6	5	W	4.35	Ferrichrome
Sony FeCr[6]	56-58	60-62	0.0	+3.0	+1.0	+0.6	1	S	4.00	Ferrichrome, 31 min/side
Scotch Chrome	58-60	60-62	+2.5	+2.0	−0.5	−0.5	4	W	3.75	
TDK SA	60-62	62-64	+3.0	+3.0	+2.7	+3.1	2	S	3.60	"Super Avilyn" ferric coating

Notes:
1—0 dB = meter reading at 1 kHz.
2—Numbers increase with increasing dropouts.
3—S = screws; W = welded.
4—For C-60 tape.
5—N = Nakamichi 500; A = Advent 201.
6—Rec. Reg./Play CrO_2.

the Wollensak decks in their FeCr modes, this tape delivers a much better account of itself.

Everything we have said about Scotch Classic applies, to an even greater degree, to Sony's FeCr tape. On a suitably designed deck, such as some of the better Sony models, it is an excellent tape. On most other decks, however, it is unusable because of its exaggerated high-end response. A possible solution is to record with normal bias and equalization and playback with the 70-µs CrO_2 equalization. This gives a not too objectionable, mildly rising high end. This tape was outstandingly free from dropouts and other irregularities.

Both test decks were designed to deliver their flattest, widest response with CrO_2 tape, and they did just that. The Scotch Chrome ranked slightly above average in its overall performance, which we expected from a well-made cassette using chromium-dioxide tape. The real reason for including it was to set the stage for TDK SA tape, which is effectively a substitute for chrome in a cassette deck, athough it is a ferric-oxide tape.

The SA placed at or just below the top in every performance category. Its S/N (dynamic range) was the best on the Nakamichi and a hair's breadth below the top-ranking Capitol Music Tape on the Advent decks. Although its maximum recording level was only slightly above average, the playback output was 2 to 3 dB better than any of the other tapes. Finally, its freedom from dropouts tied the Sony FeCr tape and was far ahead of all the others. The SA tape can be used with any deck that has a CrO_2 switch, and that includes just about every deck on which you would use a top-grade tape.

In closing, we repeat our caution: Don't read into our test results more than is justified. Most tapes perform better on some machines than they do on others. It makes good sense to experiment with different tapes to determine which is best for your needs. ◈

NEW TRENDS IN HI-FI ELECTRONICS

WHAT LATEST DEVELOPMENTS IN CIRCUITRY AND COMPONENTS WILL MEAN TO THE AUDIOPHILE.

BY LEN FELDMAN

CHANGES in audio electronics occur gradually. However, by examining some of the newer circuits and techniques that have marked the audio equipment scene during the past year, we can make some intelligent guesses about what the future of hi-fi electronics holds in store for the coming year.

Advances in hi-fi electronics technology can be categorized as follows:

- totally new circuit approaches to solve old audio problems.
- application of existing circuitry for improved audio performance.
- circuitry and products designed to improve hitherto unexplored areas of performance.
- passive or semi-electronic circuits that improve system flexibility.

Let's look at the new developments that are either part of the hi-fi scene or show promise for the future.

VFET Power Amplifiers. Perhaps the most interesting new circuit approach to appear in a hi-fi product in the past year was the use of the vertical field-effect transistor (VFET) in basic power amplifiers. Advantages claimed for this relatively new solid-state device by the two equipment manufacturers—Sony and Yamaha—who have so far incorporated it into their products include extremely fast rise and fall times (fast pulse response), availability in n- and p-channel configurations for true complementary circuit design, high input and low output impedance characteristics, and voltage-rather than current-controlled response. They feel that it is now possible to design a breed of amplifiers that possess the advantages of both bipolar-transistor and vacuum-tube equipment.

A cross section of a VFET is shown in Fig. 1. Unlike conventional FET's, in which the current flow is through a relatively narrow channel, the "grate-like" arrangement of the VFET gate permits a higher current to flow between the drain and source. In the case of the n-channel VFET shown, the digitized gate (p+) is diffused in the n+ and n− areas. (Reversing the n and p areas makes the VFET a p-channel device.)

The gate and source terminals are separated by a relatively thick silicon-dioxide insulation. Since charge storage is not significant in a VFET, it has good transient response and power bandwidth well into the ultrasonic range (Fig. 2).

A block diagram of Sony's Model TAN-8550 power amplifier in which VFET's are used is shown in Fig. 3. The

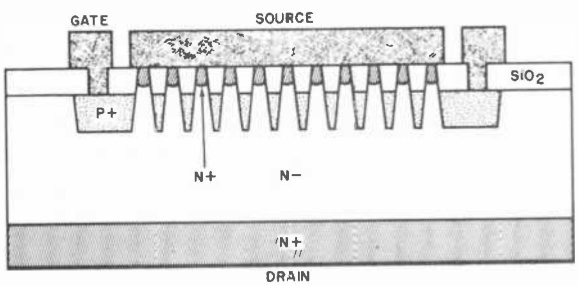


Fig. 1. Cross-sectional view of a VFET.

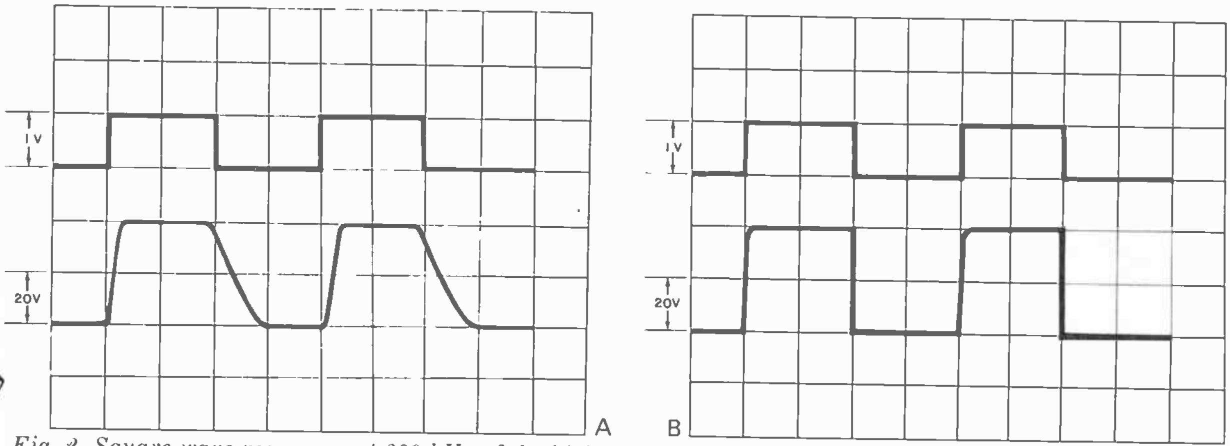


Fig. 2. Square-wave responses at 200 kHz of the highest quality bipolar transistor power amplifier (A) and a vertical FET amplifier (B). Note evidence of switching lag due to slow cut off in response at (A).

final output stage of this amplifier employs three n- and three p-channel VFETS in a push-pull parallel design. The amplifier delivers 100 watts/channel into an 8-ohm load at any frequency from 20 to 20,000 Hz.

Much attention has been paid recently to a previously undefined form of audio distortion called "transient intermodulation distortion" (TIM). Unlike harmonic or intermodulation distortion, this audio imperfection does not lend itself to simple measurement, but it is known that high orders of negative feedback applied from the output to the input in solid-state amplifiers tend to aggravate the condition. Proponents of VFET amplifier design maintain that the better high-frequency response of the device permits designers to apply less overall negative feedback to the amplifier (between 15 and 20 dB less), which, in addition to contributing to better stability and reduced higher-order harmonic distortion of the amplifier, also reduces audible TIM.

Class-D Amplifiers. Audio amplifiers operated class A, in which one or more output transistors conduct continuously, are the least efficient means for converting dc to audio power. Class-B amplifiers constitute the majority of all available hi-fi amplifiers because they offer greater efficiency, use far less current during idle, and have been refined to a high level of perfection. They have one or several pairs of complementary transistors, one type of which conducts on the positive and the other type on the negative half of the audio signal. This can lead to notch or crossover distortion if one of the transistor types cuts off before the other type conducts. (Class-C amplifiers, while considerably more efficient than class-A and class-B amplifiers, are confined to generating r-f energy because they conduct for only a portion of a half cycle and cannot create a replica of an audio signal.)

This brings us to the new class-D amplifier. Infinity, Inc., has displayed prototypes of a class-D amplifier for a few years, but still hasn't introduced it to the marketplace. It's said to be about 96% efficient, operating cool to the touch while delivering its full 250 watts/channel output power with little or no external heat sinking. This is a sharp contrast to the approximately 40% efficiency of the conventional linear class-B amplifiers that dissipate the power loss as heat.

Instead of using transistors as ordinary linear amplifiers, class-D circuitry uses them as switches. Audio inputs to a class-D amplifier are converted into pulses of varying widths that switch the output transistors on and off in excess of 500,000 times per second. With such a switching amplifier, none of the musical signal is processed through linearly operated transistors, which circumvents (theoretically) the problems of nonlinearities inherent in transistors.

The block diagram of Fig. 4 illustrates a typical configuration of a switching amplifier. As audio is applied to the input, it modulates a series of high-frequency pulses, varying pulse width as a function of instantaneous audio amplitude (Fig. 5). The power amplifier switching module amplifies the variable-width pulses, which are then fed to the demodulator. Components in the demodulator integrate the pulses into a recognizable audio waveform that follows the amplitude characteristics of the original input signal. The high-frequency residual components of the waveform are inaudible since they are well beyond the range of audio frequencies.

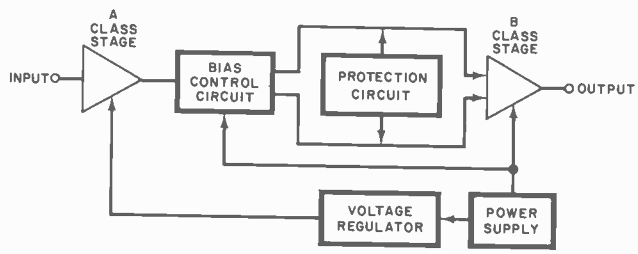


Fig. 3. Block diagram of Sony's TAN-8550 power amplifier with VFET's in output stage.

Delay in introducing this amplifier and others like it arises primarily because of r-f radiation caused by the powerful harmonics of the high-frequency pulses. These problems will no doubt be solved as work proceeds on perfecting the class-D audio amplifier.

It's interesting to note that prototypes of the Infinity class-D amplifier measure only 17" W × 11" D × 3" H (43.2 × 28 × 7.6 cm), yet produce a "cool" 250 watts of power per channel.

New Protection Levels. When solid-state amplifiers were first offered to consumers as hi-fi components, failure rates of transistors were high. This prompted manufacturers to design all manner of so-called protection circuits, ranging from simple fuses in the output lines to thermal and current sensing electronic circuitry

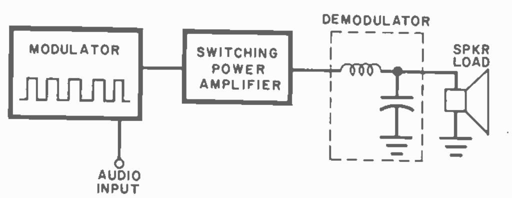


Fig. 4. Typical configuration of a class D switching power amplifier.

to turn off the audio output stages in the event of trouble. Today, output transistors are far more reliable and trouble-free, but the quest for totally failsafe protection circuitry continues. Often, the built-in circuit intended to serve as protection for the output stages of an amplifier or as speaker protection is almost as elaborate as the audio amplifier itself.

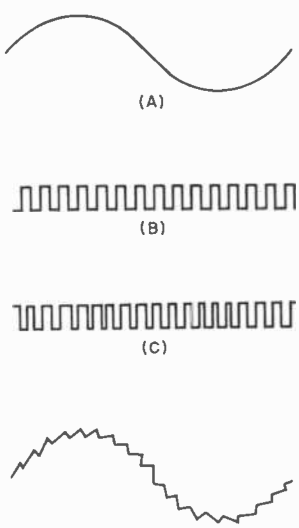


Fig. 5. With circuit in Fig. 4, audio signal (A) modulates pulses (B) to give pulses of varying width (C). These are then integrated to create replica of the original signal.

Recent rulings by the Federal Trade Commission may cause a bit of re-thinking with regard to amplifier protection design. It has been found that many top-rated amplifiers, when subjected to preconditioning requirements imposed by the FTC, often have their protection circuits triggered by the excessive heat generated during these preconditioning tests. (The tests require that an amplifier deliver one third of its rated output power for a full hour before final output-power measurements are made. Many people feel that such a preconditioning demand is unrelated to actual amplifier use in reproducing music, which calls upon only about one tenth of an amplifier's rated output power over the long-term period.)

In the interest of consumer safety and economy, most manufacturers have designed their protective circuits so that they cycle and open up the signal path before the hour of preconditioning is completed. However, according to the FTC, such cycling negates the preconditioning tests. Thus, manufacturers may have to set their thermal limits higher, add extra heat-sink material, or design protective circuits that will not be triggered by this arbitrary preconditioning requirement. The upshot is that the circulating fan is likely to become a familiar part of all high-power amplifiers if present interpretation of the preconditioning rule by the FTC persists. *(Editor's Note: As we went to press, we learned that the FTC, in a reinterpretation of the preconditioning requirement, will now permit amplifiers to cycle on and off as long as the total time accumulated in the on condition adds up to the required one hour.)*

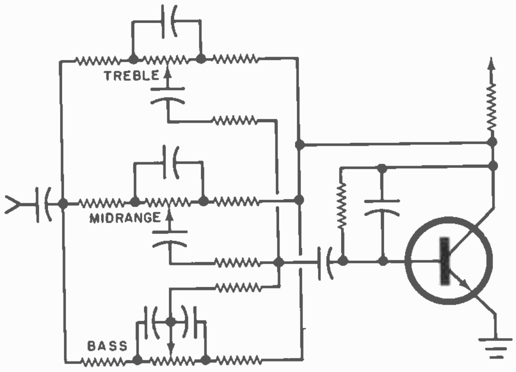


Fig. 6. Typical circuit of bass, treble, and midrange tone control arrangement.

Tonal Compensation. There was a time when serious audiophiles shunned the use of tone controls in a hi-fi music system, preferring flat response in the electronic portion of the system. Today, more and more people recognize that tone controls, when used properly, can restore tonal balance to compensate for speaker system irregularities, room acoustics, and associated component limitations. Perhaps part of the objection to the use of tone controls in the past stemmed from the limitations imposed by the conventional bass and treble control scheme. They affect wide portions of the audio spectrum but cannot provide the degree of precision that is often needed to adjust system response.

One control that is appearing on even some moderately priced receivers and amplifiers is the midrange tone control that offers boost or attenuation of the middle frequencies. A partial schematic diagram of the tone-control section of the Realistic Model QTA-770 4-channel

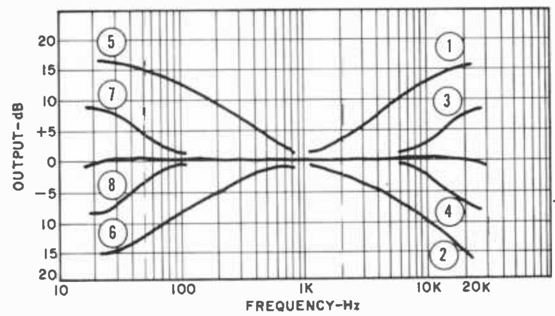


Fig. 7. Curves 1 & 2 and 3 & 4 are for treble controls; 5 & 6 and 7 & 8 are bass.

receiver illustrates this in Fig. 6. It shows how the midrange control is incorporated into the familiar feedback tone-control system. Components surrounding the center potentiometer in the diagram are chosen to provide a midrange boost or cut of about 6 dB at a 1000-Hz center frequency. The other two potentiometers are the conventional bass and treble controls that are hinged at about 1000 Hz.

Other manufacturers have made tone controls more flexible by using main and "sub" tone controls for the bass and treble. The main controls are hinged at 1000 Hz, while the sub controls alter frequency response only at the extremes of the audio spectrum — in the regions where only a small amount of tonal compensation is often required for correction of speaker deficiencies. The

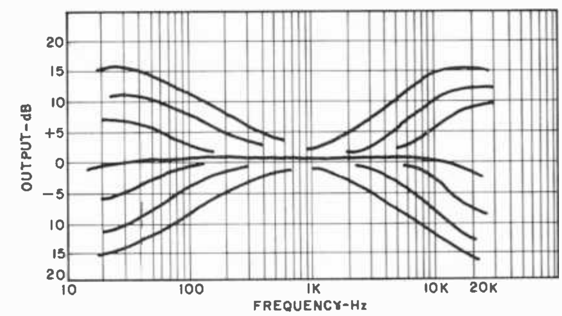
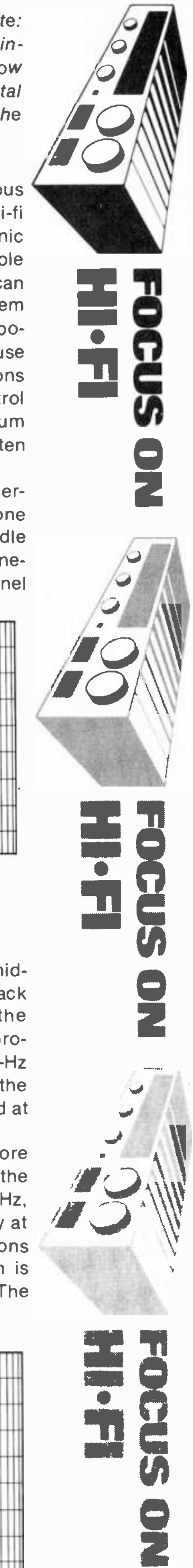


Fig. 8. With multiple switching, tone controls have selectable turnover points.



control range afforded by these dual-control arrangements is shown graphically in Fig. 7. Alternatively, other manufacturers offer variable turnover tone controls. The usual bass and treble controls are supplemented by multiple-position switches that are used to select the frequency at which the bass or treble boost or cut action begins (see Fig. 8).

It is difficult to say whether the presence of multiple tape monitoring facilities on modern hi-fi equipment has given rise to the creation of new kinds of accessory products or that the situation is the other way around. One accessory that appears to be gaining in popularity is what might be called the "ultimate" tone control: the tonal (or graphic) equalizer. Such multi-control units permit specific adjustment of small frequency segments and, if they are equipped with a sufficient number of controls, allow the user to tailor overall response to meet personal tastes or to provide compensation for room acoustics.

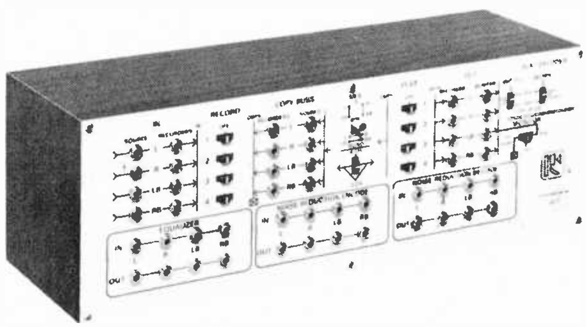


Fig. 9. Russound/FMP control center and patch bay.

The Phase-Locked Loop. The phase-locked loop, or PLL, first made its appearance in hi-fi equipment in the form of multiplex (stereo FM) decoders. Offering more stable performance and lower distortion than conventional decoders, the PLL is unencumbered by tuned coils or variable capacitors and is more stable and offers better stereo separation across the audio band. Other current applications for the PLL include its use in the front ends of FM tuners and receivers, where (when combined with crystal frequency synthesizer tuning and digital electronics) they can ensure precise tuning of FM stations. With such tuning accuracy comes lowest possible audible distortion.

Examples of the combined use of PLL's are already represented by Kenwood's Model 700-T frequency-synthesizing tuner and Scott's newly announced digital receiver.

Four-Channel Sound. Interest in 4-channel sound should be heightened as complex SQ decoder circuitry (including logic enhancement) and new and better CD-4 demodulator circuits (which also use the PLL principle in their latest designs) are reduced to large-scale IC form.

Developments in 4-channel sound are not confined to price reduction and miniaturization. Almost two years ago, a company called Tate and its inventor-engineer Wes Ruggles demonstrated to an amazed audience a "retro-fit" SQ decoder that yielded 4-channel reproduction that was indistinguishable from original discrete quadraphonic master tapes.

The Tate device accepts the four outputs from a basic SQ decoder and electronically processes them to provide as much channel separation as characterized by the best 4-channel discrete tape program sources. Now, National Semiconductor and Wes Ruggles, in a joint effort, have reduced the processor circuit to IC form. We may soon be able to buy a retro-fit SQ decoder that will make any 4-channel system, however minimal its previous SQ decoder circuitry, into a super-performance 4-channel sound system.

In the coming months, we may also hear news of a decision on the part of the Federal Communications Commission on permitting 4-channel discrete broadcasting over the FM band, using one of the recently tested systems designed for that purpose. The foregoing and the ever-growing amount of software suggest that quadraphonic sound is here to stay, though its initial growth pattern was slower than anticipated.

Noise and Dynamic Range. During the past year, we have been witness to increasing effort devoted to overcoming what many people consider to be the remaining two impediments to faithful reproduction of sound in the home: restricted dynamic range and residual background noise.

Dolby noise reduction systems have been a part of the hi-fi scene for some years now. But who would have guessed a few years ago that a cassette deck, complete with Dolby circuits, could be obtained for less than $200 when the Dolby circuits alone initially cost that much money? Again, the credit goes to putting the circuits in IC form.

Other noise-reduction systems have also come onto the market, holding fully as much promise as that first offered by the Dolby system. There is the dbx encoding/decoding system, for example, that operates on a compression/expansion (compander) principle. In theory, it can double available dynamic range on tape and disc recordings, while at the same time reducing background noise to virtual inaudibility.

Both the Dolby and the dbx systems are double-ended. Program material must first be encoded, either during recording or broadcasting, and then decoded at the listening end. Many techniques have been and are being developed that are single-ended while still reducing noise, increasing dynamic range, or both when simply added to the playback system. The most sophisticated of these so far is Phase Linear's Auto-Correlator circuit that can actually differentiate between noise and musical waveforms. It is designed to reduce the noise and pass the music.

Another approach to dynamic expansion and noise reduction can be found in Pioneer's Model RG-1 dynamic processor. The processor has a switch that determines the amount of expansion required, based on how much compression you feel has taken place in the original program. (Some recordings and FM broadcasts are compressed more than others.) In addition, the processor employs "forward expansion" to make the softs softer and the louds louder. This system not only restores greater dynamic range, but it actually reduces audible background noise to a level where it can be further expanded downward in amplitude.

A somewhat simpler approach to the problem of noise reduction is employed in the Burwen Model 1201 dynamic filter, which opens up full bandwidth when high-frequency program content is supposed to come through but restricts bandwidth when highs are absent. As a result, the system dynamically reduces noise, which is basically a high-frequency phenomenon. Single-ended, the system does not require prior encoding of the program material.

Handling the Accessories. Many of the new devices we have described are intended as add-ons to existing hi-fi amplifiers and receivers via tape monitoring jacks. Unfortunately, even the best hi-fi equipment often lacks

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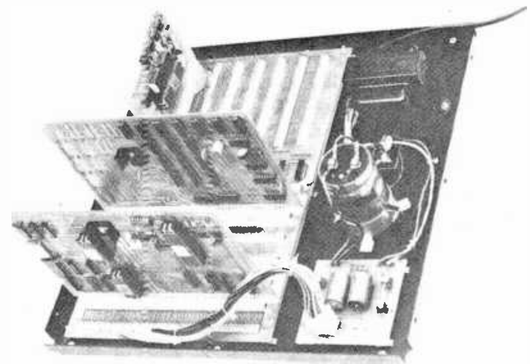

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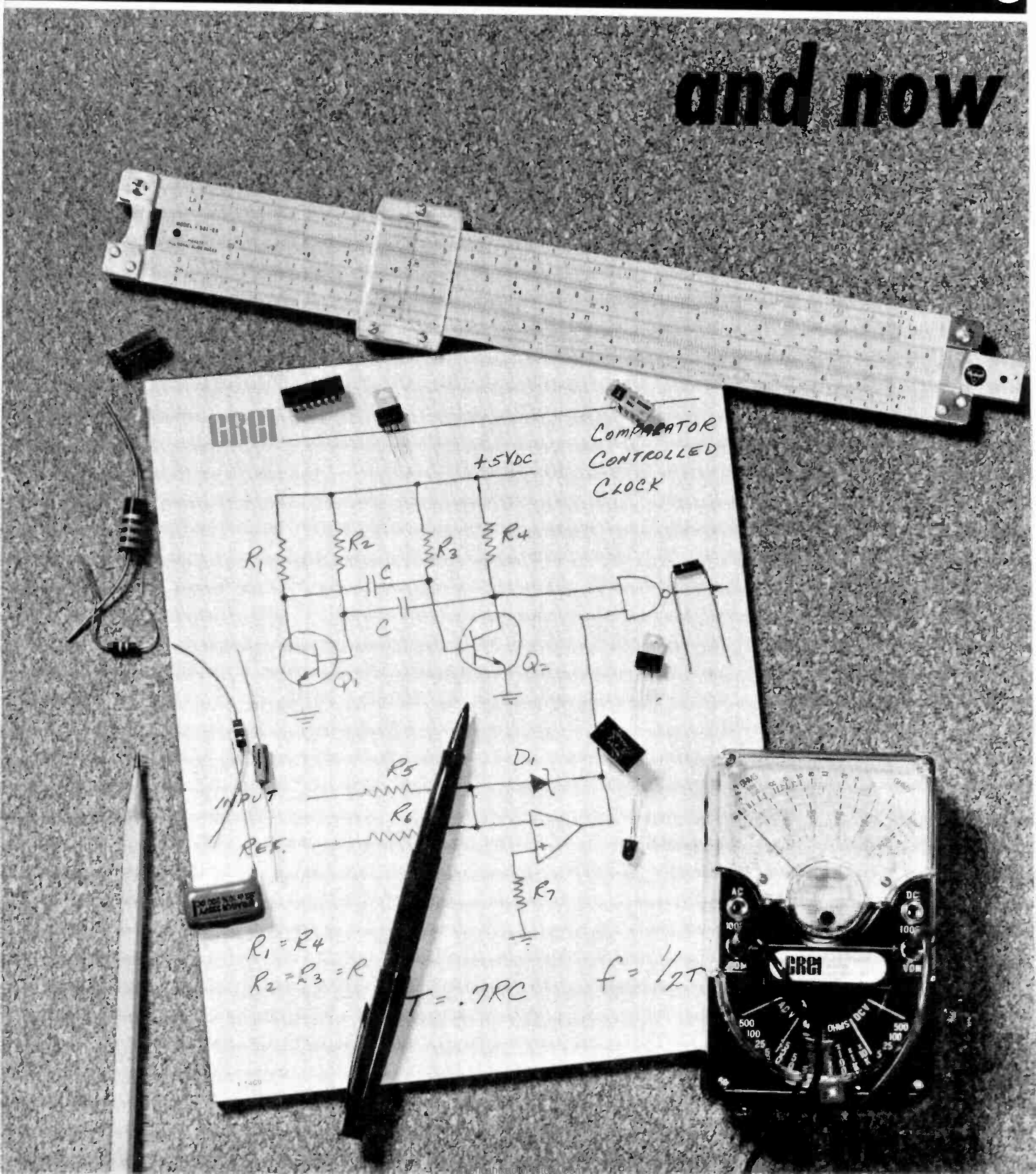


sufficient numbers of tape monitor jacks to accommodate all of the accessories one might want to use in his system. Consider the plight of the demanding audiophile who has one or two tape decks, an equalizer, a 4-channel decoder, and a noise-reduction accessory—all to be connected into his system through tape monitor jacks. This is exactly what Russound/FMP, Inc. had in mind when they devised the Model QT-1 control center and patch bay shown in Fig. 9.

The control center is a completely passive accessory that permits connection of as many as four tape decks, a discrete and matrix 4-channel decoder, an equalizer, and a noise-reduction system in either a stereo or a 4-channel system. Only a single set of tape monitor jacks is needed on the amplifier or receiver. Everything else is handled by the input and output jacks on the rear panel of the control device.

Closed-circuit jacks and switches on the control accessory's front panel enable you to patch just about any program source to any destination.

Non-Audible Circuitry. Advances in the electronics of hi-fi equipment are not confined to circuits that contribute directly to the manner in which sound is reproduced. Electronic circuits have been developed to ease the use of the equipment as well. For example, one hi-fi component carries audio muting to a new level of simplicity.

Many audio amplifiers feature a toggle or pushbutton switch that can be used to lower the volume level of the sound by a fixed amount (usually 20 dB), which is useful when you have to answer a telephone. By throwing the switch, it eliminates the need to alter master volume settings.

Now, Lux Audio of America, Ltd., has introduced a feature called "touch muting" to two products in its line. The master volume control knob on the Model C-1000 preamplifier and Model L-100 integrated amplifier contains a metal insert on the front and a separate metal trim around the rim. You simply touch the front insert to reduce the volume level by about 20 dB and restore full volume by touching the outer rim.

Conclusion. If you survey the entire field of electronics as it relates to the design of hi-fi components each year, advances in technology and features seem rather small. Looking back 10 years or so, however, the cumulative improvement in hi-fi equipment has been tremendous. ◈

FOCUS ON HI-FI

CHOOSING A PHONO CARTRIDGE

A GUIDE TO THE VARIOUS TYPES AVAILABLE AND HOW TO INTERPRET SPECIFICATIONS

BY JULIAN D. HIRSCH

The task of the phono cartridge is to trace the microscopic groove modulation on a record disc and convert the mechanical motion into an analagous electrical voltage. The performance of this function depends on the interaction of the cartridge's mechanical and electrical circuit elements. Mechanically, the cartridge's element usually consists of a precisely shaped jewel stylus mounted at the free end of a cantilever tube or rod. The stylus rides in the V-shaped groove of the disc and follows the contours of the groove wall. At the pivoted end of the cantilever is a transducing element that converts the motion of the stylus into an electrical voltage. Needless to say, much design effort has gone into developing cantilevers with low mass and high stiffness so that stylus motion is faithfully transmitted.

The electrical circuit of the phono cartridge must generate an output that is linearly related to some aspect of the stylus motion. In magnetic cartridges, this is the *velocity* of the stylus or how rapidly in cm/s it moves from side to side or up and down as it follows groove modulation. Some cartridges are *amplitude* responsive and have an output that is proportional to the amount of stylus deflection rather than to how rapidly it occurs.

The vast majority of hi-fi cartridges employ a magnetic principle and contain coils of fine wire in which the output voltage is induced by a magnetic field varying with the motion of the stylus. The inductance of these coils, interacting with the external circuit capacitance and resistance loads, can significantly affect the frequency response of the cartridge.

Types of Cartridges. There are several types of magnetic cartridges. Most of them use the *moving magnet* principle, with a piece of magnetic material at the pivoted end of the cantilever, surrounded by the pole pieces of the coils into which voltages are induced as the magnet is set into motion by the stylus motion. Another type has fixed magnets embedded in the plastic body of the cartridge. A small piece of magnetically permeable material on the cantilever varies the flux distribution between the pole pieces to generate the output voltage. Other designs, known as *variable-reluctance* or *induced-magnet* cartridges, accomplish the same end with slightly different internal construction.

Moving-coil cartridges, considered by many people to have the most ideal characteristics, have fixed magnets and pole pieces. Tiny coils attached to the cantilever are moved between the poles. Since the coils contain no magnetic material, the effective mass that must be accelerated by the stylus is low—a desirable feature for extended high-frequency response and low record wear. On the other hand, the coils are very small and delicate. Since they consist of relatively few turns, the output voltage is much lower than in other types of magnetic cartridges. A separate step-up transformer (or preamplifier) is usually required to increase the output of the cartridge to a level that is usable with conventional phono preamplifiers. Also, the moving-coil construction does not easily lend itself to stylus replacement by the user. In general, the entire cartridge must be returned to the factory for stylus replacement, in contrast to the easy plug-in stylus assemblies used on most cartridges.

Piezoelectric, or ceramic, cartridges have not been popular for hi-fi applications. They are inexpensive, however, and generate a rather high output voltage. The stylus motion bends or twists a ceramic element, which

FOCUS ON HI-FI

generates a voltage that is proportional to stylus displacement. Ceramic cartridges require an appreciable amount of work from the stylus, which translates into higher tracking force and greater record wear than would be acceptable in quality hi-fi systems. Also, since every modern amplifier has inputs for magnetic cartridges, there is no economic advantage in using a cartridge whose chief feature is that it does not require the high gain and equalization afforded by such inputs.

Electret cartridges (manufactured by Micro/Acoustics) are a more promising variation of the piezoelectric effect. The electret is a permanently polarized plastic capacitor that responds to stylus motion in much the same manner as a ceramic element. However, it requires considerably less effort from the stylus and record groove. In its commercial form, the output level and response characteristics are made to be compatible with standard magnetic cartridge inputs on amplifiers. The advantage of the electret cartridge over magnetic cartridges is its independence of load capacitance (it has no inductance) and immunity to magnetically induced hum, although it is potentially sensitive to electrostatic fields.

Strain-gauge cartridges (made by Panasonic) have many of the virtues of the electret cartridge. In this cartridge, the stylus motion bends semiconductor elements and varies their dc resistance. A direct current is passed through the element, converting its resistance variations into a signal voltage. The cartridge is an amplitude-responsive device. It requires a suitable direct-current source for its operation. Therefore, it is presently usable with only certain receivers and CD-4 demodulators manufactured by Panasonic for the company's Technics line.

Cartridge Specifications. Although it might appear to be a simple procedure, interpreting phono cartridge performance specifications is not easy. The published specifications for a cartridge will usually list a "frequency response," often without stating the tolerance in decibels and almost never specifying the test record or load conditions. Since every test record has its own peculiarities, such a specification is worthless. The same cartridge tested with 10 different test records will almost certainly yield as many different response curves. The output voltage is usually stated, and even though this is an ambiguous rating in the absence of the test velocity, it is adequate for establishing system compatibility.

The most important specification, fortunately, is always given: the range of tracking forces over which the cartridge is designed to operate. Knowing this, it is possible to determine in advance if the cartridge will be compatible with a given tonearm or record player. To a considerable extent, one can also infer from this rating the overall quality of the cartridge and the compliance (hence, fragility) of its stylus cantilever. There are exceptions to this rule, but it is usual to find lower tracking forces, directly related to high compliance, associated with good tracking ability, wide frequency response, and generally good sound characteristics.

Stereo channel separation is often stated, sometimes as a single (meaningless) figure and sometimes at a single frequency (almost as meaningless), usually 1000 Hz. Once the separation exceeds 15 dB, a further improvement will probably not be audible. More important is the manner in which the separation is maintained over a wide frequency range. Some early stereo phono cartridges had little or no separation at the higher frequencies, which could seriously degrade their stereo imaging. Fortunately, this problem is virtually nonexistent in modern cartridges.

Since the load resistance and capacitance can have a significant effect on the frequency response of a magnetic cartridge, the manufacturer usually specifies a recommended load. For stereo cartridges, the recommended load is usually 47,000 ohms, while for CD-4 cartridges, it is usually 100,000 ohms. If capacitance is an important factor, it may also be specified. Most stereo cartridges are not too critical with respect to capacitance so that the typical 200 to 300 pF is satisfactory. (Shure cartridges deliver their flattest response with a higher load, in the range of 400 to 500 pF.)

For a magnetic CD-4 cartridge to maintain an effective frequency response up to 45,000 Hz, the circuit capacitance should be kept to less than 100 pF. It is difficult, if not impossible, to determine the actual load capacitance of a cartridge without measuring it, but CD-4 cartridges perform at their best when the special low-capacitance cables are used, in conjunction with low-capacitance wiring in the tonearm.

Sometimes, the inductance and capacitance of the coils of a magnetic cartridge are specified. The inductance is of interest if the preamplifier's input circuit is affected by it. To some degree, most inputs are so affected, usually resulting in a loss in high-frequency response (above 10,000 Hz or so) whose magnitude increases with the inductance of the cartridge. On the other hand, some amplifiers are relatively immune to the effects of inductance.

Although cartridges differ widely in their external physical form, the ½" (12.7-mm) mounting center dimension is universal. Additionally, most cartridges have the tip of the stylus located ⅜" (9.5 mm) in front of the mounting holes. This simplifies interchanging several cartridges in plug-in shells on the same tonearm. The arm position for correct overhang will be correct for all cartridges with the same dimensions.

Output terminal sizes and locations are not standardized. However, most cartridge manufacturers adhere to a color-code convention that simplifies installation in tonearms that use the same code (white for left, blue for left ground, red for right, and green for right ground).

One cartridge parameter that is more important than you might at first think is its *mass* (sometimes referred to as its weight). Don't confuse this with tracking force, to which it is not related. The cartridge mass can affect the system in two ways. Tonearms are designed to balance cartridges within a limited range of masses, such as 5 to 12 grams. It may not be possible to balance the tonearm correctly if the mass falls outside those limits. The low-frequency resonance of the cartridge's compliance and the combined mass of the tonearm and cartridge can affect the stability of the pickup when playing warped discs or when under the influence of external vibration or shock.

Cartridges Today. Stereo phono cartridges still dominate the market. In fact, most manufacturers appear to be cautious about releasing new CD-4 cartridges. A successful CD-4 cartridge must have a specially shaped stylus, such as the Shibata or equivalent shapes developed by manufacturers outside of Japan. This is an expensive stylus, and CD-4 cartridges are themselves quite costly. Prices appear to be going up rather than coming down, but performance is rising proportionately. There has been one attempt to make a CD-4 cartridge with a conical stylus (the low-priced Grado Model FTR+1). However, its very small stylus radius causes greater record wear than does a Shibata stylus.

Many of the design considerations needed to provide a flat frequency response and good channel separation in the 20,000-to-50,000-Hz range are not consistent with the best performance in the audio band. As a result, until recently, none of them could seriously challenge the top three or four stereo cartridges in tracking ability and smoothness of response in the audible range. ◈

A NEW INDUSTRY STANDARD FOR FM TUNER MEASUREMENT

BY LEN FELDMAN

Copies of the new "Standard Methods of Testing Frequency Modulation Broadcast Receivers," IEEE Std 185-1975 and IHF-T-200, 1975, are available from the Institute of High Fidelity, 489 Fifth Ave., New York, NY 10017 and from the Institute of Electrical and Electronics Engineers, 345 E. 47th St., New York, NY 10017. 35 pages (8½" × 11"), $6.00 soft cover.

PART 2

LAST month, we examined the new reference level of signal strength for FM tests, the *femtowatt*. From now on, measurements such as sensitivity will be based on this dBf yardstick (0 dBf = 1 femtowatt = 10^{-15} W). Besides simplifying tuner tests, the new Standard also eases the task of presenting results in graph form.

Curve Plotting. Since signal strength, or more precisely the amount of signal power available to the tuner, is now to be expressed by a logarithmic function, semi-log graph paper is no longer needed. So, quieting and distortion curves can be drawn on ordinary (cartesian) graph paper. This is shown in Fig. 3, a sample set of Monophonic Sensitivity Curves. Note that "Muting Threshold," a newly required spec, is depicted on this graph (at about 25 dBf). Also shown are the "Muting Ratio" (not all muting circuits produce absolute silence between stations) and the "Hysteresis" effect (some circuits don't cut off the audio at exactly the same signal level that they turn it on).

Other significant points that can be picked off these curves are:

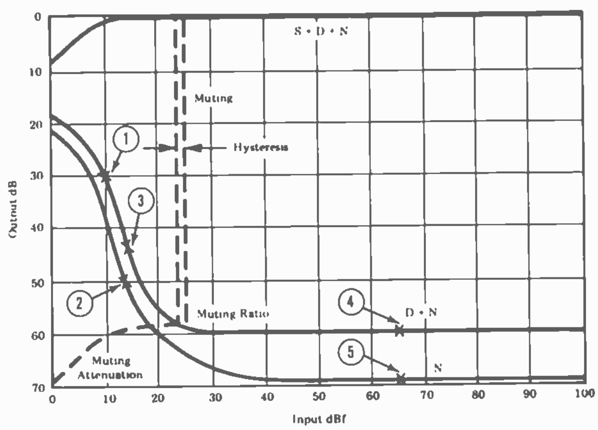


Fig. 3. Monophonic sensitivity curves.

(1) "Usable Sensitivity" (about 10 dBf here);
(2) "50-dB Quieting Sensitivity" (13 dBf);
(3) "Distortion at 50-dB Quieting" (about −43 dB, or 0.71%);
(4) "THD at 65 dBf" (−60 dB, or 0.1%); and
(5) "S/N at 65 dBf" (69 dB).

Some tests remain more or less unchanged, except for their use of the dBf reference. Among them are "Frequency Response from 30 to 15,000 Hz," "IM Distortion," "Image Rejection," "IF Rejection," "Spurious Response," "AM Suppression" ratios, and "Frequency Drift." Secondary monophonic measurements that are not an IHF requirement for disclosure include "Hum and Noise at 65 dBf," "Minimum Volume Hum and Noise," "RF Intermodulation," "AFC Correction Factor," and "AFC Offset Error." Testing procedures for these supplementary specs are detailed in the new Standard.

Stereophonic Performance Tests. Here's one of the most important contributions of the new Standard. As mentioned in Part One, the previous standard did not cover stereophonic performance of FM tuners and receivers. The result was an incomplete and inconsistent picture of stereo FM components. With the new Standard, stereo FM performance tests are delineated, and manufacturers must disclose all performance qualities that differ from those in the monophonic mode.

Thus, "Usable Stereo Sensitivity," "50-dB Quieting Sensitivity in Stereo," "Stereo Threshold," "S/N at 65 dBf in Stereo," "Stereo Frequency Response," and "Stereo Distortion" (at 50-dB Quieting and at 65 dBf) must be reported along with their mono counterparts. To make the figures more realistic, the modulation signal used must be "L = −R," not "L only" or "R only," as was formerly the case. This results in a composite signal containing no baseband information, but only the stereo subchannel and the 19-kHz pilot carrier. Although results from these tests will appear to be somewhat poorer than before, they will reflect what the "worst case" performance will be.

A typical set of Stereophonic Sensitivity Curves is shown in Fig. 4. The stereo switching action (1) is

Table II. Sample Specification Sheet

Specification	Monophonic	Stereophonic
Usable Sensitivity	10 dBf (1.8 μV)	20 dBf (5.5 μV)
50 dB Quieting Sensitivity	13 dBf	33 dBf
S/N at 65 dBf	70 dB	65 dB
Muting Threshold (Stereo Threshold)	20-30 dBf (variable)	30 dBf
Frequency Response, 30-15 kHz	± 1dB	+0, −2 dB
Distortion at 50 dB Quieting		
100 Hz	1.05%	1.0%
1,000 Hz	0.8%	0.9%
6,000 Hz	1.0%	2.0%
Distortion at 65 dBf		
100 Hz	0.4%	0.6%
1,000 Hz	0.3%	0.5%
6,000 Hz	0.5%	1.3%
Intermodulation Distortion	0.5%	1.0%
Capture Ratio	1.3 dB	—
Adjacent Channel Selectivity	22 dB	—
Alternate Channel Selectivity	80 dB	—
Spurious Response Ratio	95 dB	—
Image Response Rejection Ratio	85 dB	—
IF Rejection	90 dB	—
AM Suppression Ratio	60 dB	—
Frequency Drift	±30 kHz	—
Stereo Separation		
100 Hz	—	35 dB
1,000 Hz	—	42 dB
10,000 Hz	—	30 dB
Subcarrier Product Rejection	—	60 dB
SCA Rejection Ratio	—	65 dB

indicated, by the sudden drop in output (S+N+D) and decreased noise and distortion as the tuner automatically "switches back" into mono at the stereo switching threshold. And thanks to the linear scales, the curves are much easier to interpret. Other salient points are (2) "Usable Sensitivity in Stereo," (3) "50-dB Quieting Sensitivity in Stereo," (4) "Distortion at 50-dB Quieting in Stereo," (5) "Distortion at 65 dBf in Stereo," and (6) "S/N at 65 dBf in Stereo."

Stereo Separation. In the past, most manufacturers reported their products' stereo separation capacities at 400 or 1000 Hz only. The new Standard specifies that channel separation must be rated at three separate frequencies—100, 1000, and 10,000 Hz. Furthermore, if a tuner or receiver is equipped with a "blend" circuit (to reduce noise on weak-signal stereo programs), reduced separation will be experienced at mid and high frequencies with the "blend" activated. To reflect this, the manufacturer is expected to disclose realizable separation at 1000 and 5000 Hz under "blend" conditions.

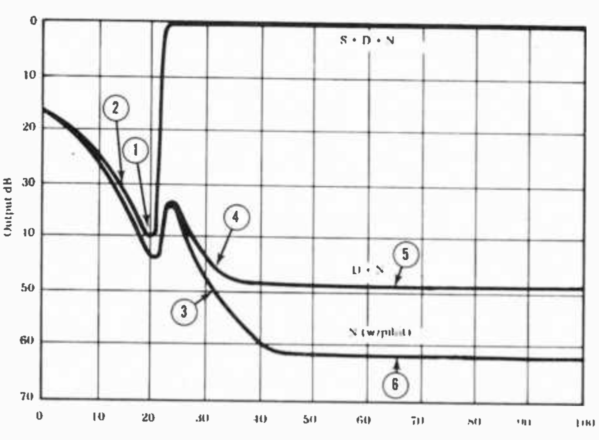
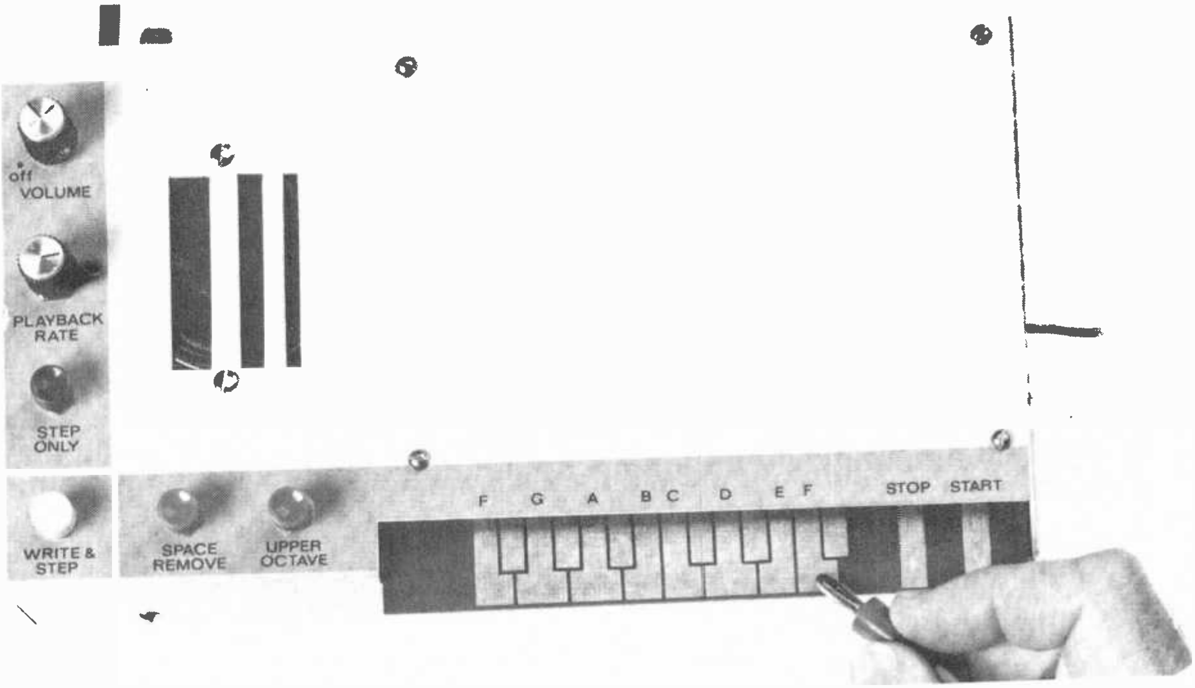


Fig. 4. Stereophonic sensitivity curves.

Other Stereo Specs. Multiplex circuits often generate high-frequency products that are not part of the desired audio information. Such products consist of 19- and 38-kHz carrier components which have not been totally filtered out. Although they are inaudible, they can adversely affect "off-the-air" recordings made on ac-biased tape machines. Accordingly, "Subcarrier Product Rejection" (expressed in dB referenced to 100% modulation) must now be reported.

Additionally, the unit's ability to reject SCA subcarriers (67-kHz signals modulated by "background music") must be specified in dB referenced to 100% modulation. For this test, a 67-kHz SCA subcarrier modulates the main carrier 10%. In turn, the sub-carrier must be modulated by a 2500-Hz audio signal, causing a maximum subcarrier deviation of ±6 kHz—the "worst case" condition.

A Typical Spec Sheet. The specification sheet—a capsule summary of tuner performance—reflects all the changes induced by the new Standard. For a preview of what it will now look like, see Table II. This not only lists the required specifications that we've examined, but also offers a sample set of figures for a modern, good-quality component. Undoubtedly, you'll learn a lot more than before about the new tuner that's caught your eye and ear by considering its specifications based on the new FM broadcast receiver standard. ◈



CONSTRUCTION

THE PROGRAMMABLE MUSIC BOX PART 1

Compose your own tunes for playback at any time.

BY MITCHELL WAITE AND LARRY BROWN

THE PROGRAMMABLE music box presented here represents an important evolutionary step in music box design. Employing a *reusable* RAM (random-access memory) rather than a nonvolatile ROM (read-only memory) IC, a melody can be programmed, stored, and played back on command. The melody can be erased or a programming error corrected without spending an additional cent. And you can hear each note as it is programmed. Furthermore, it features a unique piano type of keyboard entry to simplify programming, play tunes much as one would do with a forefinger on a conventional piano, and double as a teaching tool for music scales. The memory system is static. As long as power is applied to the music box, a tune in the memory will remain there until it is erased or power is interrupted.

The music box can be started by any type of spst switch. Thus, it can be used as a musical doorbell, jewelry box, cigar case, etc. Although it is self-contained, if you wish louder volume for the tune being played, the output of the music box can be fed into an amplifier.

As presented here, the music box has a 40-word memory system. Next month, we will describe how to add another 256 words to the system for playing long tunes, and describe how to program the Music Box.

About the Circuit. The block diagram shown in Fig. 1 illustrates how the system operates. The input is via a monophonic 26-note keyboard. Depending on the shortest note in the tune, you can store up to 40 notes in a hex 40-bit shift register. A WRITE/STEP switch enters the selected note into the memory and then advances to the next memory position. The SPACE REMOVE switch controls the pause between individual notes and allows the user to control the duration of the note. A RATE control permits regulation of the playback speed. Supplementing these controls are the VOLUME control, OCTAVE switch, and a STEP ONLY switch. START and STOP pads on the printed circuit board to the right of the "piano" keys control the operation.

In operation, a positive voltage applied to the keyboard (via a simple probe) forms the input to a diode encoder that produces a four-bit parallel binary word each time a key is activated. The words are deposited in the shift register (reusable memory) by activating the WRITE/STEP switch. This also steps the memory forward by one

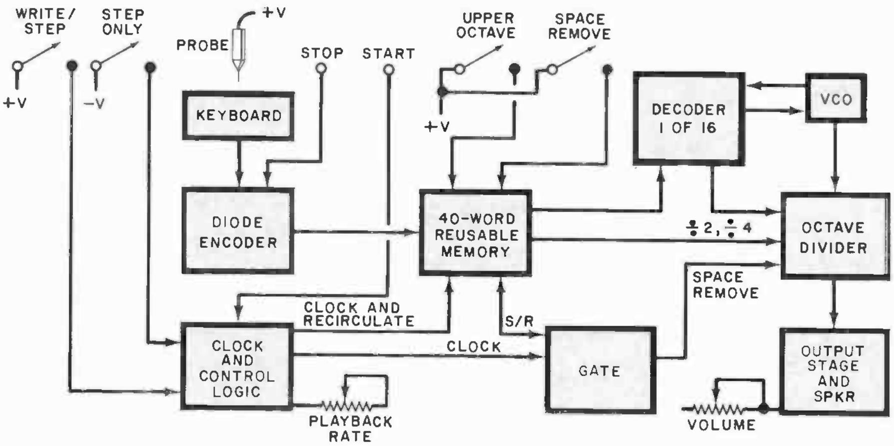
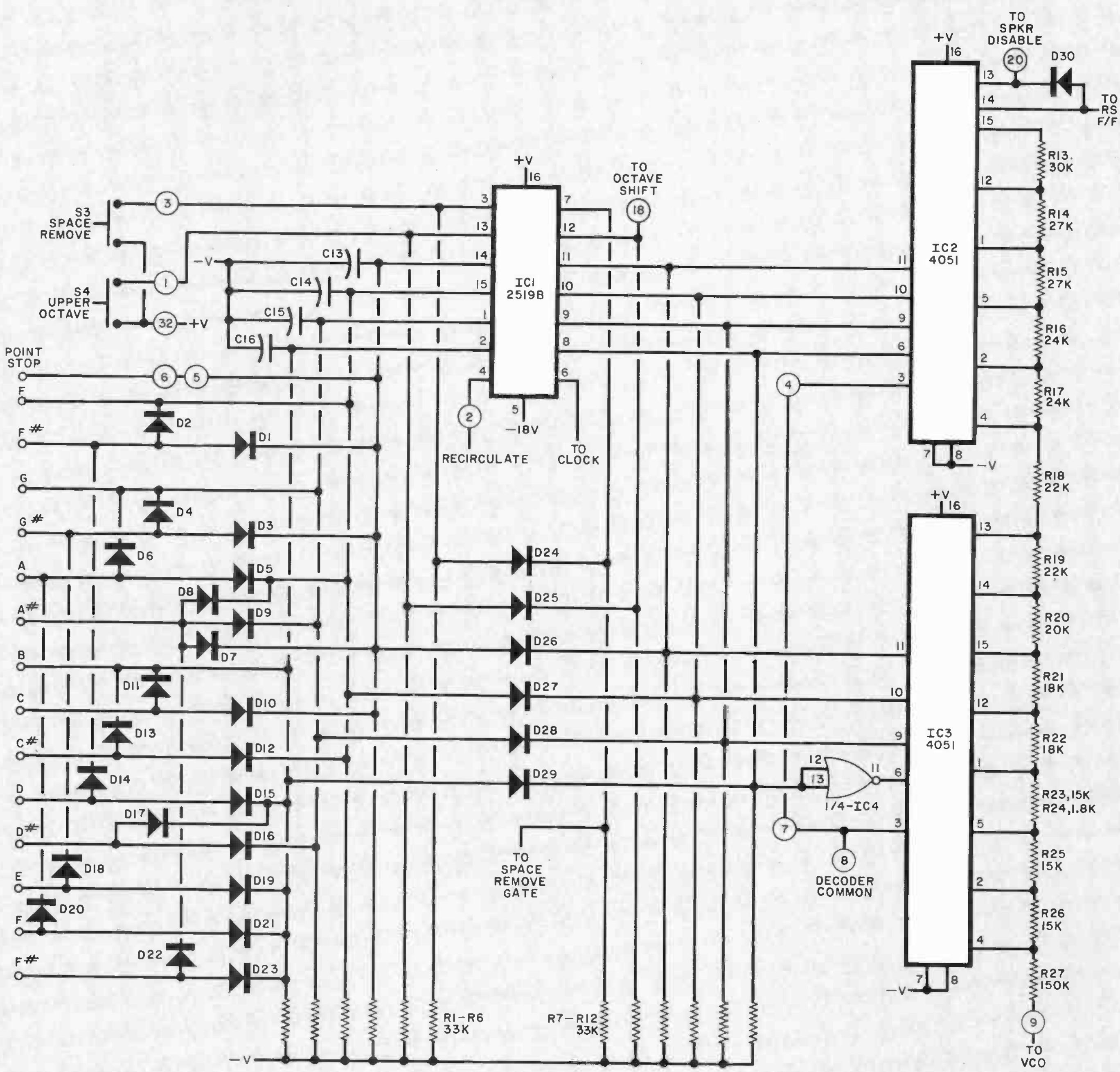


Fig. 1. Block diagram shows how the music box works. Input is made by touching a probe to the keyboard.

word. The output of the memory is decoded into a four-bit binary pattern and passed to a one-of-16 decoder that programs the frequency of the audio vco. This part of the system is basically a digital-to-frequency converter that has 14 frequencies spaced according to the musical scale. An OR'ing diode network connects the keyboard directly to the decoders to allow the keyboard to operate the vco, space remove, and octave functions.

The output of the vco goes to an octave divider for division by 2 or 4 to double the range of the keyboard. The divider and gate-enable circuits work together to insert a space between



notes, which controls the timing and each note's relative length. The memory also contains a register that holds the space information and the state of the bit in this register tells the clock whether or not to insert a space after the note is played. Leaving out the space makes the notes run together. The output of the octave divider goes to an audio amplifier that drives a speaker.

An astable oscillator, which contains a variable RATE control, provides the clock pulses that step the memory through each word and play the programmed melody.

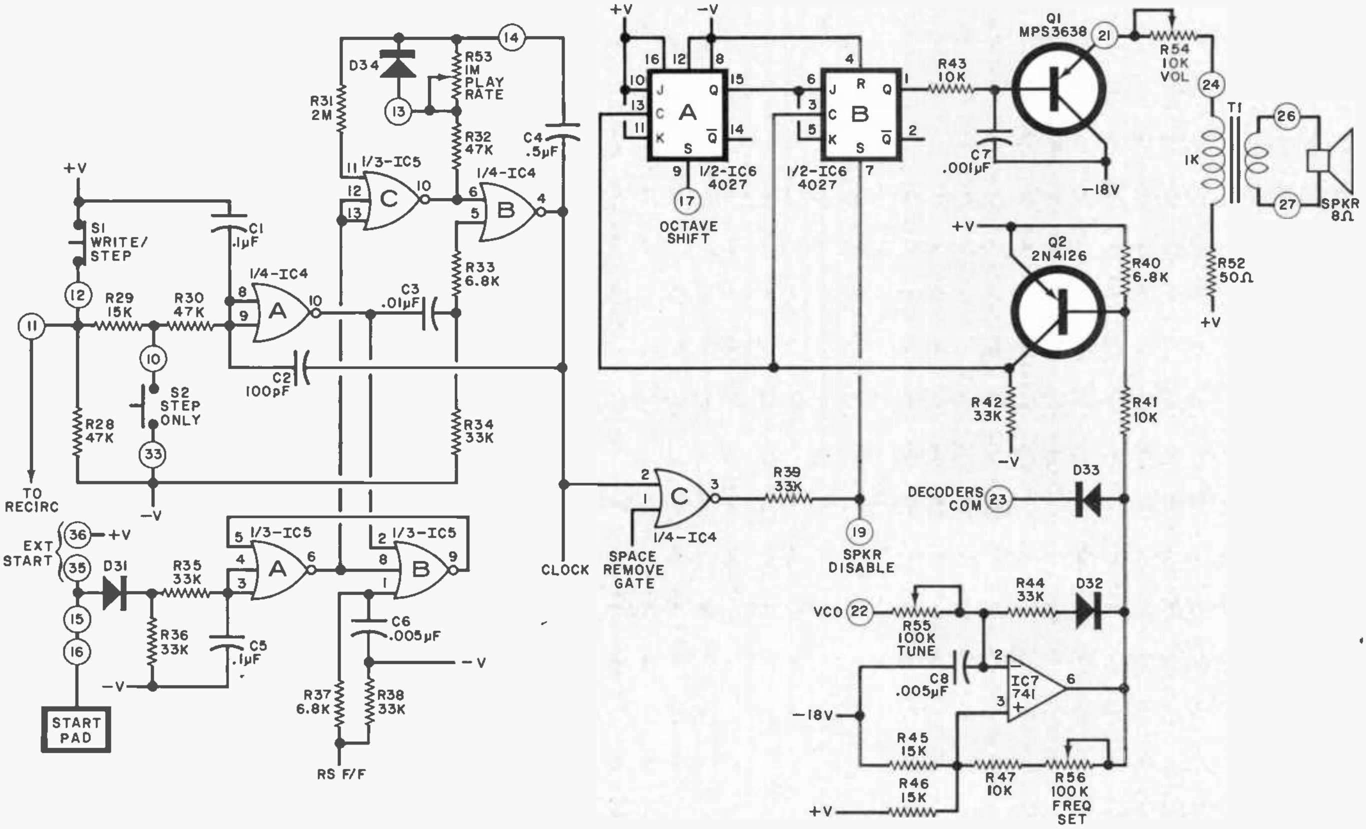
The complete schematic diagram of the music box is shown in Fig. 2. The vco consists of *IC7* (a 741 op amp). Two binary-to-octal decoders, *IC2* and *IC3*, produce the 14 frequencies spaced according to the western equally tempered scale (ETS). The actual frequencies are determined by *R13* through *R27* in the feedback loop of the vco. Four-bit parallel words from memory *IC1* or the keyboard are decoded and a register junction is enabled. The vco then oscillates at a frequency determined by the total resistance in the chain. The key of the vco is

PARTS LIST

C1,C5,C11,C12—0.1-μF, 50-volt Mylar capacitor
C2—100-pF, 50-volt disc capacitor
C3—0.01-μF, 50-volt Mylar capacitor
C4—0.5-μF, 50-volt Mylar capacitor
C6,C8—0.005-μF, 50-volt Mylar capacitor
C7—0.001-μF, 50-volt Mylar capacitor
C9—50-μF, 25-volt electrolytic capacitor
C10—470-μF, 25-volt electrolytic capacitor
C13 through C16—200-pF, 50-volt disc capacitor
D1 through D34—1N4148 (or similar) diode
IC1—2519B 40-bit shift register (Signetics)
IC2,IC3—34051CP one-of-eight decoder (Fairchild)
IC4—34001CP quad 2-input NOR gate (do not substitute) (Fairchild)
IC5—34025CP triple 3-input NOR gate (do not substitute) (Fairchild)
IC6—34027CP dual JK flip-flop (Fairchild)
IC7—741 operational amplifier
Q1—MPS3638 transistor
Q2—2N4126 transistor

Following resistors are ¼-watt, 5% tolerance:
R1 through R12,R34,R35,R36,R38,R39, R42,R44—33,000 ohms
R13—30,000 ohms
R14,R15—27,000 ohms
R16,R17—24,000 ohms
R18,R19—22,000 ohms
R20—20,000 ohms
R21,R22—18,000 ohms
R23,R25,R26,R29,R45,R46—15,000 ohms
R24,R49—1800 ohms
R27—150,000 ohms
R28,R30,R32—47,000 ohms
R31—2 megohms
R33,R37,R40—6800 ohms
R41,R43,R47,R48,R51—10,000 ohms
R50—330 ohms
R52—47 ohms
R53—1 megohm
R54—10,000-ohm audio-taper potentiometer with spst switch
R55,R56—100,000-ohm horizontal printed-circuit trimmer potentiometer
S1—Spst momentary-action, normally closed switch
S2 through S4—Spst momentary-action normally open switch
SPKR—8-ohm, 2" diameter speaker
T1—1000:8-ohm, 150-mW matching transformer
Misc.—Probe with banana-type tip; control knobs (2); battery holder (optional); chassis (LMB No. LMB-5952 or similar); spacers; dry-transfer lettering kit; mounting hardware; hookup wire; solder; etc.
Note: The following items are available from Cal Kit, P.O. Box 877, Sebastopol, CA 95472: Drilled and plated printed circuit board No. MC1-3 at $8; complete kit, including pc board, ready-to-use enclosure, all components (less battery) No. MC1-1 at $70; same as MC1-1 kit but for ac operation, No. MC1-2 at $86; MOS IC's (IC1 through IC6) No. MC1-9 at $18; sockets for all IC's, No. MC1-10, at $5. California residents, please add 6% sales tax.

Fig. 2. Complete schematic of the music box is shown below and on opposite page.



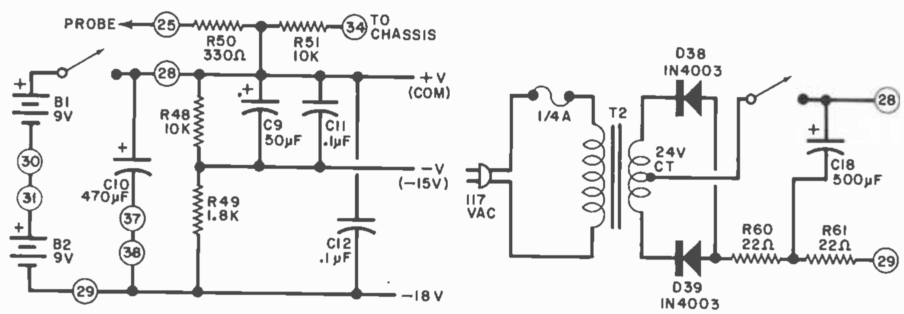


Fig. 3. Battery or line-operated power supply can be used. Components following C10 (left) must be added to other circuit also.

set by *R56*, while the tune (expanded or compressed) is set by *R55.*

Two of the words stored in the memory are decoded as instructions. One instruction, no note, is used to store the condition for no note played, or a pause. Each time it is decoded, the speaker is silenced for one clock cycle. This is accomplished by making the *set* input of *IC6B* low for one clock cycle.

The other instruction, stop, is used to disable the speaker and stop the clock. When this instruction is decoded, the astable multivibrator that clocks the tune out of memory is stopped. This allows a one-shot operation for doorbell or other switches.

Starting and stopping the clock is controlled by *IC5A* and *IC5B* connected as an RS flip-flop. One input to this flip-flop goes to the keyboard pad labelled START, while the other input goes to the decoder output labelled STOP. The output of the flip-flop enables the input of the astable clock. When +V is applied to the START pad, via the probe, the flip-flop goes to a state that frees the clock to permit it to run. When a stop instruction is decoded, the flip-flop disables the clock. The clock remains disabled until the START pad is again activated. The start input is debounced by *R35, R36,* and *C5,* while *R37, R38,* and *C6* debounce the stop input.

The astable multivibrator, comprised of *IC4B* and *IC5C*, uses *R53* for varying its operating frequency. The output of the multivibrator goes to the clock input of *IC1*. When the clock is

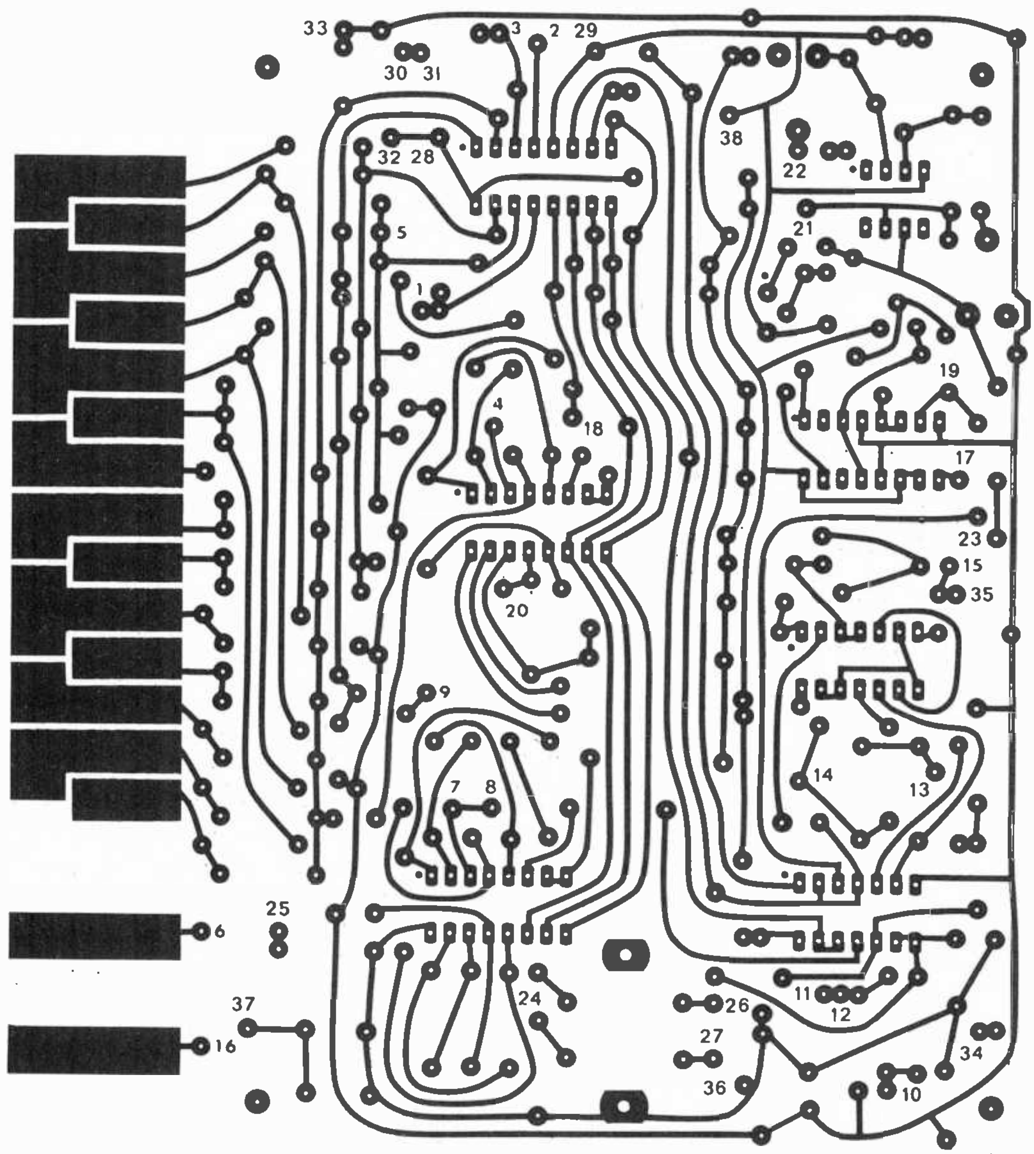


Fig. 4. Etching and drilling guide for printed circuit board is at right; component layout on opposite page. Table below layout gives connections to numbered points on the pc board.

disabled, *IC1* can be single stepped a word at a time by the *IC4A* gate. STEP ONLY switch *S2* is debounced by *R30* and *C1*, and *IC4A* produces a pulse that is differentiated by *R33*, *R34*, and *C3*. The output of *IC4B* cleans up the pulse and drives the memory clock. Capacitor *C2* provides positive feedback to speed up the rise time of the clock pulse.

WRITE/STEP switch *S1* is connected so that the recirculate input of *IC1* is enabled and step action occurs. The memory will then store whatever note is being played when *S1* is depressed, clocking the memory forward by one word.

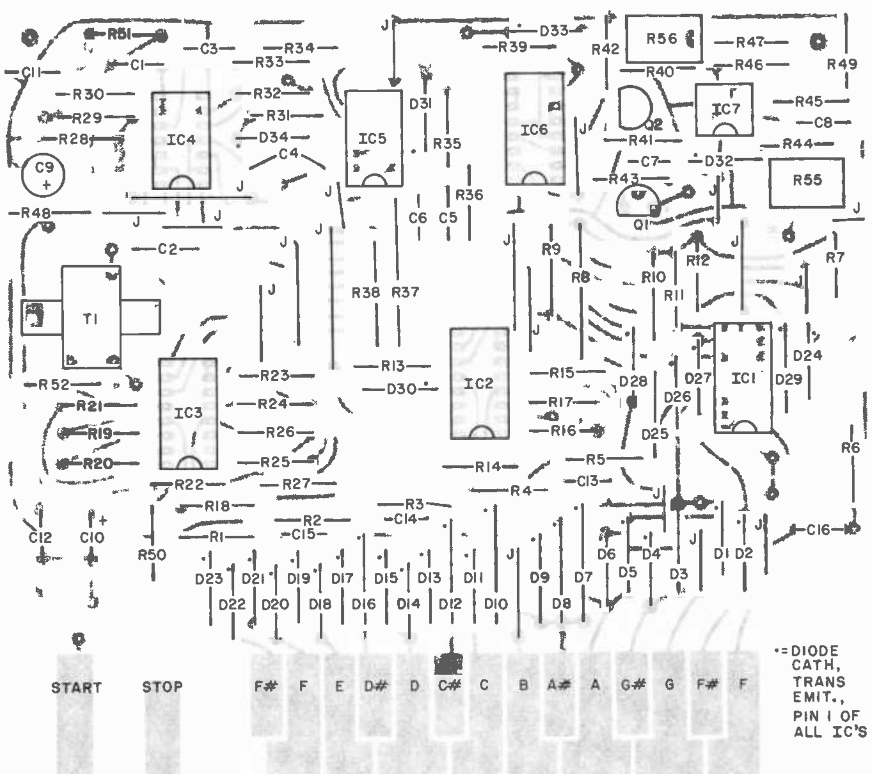
The output of the vco (*IC7*) goes to *Q2* to improve the rise time. Then the signal goes to the clock inputs of the two *IC6* flip-flops, which are arranged to divide the vco signal by 2 or 4. If the set input is high, the vco signal is divided by 2, which gives the effect of doubling the frequency when compared to division by 4. The set input is connected to a register in *IC1* so that the octave can be programmed along with the note.

A second function of the flip-flops is to control the duration of the note. The clock pulse is passed to gate *IC4C*, while the other input of this gate goes to the space-remove register in *IC1* and to space-remove switch *S3* via *D24*. The gate input is connected to the set input of *IC6B*. Hence, if the gate is enabled, the clock pulse will set the flip-flop once per clock cycle and insert a narrow (20% of on time) pulse or space after each note. Disabling the gate with *S3* removes the space and permits the notes to run together. Consequently, a note can be made an integral number of times longer than another note, which allows precise duplication of music notation.

The output from *IC6B* goes to *Q1*, a transistor driver that provides power gain for matching transformer *T1* to the speaker.

Diodes *D1* through *D33* convert the keyboard operations to four-bit parallel words for storage in memory. Diodes *D24* through *D29* are used to OR the keyboard and function switches with the memory input, allowing you to play the music box without using the storage function. Resistors *R1* through *R12* serve the pulldown function for *IC1*, and *R50* is in series with the probe to limit probe current.

With the music box, you have a choice of either ac or battery operation. Both power supply circuits are shown in Fig. 3.



1. To upper octave switch
2. Recirculate
3. To space remove switch
4. To 7
5. To 6
6. Stop pad
7. Pin 3 IC3
8. Pin 3 IC3
9. To 22
10. To step only switch
11. To 2
12. To write & step switch
13. To play rate pot
14. To play rate pot
15. To 16
16. Start pad
17. To 18
18. Pin 12 IC1
19. To 20
20. Pin 13 IC2
21. To volume pot
22. Tune trimmer
23. To 8
24. To volume pot
25. To probe
26. To speaker
27. To speaker
28. To on/off switch
29. −18V in
30. Negative Battery A*
31. Positive Battery B*
32. +V to all but step only switch
33. −15V to step only switch
34. To chassis lug
35. External start in**
36. External start in**
37. To 38
38. −18V

*For battery supply only
**For remote starting

Construction. We recommend that you use a printed circuit board for the music box for two reasons. First, the circuit's extensive use of IC's demands an easy-to-control wiring medium. Secondly, the keyboard is an integral part of the pc foil pattern. Therefore, if you plan to make your own pc board, use the actual-size etching and drilling guide shown in Fig. 4.

When installing components on the board, make certain that diodes and electrolytic capacitors are properly polarized and that the IC and transistor pin configurations properly mate with the appropriate solder pads on the board. (See Fig. 4 components placement diagram for parts locations.) Use a low-wattage soldering iron and fine solder, and apply only enough heat to assure good solder connections.

For the IC's, we recommend the use of sockets or Molex Soldercons, which will eliminate the possibility of heat damage to these sensitive components. Furthermore, sockets will permit you to install the CMOS IC's without fear of damaging them with static electricity during the soldering operation. Always install the CMOS devices last. Handle these devices only by the narrow edges of their cases—never by their pins. (If you elect to solder the IC's directly to the pc board, wrap a bare wire around your soldering iron's tip and connect the free end to the +V conductor on the pc board to prevent high static charges from building up.)

Once the pc board is wired, refer to the table accompanying Fig. 4 for making interconnections between the circuit board assembly and off-the-board components. When wiring the power supply, note that all of the components shown after *C10* in Fig. 3 are common to both types of supply. If you elect to use the ac supply, connect it to the board assembly across *C10* via pads 28 and 29 on the board.

The chassis in which you house the music box should have an open bottom and a slot cut in one side (see photo) so that the keyboard can protrude for easy accessibility. Mount the board in the box with the aid of spacers and machine hardware. The speaker, switches, controls, and power supply mount directly on the chassis box, the last with terminal strips and point-to-point wiring.

Each switch, control, and keyboard pad must be identified. They can easily be labelled according to function with a dry-transfer lettering kit. Finally, the flexible stranded probe wire exits to the chassis through a grommet-lined hole and is terminated in a banana-type plug.

Checkout and Tuning. Turn on the music box and try playing it by touching the probe tip to the contacts on the keyboard. As you move the probe up the scale, each note should increase in frequency. Try using the OCTAVE switch; depressing it should cause the pitch of the notes to double in frequency.

Clear the memory by turning off the power for about 10 seconds. Then, to check the storage function, load each note of the scale into a memory location by holding the probe tip against the desired keyboard note pad and pressing the WRITE/STEP switch once for each note. Touch the probe to the START pad. The notes you just stored should play back continuously, at a rate determined by the PLAYBACK RATE control.

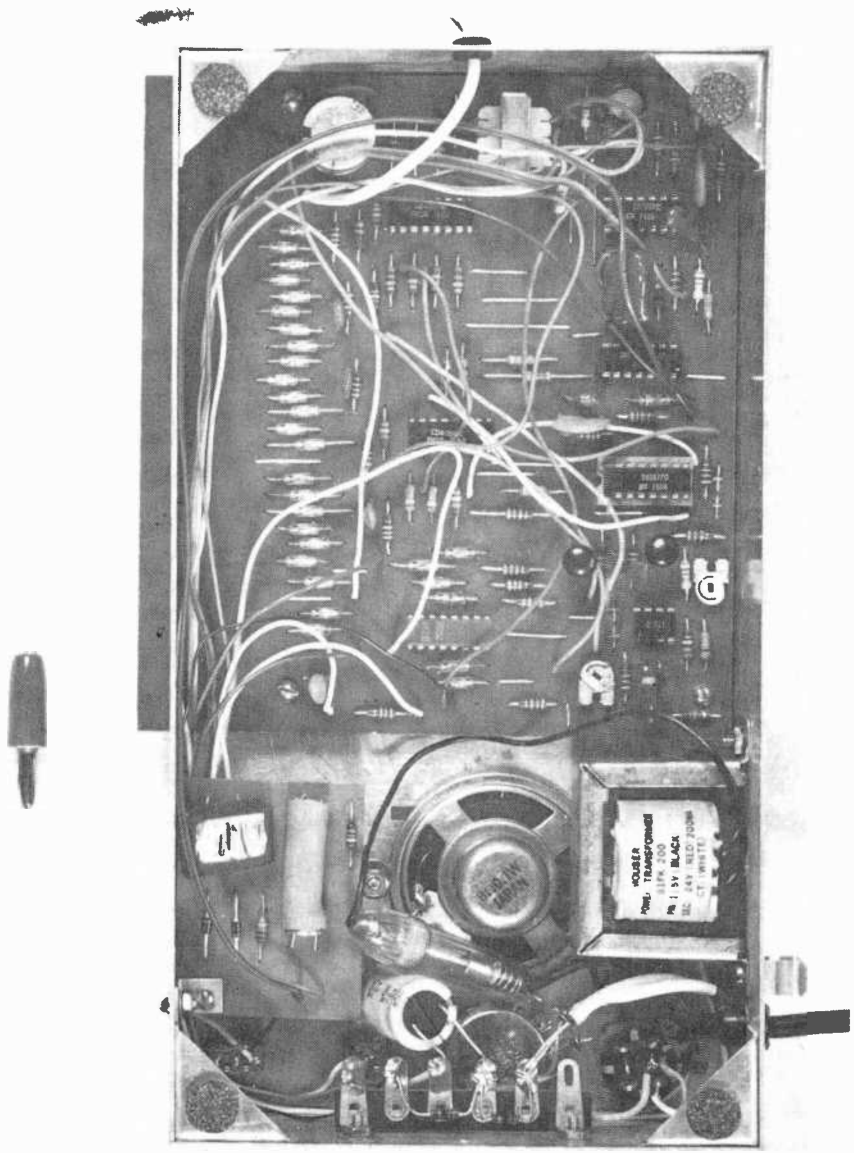
Check the STEP ONLY function by pushing the button. The tune should cease playing, and repeated pressing of the switch should step the tune one note at a time. Next, check the SPACE REMOVE function by holding down the switch while a melody is playing. The notes should all run together. To test the stop function, stop the melody by pressing the STEP ONLY switch at a clear spot in the tune. Hold the probe on the STOP pad on the keyboard and press the WRITE/STEP switch. This should deposit in memory the code for stopping a tune after it has played through once. Touch the probe tip to the START pad and confirm this.

Verify that you can store the octave information by loading the scale into the memory first with the OCTAVE switch closed and then with it open. Then, when you touch the START pad with the probe, the melody should play exactly as it was entered. Now, store the space-remove function. Load in the scale as before, only this time, hold down the SPACE REMOVE switch as you store the notes. In playback, all the notes should run together.

You can now tune the music box. Touch the probe to the F key (lowest note) on the left end of the keyboard, press the OCTAVE switch, and store it. Touch the probe to the F key at the right end of the keyboard, leave the OCTAVE switch alone, and store the note. Do these about six times, then touch the probe to the START pad. As the melody comes out, you should hear two notes alternating with each other. Adjust *R55* until they sound like one continuous note. You now have the scale properly compressed to fit the ETS. Later, you can experiment with changing it and then easily get back into tune by following this procedure.

A simple way to adjust the frequency of the keyboard is to use an oscilloscope to adjust FREQUENCY trimmer *R56* so that the higher F (right key), with the OCTAVE switch pressed, has a period of about 715 μs, corresponding to 1396 Hz, or F in the sixth octave.

With everything operating properly, you can try your hand at storing some melodies. ◈



Internal view of the music box. Power supply here is line-operated (components at bottom right).

BY RICHARD PHARES

The Mysterious "Negistor"

A negative-resistance element, disguised as a transistor, with many useful applications.

IT IS known that some transistors, when connected into a circuit in reverse, have a negative resistance similar to that of the tunnel diode. That is, the current through and the voltage across the transistor both increase until the voltage reaches a certain point. Then the transistor breaks down and any further increase in current results in a decrease in voltage. To simplify our discussion, we will call such devices "negistors." In circuit diagrams, we represent it as a conventional transistor with the letter "N" added.

Chances are you can't buy a negistor as such at your local electronics store. (They probably wouldn't know what you were talking about anyway.) However, if you have a few npn silicon transistors, you probably already have a supply on hand without knowing it. (But don't expect to find a negistor among the germanium or the pnp silicon units.)

There are a number of types of npn transistors among which negistors can be found: Motorola's MPS-5172, the 2N2218, 2N2222, 2N697, for example. Transistors which may be useless for anything else may be excellent negistors. We have used negistors to build both crystal-controlled and tunable sine-wave oscillators, variable-width pulse generators, oscilloscope sweeps, and many other circuits. Other suggested applications include timing circuits for SCR power control, latching circuits for power-supply regulator protection, timers, etc.

What Makes It Work. The behavior of the negistor is caused by avalanche multiplication as a result of impact ionization produced by mobile charge carriers. This characteristic is also used to enhance switching speed in some logic circuits.

The negative-resistance characteristic shown in Fig. 1 results when a 2N2218 is connected as shown. In this case the breakdown voltage is about 7.7V. Using this characteristic, the negistor can be used to perform some of the functions of a tunnel diode or a UJT—often with simpler additional circuitry.

When used in tunnel diode applications, the output of a negistor is much greater than that of the diode. As a UJT, the reverse transistor dissipates power only during breakdown and therefore its use is limited only by the peak current.

Applications. A useful circuit employing the negistor is the sawtooth and pulse generator shown in Fig. 2. Output frequency is determined primarily by *R1*, *R2* and *C1*. The current through the negistor is limited by *R2*, which also sets the maximum fre-

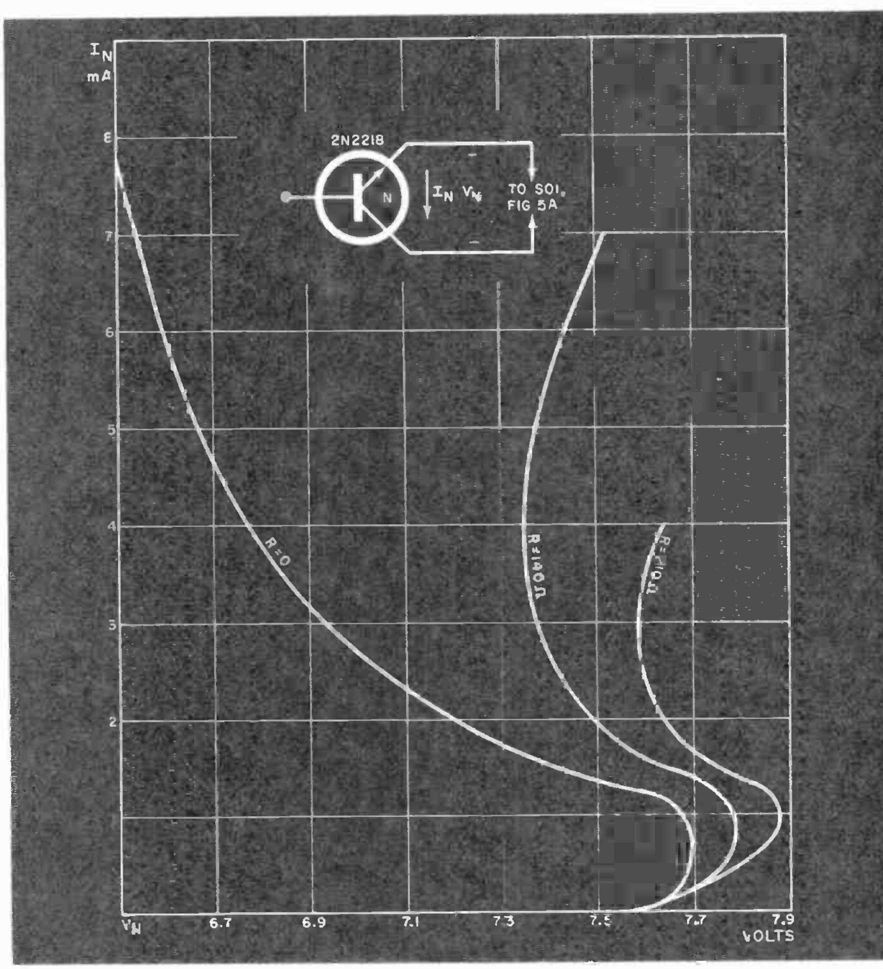


Fig. 1. I-V characteristics of a typical negistor. Many npn transistors exhibit negative-resistance behavior.

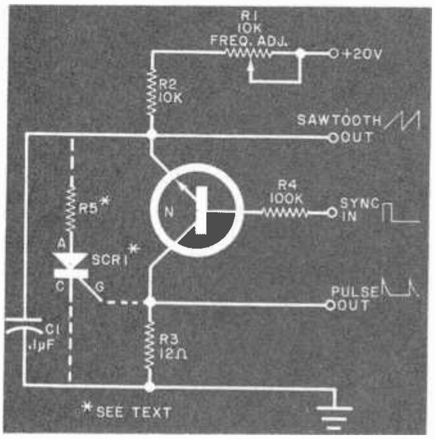


Fig. 2. Sawtooth and pulse generator. SCR circuit increases output.

quency of oscillation. Resistor *R3*, typically 10 to 20 ohms, also affects the frequency somewhat, and decreasing *R3* will lower the rise-time of the pulse and its amplitude. As *C1* increases, the magnitude of the sawtooth will decrease since the resistance of the negistor will rapidly increase once the voltage minimum (also called the "valley point" in UJT circles) is reached. The valley point varies from one negistor to the next, and if they will oscillate at all, peak-to-peak output will generally be greater than 1 volt.

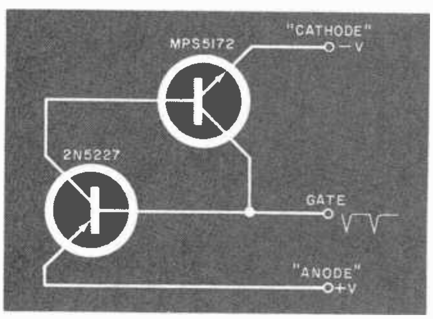


Fig. 3. Reverse-polarity SCR. Transistors simulate SCR.

In some applications, larger output is needed. If this is the case, the SCR-resistor network shown in dashed lines may be added to discharge capacitor *C1*. When the negistor breaks down, the pulse appearing across *R3* will trigger the SCR, discharging *C1* down to the saturation voltage of the SCR. Since *R3* is very small, the SCR will require more holding current than *R1* and *R2* can supply. When *C1* is discharged, the SCR will turn off and *C1* will begin to recharge. The value of *R5* is selected to limit the current through the SCR. A sync input is provided for control purposes. Output will be about 8 volts peak-to-peak with the SCR installed.

An inverse sawtooth may be obtained by reversing the leads of the negistor and polarities of the power supply. However, a conventional SCR cannot be used in this circuit, so the transistor analog of a reverse-polarity SCR (Fig. 3) must be used. This configuration may be used in place of a conventional SCR in any power-control circuit by interchanging the pnp and npn types.

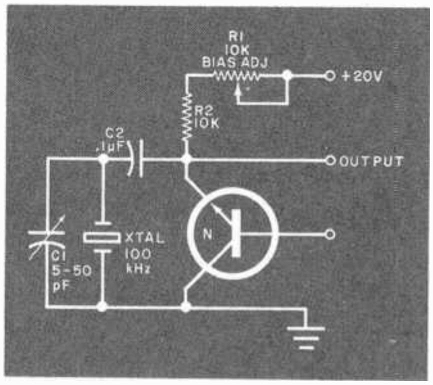


Fig. 4. Negistor used in standard frequency marker generator.

A second negistor application is a series-tuned crystal oscillator, shown in Fig. 4. In this circuit, the negistor is biased into the negative resistance region by *R1*. Capacitor *C1* tunes the oscillator to the operating frequency, and C2 isolates the crystal from the dc voltage.

Negistor Selection. Three test circuits are shown in Fig. 5 to aid in identifying negistors in your supply of npn transistors. If you have access to an oscilloscope, use the circuits shown in Fig. 5A and 5B. A standard transistor socket can be used. Be sure to insert devices with the emitters and collectors reversed. Figure 5A will give the I-V characteristics of a negistor, as in Fig. 1. Set the vertical sensitivity of your scope to ½ V/cm. Each vertical division will represent 1 mA of negistor current, I_N, when the vertical amplifier input is across the 2000-ohm resistor. Connect the horizontal inputs as shown, setting the sensitivity to 2 V/cm. Vary the 1000-ohm potentiometer through its range, and thereby the voltage applied to the test circuit from 0 to 20 V. Note the movement of the trace. Since resistance is the reciprocal of the slope of the V-I curve shown, a downward (negative) slope means the transistor is displaying a negative resistance.

The circuit in Fig. 5B can be used with a scope, or with a peak-reading VTVM. When inserting or removing a device from socket *S01*, always be sure that switch *S1* is closed. After inserting the transistor and opening *S1*, a linear sawtooth waveform will be seen if the device can function as a negistor. We have found that about half of the npn transistors we test turn out to be negistors.

If a scope or peak-reading VTVM is not available, try the circuit shown in Fig. 5C. This test rig will not give any indication of the quality of the device, but it will indicate whether or not it displays a negative resistance. Connect a dc milliammeter and voltmeter as shown. Slowly advance the potentiometer and observe whether or not current increases while voltage at any point starts to decrease. If this happens, the device is a negistor.

Conclusion. This article has not delved deeply into theory, but rather is intended to be a "hands-on" guide to negistors. Look in your junk box—you'll be surprised how many negistors you have, and what you can do with them! ◈

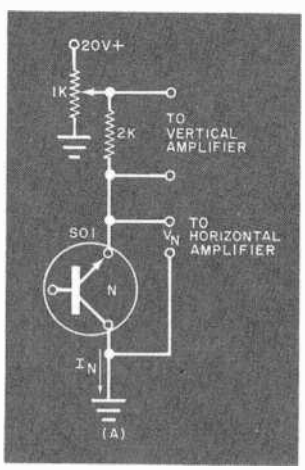
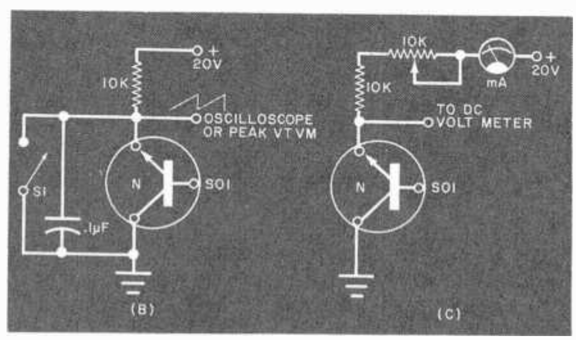


Fig. 5 Test circuits identify negistors using a scope, VTVM, or dc voltmeter.



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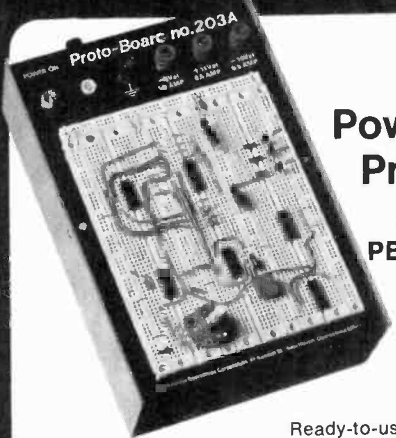

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Ripple & Noise	@ ¼ AMP, 10 millivolts
Load Regulation	Better than 1%

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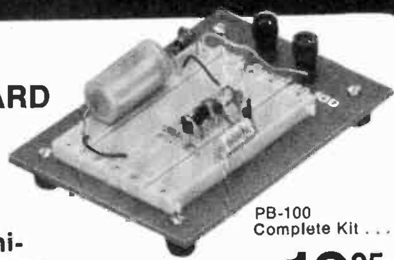

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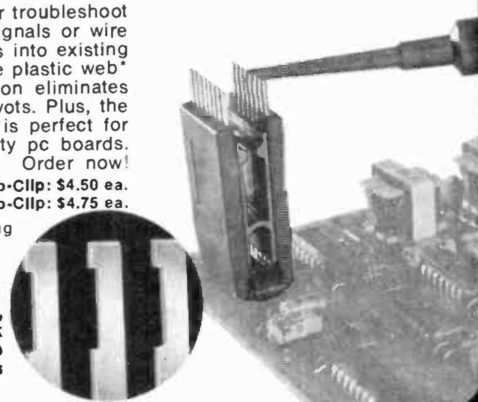

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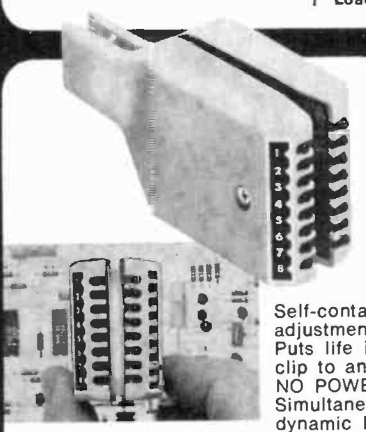

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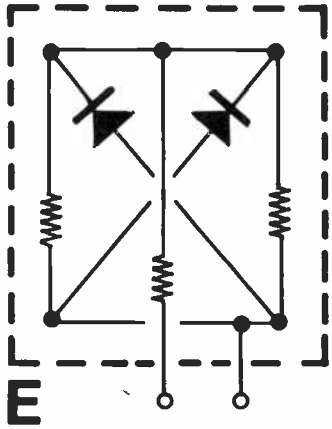
BLACK BOX QUIZ

BY ROBERT P. BALIN

A technician measured the resistance at the terminals of eight black boxes. He then reversed the leads of the ohmmeter and obtained a set of eight different readings. The two sets of readings were as follows:

1. 8 ohms, 12 ohms
2. 9 ohms, 24 ohms
3. 4 ohms, 18 ohms
4. 6 ohms, 12 ohms
5. 10 ohms, 9 ohms
6. 18 ohms, 2 ohms
7. 9 ohms, 6 ohms
8. 3 ohms, 12 ohms

Can you match his readings (1 to 8) with the internal circuits of the black boxes (A to H)? The resistors are all rated at six ohms. Assume that the diodes have zero forward resistance and infinite reverse resistance.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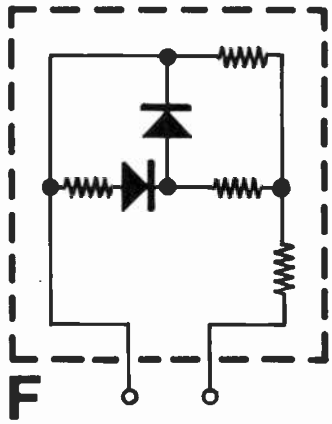
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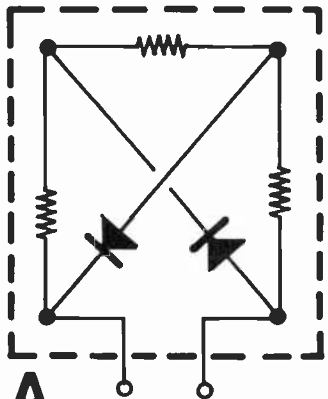
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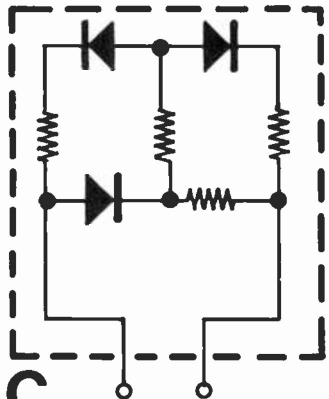
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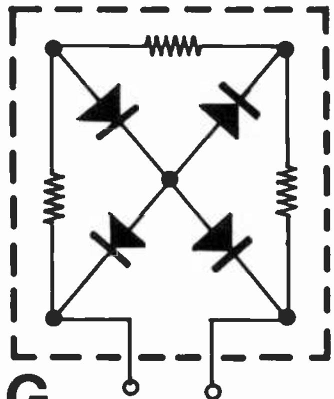
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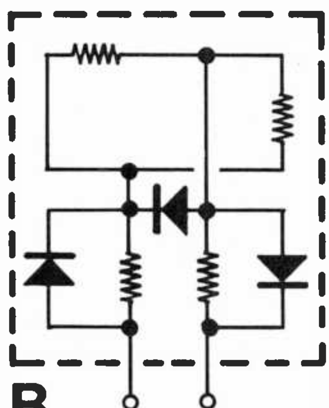
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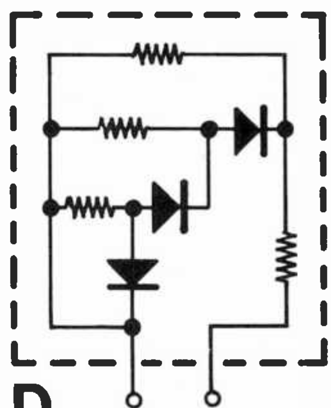
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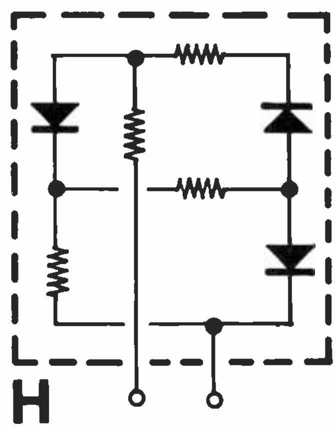
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Answers: 1-D, 2-H, 3-C, 4-G, 5-F, 6-A, 7-E, 8-B

PERSONAL TIMING TESTER

BY J. R. DAVIES

HOW accurate is your sense of time? This little circuit, employing a 555 IC, tests your timing judgment by flashing a LED every 1.5 seconds (this interval can be changed). If you press a pushbutton at the right time, the LED will stay lit.

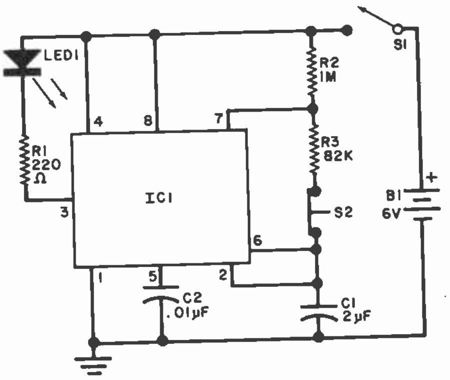
The LED is strobed on for 0.1 second. Since human reaction time is on the order of 0.3 second, you can't catch the LED once it is on. It is necessary to judge the time which has passed after the LED turns off before operating the test switch. A person with a good sense of timing should be able to "freeze" the LED on 20 to 40% of his attempts.

The circuit is basically an astable multivibrator built around a 555 timer IC. Switch *S1* is the master ON/OFF switch, and *S2* is the pushbutton reaction switch.

When not depressed, *S2* is closed and timing capacitor *C1* starts to charge up through resistors *R2* and *R3*. When the voltage across *C1* reaches two-thirds of the supply voltage, the 555 changes states allowing current to flow through *LED1*. When pin 3 goes high, no current flows through the LED.

Consequently, the LED glows only during the discharge interval. Since the capacitor charges through *R2* and *R3*, but discharges only through *R3*, the discharge time is much less than the charge time.

If *S2* is pushed at any time during the cycle, the charge and discharge paths are opened. The voltage across *C1* remains fixed, and the output remains in the same state as when *S2* was depressed. Thus, if the switch is opened while the LED is on, the LED will stay lit. Closing *S2* allows the cycle to resume at the point where it was interrupted. The circuit can be assembled on perforated board in a small utility box. Any LED which glows brightly with a forward current of 20 mA can be used for *LED1*. Capacitor *C1* should be a metalized film, Mylar, or polyester unit. If you can't find a close-tolerance capacitor with a large enough capacitance, parallel a number of smaller units to get 2 microfarads. Any 6-volt source, such as four "C" cells in series, can be used. ◈



PARTS LIST

B1—6-volt battery
C1—2-μF polyester capacitor (see text)
C2—0.01-μF capacitor
IC1—555 timer IC
LED1—20-mA LED (Texas Instruments TIL209 or equivalent)
R1—220-ohm, ¼-W, 10% resistor
R2—1-megohm, ¼-W, 10% resistor
R3—82,000-ohm, ¼-W, 10% resistor
S1—Spst miniature toggle switch
S2—Normally closed pushbutton switch
Misc.—Printed circuit or perforated board, suitable enclosure, mounting hardware, rubber feet (4), battery holder, hookup wire, solder, etc.

PROGRAMMING NOTES FOR THE ALTAIR 680 μCOMPUTER

BY H. EDWARD ROBERTS AND PAUL VAN BAALEN

The 6800 microprocessor IC is the central processor (MPU or CPU) for the Altair 680 computer. Other components in the system, such as the memory and the terminal connected to the I/O port do not initiate data transfers. They respond only to requests from the MPU to send or receive data. Through the interrupt facility, a device (such as a terminal) can signal that it has completed a data transfer or that it has new data available.

The MPU initiates a data transfer by placing an address on the address bus, setting the read/write flag to signal whether it is sending or receiving, raising a VMA (valid memory address), and putting data on the data lines if it is sending. A device on the bus must recognize when an address that refers to it has been sent out and take appropriate action. In the case of a read from a memory address, the memory will examine the appropriate memory cells and set the data lines, depending on what is stored in those cells.

All data is 8-bits wide (eight binary digits), which means that data has 256 (2^8) possible values. Addresses are 16-bits wide, giving the system up to 65,536 (2^{16}) possible locations to use for memory locations and device registers. The idea of using addresses to refer to I/O devices as well as memory locations, as opposed to having special I/O instructions and a special I/O bus, is relatively new. It has greatly simplified the computer's structure.

The MPU has a number of internal registers: the program counter (PC), A and B registers, condition code flags, index register, and stack pointer. The 16-bit PC is used to keep track of which instruction the computer will execute next. Once the computer is started and the PC initialized, the MPU will start executing instruction cycles. An instruction cycle begins when the PC is sent out on the address lines. When this data comes back to the MPU, the instruction is decoded and the MPU performs the appropriate operation.

There are 59 instructions, 197 of the possible 256 codes being unassigned. These 197 instructions are grouped into 72 different types. Some instructions require one or two additional arguments. These arguments occupy the memory locations following the instruction. When the instruction is fetched, and as each argument is fetched, the PC is incremented by 1, so that after all the arguments are fetched, the PC will give the address of the next instruction to be executed (unless the execution of the current instruction modifies the PC). When the current instruction is completed, a new instruction cycle is initiated. The MPU will continue to execute instructions until the RUN/HALT switch is set to the HALT position or the power is turned off.

The MPU has two 8-bit accumulators, designated A and B. They are called accumulators because they are used for storing arithmetic results. An example of some instructions that operate on the accumulators and take no additional arguments aside from the instruction itself are:

DEC A	Decrement value of A by 1
TAB	Set B = A
CLR B	Set B = 0
NEG A	Set A = O − A
COM B	Complement B [B = B − (B + 1)]
SBA	A = A − B
ADD	A = A + B

Since only a small amount of data can be stored in the MPU itself, there are a number of instructions that specify addresses in memory as operands. The method an instruction uses for specifying a memory address is called the addressing mode of the instruction. There are seven different addressing modes for the 6800 chip.

The simplest addressing mode is extended addressing. An instruction that employs the extended mode takes two arguments and is, therefore, a three-byte instruction. The first argument gives the high-order eight bits of the address to use and the second argument gives the low-order eight bits. For example:

LDA A 3000	Load A with contents of location 3000
CLR 2000	Set location 2000 to 0
STA B 2001	Store B in location 2001

Extended addressing is the most general form of addressing since it can refer to any possible address. However, instructions employing extended addressing require three locations in memory; so, other less general but more compact addressing modes are provided.

In the direct mode of addressing, an instruction takes a single argument, which is taken to be the low eight bits of the address of the operand. The high eight bits of the address are assumed to be zero.

In the immediate mode, an instruction's single argument to the instruction is used as an operand of the instruction. For example:

LDA A	30	Set A = 30
ADD B	20	Add 20 to B

The indexed mode of addressing takes a single argument that is added to the 16-bit index register to give the address of the operand. The index register can be loaded (LDX), stored (STX), incremented (INX), decremented (DEX), and compared with another 16-bit quantity (CPX).

All of the common arithmetic and

```
FND PRT  LDX    PLIST   Initializes index
                        register to point
                        at parts list
         CMP A   X      See if A = con-
                        tents of location
                        index pointed to.
                        A is not changed,
                        but zero flag is
                        set if equal
         BEQ   HAVPRT   If equal, check
                        count
         TST     X      Set zero flag if in-
                        dex register points
                        at 0, which means
                        list ended
         BEQ    PERR    If so, go to PERR
         INX            Point to next
         INX            Part number
         BRA   FNDPRT   Unconditionally
                        branch back,
                        search more
HAVPRT   CMP B  1,X     1,X gives address
                        of availability
                        count; see if enough
         BLS   PORDER   If not, order more
        PUSH A          Save part number
         LDA A  1,X     A = old stock count
         SBA            A = A - B = new
                        stock count
         STA A  1,X     Store new count
         POP     A      Restore part number
         RTS            Return to caller
```

logic operations can be performed (that is, add, subtract, and, or, exclusive-or). One of the accumulators is specified as the first operand and used to store the result. The second operand can be specified using one of the addressing modes. Arithmetic operations also set/clear the condition codes, depending on the result of the operation. (That is, if the result of an operation is zero, the zero flag is set; if the result of an addition is greater than 256, the carry flag is set.) These condition codes can be used for multiprecision arithmetic or for the conditional branching described below. For example:

SUB A 1456	Subtract contents of location 1456 from A. The zero flag will be set if the result is 0.
EOR B 1,X	Set B = exclusive-or of B and contents of location given by adding 1 to index register.

Unless a branch, jump, JSR, BSR, or RTS instruction is executed, the computer will execute instructions sequentially out of memory. The jump and branch instructions change the PC, which changes the address from which the next instruction will be fetched. A jump instruction is unconditional and stores its two eight-bit arguments in the 16-bit PC, using the first argument for the high-order bits in the PC. Branching, which can be executed conditionally, based on the state of the condition codes, takes a single argument that is added to the PC. The argument is taken as a signed number, which means you can branch to any location that is less than 130 locations beyond the current location or any location that is less than 127 locations behind the current location. For locations further away, the jump instruction must be used.

The 16-bit stack pointer (SP) can be decremented, incremented, loaded, stored, and transferred to or loaded from the index register. The importance of the SP comes from its use in the JSR (jump to subroutine), BSR (branch to subroutine), RTS (return from subroutine), PUSH (save an accumulator on the stack), POP (fetch a value from the stack), and the handling of interrupts. The PUSH A instruction, which takes no arguments, stores A in the address contained in the SP and decrements the SP. By setting SP to point to an area of free RAM, a programmer can save and restore temporary values with 1-byte instructions. When a JSR or BSR is executed, the PC is saved on the stack by storing the low eight bits of the PC at the address the SP contains, decrementing the SP, storing the low eight bits of the PC, and decrementing the SP again. Other than pushing the PC onto the stack, BSR is exactly like branch always, and JSR is exactly like jump.

An RTS fetches the PC off the stack in a similar manner. The use of the stack for saving return addresses for subroutine calls allows for subroutines that call themselves and does not require that locations be set aside to store the return address of every subroutine. The stack is invaluable in making the programming of the Altair 680 easy.

The sample subroutine shown on the preceding page is called with a part number in the A register and the number wanted in the B register. It searches the parts list that starts at memory location PLIST and consists of a part number followed by the quantity of that part in stock. If the desired part is not in the list, the subroutine branches to memory location PERR. If the part is located in the list, the quantity in stock is checked to make sure there are enough of the part available. If there is not a sufficient quantity in stock, the sequence at location PORDER gains control. Otherwise, B is subtracted from the number of parts in stock and the subroutine returns.

Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

Pioneer's new Model TX-9500 AM/stereo FM tuner includes, among other features, an unusual built-in calibrating tone for use when decoding Dolby FM broadcasts.

Although there is no lack of fine stereo cassette decks, especially when one can spend as much as $500, the Tandberg Model TCD-310 is a remarkable machine even in this price range. It offers impressively low flutter and low noise, even outperforming some open-reel decks in these respects.

—Julian D. Hirsch

PIONEER MODEL TX-9500 AM/STEREO FM TUNER

Top-of-line tuner features exceptional operating characteristics.

HIRSCH-HOUCK LABS REPORT

Displacing the company's top-of-the-line Model TX-9100 (which is still available) is the Pioneer Model TX-9500 AM/stereo FM tuner. The tuner presents a new face to the hi-fi enthusiast. Its clean, functional front panel is almost totally devoid of the colored lights that are typical of most of today's tuners and receivers. Furthermore, it has no "blackout" dial window. Behind the clear plastic window are the AM and FM logging scales, separate light slots for power and stereo beacon, and relative signal strength and tuning meters.

The tuner measures 16⁹⁄₁₆" W × 14¾" D × 5⅞" H (42 × 37.5 × 15 cm) and weighs 20 pounds (9.1 kg). It retails for $399.95.

General Description. The dial scales occupy most of the dial window's width. The FM scale is especially legible, with numbered marks at every odd megahertz, long ticks at every even megahertz, and small ticks every 200 kHz (0.2 MHz) apart to correspond with the FM broadcast channel assignments in the U.S. The tuning meter is active for FM only, while the relative signal strength meter is active on both AM and FM.

The lower half of the tuner's front panel is reserved for the controls, which number a total of six. Three of these are lever-type switches for POWER, MPX NOISE FILTER, and MUTING LEVEL. One more is a multi-position rotary switch labelled FUNCTION with positions for AM, FM AUTO, FM MONO, and REC LEVEL CHECK. The remaining controls are for tuning and setting the output level.

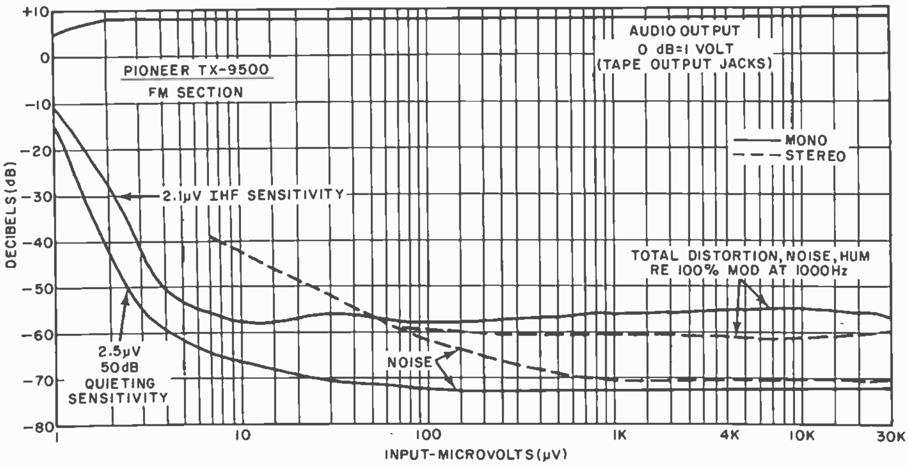
In the ON position, the MPX NOISE FILTER blends the higher audio frequencies to reduce both noise and channel separation on weak stereo FM signals. The interstation noise MUTING LEVEL switch has two threshold level positions. The OUTPUT LEVEL control varies the output level from the VARIABLE output jacks on the tuner's rear apron. (Another pair of output jacks delivers fixed-level signals to the amplifying system.)

While the first three positions of the FUNCTION switch are self-explanatory, the REC LEVEL CHECK position may not be. When the switch is in this position, the normal tuner output is replaced by 400-Hz bursts at 1.3-second intervals. The burst amplitude corresponds to the Dolby FM calibration level (50% modulation). This greatly simplifies adjustment of the recording gain of a tape deck before taping a Dolbyized FM broadcast in its encoded form. (Dolby-equipped FM stations broadcast the reference tone at infrequent intervals, which makes this unique feature a welcome addition to the basic tuner.)

The rear apron of the tuner contains AM and FM antenna terminals (the latter for both 300- and 75-ohm systems), a hinged ferrite rod antenna, the fixed and variable audio outputs, and oscilloscope outputs for use with an accessory multipath/tuning indicator. The horizontal scope output can also be used to feed a signal to a 4-channel discrete FM demodulator if and when such demodulators come on the market. There is also a slide switch on the rear apron that allows the user to select either 75- or 25-µs FM deemphasis for proper reception of Dolby FM broadcasts through a Dolby decoder. Finally, there is a single unswitched accessory ac outlet.

This tuner makes extensive use of integrated circuit technology, including seven IC's and four ceramic filters in the i-f section. IC's are also used in the FM detector, phase-locked loop (PLL) multiplex detector, FM muting system, and the entire active portion of the AM tuner. The FM front end has two FET-type r-f amplifiers and a FET mixer. The local oscillator is isolated from the mixer by an emitter-follower buffer.

Laboratory Measurements. As might be expected, in this price category most of the specifications for the TX-9500 tuner are impressive. Our laboratory measurements confirmed almost all of them within normal limits of instrument error. In a few minor instances, the test results fell slightly short of meeting the published ratings, but in as many other cases, they far exceeded them.



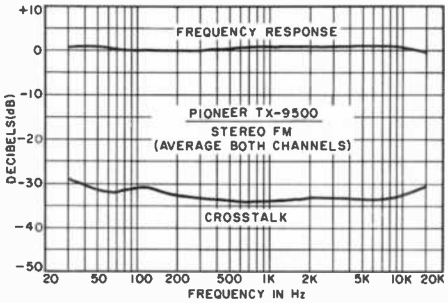
The IHF usable sensitivity in mono was 2.1 μV, while in stereo it was 5 to 7 μV, which was the stereo threshold. The 50-dB quieting sensitivity, a more meaningful indicator of a tuner's weak-signal performance, was an excellent 2.5 μV in mono and 25 μV in stereo. The ultimate S/N ratio was 72 dB in mono and 70 dB in stereo. Although our S/N measurements did not match Pioneer's, they are about as good as we have measured in an FM tuner.

Distortion at 1000 μV input was 0.17% in mono and 0.10% in stereo. This is one of the very few tuners we have tested in which the stereo distortion was *less* than the mono distortion. (Perhaps this is due to the compensating distortion characteristics in the tuner's detector and multiplex circuits.)

The FM frequency response was within ±0.5 dB from 30 to 15,000 Hz. The stereo channel separation was 33 to 34 dB between 250 and 8000 Hz and about 30 dB at 30 and 15,000 Hz. Although this was a few decibels lower than the rated values, it indicates exceptionally uniform channel separation across the audio band, with almost perfect symmetry between channels.

The capture ratio measured 1.7 dB and AM rejection measured an outstanding 72 dB. We were barely able to measure the image rejection by using the full output of our signal generator; it was 102.5 dB, ranking it among the very best we have seen. Although it is rated at 110 dB, most laboratory-grade signal generators lack sufficient output to verify such a rating. The 81-dB alternate-channel selectivity was also very good, and the 19-kHz pilot carrier leakage measured −64 dB. The muting threshold could be set at either 10 or 27 μV.

The fixed audio output was 0.71 volt



at 100% modulation, and the maximum variable output level was 2.4 volts. The REC LEVEL OUTPUT was about 3 dB lower than it should have been, corresponding to 35% instead of 50% modulation. The AM frequency response was down 6 dB at 30 and 3700 Hz.

User Comment. Our lab measurements show that, in all parameters that bear directly on performance in a hi-fi system, the TX-9500 is an especially fine FM tuner. Certainly, to obtain a tuner that outperforms it by any significant margin, one would have to spend substantially more. In use, the FM muting action was as near to perfect as we have encountered, operating with positive action and without a trace of extraneous noise when tuning on or off a station—the sound was either there or it wasn't.

The dial calibration was essentially perfect across the entire FM band, with the tuning accuracy limited only by the width of the pointer. The pointer is a relatively slim metal projection instead of the undesirably wide plastic pointers used on most tuners and receivers. The tuning system was accurate to better than 100 kHz. We could set the tuner before tuning it on to any channel with complete assurance that when power was applied, the station would be tuned in virtually perfectly.

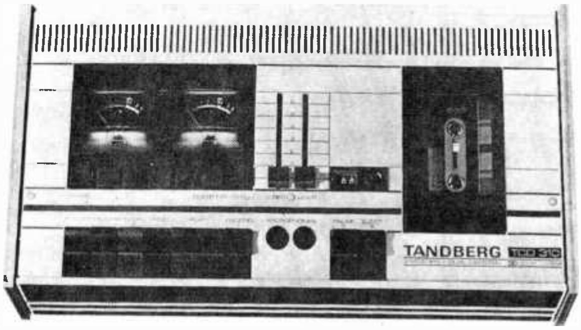
Very few tuners can approach the

handling characteristics and superior overall performance of this tuner. From a human-engineering point of view, much of the pleasure of using this tuner is in its handling. All the controls operated with positive action, and the tuning mechanism operated sikly smooth. In sum, the TX-9500 tuner is a thoroughbred in every respect.

CIRCLE NO. 65 ON FREE INFORMATION CARD

TANDBERG MODEL TCD-310 STEREO CASSETTE DECK

Signal/noise performance rivals many open-reel decks.



HIRSCH-HOUCK LABS REPORT

Tandberg high-fidelity products, principally open-reel tape decks and stereo receivers, have always been characterized by distinctive external styling, somewhat unconventional circuit and operating features, and outstanding overall performance. In view of this tradition, one would expect a Tandberg cassette deck to be somewhat unusual—an apt descriptive for the Model TCD-310.

The Model TCD-310 cassette recorder has a three-motor, dual-capstan, solenoid-operated transport. It is driven by a hysteresis synchronous capstan motor and two dc reel-drive motors. A servo system controls tape movement, preventing tape damage regardless of any slack in the tape or even if a loop of tape extends from the cassette. The tape can move only if the tension is correct over the entire tape path.

The dual-capstan drive maintains a controlled tension on the tape as it passes over the heads, minimizing wow and flutter. In addition, a time-delay circuit prevents the head assembly from contacting the tape until all loops and slack in the tape have been removed. This eliminates the transient wow that often accompanies the use of a pause control.

The deck measures 16⅞"L × 9"D × 4⅛"H (42.9 × 22.9 × 10.5 cm) and weighs 14.5 pounds (6.6 kg). It retails for $499.95.

General Description. The transport is operated by solenoids that are energized by pushing the usual piano-key controls found on most cassette decks. The tape transport can be shifted from any operating mode to any other mode without the need to first hit STOP. The keys can be left in an energized condition, and by controlling the ac power with an external timer, a recording (or playback of a recorded program) can be made with no one in attendance.

To achieve very low noise and distortion levels, the deck employs a low-distortion bias oscillator, low-noise transistors and other components, and a novel microphone preamplifier circuit. The gain of the mike preamp automatically adjusts to suit the impedance (and output level) of the mike used. This reduces circuit noise to a minimum and makes it very difficult to overload the preamp when recording high-level sounds. The mike inputs can be mixed with the line inputs simply by plugging in the mikes. Independent adjustment of the recording levels from the two sources, however, is possible only in the mono mode. For stereo, the gain must be set for the mikes and the external line input level adjusted at its source.

Operation of the deck is similar to that of other cassette recorders, but there are some fundamental differences. For example, to make a recording, the PAUSE key must first be pressed, followed by operation of the RECORD key. The PLAY key is not operated, except when playing back a tape. The main operating controls include: POWER, REWIND, STOP, WIND, PLAY, and RECORD keys. There are two microphone jacks and the PAUSE and EJECT keys. (The EJECT key can be operated only after the STOP key has been operated.)

Behind the operating keys are two recording-level meters that are illuminated in green and red. They are fast-responding peak indicators with a 50-ms rise time and are connected into the circuit after the recording equalization to indicate the actual signal level applied to the recording head. A red bar between the meters is illuminated when the deck is in the record mode.

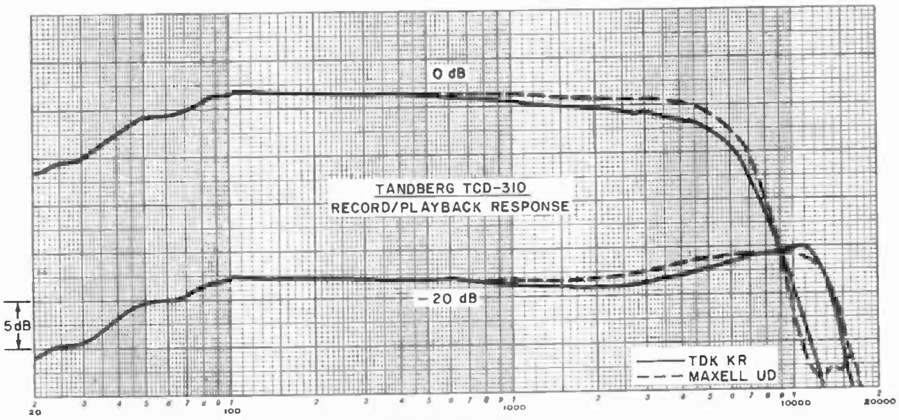
Just in front of the meters is what appears to be a row of seven black pushbuttons. Most of them, however, are dummies. One button parallels the input channels for mono recording and two of the remaining buttons are for switching the Dolby noise reduction system in/out and switching bias and equalization for ferric-oxide or chromium-dioxide tapes.

The recording level controls are slide-type potentiometers. (There are no controls for adjusting the playback level, which is fixed.) There is a resettable index counter. The cassette well is rotated 90° from the usual orientation so that the cassette loads from the right side of the deck to permit operation of the deck vertically or horizontally. (In vertical operation, a cassette might tend to fall out of a conventionally oriented loading slot.)

The inputs and outputs, including a DIN socket, are located on the rear apron of the cassette deck.

Laboratory Measurements. The record/playback frequency response of the deck was within ±3 dB from 40 to 14,500 Hz with Maxell UD tape, for which the deck was biased. The CrO_2 response, with TDK KR tape, was very similar at ±3 dB from 43 to 14,000 Hz. With both tapes, the frequency response at a 0-dB recording level revealed the expected high-frequency rolloff, intersecting the normal −20-dB curve at about 9000 Hz. The Dolby circuit tracking was very good, with less than 1 dB change in frequency response at a −26-dB level with the Dolby system switched in.

The playback frequency response was ±2 dB from 31.5 to 10,000 Hz with standard tape (120-μs equalization).



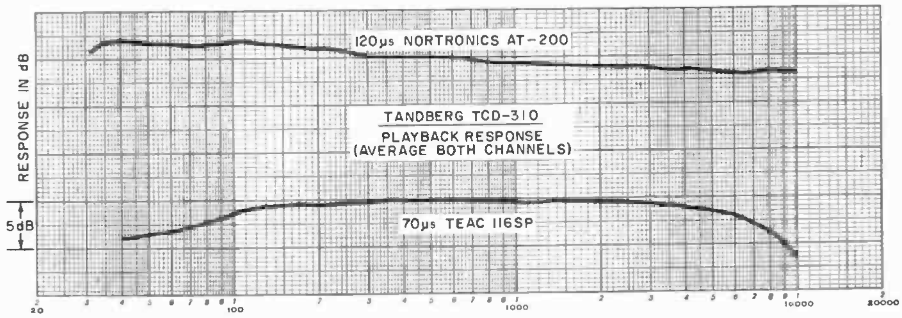
With the 70-µs equalization used for CrO_2 tape, the playback response was ±3 dB from 40 to 10,000 Hz.

With the recording gain at maximum, a LINE input of 30 mV at 1000 Hz produced a 0-dB meter reading. The recording amplifiers overloaded at a very safe 4.4 volts input. The microphone sensitivity and overload level are not so easy to define, since they vary widely with input impedance. From our 600-ohm signal generator's output, only 0.08 mV (80 µV) was needed for 0-dB recording, with a seemingly low overload input of 16 mV. Experimenting with different source impedances, we determined to our satisfaction that as long as the recording gain controls are set at least a half division above their minimum points (there are six divisions in all), the mike circuits will not be overloaded by any signal that does not drive the meters beyond the 0-dB point. In other words, under any conceivable normal operating condition, the tape will overload before the mike preamp's range is exceeded. The playback output from a 0-dB recorded signal was 0.78 volt.

A standard Dolby level (200 nano-webers/meter) tape provided meter indications of about −1 dB on playback. The playback THD from a 0-dB recording was 1.5% with Maxell UD and 1.6% with TDK KR tape. The reference distortion level of 3% was reached with a recording input of about +3 dB with both tapes. The overall unweighted S/N, referred to the 3% THD level, was 52 dB with Maxell UD and 54 dB with TDK KR tape. The 70-µs playback equalization used with the TDK KR tape contributed to its lower output noise. With IEC A weighting to reduce the effect of residual hum on the measurement, these figures improved to 59 and 62 dB, respectively.

When the Dolby system was used, the weighted S/N was 66.5 dB with UD and 68 dB with KR tape. The noise increased somewhat when the microphone inputs were terminated to simulate the connection of mikes, although the amount of the increase depended on the impedance. The gain of the mike amplifier is so great that one should never have to operate it near maximum.

The tape speed was almost exact (about 0.2% fast) and the flutter and wow were among the lowest we have measured on a cassette deck. The wow was the 0.02% residual of the test tape, and the unweighted rms flutter was a mere 0.08% (in playback only and on combined record/playback). The three-motor transport gives this deck a very fast winding capability—less than 34 seconds to fully wind a C-60 cassette! This is a good 10 seconds faster than any other cassette transport we know and is one-third to one-half the fast winding time of most good cassette decks.



changes in counter design philosphy is the Fluke Model 1900A multi-counter that sells for $349.

The multi-counter has a 5-Hz to 80-MHz count range and a full six-decade (seven-segment) LED display with overflow indication. It offers a choice of frequency-counting, timing (period), and events-counting (totalize) modes of operation. In its standard format, the counter uses an ac power supply. However, it can be equipped to operate on rechargeable batteries for field use.

The instrument measures 10¾"D × 8½"W × 2½"H (27 × 21.6 × 6.4 × cm) and weighs 2.75 pounds (1.25 kg). Its molded plastic case has a convenient carrying handle that doubles as a tilt stand.

General Description. The multi-counter, in each of its three modes, has a 1-megohm input impedance, shunted by 30 pF. Typical sensitivity is 15 mV rms. Four switch-selectable gate times are available for 100-, 10-, 1-, and 0.1-Hz resolution. When activated, an autorange (AUTO) circuit automatically seeks to fill all six digits of the display but does not select a gate time that can produce better than 1 Hz resolution. When fewer than six digits are displayed, the leading zeros in the display are suppressed. The autorange feature eliminates redundant up/down range commands and allows measurements on signals that contain large amounts of FM and PM. An automatic reset starts a new measurement sequence.

The frequency-count mode is activated by pressing the FREQ switch, while the timing and events-counting modes are activated by pressing the PER and TOT switches, respectively. In the timing mode, the counter can be used for making period measurements at rates ranging from 5 Hz to 1 MHz in both single- and multiple-period averages. The periods range from 10^0 to 10^3 in decade steps, individually selectable by depressing the appropriate switch. Resolution in this mode is 100 ns to 100 ps. The display readout is in either milliseconds or microseconds as indicated by the ms or μs LED.

In the events-counting mode, the instrument's range is from 0 to 999,999, after which an OVERFLOW LED indicator comes on. The rate at which the instrument can count events is from 5 Hz to 80 MHz.

The time base for all of the instrument's functions is a 10-MHz crystal whose aging rate is less than 5 parts in 10^7 per month. The short-term accuracy is less than 5 parts in 10^8 over one second, and the accuracy is less than 1 part in 10^7 for a 10% variation in line voltage.

There is a data output option with an 8-4-2-1 BCD output from each digit, plus encoded decimal point and units annunciator information. All outputs are CMOS and low-power TTL compatible. A print command is also provided. A built-in self-check mode provides a means of verifying proper overall operation, excluding the input amplifier, attenuator, and filter.

User Report. Before testing the multi-counter, we reset our frequency standard as accurately as possible to WWV on 10 MHz. Then we kept the standard on to keep track of any frequency drift. In the frequency-counting mode, the Fluke instrument was right on the money. Even after a few hours of use, it remained rock steady.

Next, we performed a few period measurements at rates of less than 1 MHz. In this mode, the period of an unknown signal is measured by counting a known frequency (in this case, the 10-MHz crystal oscillator inside the multi-counter) during 1, 10, 100, or 1000 periods of the unknown frequency. The instrument did too good a job in this mode; now we have to do some work on our audio generator with its digital readout system to get it back on the track.

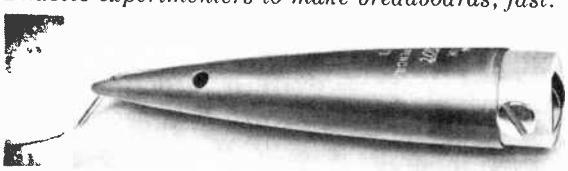
We never really found much use for the totalizing mode, since this is basically a manual operation. To use this mode, a manual reset command sets all displays in the instrument to zero. From this point, all input pulses (random or uniform) are gated through to the counters. We did use this mode to check some switches we had laying around to determine whether or not they exhibited a high degree of contact bounce (and they did).

Having used the 1900A for about three months, we can recommend it highly as an accurate serviceable instrument for frequency measurements.

CIRCLE NO. 68 ON FREE INFORMATION CARD

VECTOR ELECTRONIC MODEL P173 WIRING PENCIL

Enables experimenters to make breadboards, fast.



VECTOR ELECTRONIC is now marketing a tool that gives all the advantages of point-to-point wiring with few of its disadvantages. The Model P173 wiring pencil eliminates the time-consuming job of having to cut hookup wire to the lengths needed, stripping away insulation, and crimping and soldering them to terminals. You simply wrap the free end of a special wire coming from the probe-like pencil's slender hollow tip around a terminal and apply heat and solder to the joint. Then, still feeding the wire from the tool, you continue wrapping and soldering until a run is complete. At the end of the run, just give the pencil a twist and the wire is cut neatly and cleanly.

The probe-like pencil contains a replaceable bobbin on which are wound 250' (76 m) of fine wire. The wire has a special polyurethane coating to insulate it. When soldering heat is applied, the coating instantly vaporizes and exposes bare wire. The insulation vaporizes only locally, remaining intact between solder connections. This means that you can cross wires with complete safety.

With the wiring pencil, you can make a circuit as compact as (and in some cases more compact than) you can using a printed circuit board. Furthermore, the job will be neat, with none of the "rat's nest" look of circuits that are hard wired by the usual method. The great advantage the wiring pencil technique has over the pc method is that it permits easy changes in circuit wiring.

The Model P173 wiring pencil retails for $9.50 and comes with two bobbins of wire (one red and one green insulated) and a wire threading loop. The wire is also available with four colors of insulation: green, red, blue, and clear. Packages of three bobbins of wire (one color per package) are available separately for $2.40 each.

More Details. There is only one gauge of wire available for use with the wiring pencil. While this 36-gauge, single-strand wire cannot be used in circuits where relatively high currents must flow, the majority of modern solid-state circuit designs have low current demands. Hence, the wire size doesn't present much of a limitation. In circuits that draw higher current, ordinary heavy-duty hookup wire would be used.

During a wiring operation, correct tension on the wire is maintained by holding an index finger against the wire where it exits the body of the probe. The result is a very neat wiring job, especially when perforated board is used for circuit assembly. The wire runs are straight and easy to follow.

User Comment. Loading the pencil is very simple. The threading loop is fed through one of two holes near the probe end of the tool (depending on whether you're left or right handed), the end of the wire is wrapped around the loop, and the wire pulled through the hole. The bobbin is then snapped into the top end of the pencil, and the free end of the wire is threaded through the hollow tip.

We used the wiring pencil to prototype a number of projects and found it to be a very handy tool indeed. In one rather complex digital project containing 12 IC's and a large number of discrete components, the different colors of the insulation proved a real advantage. By assigning different colors to the power, signal, and common buses, we had no trouble keeping tabs on our wiring.

In all cases, the pencil performed flawlessly. The wire's insulation vaporized exactly as claimed, and every solder connection was sound. We estimate that wiring time using the tool can be cut about 75% compared to standard point-to-point wiring.

Finally, the pencil is by no means limited to circuit and project prototyping. It is an excellent tool for repair work. Working inside a very crowded transistor radio assembly, we were able to repair a break in the circuit with no difficulty whatever. Had we attempted such a repair by ordinary wiring methods, we would certainly have burned insulation or damaged nearby components.

CIRCLE NO. 69 ON FREE INFORMATION CARD

Build this set...
CAUTION
HIGH VOLTAGE

MAC'S SERVICE SHOP

SELECTING A CALCULATOR

By John T. Frye, W9EGV

IT WAS late autumn, and TV commercials on the portable color receiver Mac was checking out were frantically hustling both Thanksgiving and Christmas. Heaving a sigh, Mac snapped off the set and remarked, "People are beginning to drive me flakey asking what type of calculator they should buy for a christmas present."

"I know," Barney, the *numero dos* technician of Mac's Service Shop, replied sympathetically. "I'm being shot down with the same question, and it's as tough to answer as that oldy: 'What camera should I buy?' What do *you* tell them?"

"I say it all depends on such factors as: (1) who will use the calculator and for what purpose—and don't forget more than one family member may use it; (2) how much math the user has and whether he intends to study more math; and finally (3) how much the buyer wants to pay. If these factors are considered in depth, a wise purchase can be made."

The Basic Four-Banger. "For instance, let's consider who should buy the basic four-function calculator that adds, subtracts, multiplies, and divides—called a 'four-banger' in the trade—and can be had in a battery-powered form for less than $20. It will do everything an electric adding machine will do except provide hard-copy printout, and it will do it silently, lightning-fast, and every bit as accurately. Every member of the family will find a use for a pocket calculator. The housewife can use it to check grocery slips, work out her budget, and keep household accounts. Dad will use it to balance his checkbook, do his income tax arithmetic, and estimate how many cubic yards of concrete he needs for a new patio or squares of roofing for a new roof. The children can use it to check the answers they've worked out for their school arithmetic problems, but I'm opposed to the indiscriminate use of calculators by children who have not completed the eighth grade in school. It's most important they learn to manipulate numbers accurately and confidently with pencil and paper and in their heads before they start leaning on a calculator.

"Actually the basic calculator has a lot going for it besides mere price. The simplicity of the keyboard allows for large, well-separated keys that encourage the learning of touch operation for greater speed and accuracy—something much more difficult with a complicated calculator that has 40 or 50 smaller keys crowded into the same area. You use all the keys every day and quickly acquire proficiency and confidence. While you cannot work trigonometric problems or those involving extremely large or

Hewlett-Packard HP-25 programmable scientific calculator.

extremely small numbers directly, the use of supplementary trig and log tables allows such problems to be handled easily with the aid of the calculator. It does the tedious addition, subtraction, multiplication, and division of multi-digit numbers obtained from the tables. The tables can be used to extract any root of a number or to raise a number to any power. There is, however, a method that will permit the extraction of a square root by a simple calculator without resorting to log tables.

"While the four-function calculator is sufficient for general family use, the owner of a small business will need a few extras that will run the cost of the improved four-banger up to around $50. One such extra is rechargeable nickel-cadmium batteries so the unit can be operated off these batteries or from the power line. During long hours of continuous operation, as when taking inventory or doing year-end book balancing, power-line operation is preferable; yet battery-operation portability is not sacrified. A percent (%) key that will figure mark-ups or discounts at a single stroke will be a great help. So will a 'constant' or a 'memory' facility. When a problem requires the repeated use of a single constant, you key this in only once and then multiply, divide, add, or subtract with this constant by simply pressing the constant key. A 'memory' allows you to park a displayed number in invisible storage with a stroke of a key for as long as you like; then the touch of another key magically brings it back, over and over again, for use in a problem. This saves having to write down sub-totals and partial answers to problems before proceeding."

"How about a calculator for the high school kid who is wrestling with trigonometry and logarithms?"

Slide-Rule Calculators. "Now you're talking about the so-called 'slide-rule' calculators in the neighborhood of $100. They are intended to do (aside from addition and subtraction), the things you can do with a good log-log-duplex-decitrig slide rule: display common and natural logarithms of any number, square a number or extract its square root with a single key stroke, display the sine, cosine, tangent, or the inverse trigonometric functions of any angle, instantly find the reciprocal of a number, display *pi* with the stroke of a special key, raise a number to any power or extract any root of a number—while doing all the things an advanced basic calculator will do. Be warned, however, that 'Slide Rule Calculator' is a very loose term. You can buy slide rules that have six to more than twenty scales, and some so-called slide-rule calculators may have more functions than I have mentioned, but a great many will have far fewer; so *caveat emptor*!"

"I can understand how one of those calculators would see a bright youngster through high school and into college; but if he takes up engineering, business administration, statistical analysis, nuclear physics, or some other course involving advanced math, can he buy a pocket calculator still better suited to his needs?"

"That he can—if he has enough money. You're talking about professional calculators that divide into two broad classes: the *scientific* and *business* types. These instruments sell for $100 and up and they should be selected carefully. Only the user knows his own math background and how much calculator he requires in his study or work. In general, though, it's a good idea for a college freshman to buy all the calculator he can possibly afford. That way he won't outgrow it as he goes through college. Once he has become thoroughly familiar with it and has learned to trust it, it will save much precious time during his hectic college career and will continue to be his strong right arm after graduation."

"What can a professional calculator do that a good slide rule calculator can't?" Barney wanted to know.

"It's not that the professional calculator is capable of doing so much more; it just does it easier and quicker," Mac replied. "The professional calculator is pre-programmed so that one or two key strokes will do what might require a half dozen operations on a simpler calculator. An advanced scientific calculator can convert polar coordinates to rectangular coordinates and vice versa. It can calculate trig functions in any of three angular modes—degrees, radians, or grads—and can convert decimal angles into degrees, minutes, and seconds. It performs metric/U.S. conversions, calculates the factorial of positive integers, and simultaneously calculates the mean and standard deviation of an x value. It has several addressable memories instead of only one, and you can do register arithmetic—"

"Hold it!" Barney interrupted. "What does all that mean?"

"It means the calculator has several memories into which you can store constants or other numbers used more than once in a problem and you can call any one of these back at will so that you have to do very little writing down of numbers. What's more, you can directly add to, subtract from, divide into, or multiply the contents of a memory register. This is mighty handy in solving three simultaneous linear equations or doing similar problems. In addition, certain pocket calculators such as the Novus I'm going to show you presently and the Hewlett-Packard line, have a memory called an operational stack. With these, entries and intermediate answers are stored automatically and then re-entered into the calculation at the appropriate time. We haven't time to go into this thoroughly, but it works sort of like pushing 'Dixie Cups' one at a time up into a bathroom dispenser from the bottom and then having the stack of cups inside the dispenser drop down one cup at at time every time you take a cup away. This vertical stack arrangement is an essential part of RPN (Reverse Polish Notation) logic.

Logic Systems. "A logic system describes how you key in problems and the way the calculator is designed to handle them. There are essentially two logic systems used in pocket calculators: the RPN system just mentioned and the algebraic system. The latter, used in most basic calculators, works well with simple calculations and may be a little easier for the average person to use in entering a problem, but in working complex problems it often requires restructuring the equation, although a few calculators feature nested parentheses to simplify things. Calculators with RPN logic handle equations with nested parentheses much more easily. All Hewlett-Packard calculators use RPN logic with a four-stack memory."

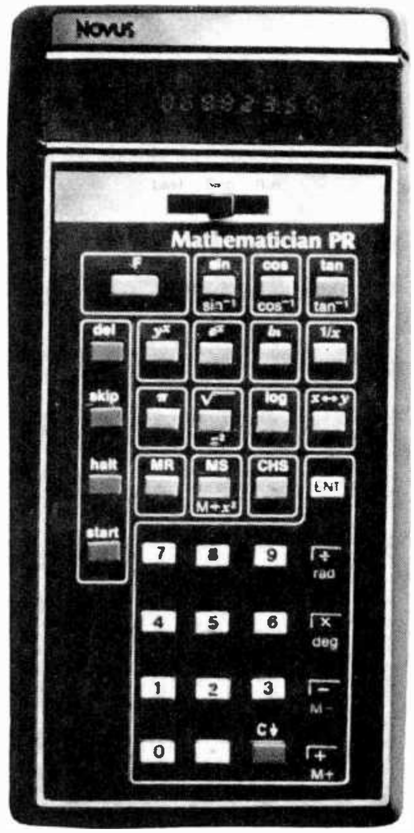
"What's different about business pocket calculators?"

"They feature more pre-programmed operations especially designed to solve business problems. While having deceptively fewer keys, they can solve specialized problems in compound interest, discounts, markups, remaining principle on a mortgage, future value of an annuity, depreciation, statistics, bond prices and yields, etc., far quicker than can scientific calculators. But now I want to show you an example of the next step up in pocket calculator complexity."

Mac took a slender calculator out of his shirt pocket and put it on the bench. "That," he said, "is a Novus 4515 Programmable Mathematician Calculator marketed by the Consumer Products Division of the National Semiconductor Corporation, Sunnyvale, California 94086. Selling for less than $150, it's the lowest priced programmable calculator I know of. It's not mine. I just borrowed it to find out how a programmable calculator really works."

"So how does it work?"

"As the key legends tell you, it's an advanced slide-rule calculator with three-stack RPN logic. Several of the 36 keys are made to do double duty by use of a gold-colored shift key. When this is touched before pressing a key, the function printed in gold beneath the key is brought into play instead of the one in silver above it. The programmable feature is controlled by these four blue keys arranged vertically along the left side of the keyboard



Novus 4515 programmable calculator.

and labelled from top to bottom: DEL, SKIP, HALT, and START; plus a three-position slide switch at the top labelled: LOAD, STEP, RUN.

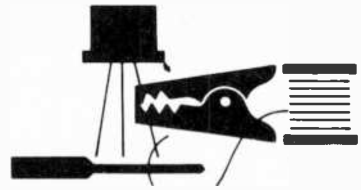
"Learn-mode programming is essentially automatic key pressing. With the slide switch at LOAD, you press START and then key in a sequence of steps to solve a problem, pressing HALT each time before you insert a variable. The calculator 'remembers' exactly how you did it, and when you put the slide switch at RUN and press START, it will go through the same sequence of steps automatically, only stopping at any HALT for you to insert a new variable, and with the new answer displayed at the end of the sequence.

"There are 100 steps of programming available at one time so you can program the 4515 with one large program or as many small programs as will fit into 100 steps. Pressing SKIP in the LOAD position terminates one program and marks the beginning of another. In the RUN position, the SKIP key is used as a kind of tab key to skip over unwanted programs to reach the one you want. The DEL key is used to erase, or delete, erroneous steps. With the switch in the STEP position, you can go through a program or programs a step at a time by repeatedly pressing the START key.

"I can see that programmable feature would really be a time-saver and error-avoider in situations requiring the repeated working of the same basic problem with different data used each time," Barney said. "But isn't the program you've keyed in lost when the calculator is switched off?"

"That's right. But for $795 you can buy a Hewlett Packard HP-65 fully programmable calculator in which programs are stored on tiny magnetic program cards. One of the cards can be slipped into the calculator and in two seconds the program is duplicated in the calculator's memory and the card exits for use another time. You can buy these prerecorded magnetic cards with programs for solving problems in any math-connected discipline, or you can custom-record your own programs on blank magnetic cards for repeated use."

"Enough!" Barney said wearily, holding up his hand. "It's possible to know too much. As Lee Segal remarked, 'A man with one watch knows what time it is; a man with two watches is never sure.' After listening to your parade of calculator choices, I know what he means." ◈



Tips & Techniques

BLOWN-FUSE INDICATOR FOR MOBILE EQUIPMENT

Mobile and portable equipment using low-voltage dc supplies often contain a protective fuse. When the gear suddenly goes dead, it is hard to tell if the fuse blew when it is tucked away in a crowded chassis. By installing a LED and a series resistor, it is possible to monitor the condition of the fuse. Connect a 25-k pot in series with a LED (voltage depends on supply) across the fuse socket. Before applying voltage, turn the pot to maximum resistance and remove the fuse. Slowly turn the pot until the LED just starts to glow. Remove voltage and disconnect the pot. Measuring its resistance gives the value of *R1*. Reconnect the LED and a fixed resistance across the socket and mount the LED in a convenient viewing position. When the fuse blows, the LED will give a visual indication of its open condition.

—*Paul Angelino*

SAFETY TIPS FOR INSTALLING IC'S IN SOCKETS

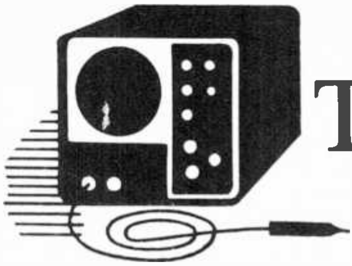
Installing new IC's in new sockets can be difficult and hazardous to both IC and socket unless you observe a few precautions. First, if possible, examine the socket contacts to discover if there are any bent prongs that can snag an IC pin. With many sockets, the defective pin can be removed and its contact reshaped. Next, break in the socket by inserting and removing a defunct IC several times. Then, before installing the new IC, carefully bend its leads so that they are perpendicular to the case. This insures that pin rows rest between the contacts and not on top of the outer contact.

—*Raymond F. Arthur*

TAPE "FLAG" ON TOOL TAKES GUESSWORK OUT OF ALIGNMENT

Keeping track of the number of turns made with an alignment tool on the slug of a transformer or coil during an alignment procedure can be a chancy proposition. One way to minimize the element of chance is to use some type of marker on the tool. A "flag" made from a 1-in. (2.54-cm) length of self-adhering tape wrapped around the tool with its ends pinched together makes a good marker. Keeping track of the number of rotations of the flag is much easier than trying to estimate how many times you turned a featureless alignment tool.

—*Thomas Fagan*



Test Equipment Scene

By Leslie Solomon

THE MICROPROCESSOR REVOLUTION

There's a slightly different twist to my column this month. It may not be as practical (for immediate use, that is) as some of the others; but it will give you an idea of what is to be expected in test equipment in the not-too-distant future.

I would like to talk about the microprocessor IC chip (usually called an MPU, or microprocessing unit) and its future use in test equipment. For the last year or two, the MPU has been used as the heart of a number of digital computers—many of which are of interest to hobbyists. Looking around the industry, I get the feeling that a considerable number of engineers (especially test equipment designers) are viewing the MPU as a device whose potential is not limited to the computer.

According to some industry spokesmen, the MPU will completely revolutionize the analytical instrument industry by the beginning of the 1980's. One of these experts claims that by 1982, 65% of the instruments on the market will use microprocessors. Many of these "smart" instruments will be capable of performing measurement functions not even thought of today. Even now, there is one scope (admittedly in the thousands of dollars range) that uses an 8080 MPU to make astounding measurements.

Where It Started. A few years ago, low-cost digital logic and readouts were introduced to provide a multiplicity of test instruments— primarily digital multimeters and frequency counters. Look at any recent electronics magazine and you will invariably see a new digital instrument. Many of them perform functions that were never thought of before, but they turn out to be highly usable. The trend is carried over, of course, into the analog world, where new types of A/D converters are being introduced as interfaces.

So the microprocessor (with its associated logic) should play a natural role in the handling of the enormous amount of digital data that will soon be flowing our way.

For the Future. Now the question is what can the microprocessor do for service test equipment that isn't already possible with current equipment? First of all, take a cl ose look at, for example, multimeters (either the older vacuum-tube or solid-state types) with the number of controls they have on the front panels. There is a function switch to select either ac or dc volts, ohms, or current, a range switch for each function (usually having several ranges for each function), a zero set or an ohms-adjust control. Then there is the problem of selecting the proper range and interpreting the reading of the needle on the multi-scale meter. All of which can lead to erroneous readings.

Now, consider modern digital multimeters. Note the reduction in the number of controls. Most have ranging, zeroing, and polarity features that are automatic and they are coupled to an unambiguous seven-segment display that leaves nothing to chance in making a reading. Of course, analog instruments are not completely passe. There are many places where they really shine, but the switch to digital is inevitable in most cases.

Of course, there is really no analog equivalent to the digital frequency counter. It took the introduction of low-cost digital logic to produce this new form of test instrument, which is an important part of a number of service shops. Note also that there is a minimum of controls on such an instrument.

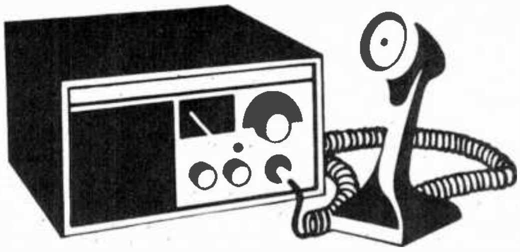
The MPU's Contribution. What improvements can the microprocessor bring? First, it can be used in a piece of test equipment that can be programmed to perform a series of measurements by sampling the particular signals at high speed. Then, if it encounters a signal that is out of its predetermined level, it will sound some form of alarm and possibly provide a hard-copy printout.

A popular European car has been featuring a "computer" connector so that when the vehicle is brought into a suitably equipped garage, the car can be "plugged in" and a series of measurements will determine the "health" of a number of areas. With this type of usage, there may well appear, at some time in the future, an industry standard for interfacing consumer devices (similar to the IEEE interface standard being considered for the OEM market). Imagine a TV or FM receiver or an audio system having a "standard" test connector on its rear apron. All you would do is plug in your microprocessor test set and every important parameter would be measured. It would be checked against some predetermined standard; and if anything was wrong, you would get an immediate alarm or printout.

Similarly, imagine a super-oscilloscope that you could connect to a piece of faulty gear, operate a few calculator-type switches, and right away any problems are spelled out on the CRT of this electronic marvel.

Besides opening up a whole new ballpark of test instruments, the MPU may also bring down the price of currently expensive test gear because the same "master" MPU system can be used in many different instruments simply by changing the external "software". The more uses for a common board, the lower in cost it becomes.

Don't think that these devices are far in the future. Visitors to the IEEE show in New York or WESCON in California are aware of the many microprocessor-controlled test instruments already available. True, many of them are still expensive, but it will not be long before similar instruments at prices suitable for the hobbyist's pocketbook will make them more attractive. In our latest observations, the costs of some microprocessors have dropped to under $10, which makes them look interesting to the test equipment manufacturer. When a single $10 MPU can replace 15 or 20 $1 TTL chips, the door is open. ◈



CB Scene

By Lee Craig

THE FCC CHANGES SOME CB RULES

THE FCC has presented CB'ers with a nice Christmas present—relaxed rules! The action, which amends Part 95 of the FCC regulations, deals with station identification, permissible communications, antenna height and the reservation of Channel 11 as a calling channel.

Section 95.5 was amended to require a transmitting station to identify itself at the beginning and end of transmissions. It will no longer be necessary to identify the station you're communicating with also.

Interestingly, the FCC deleted Section 95.83, thereby removing the prohibition against hobby use. A new Section 95.81 was adopted, specifying permissible types of communications—personal or business use, communications for the safety of life, protection of property, assistance to motorists, mariners, or other travellers, and civil defense activities.

Further, Section 95.41 was amended, designating Channel 11 as a calling frequency. Another amendment to this section eliminates the interstation restriction. Communications may now be conducted between units of different stations, as well as between those of the same station.

The Commission modified Section 95.37 (height restrictions) to apply to receiving antennas as well as transmitting ones. All directional antennas and support structures can not exceed 20 feet (6.1 m). Omnidirectional antennas and support structures have a 60-foot (18.3 m) "ceiling."

Finally, Section 95.91 was amended to reduce the five-minute silent period after a transmission. (Continuous transmissions are still limited to five minutes.) The waiting period before beginning a new transmission is now one minute.

Glossary of CB Terms. To help you understand more of what is going on in the CB world, here is a glossary of terms which you can tack up next to your rig as a ready reference.

Amplitude Modulation (AM). A technique of modulating a radio signal (the power output level being varied) so it can be used for conveying intelligence.

Automatic Noise Limiter (anl). A circuit built into almost all CB transceivers to reduce impulse-type ignition noise.

Base Station. A radio station at a fixed location used primarily for communicating with mobile units.

Beam Antenna. A directional antenna that radiates or intercepts more energy in one direction than in others.

Breaker. A CB'er who breaks into a radio conversation.

Callsign. The station identification assigned to a licensee by the FCC.

Carrier Power. The r-f power output of an AM transmitter when not modulated.

Citizens Band. A band of radio frequencies allocated to the Citizens Radio Service.

Clarifier. A control on an SSB transceiver which enables adjustment of frequency so that the frenquencies of the recovered audio signal will be essentially the same as the frequencies of the modulating signal fed to a distant transmitter.

Class A Station. A Citizens Radio Service station licensed to operate on frequencies in the 460-to-470 MHz uhf band.

Class C Station. A radio station authorized to transmit control signals on specified frequencies in the 26.96-to-27.26 MHz and 72-to-76-MHz bands.

Class D Station. A Citizens Radio Service station licensed to use radio telephony on authorized channels in the 26.96-to-27.26-MHz band.

Decibel (dB). A unit for expressing the ratio of two values of (usually) power or voltage. In the CB field, dB is most often used in reference to coaxial cable attenuation loss and antenna gain.

Delta Tune. A control provided on some transceivers which permits tuning the receiving frequency slightly off the center to compensate for variations in transmitting frequency of other transceivers.

Double-Conversion Receiver. A receiver using a superheterodyne circuit in which the incoming signal frequency is converted twice, first to a high i-f and then to a lower one.

Effective Radiated Power (erp). The erp may be greater or less than the power generated by the transmitter, depending on antenna system gain or loss.

Fixed Station. A radio station at a fixed location.

Frequency Synthesizer. A circuit which enables transmit and receive on a number of channels without separate crystals for each function and channel.

Handle. A nickname used by a CB'er.

Microvolt (µV). One millionth of a volt.

Mike. Colloquial for microphone

Mobile Unit. A radio station either installed in a conveyance, carried by a person, or installed temporarily at a fixed location.

Modulation Percentage. In an AM transmitter, the relative amount the power increases with modulation. When an AM transmitter is 100% modulated by a sine wave, power output increases 50%.

Negative Ground. The negative battery terminal of a vehicle is connected to the body and frame.

Noise Blanker. A circuit used in some CB receivers just before the detector to minimize ignition noise.

Omnidirectional Antenna. An antenna that radiates equally well in all directions.

Part 95 Rules. FCC Rules and Regulations governing the Citizens Radio Service.

Peak Envelope Power (pep). The power generated by an SSB transmitter when modulated.

PTT. Abbreviation for press-to-talk or push-to-talk, generally with reference to a pushbutton switch on a microphone which is operated to turn the transmitter on and which is released to enable the receiver.

Positive Ground. The positive battery terminal of a vehicle is connected to the body and frame.

QSL Card. Sent by some CB'ers to other CB'ers with whom they have had radio communications.

Receive Current. The amount of current drawn by a transceiver when receiving radio signals.

Rig. Colloquial for a transceiver.

73. Abbreviation for "best regards" in radio communications.

Single-Conversion Receiver. A receiver employing a superheterodyne circuit in which the input signal is down-converted once.

Single Sideband (SSB). An AM-radio transmission technique in which only one sideband is transmitted. The other one and the carrier are suppressed.

Skip. Term referring to propagation of radio signals over considerable distances due to reflection back to earth from the ionosphere.

Squelch. A circuit used in most CB transceivers to silence the speaker except when an adequately strong signal is received.

S/r-f Meter. Provided on some CB transceivers to indicate relative strength of an intercepted signal when receiving and the relative r-f power output when transmitting.

SWR Meter. An external or built-in circuit which measures the standing wave ratio at the transceiver end of the antenna transmission line.

Station License. In the Citizens Radio Service, a license granted by the FCC to operate any number of transceivers under the control of the same licensee.

10-Code. Abbreviations used by CB'ers and other radio communications users to minimize use of air time.

Transceiver. A combination radio transmitter and receiver in which some of the circuits are used in both operating modes.

Transmission Line. In CB applications, the coaxial cable that is used to connect the transceiver to the antenna.

Transmit Current. The current drawn by a transceiver when in the transmit mode.

TVI. Television interference sometimes caused by CB transceivers. It is often due to inadequate design of the TV receiver rather than being a fault of the transceiver.

Unit. One of the transceivers covered by a CB station license when more than one transceiver is used.

Walkie-Talkie. A hand-held transceiver.

Electronics Library

THE WAY THINGS WORK BOOK OF THE COMPUTER

Billed as "an illustrated encyclopedia of information science, cybernetics, and data processing," this book provides a basic overview of the theory and practice of "thinking machines." Beginning with the concepts of energy and information flow, it develops both a systems and hardware approach to the mechanical and electrical means of automation and cybernetics. Memories, Boolean gates, flip-flops, A/D and D/A converters, and interfaces are described. Hardware is approached on an unassuming level, and the explanations are quite simple and lucid.

Published by Simon and Schuster, 630 Fifth Avenue, New York, NY 10020. 245 pages. $8.95 hardbound.

FUNDAMENTALS OF ELECTRONIC DEVICES

by David Bell

Written as a text for an introductory electronics course, this book covers the currently important electronic devices, and the characteristics of circuits in which they typically appear. Separate chapters are devoted to vacuum tubes, the modern CRT, zener diodes, UJT's, SCR's, bipolar and field-effect transistors, IC's, LED's, tunnel diodes, thermistors, and LCD's. Algebra and logarithms are used in the text. Worked-out problems appear in each chapter, and review questions will help the reader gauge his understanding of the material presented. Over 300 line drawings, schematics, and graphs supplement the text.

Published by Reston Publishing Co., Box 547, Reston, VA 22090. 467 pages. $15.95 hard cover.

LINEAR IC PRINCIPLES, EXPERIMENTS, AND PROJECTS

by Edward Noll

The principles of operation of integrated circuits for linear applications are introduced in this work. Chapter One covers basic semiconductor principles: the pn junction, the bipolar and field-effect transistor, transistor fabrication and basic IC structures. Succeeding chapters explain basic IC circuits, operational amplifiers, multipurpose IC's, and special IC systems. Applications in commercial, industrial and test equipment are shown, as well as audio, broadcast, and two-way radio applications. A collection of projects for the lab and home is included.

Published by Howard W. Sams & Co., 4300 W. 62nd Street, Indianapolis, IN 46206. 384 pages. $8.95 soft cover.

Operation Assist

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Hallicrafters S-38A receiver. Instruction manual. Doug Kowalski, 2035 S. 58 St., West Allis, WI 53219.

Viscount Model 8TP-803N Polaris 3-band portable receiver. Schematic and parts procurement information. Russ Harvey, 625 E. Princess Dr. #5, Tempe, AZ 85281.

RCA Model RK327B Modular Stereo. Schematic. Herman Rummelt, Rt. 2 Box 121A, Greenville, MI 48838.

Micró-Switch Model 49SW1-1 Keyboard. Schematic and/or operations data. John Riley, 914 Cordova St., Burbank, CA 91505.

AGS AM/SW Receiver Trio Model 9R-59. Schematic and/or service manual. Brian Stepien, 30 Mohawk Dr., St. Catherines, Ontario, Canada L2R 1C1.

Monacor Model STA-150X tube-type AM/FM receiver. Schematic and transformer PT-150. Charles Allen, 6746 Parkinsonia Drive, Miami Lakes, FL 33014.

RBM 7-channel vhf scanner. Schematic. John Crockett, 2922 Keenwood Rd., Norristown, PA 19403.

Jackson Model 115 Dynamic Tube Tester. Old roll chart covering antique (No. 42, 6F7, etc.) tubes. **Bell & Howell** Model PH-131-G 16-mm Sound Projector. Amplifier schematic. Harry Buchlein, 1852 Ocean Ave., Ventura, CA 93003.

Karlton Instruments Model A-3000 49-note electric organ. Schematics and parts list. Robert Gerald, Box 406, New York, NY 10013.

Browning Drake Receiver with 5 UX-type tubes. Circa 1925. Schematic and parts list. Robert Moisio, Box 321, Ashburnham, MA 01430.

Heathkit Model OL-1 Oscilloscope. Operating/assembly manual or schematic. J.D. Caldwell, 904 S. 18th St., Arlington, VA 22202.

Radio City Products Model 322-A Tube Tester. Tube update roll. Ernie Redpenning, 4200 Van Buren St., Gary, IN 46408.

Bogen Models TR54A, B, C, and R135BT 35.66-MHz paging receivers. Any available information. Robert R. Scott, 15955 E. Iliff Place, Aurora, CO 80013.

Shell Electronics stereo amplifier Model 2020P. Schematic and/or any available information. C.L. Baumbruck, 2919 Hickory St., Yorktown Heights, NY 10598.

Hammarlund Pro long/medium/shortwave receiver. Schematic and/or service manual. P.R. Pettingell, 3 Weave Road, Seabrook, NH 03874.

Gonset power supply No. 3069. Schematic. Steve Ackerman, 11114 Garfield Ave., Culver City, CA 90230.

Superior Instruments Genometer TV 50. Operations manual and schematic. G.T. Hermida, 1000 W 92nd Place, Overland Park, KS 66212.

"Dimension 48" Japanese auto tape player. Any available information. Charles D. Prater, Edna, KY 41419.

Webcor Model ED-2950 tape recorder. Need schematic or company's new address. T. Cranford, 1125 N. 29th St., Fargo, ND 58102.

Consolidated Electrodynamics Model GIC-100 ionization gauge. Any available information. Summer Freeman, 49-018 Bel Vista Ct., Lodi, NJ 07644.

Auto Data Inc. Model 2643-2 Digital VOM, serial 254, mfg. date 12/65, "Contr. MSW3X5X-834863." Any available information. William Palya, Dept. of Psychology, St. Joseph's College, Rensselaer, IN 47978.

Splitdorf Radio Corp (Div. of Bethlehem Electrical Co.) old radio receiver. Uses type 201 A tubes. Schematic and any other information. Edward Reinhardt, 60 Stanley Street, Little Falls, NJ 07424.

TEC Model S-25 Stereo Amp. by Transis-Tronics. Specs and/or schematic. G. Lewis, 3916 Monroe St., Riverside, CA 92504.

Experimenter's Corner

By Forrest M. Mims

APPLICATIONS FOR QUAD OP AMPS

NO IC is more useful or versatile than the operational amplifier unless it's four op amps in the same package. Quad op amps, as these relatively new chips are called, are now stocked by many parts dealers, and one of my favorites is National's LM324.

The LM324 (Fig. 1) comes in a 14-pin DIP for less than two bucks. The most impressive fact about this neat little package is that it can be operated from a single-polarity power supply. Some more experienced tinkerers might find it hard to believe that many new experimenters are reluctant to use op amps because conventional units require a double-ended power supply.

Another nice thing about the LM324 is that it will operate from a power supply ranging from as little as 3 volts to as much as 30 volts. This makes it compatible with TTL (5.5 volts) and ideal for operation from almost all common battery voltages.

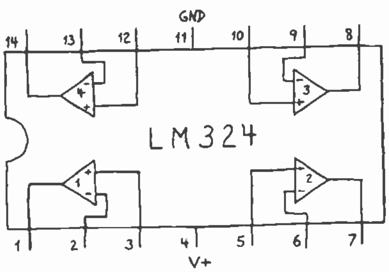

Fig. 1. Top view of the LM324.

I've been using LM324s for about a year now and haven't blown one yet, but the manufacturer warns that reverse polarity can quickly zap the device. The moral here is that if you use breadboard construction or conventional sockets be sure to plug the LM324 into the board or socket correctly.

Another precaution is to avoid output shorts to either ground or the positive power supply. Momentary shorts are no problem, but longer ones, especially on more than one amplifier, will cause excessive thermal build-up and eventual device destruction.

The LM324 will handle just about any op amp application, but it is particularly well suited for those utilizing several similar or identical circuits to perform parallel functions. I've particularly enjoyed tinkering with a versatile pulse generator and a nonlatching touch switch.

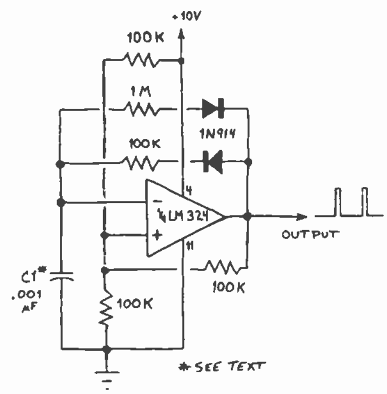

Fig. 3. Change C1 to vary pulses.

A basic pulse generator circuit which uses ¼ of an LM324 is shown in Fig. 2. Except for the common power supply, each of the four amplifiers in the LM324 is independent of the others, and one or more can be used simultaneously as noninteracting pulse generators.

With the values shown in Fig. 2, the pulse generator has a repetition rate of about 600 Hz and a pulse width of 600 microseconds. The pulse amplitude is 8.5 volts when the power supply voltage is 10 volts. All these parameters can be changed by varying *C1* and the power supply voltage.

A somewhat more versatile pulse generator is shown in Fig. 3. The repetition rate of this circuit can be changed from one pulse every few minutes to 200 kHz by simply changing *C1*. Here's a table of pulse parameters I measured with the prototype circuit:

C1 (μF)	Frequency (kHz)	Pulse Width (ms)
0.0001	200.0	0.025
0.001	20.0	0.25
0.01	2.0	2.5
0.1	0.2	25.0

You can use even larger values for *C1* to further reduce frequency.

The conventional pulse generator of Fig. 3 can also be used to experiment with applications like these:

1. A quadruple-output, nonsynchronized pulse source. Just connect each of the op amps in the LM324 as an independent pulse generator.
2. A dual-synchronized pulse generator with two independent repetition rates. Figure 4 shows how to connect two op amps in the LM324 to achieve this function. A circuit like this has obvious uses in electronic music, frequency synthesis, frequency division, etc.

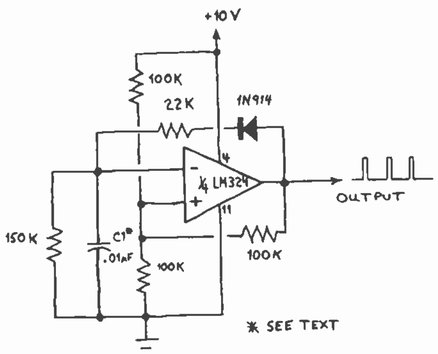

Fig. 2. Pulse generator circuit.

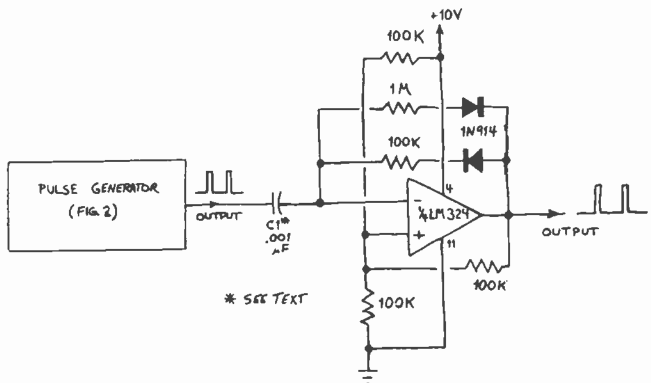

Fig. 4. Synchronized pulse generator uses half of an LM324.

3. A LED "random" flasher. See Fig. 5 for this variation of the circuit. For best results, use different values for the capacitors (*C1* in Fig. 3) to provide different flash rates. These values should range from about 0.2 to 1.0 µF so that the flashing will be discernable to the eye. Incidentally, you can house this circuit in a small plastic enclosure for permanent use as a novelty or attention-getting device.

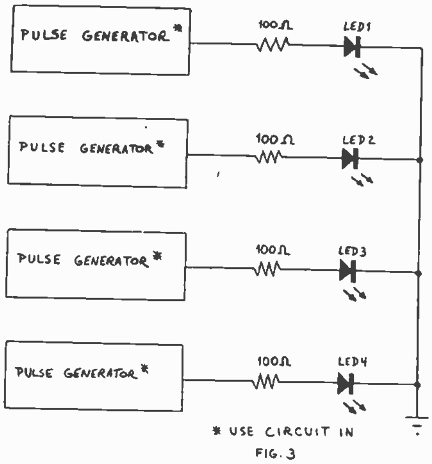

Fig. 5. Random LED flasher.

If the assorted pulse generator circuits described thus far don't appeal, try the super-simple nonlatching touch switch shown in Fig. 6. In this circuit, ¼ of an LM324 is operated as a comparator by simply omitting the feedback resistor. The noise signal injected into the op amp by a finger on the touch plate causes a positive voltage swing which activates the relay.

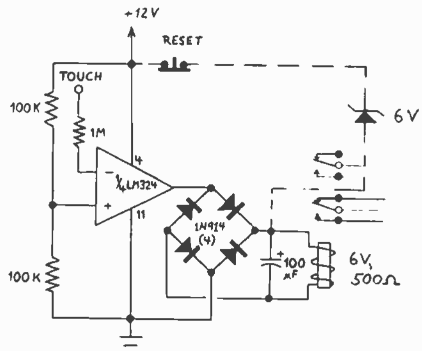

Fig. 6. Touch switch. For latching operation, add dashed circuitry.

Since the input noise signal is ac, the rectifier bridge is necessary to convert the output to dc. The pulsed dc output is smoothed by the capacitor to keep the relay from chattering. For best results, operate the circuit from a line-operated power supply instead of batteries. When used with a 6-volt, 500-ohm relay, the circuit will draw less than 10 mA. ◈

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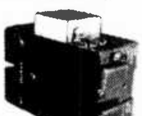

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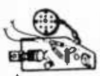

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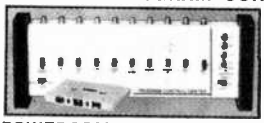

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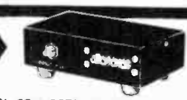

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CD4020	1.49	CD4069	.45	74C161	3.25
CD4022	1.25	CD4071	.45	74C163	3.00
CD4023	.25	CD4081	.45	74C164	3.25
CD4024	1.50	74C00N	.39	74C173	2.60
CD4025	.25	74C02N	.55	74C193	2.75
CD4027	.69	74C04N	.75	74C195	2.75
CD4028	1.65			80C97	1.50
CD4029	2.90				

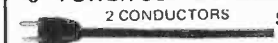
LINEAR

LM100H	15.00	LM373N	3.75	LM1310N	2.95
LM106H	2.50	LM377N	4.00	LM1351N	1.65
LM171H	3.75	LM380N	1.39	LM1414N	1.75
LM212H	7.00	LM380CN	1.05	LM1458C	.65
LM300H	.80	LM381N	1.79	LM1496N	.95
LM301H	3/1.00	LM382N	1.79	LM1556V	1.85
LM301CN	3/1.00	NE501K	8.00	LM2111N	1.95
LM302H	.75	NE510A	6.00	LM2901N	2.95
LM304H	1.00	NE531H	3.00	LM3065N	.69
LM305H	.95	NE536T	6.00	LM3900N	.55
LM307CN	.35	NE540L	6.00	LM3905N	.60
LM308H	1.00	NE550N	.79	LM5556N	1.85
LM308CN	1.00	NE553	2.50	MC5558V	1.00
LM309H	1.10	NE555V	.49	LM7525N	.90
LM309K	1.25	NE565H	.99	LM7528N	2.20
LM310CN	1.15	NE565N	1.25	LM7534N	2.20
LM311H	.90	NE566CN	1.95	LM7535N	1.25
LM311N	.90	NE567H	1.25	8038B	4.95
LM318CN	1.50	NE567V	1.50	LM75450	.49
LM319N	1.30	LM703CN	.45	75451CN	.39
LM319D	9.00	LM709H	.29	75452CN	.39
LM320K-5	1.35	LM709N	.29	75453CN	.39
LM320K-5.2	1.35	LM710N	.79	75454CN	.39
LM320K-12	1.35	LM711N	.39	75491CN	.79
LM320K-15	1.35	LM723N	.55	75492CN	.89
LM323K-5	10.50	LM723H	.55	75494CN	.89
LM324N	1.80	LM733N	1.00	RCA LINEAR	
LM339N	1.70	LM739N	1.29	CA3013	1.70
LM340K-5	1.95	LM741CH	3/1.00	CA3023	2.15
LM340K-12	1.95	LM741CN	3/1.00	CA3035	2.25
LM340K-15	1.95	LM741 14N	.39	CA3039	1.35
LM340K-24	1.95	LM747H	.79	CA3046	1.15
LM340To-5	1.75	LM747N	.79	CA3059	2.46
LM340To-6	1.75	LM748H	.39	CA3060	2.80
LM340To-12	1.75	LM748N	.39	CA3080	.85
LM340To-15	1.75	LM1303N	.90	CA3083	1.60
LM340To-24	1.75	LM1304N	1.19	CA3086	.59
LM350N	1.00	LM1305N	1.40	CA3089	3.25
LM351CN	.65	LM1307N	.85	CA3091	8.25
LM370N	1.15			CA3123	1.85
LM370H	1.15			CA3600	1.75

DATA HANDBOOKS

7400	Pin-out & Description of 5400/7400 ICS	$2.95
CMOS	Pin-out & Description of 4000 Series ICS	$2.95
LINEAR	Pin-out & Functional Description of Linear Circuits	$2.95

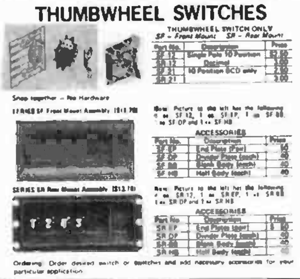
6' POWER SUPPLY CORDS . . . .



2 CONDUCTORS

SPECIAL 3/$1.00

THUMBWHEEL SWITCHES



JAMES CHRISTMAS SPECIALS

DIODES

1N4001	50V @ 1 Amp	15/$1.00
1N4002	100V @ 1 Amp	15/$1.00
1N4003	200V @ 1 Amp	15/$1.00
1N4004	400V @ 1 Amp	15/$1.00
1N4148	Switching	20/$1.00

TRANSISTORS

2N2907A	PNP Switching	6/$1.00
2N2222A	NPN Switching	6/$1.00
2N3904	NPN Amp	6/$1.00
2N3906	PNP Amp	6/$1.00
2N918	NPN RF	6/$1.00
2N5951	NJ Fet	6/$1.00
C106B1	3.6 Amp SCR	2/$1.00

TTL/LINEAR

7400	Gate	7/$1.00
7447	Decoder	.79
7490	Counter	.49
74100	8 Bit Latch	.99
74154	Decoder	.99
74197	Counter	.75
LM301H–LM741H		4/$1.00
LM324N	Quad 741	1.19
LM309H	5V Reg TO-5	.79
LM309K	5V Reg TO-3	.99

CLOCK & CALC. CHIPS

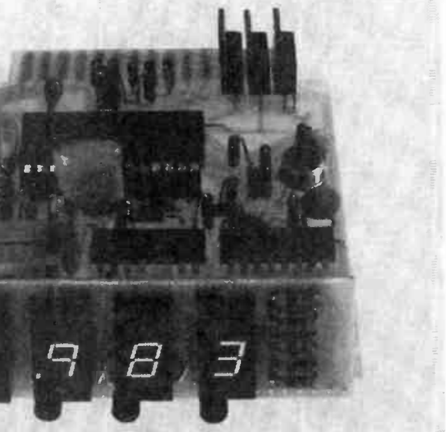
MM5311N	6 Digit	$2.95
MM5312N	4 Digit	2.95
MM5313N	6 Digit	2.95
MM5314N	6 Digit	2.95
MM5316N	6 Digit Alarm	3.95
MM5725N	8 Digit-4 Funt.	1.85
MM5736N	6 Digit-4 Funt	1.95
MM5738N	8 Digit-5 Funt.	2.95

MM5262 DYNAMIC 2K RAM $2.95

26 Awg RIBBON CABLE

1 Ft. Minimum	1-9 ft	10 ft.
6 Cond	.29 ft.	.25 ft.
8 Cond.	.59 ft.	.49 ft.
16 Cond	.89 ft.	.79 ft.
32 Cond	1.89 ft.	1.69 ft.

DIGITAL VOLTMETER JE801 DVM



$39.99 Per Kit SINGLE UNIT

GENERAL DESCRIPTION

The JE801 is a three and one half digit, auto polarity digital voltmeter, in a kit form. It features several options not available in any commercial digital voltmeter. Its low cost is perhaps the most important feature, which is achieved by offering it in a kit form. A kit allows the unit to be used by small OEM's where cost effectiveness is an important factor, and by the hobbyist who has to be concerned with cost. The unit also features on card regulators, allowing it to be operated off a single plus and minus fifteen volt, unregulated power supply. The unit has a small size of three inches width, three and three quarters of an inch length, and one and a quarter inch height.

DISPLAY LEDS

FND70	Com. Cath.	.250	.59
MAN 1	Com. Ano.	.270	$1.95
MAN 2	5x7 Matrix	.300	3.95
MAN 3	Com. Cath.	.125	.39
MAN 4	Com. Cath.	.187	1.95
MAN 7	Com. Ano.	.30	1.50
DL33	Com. Cath.	.125	1.95
DL747	Com. Ano.	.625	1.95

DISCRETE LEDS

MV 10	Red	5/$1.00
MV 50	Red	6/$1.00
MV 5024	Red	5/$1.00
MV 5024	Green	4/$1.00
MV 5024	Yellow	4/$1.00
MV 5024	Orange	4/$1.00
MV 50'	Red 1½" Leads	5/$1.00

IC SOLDERTAIL – LOW PROFILE (TIN) SOCKETS

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

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$.70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.55	1.40	1.26
18 pin	.52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

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

50 PCS. RESISTOR ASSORTMENTS $1.75 per assort.

Each assortment contains 50 pcs. of ¼ watt, 5% resistors

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

14 PCS. POTENTIOMETER ASSORTMENTS $9.95

Each assortment contains 14 pcs of 10 turn pots.

ASST. A 2 ea: 10 OHM-20 OHM-50 OHM-160 OHM 200 OHM-250 OHM-500 OHM

ASST. B 2 ea: 1K, 2K, 2.5K, 10K, 20K, 25K, 50K

ASST. C 2 ea: 50K, 100K, 200K, 250K, 500K, 1M, 2M

All pots are available in single unit quantities. $.99 ea.

DPST C & K ROCKER SWITCH

They are rated at 125 Vac @ 5A. They are excellent in application such as Microcomputer Panel Switches **$0.69**

Dim: 1" x 1" x ¾"

PRIME INTEGRATED CIRCUIT ASSORTMENTS

ASST. 8	3 ea	SN7400 SN7410	7401 7430	7402 7438	7403 7440	7404 7472	SSI/TTL	$5.95 ASST.
ASST. 9	2 ea	SN7447 SN74145	7490 74175	7491 74180	74100 74191	74121 74193	MSI/TTL	$9.95 ASST.
ASST. 10	2 ea	CD4001 CD4016	4002 4017	4011 4019	4012 4023	4013 4030	CMOS	$7.95 ASST.
ASST. 11	2 ea	LM301T LM311T	301N 565T	302T 567T	307T 741T	309K 741N	LINEAR	$10.95 ASST.

Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax
Write for FREE 1976 Catalog — Data Sheets .25¢ each

JAMES

P.O. BOX 822, BELMONT, CA. 94002
PHONE ORDERS — (415) 592-8097

MICROPROCESSOR COMPONENTS

8008 – $19.95   2102 – $2.95

CPU'S			RAM'S			
8008	8 bit CPU	$19.95	1101	256x1	Static	$2.25
8080	8 bit Super 8008	149.95	1103	1Kx1	Dynamic	2.95
4040	4 bit 8080	39.95	2102	1Kx1	Static	2.95
UARTS			2107	4Kx1	Dynamic	19.95
AY-5-1013		6.95	7010	1Kx1	Mnmos	29.95
PROM'S			7489	16x4	Static	2.49
8223	32x8 Prom	3.00	8101	1Kx1	Static	7.95
1702A	2K E Prom	15.95	8111	1Kx1	Static	7.95
5203	2K E Prom	14.95	8599	16x4	Tristate	3.49
74S287	1K x 1 Prom	7.95	91L02	1Kx1	Low Power	3.95
SR'S			74200	256x1	Static	6.95
2401	2K DSR	9.95	74LS670	4x4	Register	3.95
2533	1K SSR	7.95	93410	256x1	Static	2.95

91L02 1K Static RAM Direct Replacement for 2102-1 with 40% Less Current Drawn 2.49

Vector General Purpose Logic CARD Board 14.95
*Very High Noise Immunity *Holds 12 ea. 14 pin DIPS
*44 pin Edge Connection

THE KILOBYTE RAM CARD Per Kit $49.95
*Complete 1Kx8 Memory *High Noise Immunity Components
*Single 5v supply *500NS Access Time & Kit includes sockets, ICS & Board

4 PDT SWITCHES, HIGH QUALITY P.B. TYPES .69

KITS EXAR ICS

XR-2206KA SPECIAL $17.95
Includes monolithic function generator IC, PC board, and assembly instruction manual.

XR 2206KB SPECIAL $27.95
Same as XR-2206KA above and includes external components for PC board.

TIMERS		STEREO DECODERS	
XR-555CP SPECIAL	$.69	XR-1310P	$3.20
XR-320P	1.55	XR-1310EP	3.20
XR-556CP	1.85	XR-1800P	3.20
XR-2556CP	3.20	WAVEFORM GENERATORS	
XR-2240CP SPECIAL	3.25	XR-205	8.40
PHASE LOCKED LOOPS		XR-2206CP SPECIAL	4.49
XR-210	5.20	XR-2207CP	3.85
XR-215	6.60	MISCELLANEOUS	
XR-567CP	1.95	XR-2211CP	6.70
XR-2567CP SPECIAL	2.99	XR-2261	3.79

Special Requested Items

RC4194	Dual Track V Reg	$5.95	N8T97	$3.00	2533	$7.95
RC4195	±15V Track Reg	3.25	4024P	2.25	8263	5.95
F9368	Decoder	3.95	2513	11.00	8267	2.75
LD110/111	DVM Chip Set	28.00	2518	7.00	8288	1.15
CA3130	Super CMOS Op Amp	1.49	2524	3.50	8826	3.00
MC1408L7	A/D	9.95	2525	6.00	8880	1.35
F3341	FIFO	8.95	2527	5.00	7497	5.00

ZENERS—DIODES—RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
IN746	3.3	400m	4/1.00	IN4003	200 PIV	1 AMP	.10
IN751A	5.1	400m	4/1.00	IN4004	400 PIV	1 AMP	.10
IN752	5.6	400m	4/1.00	IN3600	50	200m	6/1.00
IN753	6.2	400m	4/1.00	IN4148	75	10m	15/1.00
IN754	6.8	400m	4/1.00	IN4154	35	10m	12/1.00
IN965B	15	400m	4/1.00	IN4734	5.6	1w	.28
IN5232	5.6	500m	.28	IN4735	6.2	1w	.28
IN5234	6.2	500m	.28	IN4736	6.8	1w	.28
IN5235	6.8	500m	.28	IN4738	8.2	1w	.28
IN5236	7.5	500m	.28	IN4742	12	1w	.28
IN456	25	40m	6/1.00	IN4744	15	1w	.28
IN458	150	7m	6/1.00	IN1183	50 PIV	35 AMP	1.60
IN485A	180	10m	5/1.00	IN1184	100 PIV	35 AMP	1.70
IN4001	50 PIV	1 AMP	.09	IN1186	200 PIV	35 AMP	1.80
IN4002	100 PIV	1 AMP	.10	IN1188	400 PIV	35 AMP	3.00

TRANSISTORS

MPS A05	5/1.00	PN3567	3/$1.00	PN4249	4/$1.00
MPS A06	5/$1.00	PN3568	4/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3569	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	2N3704	5/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3705	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3706	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3707	5/$1.00	2N4409	5/$1.00
PN2815	5/$1.00	2N3711	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3721	$.65	2N5087	4/$1.00
2N2906A	4/$1.00	2N3725	$1.00	2N5088	4/$1.00
2N2907A	5/$1.00	2N3903	5/$1.00	2N5089	4/$1.00
2N2925	5/$1.00	2N3904	4/$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3905	4/$1.00	2N5138	5/$1.00
2N3055	$.89	2N3906	4/$1.00	2N5139	5/$1.00
MJE3055	$.89	2N4013	3/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N4014	3/$1.00	2N5951	5/$1.00
2N3398	5/$1.00			C106B1 SCR	2/$1.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

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

100 VOLT MYLAR FILM CAPACITORS

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

±20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1	35V	.28	.23	.17	1.5 35V	.30	.26	.21
.15	35V	.28	.23	.17	2.2 25V	.31	.27	.22
.22	35V	.28	.23	.17	3.3 25V	.31	.27	.22
.33	35V	.28	.23	.17	4.7 25V	.32	.28	.23
.47	35V	.28	.23	.17	6.8 25V	.36	.31	.25
.68	35V	.28	.23	.17	10 25V	.40	.35	.29
1.0	35V	.28	.23	.17	15 25V	.63	.50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead					Radial Lead				
.47	50	.15	.13	.10	.47	25	.15	.13	.10
1	50	.16	.14	.11	.47	50	.16	.14	.11
3.3	50	.15	.13	.10	1	16	.15	.13	.10
4.7	25	.16	.14	.12	1	25	.16	.14	.11
10	25	.15	.13	.10	1	50	.16	.14	.11
10	50	.16	.14	.12	4.7	16	.15	.13	.10
22	25	.17	.15	.12	4.7	25	.15	.13	.10
22	50	.24	.20	.18	4.7	50	.16	.14	.11
47	25	.19	.17	.15	10	16	.14	.12	.09
47	50	.25	.21	.19	10	25	.15	.13	.10
100	25	.24	.20	.18	10	50	.16	.14	.12
100	50	.35	.30	.28	47	50	.24	.21	.19
220	25	.32	.28	.25	100	16	.19	.15	.14
220	50	.45	.41	.38	100	25	.24	.20	.18
470	25	.33	.29	.27	100	50	.35	.30	.28
1000	16	.55	.50	.45	270	16	.23	.17	.16
2200	16	.70	.62	.55	470	25	.31	.28	.26

CIRCLE NO. 37 ON FREE INFORMATION CARD

PREMIUM QUALITY TRANSISTORS

2N125	1.40
2N173	2.15
2N293	.60
2N321	.50
2N324	.55
2N336	1.00
2N338A	1.25
2N389	9.00
2N396A	1.20
2N397	1.20
2N3988	1.00
2N404	.30
2N404A	.65
2N417	.85
2N443	1.15
2N456	1.30
2N491	5.10
2N508A	.40
2N511A	3.50
2N5128	2.90
2N525	.90
2N526	.90
2N527	.90
2N555	.50
2N586	1.00
2N594	1.50
2N630	4.00
2N652	.40
2N652A	.40
2N657A	.40
2N677C	5.50
2N683	2.70
2N697	.25
2N697A	.50
2N699	.66
2N700	3 50
2N705	.60
2N706	.20
2N706B	.40
2N711	.36
2N711B	.60
2N718	28
2N718B	.40
2N720A	.50
2N744	35
2N829	2.90
2N834	.35
2N917	.80
2N918	40
2N929	.26
2N930	28
2N960	.45
2N962	.45
2N967	.48
2N976	1.80
2N984	.95
2N1035	1.90
2N1132	.30
2N1136	1.40
2N1137A	1.90
2N1143	1.90
2N1168	.65
2N1204	1.40
2N1302	.30
2N1303	.80
2N1305	.35
2N1307	.80
2N1309	.80
2N1377	1.40
2N1408	.60
2N1420	.50
2N1485	2.60
2N1521	4.80
2N1523	5.00
2N1534	1.00
2N1540	1.05
2N1543	3.40
2N1549	1.30
2N1551	3.90

2N1552	3.90
2N1554	1.90
2N1557	1.70
2N1560	3.20
2N1613	.40
2N1671	2.00
2N16718	2.10
2N1693	14 90
2N1711	.40
2N1715	.70
2N1720	4.90
2N1893	.36
2N1898	1.00
2N1907	4 90
2N1921	2 90
2N1924	1 25
2N1934	9.30
2N1990	.75
2N2060	2.05
2N2080	4 90
2N2081A	2.50
2N2100	2 90
2N2102	.45
2N2143	1.50
2N2147	1.40
2N2148	.68
2N2152	3.00
2N2192	.60
2N2192A	.66
2N2193	.44
2N2197	2.40
2N2217	.80
2N2218	.25
2N2218A	.28
2N2219	.29
2N2219A	.36
2N2221	.24
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2N2222	.24
2N2222A	.26
2N2259	1.10
2N2270	.40
2N2289	3.60
2N2290	5.90
2N2297	.95
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2N2368	.29
2N2369	.22
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2N2465	7.40
2N2468	1.00
2N2475	.55
2N2476	.79
2N2483	.28
2N2484	.25
2N2492	4.00
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2N2538	2.40
2N2600	7.00
2N2605	.49
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2N2606	3.50
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2N2648	3.90
2N2658	6.90
2N2708	.25
2N2712	.30
2N2713	.14
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2N2754	94.00

2N2802	9.70
2N2833	3.90
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2N2911	21.00
2N2913	.89
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2N2926	.14
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2N2950	6.40
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2N2969	30.90
2N3019	.50
2N3022	17.90
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2N3054	.80
2N3055	.94
2N3060	2.95
2N3066A	1.19
2N3107	.78
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2N3130	4.90
2N3202	15.90
2N3209	.89
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2N3247	3.80
2N3250	.49
2N3307	8.50
2N3308	6.50
2N3309	7.10
2N3323	1.15
2N3324	.80
2N3325	.70
2N3368	.80
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2N3390	.40
2N3391	.41
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2N3392	.20
2N3393	.20
2N3394	.22
2N3395	.24
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2N3414	.20
2N3415	.20
2N3416	.20
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2N3440	.98
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2N3478	2.00
2N3501	6.40
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2N3684	1.20
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2N3686	1.50
2N3687	1.60
2N3692	.20
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2N3694	.22
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2N3705	.25
2N3707	.18
2N3708	.22
2N3709	.22
2N3710	.20
2N3711	.18
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2N3721	.22

2N3725	.36
2N3730	1.80
2N3731	2.00
2N3732	1.95
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2N3789	3.00
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2N3796	3.00
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2N3804	8.00
2N3805	10.40
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2N3822	1.40
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2N3858	.26
2N3859	.28
2N3860	.29
2N3877	.42
2N3900	.38
2N3901	.30
2N3903	.20
2N3904	.22
2N3905	.20
2N3906	.22
2N3909	.80
2N3924	3.50
2N3925	4.75
2N3933	1.30
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2N3964	1.09
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2N3971	1.00
2N3972	1.39
2N4012	10.40
2N4032	1.90
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2N4058	.25
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2N4061	.25
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2N4123	.20
2N4124	.20
2N4125	.25
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2N4220A	1.00
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2N4226	3.90
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2N4235	1.90
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2N4289	.40
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2N4303	.30
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2N4347	1.60
2N4348	2.10
2N4352	2.00
2N4395	1.25
2N4400	.29
2N4401	.33
2N4402	.35
2N4409	.30
2N4416	.89
2N4424	.35
2N4425	.40
2N4427	1.30
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2N4443	1.40
2N4852	.85
2N4858	1.10
2N4859	1.20
2N4863	5.45
2N4870	.60
2N4878	3.85
2N4890	.95
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2N4901	2.70
2N4902	3.00
2N4903	3.90
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2N4906	4.30
2N4918	1.30
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2N4986	.95
2N4987	.65
2N4988	.95
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2N4990	.75
2N4991	.75

2N4992	1.10
2N4993	1.60
2N4994	.25
2N4995	.26
2N5016	12.70
2N5036	1.17
2N5064	.50
2N5088	.45
2N5089	.80
2N5105	3.05
2N5109	2.40
2N5127	.16
2N5130	.20
2N5131	.20
2N5133	.17
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2N5135	.16
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2N5161	2.60
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2N5198	4.25
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2N5219	.16
2N5220	.28
2N5221	.30
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2N5223	.16
2N5224	.22
2N5225	.30
2N5226	.26
2N5227	.16
2N5232	.22
2N5232A	.24
2N5249	.30
2N5249A	.31
2N5294	.75
2N5295	.60
2N5296	.95
2N5298	1.00
2N5306	.26
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2N5307	.40
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2N5309	.36
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2N5322	.70
2N5323	.66
2N5354	.30
2N5355	.35
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2N5368	.24
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2N5380	.50
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2N5397	2.90
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2N5447	.26
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2N5491	.80
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2N5496	1 90
2N5562	12 40
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2N5655	85
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2N5777	50
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2N5780	85
2N5810	.34
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2N5821	.60
2N5822	.56
2N5823	.66
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2N5826	28
2N5827	30
2N5828	.32
2N5828A	.38
2N6000	.50
2N6001	52
2N6002	.54
2N6004	.54
2N6010	.62
2N6011	.64
2N6014	.66
2N6015	68
2N6027	.50
2N6028	.64
2N6076	.16
2N6099	1.00
2N6101	.95
2N6103	.98
2N6107	1.90
2N6109	2.30
2N6111	2.60
2N6114	4.50
2N6115	2.10
2N6218	.60
2N6219	.59
2N6220	.58
2N6221	.52
2N6222	.28
2N6223	.30
2N6224	32
2N6225	34
3N81	3.60
3N82	5.00
3N83	1.70
3N84	1.68
3N85	3.30
3N86	6.10
3N153	1.05
3N189	4.10
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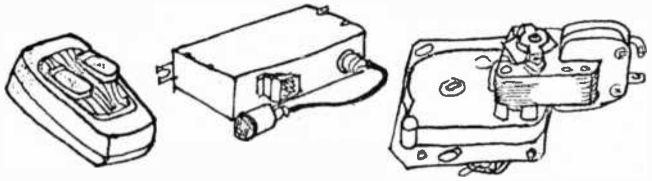

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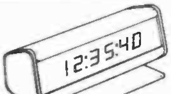

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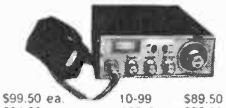

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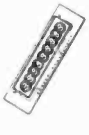

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7402	.15	7495	.79
7403	.16	7496	.79
7404	.19	74100	1.30
7405	.19	74105	.44
7406	.35	74107	.40
7407	.35	74121	.42
7408	.18	74122	.45
7409	.19	74123	.85
7410	.16	74125	.54
7411	.25	74126	.63
7413	.55	74141	1.04
7416	.35	74145	1.04
7417	.35	74150	.97
7420	.16	74151	.79
7422	.26	74153	.99
7423	.29	74154	1.25
7425	.27	74155	1.07
7426	.26	74156	1.07
7427	.29	74157	.99
7430	.20	74158	1.79
7432	.23	74160	1.39
7437	.35	74161	1.25
7438	.35	74162	1.49
7440	.17	74163	1.39
7441	.98	74164	1.59
7442	.77	74165	1.59
7443	.87	74166	1.49
7444	.87	74170	2.30
7445	.89	74173	1.49
7446	.93	74174	1.62
7447	.89	74175	1.39
7448	1.04	74176	.89
7450	.17	74177	.84
7451	.17	74180	.90
7453	.17	74181	2.98
7454	.17	74182	.79
7460	.17	74184	2.29
7464	.35	74185	2.29
7465	.35	74187	5.95
7470	.30	74190	1.35
7472	.30	74191	1.35
7473	.35	74192	1.25
7474	.35	74193	1.19
7475	.57	74194	1.25
7476	.39	74195	.89
7483	.79	74196	1.25
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567	Tone Decoder	mDIP	2.66
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710	Hi Speed Volt Comp	DIP	.35
723	V Reg	DIP	.62
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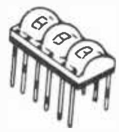

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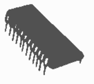

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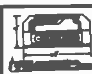

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2SA505	.70	2SB370	.65	2SC535	.95	2SC1010	.80	2SD68	.90
2SA564	.50	2SB405	.85	2SC536	.65	2SC1012	.80	2SD72	1.00
2SA628	.65	2SB407	1.65	2SC537	.70	2SC1051	2.50	2SD88	1.50
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2SA699A	1.75	2SB481	2.10	2SC644	.70	2SC1170	4.00	2SD313	1.10
2SA705	.55	2SB492	1.25	2SC681	2.50	2SC1172B	4.25	2SD315	.75
2SA815	.85	2SB495	.95	2SC684	2.10	2SC1209	.55	2SD318	.95
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2N336	.90	2N1377	.75	2N2323	1.00	2N3227	1.00	2N3866	.85	2N4442	.90		
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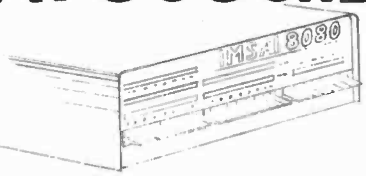

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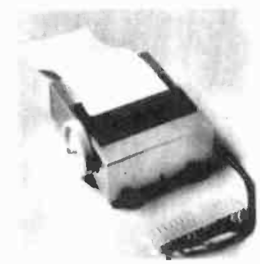

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NEW KITS! NEW KITS!

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WALL or T.V. DIGITAL CLOCK
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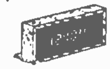
Hr. & Min.-6" High, Seconds-3" High
Kit-All Comp. & Case – $34.95
Wired & Assembled – $39.95



POCKET CALCULATOR KIT
5 function plus constant—addressable memory with individual recall—8 digit display plus overflow—battery saver—uses standard or rechargeable batteries—all necessary parts in ready to assembly form—instructions included. 3" x 5¼"

SPECIAL $12.95 each
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6 each "N" Alkaline Batteries . . . . 1.95 lot

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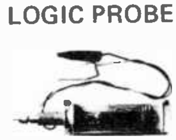
The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols. (HI)—1 (LOW)—o (PULSE)—P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.



printed circuit board **$9.95 Per Kit**

MINI POWER SUPPLIES

These power supplies offer small size, with a wide choice of voltage outputs. They are all capable of delivering 300mA and have dimensions of 1" x 1" x 3". The voltages available are +5V, –5V, +6V, –6V, +12V, –12V. All of these units easily assemble in less than a half an hour, because of the fiberglass printed circuit board construction. Please specify voltage when ordering.

$9.95 per kit

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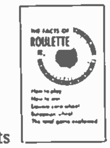
Other companies have offered a low cost digital clock kit, but do not offer mportant extras such as, printed circuit boards, power supplies cases, etc. We at James are doing just the opposita by offering a complete clock kit, that includes everything down to the line cord. This kit uses .25" FND 70 displays, for HOURS, MINUTES, and SECONDS, in conjunction with the MM5314 clock chip. The printed circuit board is of high quality fiberglass, which is plated. The case is a 6 x 1½ x 1 walnut case with a plexi-glass front, and is similer to the one in our TV WALL Digital clock. It is available without the case for $16.95.

$19.95 per kit.

ELECTRONIC ROULETTE

Complete kit with all components case and transformer.



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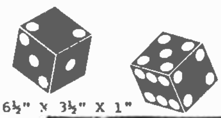
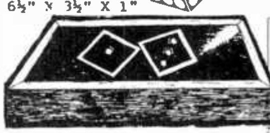


Complete kit with all components case and transformer.

6½" x 3½" x 1"



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It was no accident!

The Recording Industry needed a new calibration standard because it had been cutting discs with higher accuracy to achieve greater definition and sound quality.

So, the engineers turned to Stanton for a cartridge of excellence to serve as a primary calibration standard in recording system check-outs.

The result: the *new* calibration standard, The Stanton 681 TRIPLE-E.

The rest is history!

Major recording studios adopted it . . . as did many of the smaller producers. Radio stations across the world put the 681 TRIPLE-E on all of their turntables, both for on-the-air broadcasting and for disc-to-tape transfer.

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The Stanton 681 TRIPLE-E offers improved tracking at all frequencies. It achieves perfectly flat frequency response beyond 20 kHz. Its ultra miniaturized stylus assembly has substantially less mass than previously, yet it possesses even greater durability than had been previously thought possible to achieve.

Each 681 TRIPLE-E is guaranteed to meet its specifications within exacting limits and each one boasts the most meaningful warranty possible. An individually calibrated test result is packed with each unit.

As Julian D. Hirsch of Hirsch-Houck Labs wrote in Popular Electronics Magazine in April, 1975: "When we used the cartridge to play the best records we had through the best speaker systems at our disposal, the results were spectacular".

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STANTON

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