JANUARY 1976/75c

Popular Electronics®

14278
WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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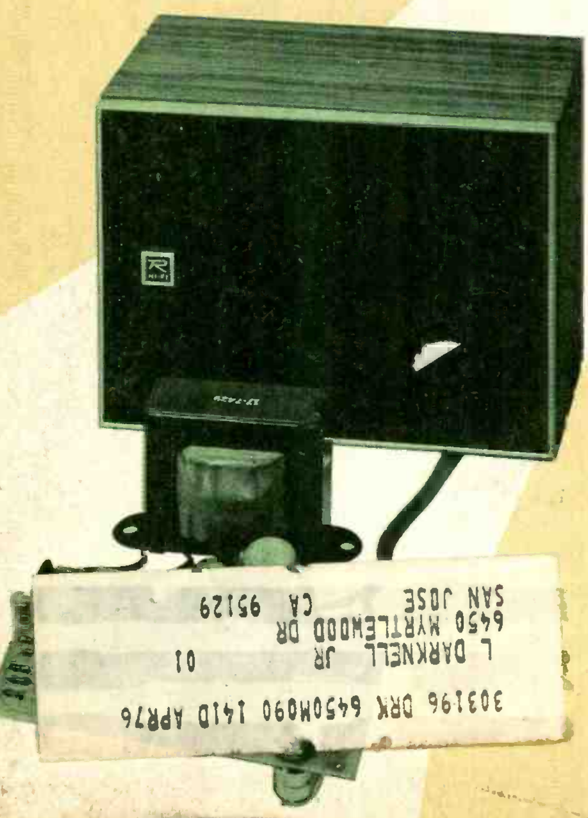
PROJECTS:

- Build a Digital Stopclock
- Voltmeter Measures to Beyond 20 MHz



FEATURES:

- How to Use CB Radio "Buzz" Words
- Introduction to Radio Astronomy

TEST REPORTS:

B·I·C Belt-Drive Record Changer
Pickering Stereo Phono Preamp
Tram AM CB Mobile Transceiver
Heath Color Organ

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JANUARY 1976 VOLUME 9, NUMBER 1

Popular Electronics®

WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE

FEATURE ARTICLES

CONSTRUCTION ARTICLES

COLUMNS

PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

BUZZ WORDS & OEM DISTRIBUTORS

Esoteric expressions used by people in special fields can drive "out" groups up the wall. The latter often view such jargon as an exercise in pretentiousness. And in some cases, this is true. Usually, however, buzz words favored by the "in" people represent easy shortcuts to quick communication.

For example, what audiophile would use the term "intermodulation distortion"? It's "IM," of course. Does an electronics experimenter talk about "100 picofarards"? Nonsense! It's "100 puffs." Hams, too, have buzz words that mark them as cognoscenti, as do other groups such as CB'ers. In fact, a list of buzz words for the latter is included in this issue to ease the entry pains for CB newcomers.

You don't have to be an expert to use buzz words successfully. A recent article on the lives of prominent women pointed out that Claire Booth Luce (her husband founded *Time*, you recall) used buzz words effectively in many fields to reinforce the authoritativeness of her assertions.

There's a host of microprocessor buzz words that have touched our sensibilities recently. Schweber Electronics just published a glossary of these new words. It's called "Microprocessor Buzz Words" and is an interesting compilation, with words such as "port"—the microprocessor's contact with the outside world. The glossary is FREE when requested on letterhead. This means that, if you work for an OEM electronics company, representing a potential customer, you can get it. Good luck on obtaining the booklet (address: Jericho Turnpike, Westbury, NY 11590).

I say "good luck" because most OEM distributors won't deal with hobbyists. (I'm digressing here, but one thing always leads to another.) This view was succinctly summed up to me by Harold H. Powell, President of Powell Electronics, Philadelphia, PA. He said his company uses video terminals to quote price and delivery on a real-time basis though inventory is spread throughout the country. The system is not suited to processing many small orders for one-time customers, he concluded.

We surveyed 25 of the largest OEM distributors in the country (with 315 stocking locations) on their policies regarding sales to nonindustrial accounts. Only three responded favorably: Almo Electronics Corp., Philadelphia, PA; Semiconductor Specialists, Chicago, IL; and Summit Distributors, Buffalo, NY. Some didn't reply.

How sad—for those who won't sell retail, and for us. I do believe that a retail, cash-only, minimum-dollar-order (say, $15 minimum) counter would be profitable for many of these distributors. A vacuum certainly exists in the walk-in electronic parts retail business; that is, local retailers with *broad* parts inventories. With so many electronics hobbyists in the country (PE has close to 400,000), spending substantial money for devices that include expensive MPU's, one would think that there is sufficient motivation to serve them.

Art Salsberg

Letters

THE CASE FOR TAPE HEAD PHASING

In his reply to reader mail with reference to his "Notes on Head Alignment" (August 1975), Mr. Hodges stated that he does not understand why phasing should be of any practical consequence in consumer tape recorders. Be assured that there is at least one application where phasing *is* important: the dubbing of SQ- or QS-encoded records on tapes when the tape deck has separate record and playback heads. Improper phasing will "confuse" the matrix decoder on playback.

I have devised a relatively simple way of adjusting the phasing between two tracks when an oscilloscope isn't handy. First, roughly align the heads as described in Mr. Hodges' column. Then combine the left and right channel outputs through two equal-value (say, 4700-ohm) resistors. Then fine adjust the heads using the same procedure as before, this time maximizing the combined output, while monitoring a VTVM, TMM, or DMM connected between the junction of the two resistors and circuit ground.

As a final check, record a tone that sweeps from about 1000 to 15,000 Hz and play it back while monitoring the recorder's output. Improper phasing will produce serious peaks and dips within the band, especially at the high end.—*D. Chan, La Salle, Quebec, Can.*

USING TACHOMETER ON CD IGNITION

I would like to know if the tachometer described in your June issue (Build a Digital Marine/Auto Tachometer") will work with either a conventional ignition or a CD system.—*John Barnhart, New York, NY.*

The type of ignition system has nothing to do with the operation of the tachometer, which is concerned only with the timing of the motor when it is running.

WORKING WITH MOS DEVICES

The instructions for safe handling of MOS devices ("Senior Scientist Calculator," October 1975) don't seem quite right. Isn't it dangerous to ground yourself when working with electrical appliances? Shock can result from touching a point connected to the "hot" side of the ac line.—*Douglas Peters, Jersey City, NJ.*

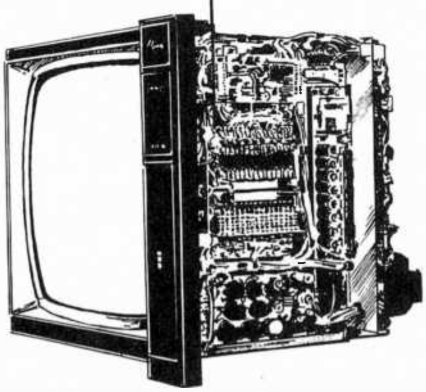
Yes, you're right. The third step on page 38 should read: "Ground yourself; wrap a length of wire mesh around your wrist, connect the free end of the mesh to a 1-megohm resistor, and terminate the free end of the resistor at a cold water pipe if metallic plumbing joints are used in the system, or to the grounding screw of an electrical outlet."

SCA DECODER

I'm having some difficulty getting the SCA Decoder from "Experimenting with Phase-Locked Loops" (October, 1975) to work. I've doublechecked my wiring and it looks OK. Any ideas?—*Edward Fagan, Portsmouth, NH*

First modify the circuit as follows: R13 should be 100 ohms. Ground pin 1, and remove the connection between pins 7 and 8. If you have connected the input of the SCA decoder to the standard output jacks of your tuner, there might not be enough drive signal, due to the effects of de-emphasis and SCA traps. If your tuner has a "Composite Output" or FM Detector Output" jack, connect the decoder input to that point. If you have an older tuner without such a jack (multiplex output jacks usually won't provide enough SCA signal), tap some of the signal directly from the discriminator output. If this loads down the circuit, use resistive coupling.

Four different schools give you this 25" hobby-kit TV...
DIAGONAL



No other home training school gives you both an exclusive solid state color TV and an SQ® Quadraphonic Receiver complete with four speakers . . . all in one course. You get both for less than the tuition cost of TV or Audio alone from the next leading school. And only NRI's Master Course in Color TV/Audio servicing lets you train on equipment designed specifically for training with exclusive "power-on" features.

NRI doesn't give you hobby kits or commercial sub-assemblies. We invested the time and money to design equipment with learning in mind.

Only NRI gives you this 25" designed-for-learning Color TV...
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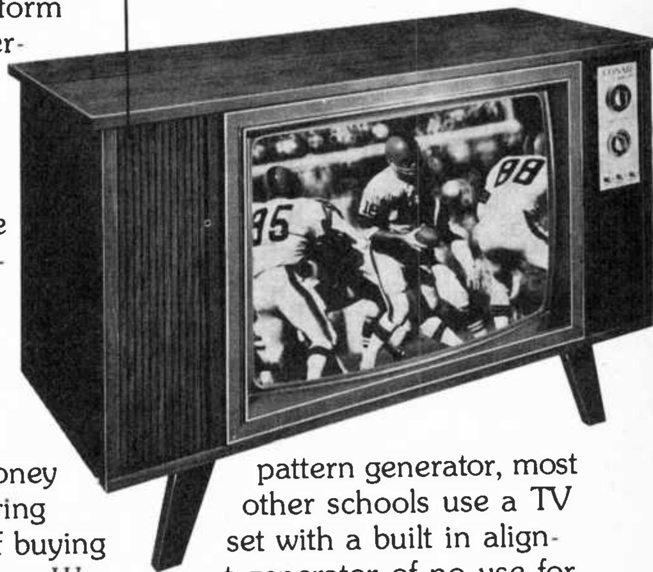
NRI can save you money because our engineering eliminates the cost of buying from an outside source. We pay no salesman's commission. Students are enrolled by mail only. The savings are passed on to you in the form of low tuition fees, extras like the TV's console cabinet and the four speaker Quad System; a 5" triggered sweep oscilloscope, CMOS digital frequency counter, and an integrated circuit color TV pattern generator. Where NRI supplies a professional color



pattern generator, most other schools use a TV set with a built in alignment generator of no use for servicing other sets. Only NRI designs, engineers, and supplies training kits specifically for learning and professional use. You can pay hundreds of dollars more for a similar course and not get a nickel's worth more in training and equipment.

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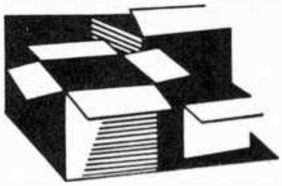


New Products

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

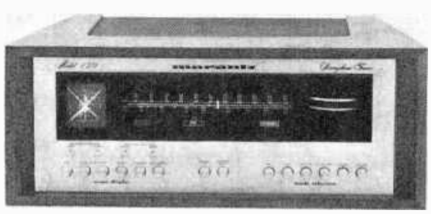
UNIVERSAL LOGIC FAMILY PULSER

Kurz-Kasch announces its new Model HL-583 in-circuit simulator or logic-state pulser for use with RTL, HTL, DTL, TTL, and CMOS. It delivers a HIGH-level pulse exceeding the value required by these families to yield a logic one, and a LOW-level pulse below the value required to yield a logic zero. Selection of one-shot or continuous operation is made by a slide switch on the probe barrel. $96.00

CIRCLE NO. 84 ON FREE INFORMATION CARD

MARANTZ AM/FM STEREO TUNER

Marantz's new Model 150 AM/FM stereo tuner has a built-in 3" (7.6-cm) oscilloscope, Dolby noise reduction circuitry, and a phase-locked-loop multiplex detector. It also boasts an 18-pole linear-phase i-f filter



and flywheel tuning. Switching functions include STEREO ONLY, HI BLEND, MUTING, and MONO. The scope can be used for 2- and 4-channel audio balancing, tuning, and multipath adjustments. $599.95.

CIRCLE NO. 85 ON FREE INFORMATION CARD

ADS TWO-WAY LOUDSPEAKER SYSTEM

Analog & Digital Systems announces its new Model L400 bookshelf speaker system, a two-driver, two-way acoustic-suspension unit. A long-throw 7-inch woofer, with a resonant frequency of 30 Hz, operates over a range of 30 to 1500 Hz. A 1-inch soft-dome tweeter is suspended in a sealed acoustic chamber with a special damping fluid. The tweeter covers the 1500-20,000 Hz range, and is said to have flat response, wide dispersion, and good transient response. Air-core inductors and metal-film capacitors are used in the cross-over network. Impedance is 5 ohms minimum. An 85-dB SPL is produced with 2 watts rms input at a distance of 10 ft. The L400 weighs 16 lb (7.3 kg), measures 17-¾" H × 10" W × 8½" D (45.1 × 25.4 × 21.6 cm). Cabinet finish is natural walnut, and the speaker grille (removable) is black double knit. $90.00.

CIRCLE NO. 86 ON FREE INFORMATION CARD

JERROLD TV SIGNAL INDICATOR

The Jerrold "Levelite" checks signal levels at a TV set's antenna or MATV input terminals and provides a go-no go visual indication (LED) of the presence of a signal. The

brightness of the LED also gives some indication of signal strength. It can be set for either distant or local signals. Battery-operated, it is hand-held and has adapters for connection to various types of terminals. $47.50

CIRCLE NO. 87 ON FREE INFORMATION CARD

CUSHCRAFT BASE ANTENNA

The Model CX-1000 by Cushcraft is an omnidirectional base station antenna using a coaxial stub matching system. The manufacturer states that heavy-gauge aluminum tubing is used along with stainless steel fasteners. Accepts any mast up to 1⅜" (3.5 cm), and is designed for use with 52-ohm coax.

CIRCLE NO. 88 ON FREE INFORMATION CARD

E.F. JOHNSON CB RADIOTELEPHONE

The Messenger 130A is a new version of E.F. Johnson's radiotelephone handset CB mobile transceiver. Features new noise suppression circuitry, a molded speaker grille and integrated mounting fins. Can be used with positive or negative ground

sources, and has the option of private listening with automatic speaker silencing when the handset is lifted. The transceiver covers 23 channels and has PA capabilities. $199.95

CIRCLE NO. 89 ON FREE INFORMATION CARD

SURVEYOR PROGRAMMABLE SCANNER

The new Model 10-P Programmable Scanner from Surveyor Manufacturing is a solid-state, dual-conversion receiver that covers the vhf HI, LO or uhf bands. A priority switch is also featured. This allows the search of Channel 1 every 1.75 seconds. Channel 1 will lock in its signal even though another channel is being received. Has squelch, volume, and manual/automatic scan controls, as well as built-in telescoping whip antennas. $189.00

CIRCLE NO. 91 ON FREE INFORMATION CARD

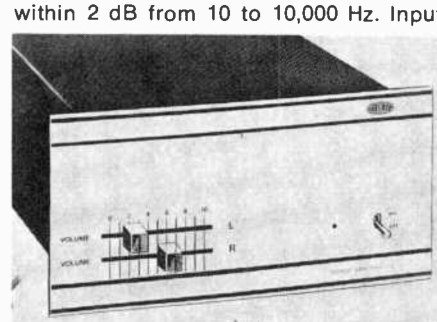
CONTINENTAL SPECIALTIES BREADBOARDING KIT

The new Proto-Board 6 by Continental Specialties offers 630 component tie points and 6 14-pin DIP IC capacity. The kit includes one QT-47S breadboarding socket, two QT-47B bus strips, four 5-way binding posts, a metal ground and base plate, rubber feet, and hardware. All connections between components can be made with #22 hookup wire. Measures 6" W × 4" D (15.24 × 10.2 cm). $15.95

CIRCLE NO. 92 ON FREE INFORMATION CARD

AMTRONCRAFT STEREO AMPLIFIER KIT

Amtroncraft announces its new Model UK 192 stereo power amplifier in kit form. Its rated output power is 50 W rms/channel at 1% THD. Claimed frequency response is within 2 dB from 10 to 10,000 Hz. Input



sensitivity is 1 V for full power output. Input and output impedances are rated at 1000 and 4 ohms respectively. Requires a 55-V dc power supply, such as the company's UK 665. $139.95

CIRCLE NO. 93 ON FREE INFORMATION CARD

ADJUSTABLE CALCULATOR STAND

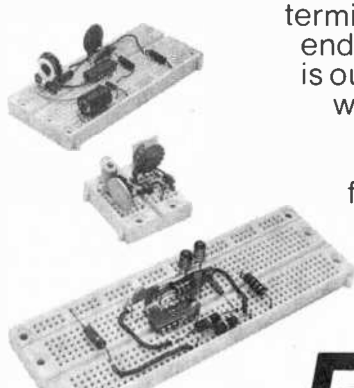
The CalCradle Executive, by one-up, inc., is a calculator stand that tilts and pivots to the angle required for glare-free viewing and easy keyboard operation of a pocket calculator. Accepts both horizontal and vertical models, and completely disassembles for storage. The CalCradle Executive is made of clear acrylic and chrome. $12.98. Address: one-up, inc., 1303 Avocado, Suite 235, Newport Ctr, Newport Beach, CA 92660.

SHAKESPEARE STATION MONITOR

Shakespeare's new base station monitor, "The Defender," measures r-f power out-

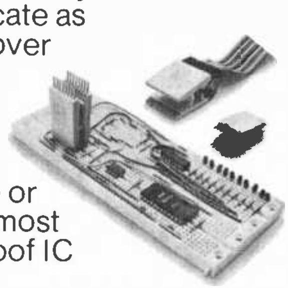
5 WAYS TO STOP WASTING TIME IN ELECTRONICS.

1. Stop wasting your time soldering. Save hours of soldering, desoldering, re-soldering with QT sockets and bus strips. Connect and disconnect resistors, capacitors, transistors, IC's etc., literally as fast as you can push in —or pull out—a lead. Make instant interconnections with short lengths of wire. And interlock sockets and bus strips for infinite expand-ability on bench, chassis, plug-in cards, etc. At $2.00-12.50* you'll wonder how you've done without them!



2. Stop wasting your time design-ing circuits. Design Mate™ 1 will help, by providing you with QT hookup versa-tility (see above), a continuously-variable 5-15V, 600mA 1%-regulated supply, and a voltmeter to monitor supply or circuit. Plug it in, turn it on and start designing more by soldering less. At $49.95* you can afford to.

3. Stop wasting your time testing. On DIP IC's, finding the lead you want—and making sure you don't short others—can be as delicate as surgery. Until you discover our handy Proto-Clip™ ...the instant, short-proof way to test IC's up to 24 pins. Available without cable or with cable, they're the most economical and foolproof IC test aids on the market.



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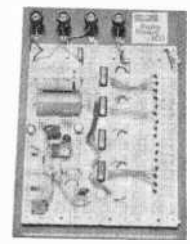
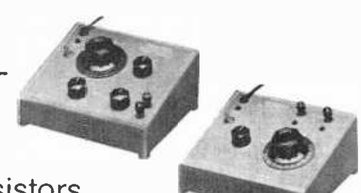


5. Stop wasting your time testing. You can own the test gear you need at economical prices. Our Design Mate 2, for instance, gives you a 3-waveform function generator— sine, square and triangle—from 1 Hz to 100 kHz...for just $64.95* Design Mate 3 R/C bridge pro-vides 5%-accurate measurements of unknown resistors and capacitors from 10 ohms to 100 meg and 10 pF to 1 uF, with built-in LED null indication. Price is a "micro" $54.95* And as you're reading this, we're busy adding new low-priced, high-quality Design Mates.



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put, SWR, and percent modulation when inserted in the coax line between transceiver and antenna. Pushbutton switches select the meter function. Also built-in is an antenna matcher to convert reactive loads to 50-ohm resistive ones. A switch controls the matcher in/out function. $99.95

CIRCLE NO. 94 ON FREE INFORMATION CARD

WEN SOLDERING GUN KIT

Wen Products' Model 222K5 Soldering Gun Kit includes a single-post soldering gun (Model 222), a fine (25-100 W) and a regular (100-200 W) tip, and a flat-iron attachment which seals plastic bags drymounts photos, and aids in furniture repair. Also includes a plastic cutting attachment for cutting plastic sheets, burning wood and leather designs, and working with plastic or asphalt tile. The soldering gun features Automatic Thermal Regulation, which is said to minimize idle current through the tip, but provides full heat flow when needed.

CIRCLE NO. 95 ON FREE INFORMATION CARD

TECHNICS DIRECT-DRIVE RECORD CHANGER

Technics by Panasonic announces its new Model SL-1350 direct-drive record changer/turntable. The changer will handle a stack of six records, and can be put immediately into the shut-off mode without having to play through the stack. Manual operation is also possible. The SL-1350 features a gimbal-suspended, low-friction, modified-S type tonearm for

stereo and CD-4 cartridges. The tonearm has two-way damped cueing, antiskating adjustment, and counterweight arm balancing and tracking force adjustments. An aluminum die-cast platter weighs 3.9 lb (1.8 kg), and has raised dots along its outer edge for stroboscopic speed checks. A built-in flasher is used for these adjustments, which can be made at 33⅓ and 45 rpm, at line frequencies of either 50 or 60 Hz. A hinged dust cover is included. $349.95

CIRCLE NO. 96 ON FREE INFORMATION CARD

LEADER HAM OSCILLOSCOPE

Leader Instruments' new Model LBO-310Ham oscilloscope monitors waveforms in the receiver i-f section as well

as SSB, AM, and RTTY outputs. The 3-inch (7.6-cm) scope has a vertical sensitivity of 20 mV/division and a bandwidth of dc to 4 MHz. Proper RTTY and SSB tuning may be made with the help of a built-in two-tone generator. With the LA-31 adapter ($22.95), the scope provides continuous monitoring of r-f output to 500 W over a frequency range of 1.8 to 54MHz with vertical sensitivity of 1 W/division into 50- or 75-ohm impedances. $269.95

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PASS TO VICTORY

The quarterback is picking just the right spot to call a screen pass. He passes. The running back carries the ball to a touchdown. Victory!

Pick yourself the right CB radio. No problems to tackle when you own a PACE CB radio. They're designed to carry your conversations with clarity and high performance. The quarterback gets total support from his team on the field. In the same manner will you get total Pace support in the field. From our experienced service centers coast to coast. From our retailers and distributors. Grant yourself that victorious feeling and pass along, "I own a PACE CB."

When you've got a Pace, you've got the world by the ears.

CB 145

((p)) PACE

See Your Dealer Now. Get this super deluxe model to transmit and receive messages while driving the wintery highways. Pickup the weather information you need. *Let others know.*
Suggested list price $209.95.

((p)) PATHCOM INC. PACE® TWO-WAY RADIO PRODUCTS 02102

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New Literature

SIMPSON TEST EQUIPMENT CATALOG

A 60-page catalog (No. 4400) from Simpson Electric Co. describes their line of analog, digital, and AnaLed panel meters, chart recorders, meter relays, pyrometers, controllers, test equipment and a variety of portable instrumentation. It is illustrated with photographs, line drawings, and charts which provide information such as ranges, calibration, dimensions and weights. Included are prices for all models and accessories. Address: Simpson Electric Co., 853 Dundee Ave., Elgin, IL 60120.

SHURE HIGH-FIDELITY CATALOG

The latest high-fidelity catalog (AL210-P) from Shure Brothers includes a selection guide to replacement styli for nearly all cartridges it has manufactured in the past 15 years. Includes trackability, stylus configuration, and tracking forces. Also highlights two tonearms, a stereo preamplifier, headphone amplifier, and stylus force gauge. Address: Shure Brothers Inc. 222 Hartrey Ave. Evanston, IL 60204.

AUTO RADIO INTERFERENCE REPORT

A report detailing a technique for reducing automobile ignition interference is now available. A team at Stanford Research Center was able to reduce radio noise from a 1972 American car by a factor of from 5 to 10 (varying with frequency) over a range of 20 to 1000 MHz. A few low-cost electrical components must be added, which according to tests have no undesirable effects on the car's operation or level of exhaust emissions. A copy of the report, Accession No. PB 239-471 is available for $6.25. Address: National Technical Information Service, Springfield, VA 22161.

THYRISTOR GATE NOISE

The latest in the Westinghouse semiconductor Tech Tips series covers noise discrimination in thyristor firing circuits. "Noise Discrimination For Your Firing Circuit," Tech Tip 4-4, discusses the effects of false triggering caused by energization or de-energization of reactive loads in the vicinity of thyristors. The article provides typical circuit diagrams, design charts, and equations to help the designer develop noise-discrimination circuitry to suppress gate-lead transients. Address: Semiconductor Division, Westinghouse Electric Corp., Youngwood, PA 15697

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CIRCLE NO. 47 ON FREE INFORMATION CARD

Stereo Scene

By Art Salsberg
(Ralph Hodges returns next month.)

AUDIO POTPOURRI

HERE ARE some kernels of audio information, ranging in variety from adjusting speaker-system level controls to the different hearing perceptions of left-handed and right-handed people.

Loudspeaker Behavior. Loudspeakers and drivers were once designed by intuition and practical experience. The empirical approach is disappearing, however. With the growing use of mathematical models, cone geometry and material can be chosen to obtain a specific frequency response.

Phillips Research Labs (in the Netherlands), for example, uses a computer program to solve driver behavior problems, such as determining frequency characteristics of the sound wavefront and radiated power as a function of cone material. Theoretical results are verified by viewing driver motion holographically. Typical results are shown in Figs. 1 and 2. At low frequencies, the cone vibrates as a rigid surface. But above a certain point, standing waves begin to appear on the cone. For example, Fig. 1 reveals loops and nodes beginning to appear at the periphery of an 8-inch (20.3-cm) cone driven at 2000 Hz. When the input signal is raised to 9000 Hz, as pictured in Fig. 2, the entire surface is covered with loops and nodes, and little sound is radiated.

Setting Speaker Level Controls. Literature from Speakerlab of Seattle, WA, sets down an interesting method of adjusting speaker level controls—you know, those tweeter and midrange level controls usually on the rear of the enclosure. According to author Pay Snyder, the center settings of these controls do not necessarily provide flat response, due to production variations in speaker sensitivities. (Room acoustics can play a part, too!)

He suggests setting amplifier tone controls to "flat" and the balance control so that only one speaker is playing. Listen to a familiar piece of music with the level controls at minimum, which should leave you with sound coming only from the woofer. Slowly turn up the midrange control until you hear sound coming from this driver as well as the woofer. Continue increasing the level until the sounds from the two drivers blend and seem to come from a point midway between the two.

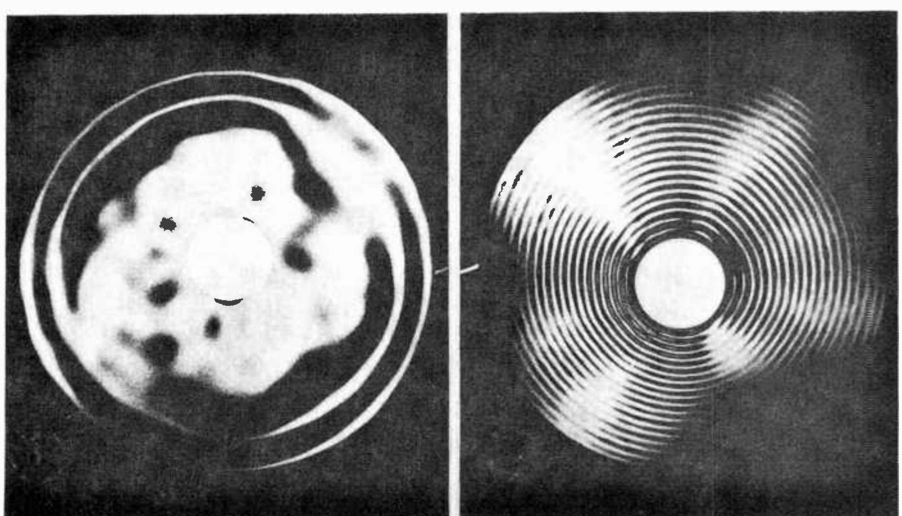
Next, follow the same procedure with the tweeter level control, increasing it until the tweeter's output blends with that of the other two, and does not appear to be coming from a separate point source. Snyder suggests adjusting the speaker in place to compensate for reflections, keeping your head down close to the enclosure. This method doesn't require test instruments, and equally important, it saves a lot of energy expended by jumping up and down to "hear" the system with a new setting!

New Audio Power Ruling. The FTC has a new interpretation of its "Rule on Audio Power Disclosure." The agency has backed off from its original requirement that amplifiers be operated at ⅓ rated power for one hour before testing. This is not the way amplifiers are used in the home, where musical passages require peak power for only short periods of time, and the average power seldom reaches the ⅓ conditioning level. So, fuses popped, relays opened, or output transistors overheated during the pre-test conditioning, especially in high-power amplifiers.

If the ruling was maintained, many manufacturers faced the choice of derating their products' power outputs, or improving thermal transfer through extra heat sinking or forced-air cooling. The former would place some manufacturers at a competitive disadvantage, while the latter course would have substantially increased costs.

Bedeviled by this requirement, nearly two-dozen manufacturers requested a reinterpretation of the conditioning procedure, supporting their contentions with test data. In response, the FTC approved automatic recycling, allowing equipment to cut off or go on automatically until a total of one hour of "on" time is accumulated. Furthermore, if thermal buildup is a problem, tests may commence at low output power to permit cooling.

Live Recording. If you've ever struggled with miking live performances (and haven't we all!), you'll appreciate the tips offered by Shure Bros., 222 Hartrey Ave., Evanston, IL 60204, in its free brochure #AL 493. It describes in nontechnical terms how to mike voices and instruments, in-



Figs. 1. (left) and 2. Holographs of motion in drivers.

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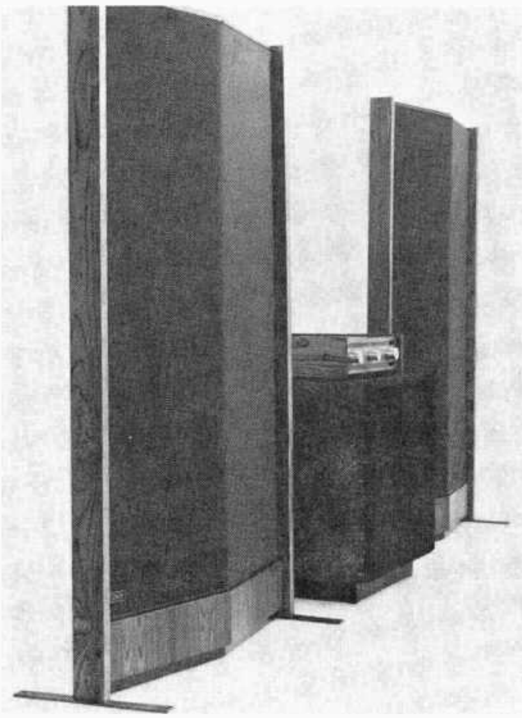
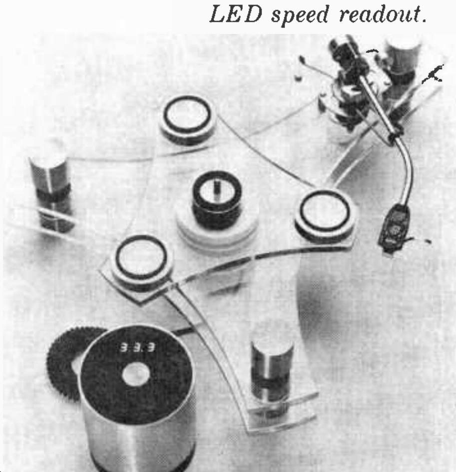
cluding piano, and specifies the types of mikes best suited for certain instruments. For example, the brochure states that a mike with a rising response gives maximum brightness when used near strings; one with a great proximity effect gives best low-frequency response when positioned at the resonant underside of a piano. Thus, two mikes are needed with a grand piano, and one of the secrets divulged here is that the mikes must be *out* of phase with each other.

The Luxury Class. Along with Rolls Royce convertibles and platinum jewelry, there is a category of audio equipment that simply ignores a "tight money" economy. Pictured here are a few new initiates to this elite club. They are: Infinity Systems' Servo-Statik 1A speaker system, which consists of two electrostatic screens, and a "base cube" containing an 18-inch (45.6-cm) woofer with its own 150-W dc servo amplifier. Only $4000. Note that separate stereo amplifiers for the mid-range (100 to 250 W) and tweeter (35 to 125 W) sections must be added. Then there's the Gale GT2101 optical servo turntable, with modernistic plexiglass and stainless-steel design. Speed is monitored on a three-digit LED display, referenced to a quartz crystal oscillator. Only $1,875 (less tone arm and cartridge, of course). Another entry is the Luxman M-6000 stereo power amplifier, rated at 300 W/channel into 8 ohms, both channels driven, with no more than 0.05% THD and IM, from 20 to 20,000 Hz. It features sophisticated thermal- and current-activated protection networks, with a 5-second (nominal) stabilization period monitored by a LED before speaker outputs are activated. Price is $2,995, or about $26 per pound.



Infinity Systems Servo-Statik 1A has two electrostatic screens and separate 18-inch woofer with amplifier.

Luxman M-6000 stereo power amplifier provides 300 watts per channel into 8 ohms both channels driven.



Gale GT2101 optical servo turntable is made of plexiglass and stainless steel with LED speed readout.

Are You Left Eared or Right Eared? According to an article in *Scientific American*, October 1975, right- and left-handed people perceive auditory illusions in different ways. In a computer-controlled experiment, reactions were monitored to a sequence of tones whose amplitudes, frequencies, and durations were precisely regulated. Tonal sequences were presented to the subjects through headphones so that when one ear received a high (800-Hz) tone, the other received a low (400-Hz) tone.

Right-handed subjects tended to localize the high tones in the right ear, alternately hearing the low tones in the left ear. Oddly enough, the results were the same when the headphones were reversed. Lefties, interestingly, were just as likely to localize the high tone in the left ear as in the right, according to the report.

The Next Sound You Hear... In the past, the program material you listened to often dictated the quality of audio equipment you purchased. It was commonplace for audio salesmen to divide their customers into two groups—those who listened to classical music and those who didn't. The former were led to higher-quality components, while jazz, pop, and rock

You make a tape with time and thought. Carefully chosen selections recorded in the sequence that most pleases you. The musical coherence and perception is yours, a personal expression. And when the time is right to share that experience with someone you care for, having to stop and turn the tape over can break the mood you worked to create. Interruptions like that don't happen with the A-4300. You can enjoy continuous music on both sides of a tape with the automatic reverse function. And with automatic repeat, a favorite tape will play as long as you like. Whether you want the music up front or in the background, the A-4300 can give you solid music for the better part of an evening.

Check out the A-4300, and listen to it for as long as you like. Just call (800) 447-4700* for the name of your nearest TEAC retailer. In Illinois, call (800) 322-4400.

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when you don't want the music to stop

TEAC A-4300

You'd never suspect that Bob Gordon leads a double life

By day,
he's a 9-to-5 man.
By night,
an explorer in a field that really interests him!

There was something different about Bob Gordon. Something you couldn't quite put your finger on. He was good at his job. And he took pains to do it well. But on certain evenings, at the stroke of 5, he'd be the first one out the door and on the bus.

The way he'd rush, people would often ask, "Doing something special *again* tonight?"

"Sure am!" he'd laugh. And off he'd go.

What his pals were never told was that after dinner Bob would head for his basement. There, on a simple old wooden table, was something very different from Bob Gordon's 9-to-5 routine.

It was a challenge. A challenge that seemed to change him into another person. Now, at last, he could work with his own two hands—roll up his sleeves, to probe, experiment, and learn. Assemble advanced electronic equipment, including a 25"-diagonal color TV with digital features! And all the while gaining important new occupational skills.

How he started...

Not long ago, Bob Gordon filled out and mailed a card much like the one attached to this page. At the time, he had almost no experience in electronics. But he did have two important qualifications: desire and ambition. Plus a knack with tools and an urge to put them to work.

And that can be your starting point, too.

Right now, you stand where Bob Gordon stood when he first started out. It's up to you to provide the ability and enthusiasm. Bell & Howell Schools, a leader in electronics education, will provide the opportunity to learn and grow—right in your home!

Bob is already on the verge of having real skills in electronics. And, almost before you know it, you can be there, too.

Learning electronics at home–what's in it for you?

When you take Bell & Howell Schools' at-home learning course in Home Entertainment Electronic Systems, you develop a lot of important skills. First, you'll gather the know-how to troubleshoot and service most models of hi-fi amps, intercoms, automobile receivers, PA systems, and AM/FM tuners.

By the end of the program, you'll know how to service most models of color and black-and-white TV's.

While no school can guarantee a job or income opportunity—our course teaches skills that qualify you to seek out an electronics job, advance in the one you may already hold, or further your education in electronics.

An independently conducted survey shows that most of our graduates feel they have gained one or more career advancement benefits from the course. (Survey results are available upon request.)

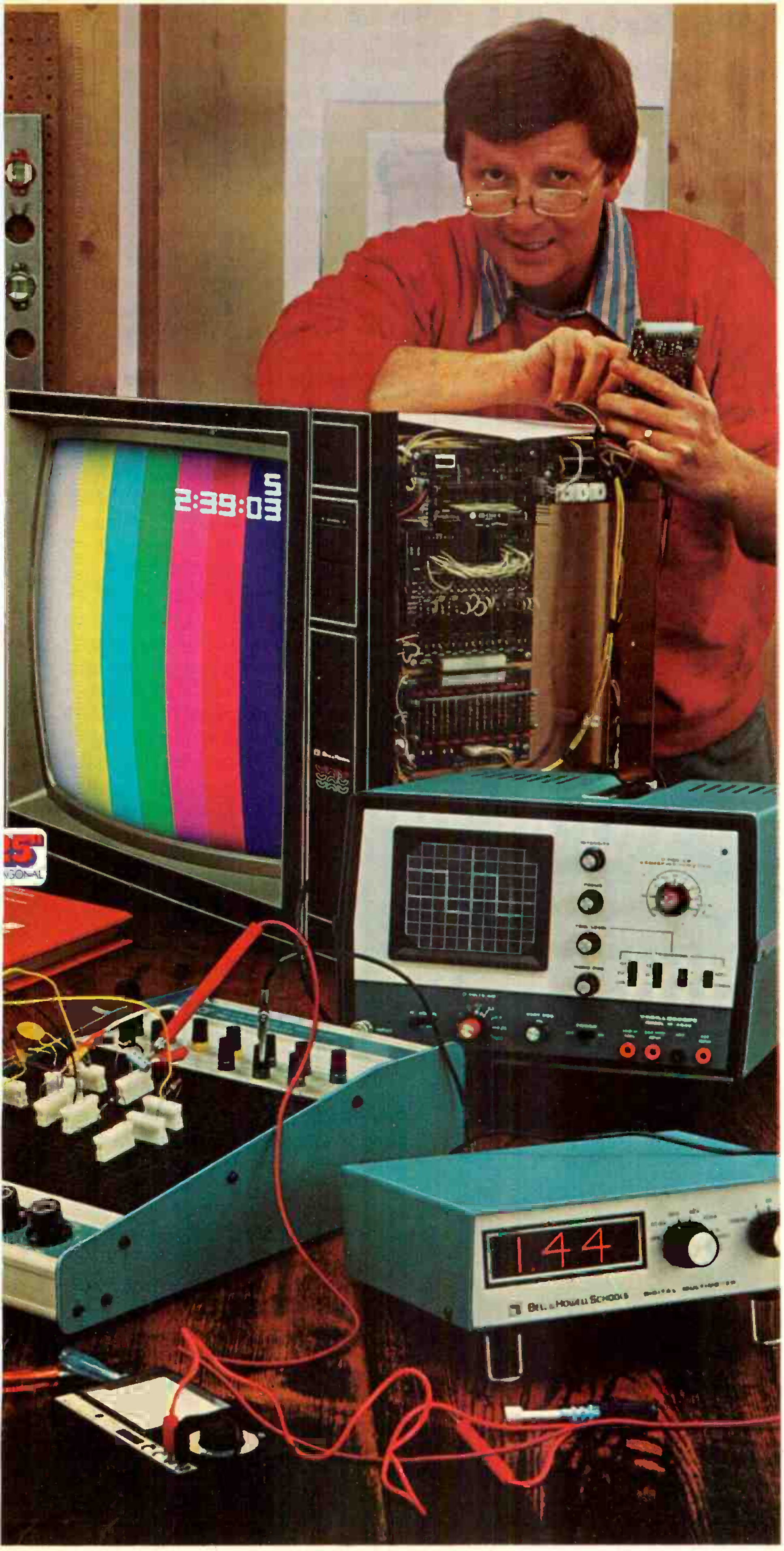
How you gain so much from Bell & Howell Schools' home-learning program...

How can you pick up skills without quitting your job or traveling to night school? You certainly won't do it just by reading a stack of textbooks. That's not the sort of thing that would make Bob Gordon (or you) rush home from work—not by a long shot!

You need actual electronic equipment to work and learn with. And that's what you'll have. Of course, we'll start you off with the basic principles. You'll build and test simple circuits with the Lab Starter Kit we'll send you.

Then you'll move up to the Electro-Lab® Electronics Training System. Piece by piece, you'll actually build a design console and put together circuits without soldering. You'll construct a digital multimeter to measure voltage, current, and resistance. You'll assemble a solid-state "triggered-sweep" oscilloscope to monitor and analyze IC circuitry.

When components for the TV arrive, you'll already be comfortable with electronic concepts



ulated TV test pattern

"Electro-Lab®" is a registered trademark of the Bell & Howell Company.

and equipment. And once you assemble that 25″-diagonal color TV, you'll understand the technology behind no-warm-up tuning, automatic channel selection, on-screen time and channel digits, plus a great deal more!

Home learning with a personal touch.

At Bell & Howell Schools, we try not to keep a student waiting. Should a question come up, we invite you to use our *toll-free phone-in service*. Talk to one of our instructors—he'll either have your answer or know where to get it in a hurry.

Face-to-face "Help Sessions" are another useful service of the Home Entertainment Electronics course. They are held in fifty cities throughout the U.S. at various times of the year. You can discuss electronics in person with trained instructors, talk of your experiences and ambitions with fellow students.

These extras are part of a carefully planned program developed by Bell & Howell Schools. Experience with thousands of at-home learners has refined our teaching methods—and is helping make the path to a Technician Certificate a little easier. A Certificate currently being pursued by over 100,000 students!

Mail the postpaid card today for all the facts–decide after you get them!

We invite you to fill out and mail the attached card now, while it's within reach. It asks no commitment on your part—just offers full details on how to learn electronics at home and enjoy it.

Who knows? You may soon be leading a double life like Bob Gordon.

And when friends ask, "Can you really service TV's?"—you'll answer with a grin. "I not only know how to service them, I know how to *build* them!"

Note: When taken for vocational purposes, this program is approved by the state approval agency for Veterans' Benefits.

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listeners were often told that top-notch equipment wasn't really needed for their uses.

Those days are gone! Today's listeners to nonclassical music now need high-quality audio gear just as much as those who prefer orchestral and chamber music. This is especially true of progressive-rock and jazz fans. Electronic instruments, such as synthesizers, have wrought this change. So have the more complex drum techniques that have evolved, which make strong use of cymbals to create a continual music line.

Representative of what one can expect from jazz and rock releases in the not-too-distant future is the use of a new instrument, the Syntar, manufactured by Electronic Music Labs, Vernon, CT. It's a marriage of the full-blown synthesizer and the electric guitar. A fiberglass-body Armstrong guitar is used, with each string controlling a separately programmable synthesizer. Therefore, a guitarist can simulate traditional instrument voices of wind and percussion, as well as special sound effects. Further, through the appropriate use of envelope generators and filters, such guitar feats as infinite sustain, polytonal slides, and deriving full chords from a single plucked note will now be made possible.

I listened to a demonstration cassette tape, and there's no doubt that a top-quality audio system would be required to appreciate the type of music the instrument can generate. Two of the finer guitarists around, John McLaughlin of the *Mahavishnu Orchestra,* and Steve Howe of the *Yes*, are said to be currently mastering the Syntar. (Sorry, the tape isn't available.)

And Next. Input jacks on the back of an audio amplifier or receiver are not restricted to use with tape decks, noise-reduction units, and record players. All manner of input equipment can be utilized, such as rhythm boxes. A new device I recently discovered is a harmonica pickup designed to be used with most Chromatic harmonicas. It plugs into the AUX jack and you'd be astonished at the "big sound" it makes possible. Frequency response is said to be 500 to 14,000 Hz; output, −57 dB; impedance, 90 kilohms; volume control, a 1-meg linear pot. A kit is available for $24.95 (about ½ the price of an assembled unit) from Barrie Sound Studios, 377 W. Montgomery Ave., North Wales, PA 19454. ◈


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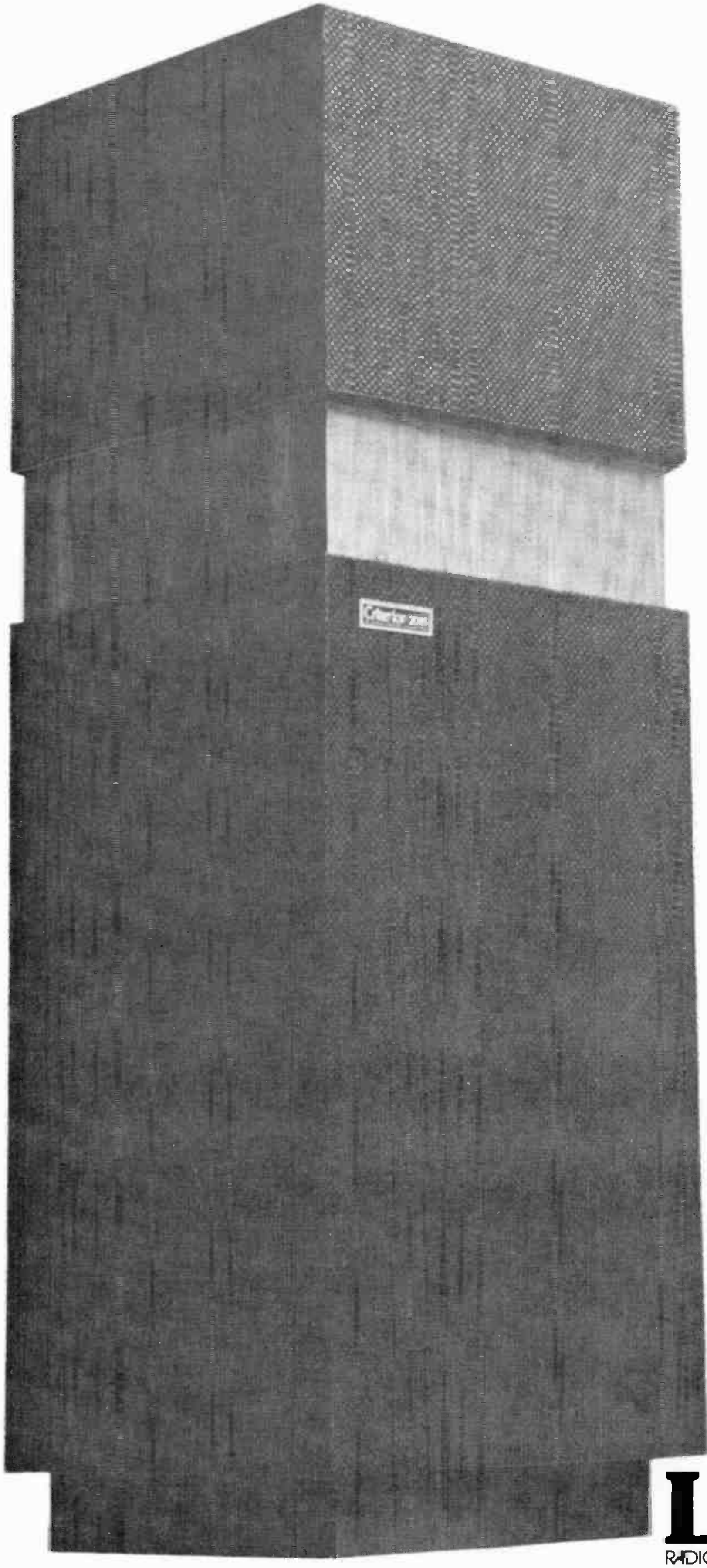

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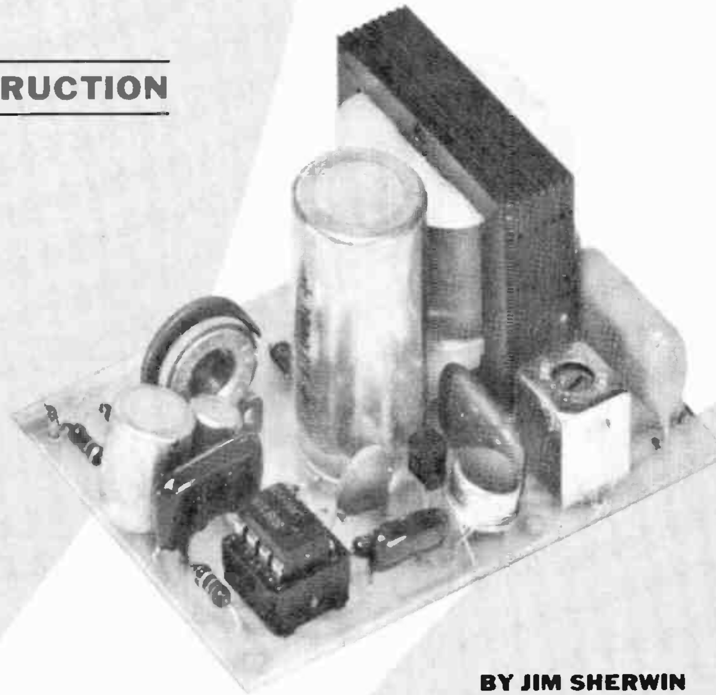


A Wireless Audio System for Remote Speakers

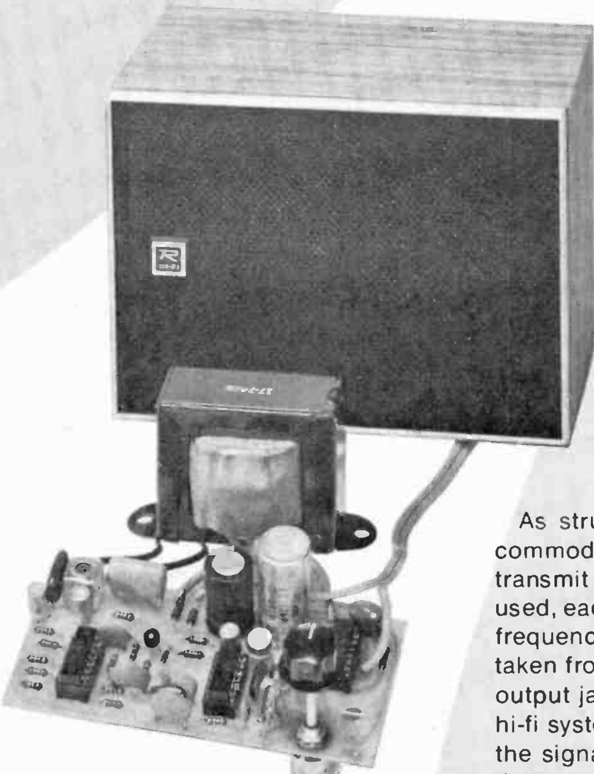
BY JIM SHERWIN

Now you can enjoy high-quality remote sound without running wires around the house.

CONNECTING extension speakers to one's stereo system or rear speakers for a four-channel setup is a terrifying task for many people. It often means running speaker wires through walls and floors, hiding them under a carpet, or tacking them to baseboards. Presented here is a "wireless" system that eliminates this problem!

The new system uses existing ac power lines, operating in an FM mode. The result is good-quality audio (wide frequency response and low distortion) and a high order of noise immunity.

To overcome the old obstacles of the wireless medium (noise, narrow bandwidth, etc.), as in AM wireless intercoms, the Wireless Hi-Fi System employs an FM carrier, phase-locked-loop (PLL) and voltage-controlled-oscillator (vco) IC's. The result claimed by the author is a 30-to-17,000-Hz ±0.2 dB frequency response, 2% total harmonic distortion (THD), and excellent noise immunity for a fine signal-to-noise (S/N) ratio of −50 dB unweighted, at 2 watts power output into an 8-ohm speaker. (How to achieve higher power output is discussed later in this article.) In addition, putting the signal on the ac line will generally assure good reception at all power outlets in your home—even if the transmitter and receiver are on *opposite* sides of the line.



As structured, the system will accommodate a monophonic signal. To transmit stereo, two systems can be used, each tuned to a different carrier frequency. The drive signals can be taken from the tape monitor and tape output jacks of your amplifier. If your hi-fi system doesn't have these jacks, the signal can be taken from across the speaker terminals, but the advantage of a fixed level will be lost.

About the Circuit. The transmitter, shown schematically in Fig. 1, uses voltage-controlled oscillator *IC1* to drive the *Q1* amplifier. The dc power bus is regulated by *IC2*.

Two inputs are provided so that both left and right channels from a stereo system can be combined for transmission to a remote speaker system. For a monophonic source, resistors *R7* and *R8* can be eliminated and

Fig. 1. Two inputs are provided for the transmitter. For a monophonic source, R7 and R8 can be eliminated.

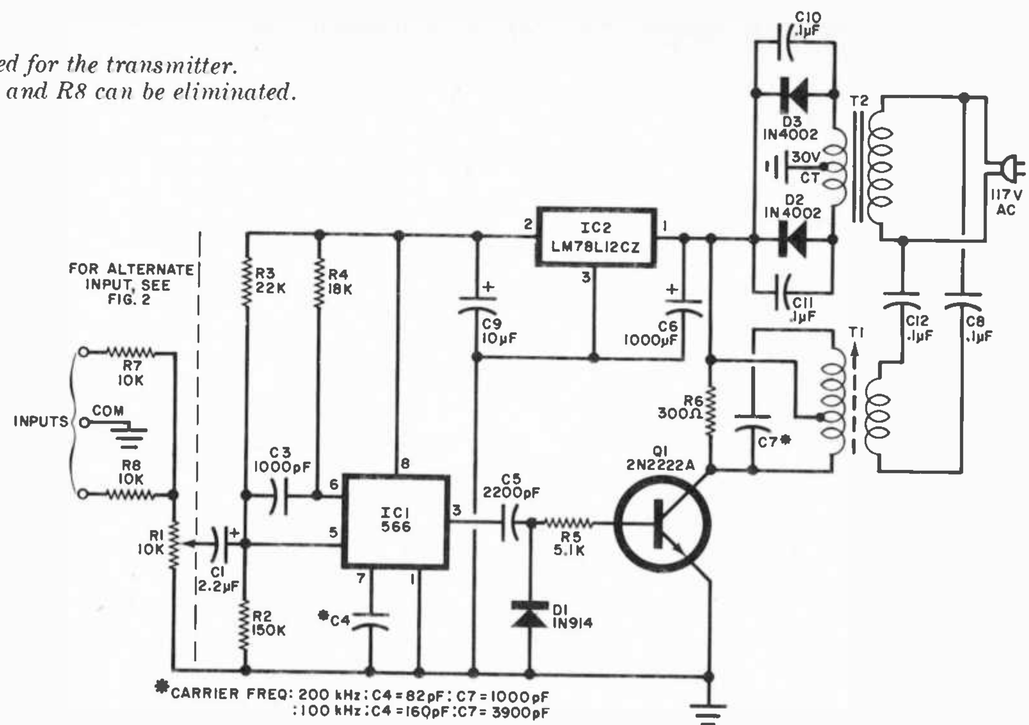
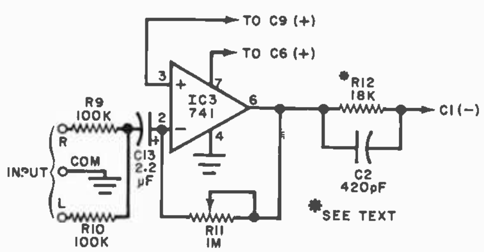


Fig. 2. Use the circuit below to provide pre-emphasis for the transmitter in Fig. 1.



TRANSMITTER PARTS LIST

C1,C13*—2.2-µF, 50-volt electrolytic capacitor
C2*—420-pF mica capacitor
C3—1000-pF disc capacitor
C4—See Fig. 1 for value
C5—2200-pF disc capacitor
C6—1000-µF, 25-volt electrolytic capacitor
C7—See Fig. 1 for value
C8,C10,C11,C12—0.1-µF, 200-volt film capacitor
C9—10-µF, 16-volt electrolytic capacitor
D1—1N914 silicon diode
D2,D3—1N4002 rectifier diode
IC1—566C voltage-controlled oscillator integrated circuit
IC2—78L12CZ—12-volt regulator integrated circuit
IC3*—741C operational amplifier integrated circuit.
Q1—2N2222A transistor
R1—10,000-ohm pc-type potentiometer
R11*—1-megohm pc-type potentiometer
The following resistors are ½ watt:
R2—150,000 ohms, 10%
R3—22,000 ohms, 10%
R4,R12*—18,000 ohms, 5%
R5—5100 ohms, 10%
R6—300 ohms, 5%
R7, R8—10,000 ohms, 10%
R9*, R10*—100,000 ohms, 10%
T1—Line-coupling transformer (see text)
T2—Power transformer with 30-volt center-tapped, 50-mA secondary (Triad No. F133P or similar)
Misc.—Printed circuit board; line cord; machine hardware; hookup wire; solder; etc.
*Optional preemphasis circuit components.
Note—See Fig. 3 Parts List for availability of parts.

POPULAR ELECTRONICS' *performance tests verified that the S/N ratio measured −65 dB, exceeding the author's claimed −50 dB. With "A" weighting it was −93 dB. At 0.9 W, distortion was 0.98%; at 2.5 W, it was 4.9%. Frequency response was 30 to 17,000 Hz ±0.5 dB*—Ed.

the input signal fed directly to the top of potentiometer *R1*. If you want to use the system to feed one channel from a stereo system to the other side of the room, for example, omit *R8* and install a 470-pF capacitor across *R7*. This will improve the frequency response so that it goes out to about 20,000 Hz.

The alternate input circuit shown in Fig. 2 should be used in either of two situations. First, if you are tapping the signal(s) from a high-impedance source, the 10,000-ohm resistor(s) could load down the driving signal in a mono circuit, or introduce unacceptable crosstalk between the two channels of a stereo system (as applied to the main power amplifier). If so, the circuit of Fig. 2 will provide the higher degree of isolation required. The parallel combination *R12-C2* will smooth out the frequency response of the system. To make up for losses in the RC combination, gain is provided (between unity and 10) by op amp *IC1*. Gain is controlled by feedback resistor *R11*.

Because the system's noise immunity is good, no preemphasis/deemphasis is required. However, if you wish to experiment, the alternate input circuit should be used, with a higher RC time constant. For standard 75-µs preemphasis, *R12* should be changed to 180,000 ohms. Then, all program material above 2120 Hz will be emphasized before it enters the transmitter. As above, op amp *IC1* provides gain (set by *R11*) to balance out losses in the preemphasis network. Of course, if preemphasis is introduced in the transmitter, deemphasis must then be incorporated into the receiver.

The free-running frequency, f_o, of voltage-controlled oscillator *IC1* in Fig. 1 is determined by the values of *R4* and *C4*. The sensitivity of the vco with the biasing shown and a V_{cc} of +12 volts is about $\pm 0.66 f_o$/V. For minimum distortion, the deviation should be limited to ±10%, which means that the maximum input signal level at pin 5 of *IC1* should be 0.3 volt peak-to-peak. The output voltage from the tape monitor or tape output jack of an audio system may range from 0.4 to 1.5 volts rms; therefore, *R1* is provided so that an appropriate modulation level can be set.

The frequency-modulated output at

pin 3 of *IC1* is roughly a 6-volt peak-to-peak square wave. This signal is used to modulate the *Q1* r-f oscillator, which uses tuned transformer *T1* as its collector load. Because *T1* is tuned to f_c by adjusting its slug and *C7*, it serves as a high-impedance collector load, which eliminates the need for additional current limiting for *Q1*. Because the collector signal can have as much as a 50-volt peak-to-peak amplitude, *Q1*'s breakdown point must be high. The transistor specified for *Q1* in the Parts List has a 60-volt breakdown to provide a margin of safety. The modulated r-f output from the transmitter is coupled to the power line via *C8* and *C12*.

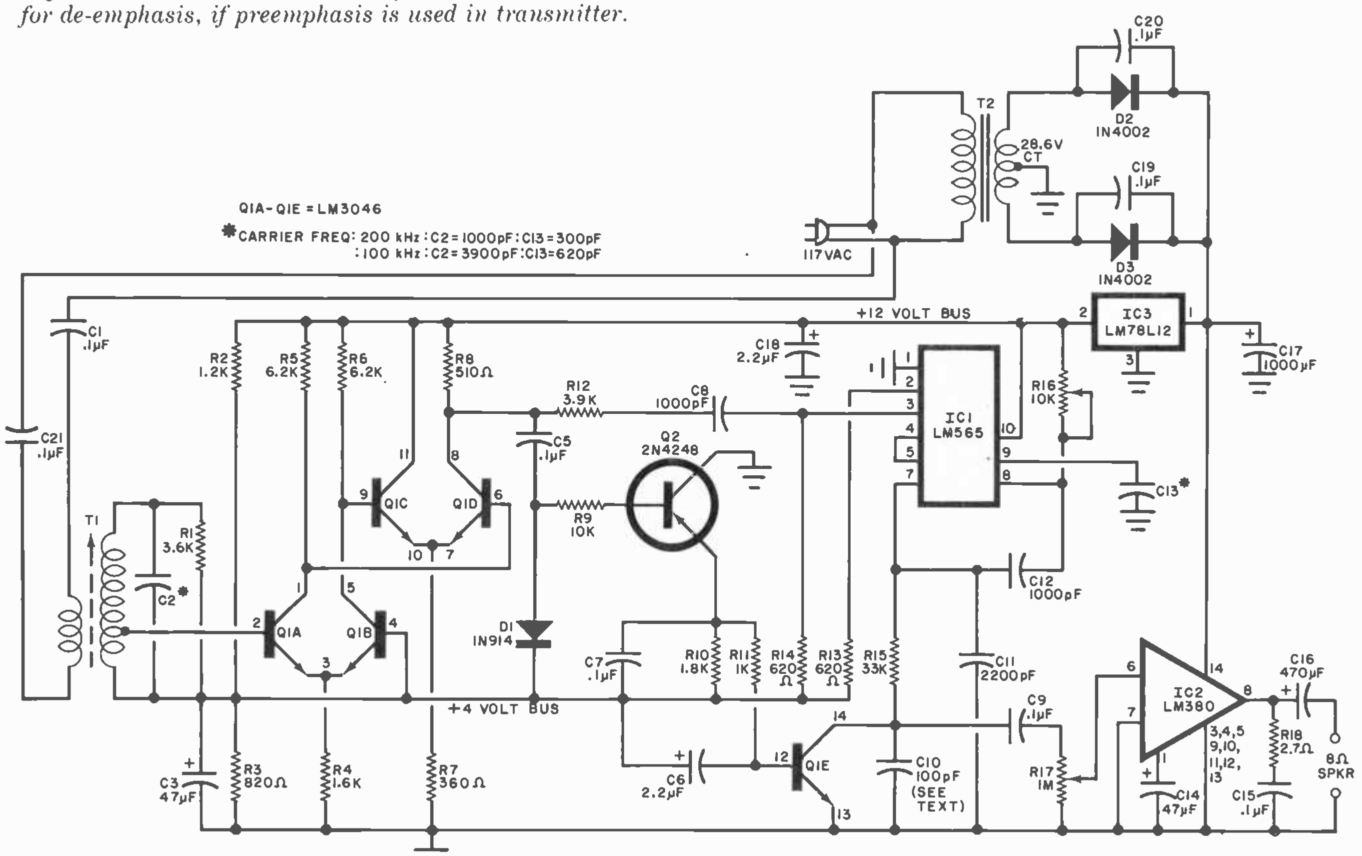
Note that Fig. 1 specifies values for *C4* and *C7* for either 100- or 200-kHz operation. Also note that capacitors *C10* and *C11* are connected across rectifier diodes *D2* and *D3*. These capacitors reduce the small step transient that might be present across the silicon diodes whose upper harmonics fall within the frequency of interest.

The job of the receiver is to amplify, limit, and demodulate the received FM signal riding on the ac power line which can have high-amplitude noise transients. In addition, the receiver must also provide an audio mute in the absence of a carrier.

The circuit shown in Fig. 3 picks up the incoming FM signal and tunes to the carrier frequency via the *T1/C2* circuit. This signal is then applied to a two-stage limiting amplifier (composed of elements inside transistor array *Q1*), phase-locked loop *IC1*, audio amplifier *IC2*, and a mute circuit made up of *Q1E* and discrete transistor *Q2*.

The FM carrier is coupled to the primary of tuned transformer *T1* through *C1* and *C21*. The secondary of

Fig. 3. In the receiver, the value of C10 must be increased for de-emphasis, if preemphasis is used in transmitter.



RECEIVER PARTS LIST

C1,C9,C19,C20,C21—0.1-µF, 200-volt film capacitor
C2—See Fig. 3 for value
C3,C14—47-µF, 16-volt electrolytic capacitor
C4—Not used
C5,C7,C15—0.1-µF, 25-volt disc capacitor
C6,C18—2.2-µF, 25-volt electrolytic capacitor
C8, C12—1000-pF disc capacitor
C10—100-pF disc capacitor (see text)
C11—2200-pF disc capacitor
C13—See Fig. 3 for value
C16—470-µF, 25-volt electrolytic capacitor
C17—1000-µF, 25-volt electrolytic capacitor
D1—1N914 silicon diode
D2,D3—1N4002 rectifier diode
IC1—565C phase-locked loop integrated circuit
IC2—LM380 audio amplifier integrated circuit (National)
IC3—78L12CZ 12-volt regulator integrated circuit
Q1 (A to E)—LM3046 transistor array (National)
Q2—2N4248 transistor.
The following resistors are ½ watt:
R1—3600 ohms, 5%
R2—1200 ohms, 5%
R3—820 ohms, 5%
R4—1600 ohms, 5%
R5,R6—6200 Ohms, 5%
R7—360 ohms, 5%
R8—510 ohms, 5%
R9—10,000 ohms, 10%
R10—1800 ohms, 5%
R11—1000 ohms, 5%
R12—3900 ohms, 10%
R13, R14—620 ohms, 5%
R15—33,000 ohms, 10%
R18—2.7 ohms, 10%
R16—10,000-ohm pc-type potentiometer
R17—1-megohm potentiometer
T1—Line-coupling transformer (see text)
T2—Power transformer with 26.8-volt center-tapped, 1-ampere secondary (Triad No. F40X or similar)
Misc.—Printed circuit board; line cord; machine hardware; hookup wire; solder; etc.
Note—The following items are available from American Scientific Corp., 1957 Old Middlefield Rd., Mountain View, CA 94043: etched and drilled transmitter pc board for $3; etched and drilled receiver pc board for $5.50; transmitter IC's and transistors and Toko line-coupling transformer for $6.00; receiver IC's and transistors and Toko transformer for $10.50; complete transmitter kit for $18.95, plus $1.00 shipping; complete electronics receiver kit for $27.95, plus $1.00 shipping. National Semiconductor IC's are available, singly or in quantity from OEMorsco, 2403 Charleston Rd., Mountain View, CA 94043.

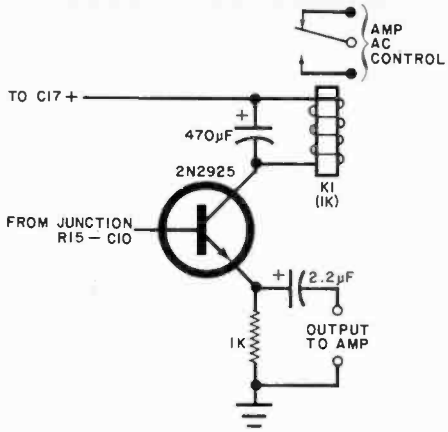


Fig. 4. Use this circuit to change receiver output for more power.

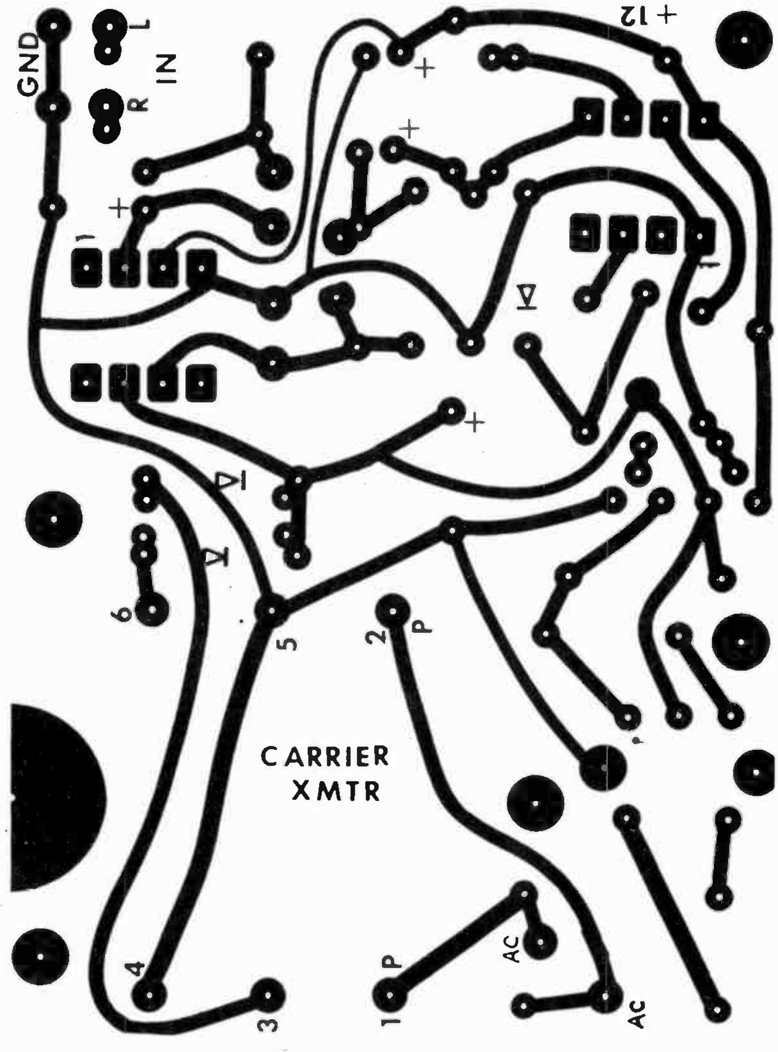
T1 is tuned by *C2*, while *R1* lowers the Q of the circuit to permit it to accept the ±10% modulation and to prevent excessive ringing on noise spikes. Such ringing would cause the mute circuit to deactivate. The secondary of *T1* is tapped to match the input impedance of *Q1A*. The recovered carrier at the secondary of *T1* can have an amplitude of between 0.2 and 45 volts peak-to-peak. The 17:1 turns ratio from the full secondary to the tap reduces the amplitude of the recovered carrier so that the base of *Q1A* "sees" a signal that ranges from 12 mV to 2.6 volts peak-to-peak.

The two-stage limiter amplifier composed of *Q1A* through *Q1D* operates as a fairly fast comparator whose slew rate is about 70 volts/μs and gain is about 3000. The output from this limiter is a roughly 7-volt peak-to-peak square wave that has rise and fall times of 100 ns. (Any fairly fast comparator that delivers more than 5 volts output could be used as the limiting amplifier. However, the transistor array specified is a low-cost item that has the advantage of containing an extra-high beta transistor, *Q1E*, which is used as the mute switch.) The 7-volt peak-to-peak output of the limiting amplifier is applied directly to the mute detector, *Q2*, but is reduced to about 1 volt by the attenuator consisting of *R12* and *R14* before being applied to PLL *IC1*.

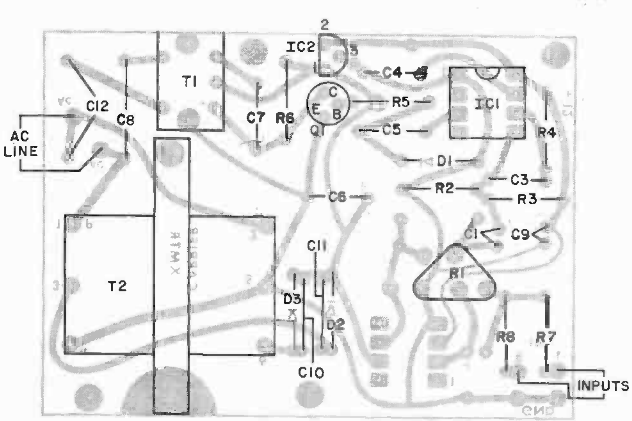
The PLL operates as a narrow-band filter that tracks the incoming FM signal and provides a low-distortion demodulated audio output whose signal-to-noise (S/N) ratio is high. The oscillator inside the PLL is set to free-run at a frequency near that of the carrier by the choice of value for *C13* and setting of *R16*.

If 75-microsecond preemphasis is used, increase the value of *C10* to 2200 pF. Increasing this capacitor's value will reduce the carrier level in the audio line at the expense of high-frequency audio response.

The mute circuit quiets the receiver when no carrier is present. Without this circuit, an excessive noise level would result as the PLL attempts to

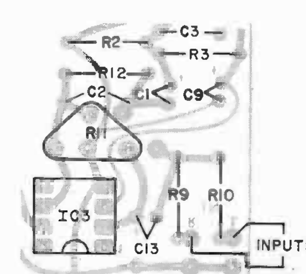


A



B

Fig. 5. Etching and drilling guide for the transmitter are shown above (A). Component placement for standard transmitter is at left (B). If pre-emphasis is used, the component placement at right is necessary (c).



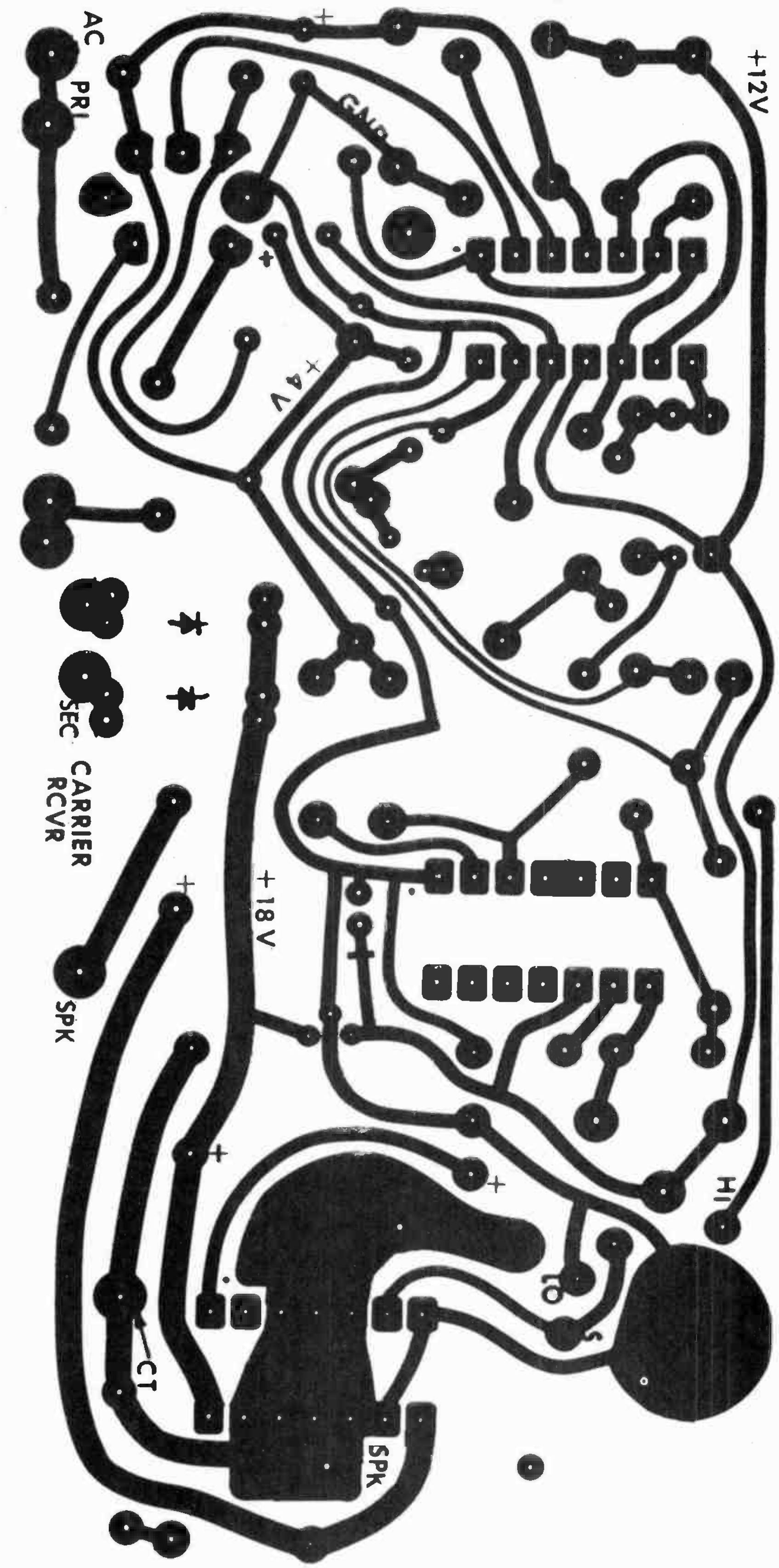
C

lock onto noise spikes when the transmitter is shut off. The mute detector is composed fo $C7$, $D1$, and $Q2$. Note that an emitter-follower transistor stage is used in place of a diode to give the peak detector a high input and a low output impedance. This permits the peak detector to shunt 1 to 2 mA of bias away from $Q1E$, without loading the limiter amplifier.

With no carrier present, the +4-volt line biases $Q1E$ into conduction via $R10$ and $R11$, shorting the audio signal to ground. When a carrier is present, the 7-volt square wave from the limiter amplifier is peak detected, producing a negative output that is integrated by $R9$ and $C7$, averaged by $R10$ across $C7$, and further integrated by $C6$ and $R11$. The resultant −4-volt output subtracts from the +4-volt bias to deprive $Q1E$ of base current. This transistor cuts off and allows the demodulated audio signal to pass to the audio amplifier. Peak detector integration and averaging prevents random noise spikes from deactivating the mute when no carrier is present.

Audio amplifier $IC2$ supplies about 2 watts of audio power to an 8-ohm speaker connected across the output of the receiver. Although this amount of power is adequate for casual and background-music listening, if you want to drive relatively inefficient hi-fi speaker systems, you'll have to modify the output of the receiver to drive a hi-fi amplifier. The circuit shown in Fig. 4 does this. To use it, audio power amplifier $IC2$ is removed from the receiver circuit and the Fig. 4 circuit goes into the receiver as specified. This switching circuit operates from the mute signal so that when the transmitter is switched on, the relay will energize to apply power to the external power amplifier. In this manner, the power amplifier will automatically switch on when a signal is received. Standby power is less than 1 watt.

Construction. The transmitter is best assembled on a printed circuit board, the etching and drilling guide for which is shown actual size in Fig. 5A. In Fig. 5B is the component placement diagram for the board, while the detail in Fig. 5C shows the additions and changes to be made when preemphasis is used in the transmitter. When comparing B and C, note that $R1$ is eliminated from the former and $R11$ is installed in the latter, *displaced one pad space to the left* but oriented the same.



A

Fig. 6A. Etching and drilling guide for the receiver is shown above. The component placement diagram (Fig. 6B) is on next page.

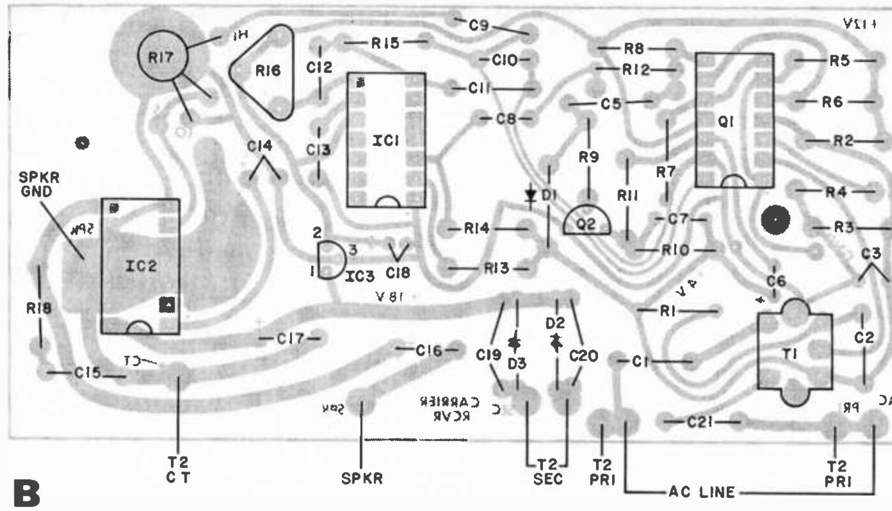


Fig. 6B. Component placement diagram for the receiver is shown above. Foil pattern (Fig. 6A) is on previous page.

Line-coupling transformer *T1* can be made from a 455-kHz AM i-f transformer. In rewinding the turns, the secondary is made up of four turns, while 154 turns are used in the primary, tapped 29 turns from one end of the coil. You can use the wire originally wound on the transformer or 41 AWG enameled wire for the turns.

As with the transmitter, the receiver is best assembled on a printed circuit board. The etching and drilling guide and components placement diagram are shown in Fig. 6A & B.

Line-coupling transformer *T1* is constructed in the same manner as described for *T1* in the transmitter, except that primary is composed of 4 turns the secondary 154 turns, tapped 9 turns from one end.

Adjustments. Make sure that the transmitter and receiver are operating at the same frequency. (See Figs. 1 and 3 for values of frequency-determining components.) Plug the transmitter and receiver into ac outlets and use an oscilloscope or ac voltmeter to check the amplitude of the waveform across the secondary of *T1* in the receiver. There is no need at this time to have the carrier modulated.

Adjust the slugs in the *T1*'s in both the transmitter and the receiver for maximum signal amplitude across the secondary of *T1* in the receiver. If the receiver is to be located some distance from the transmitter or on the opposite side of a 117/220-volt service line, *T1* will have to be readjusted in the receiver to maximize rejection of ac line noise.

The free-running frequency of the PLL in the receiver is trimmed by adjusting *R16*, which should initially be set near the center of its range. Rotate *R16's* wiper slowly in both directions until the PLL loses lock, indicated by a sharp increase in noise and a distorted output from the receiver. Note the two positions where drop-out occurs; center *R16* between these two points. A finer adjustment may be required to obtain minimum noise if an SCR light dimmer is in operation.

The final adjustment is for modulation amplitude in the transmitter. Connect an audio signal source to the input of the transmitter and adjust *R1* for a signal amplitude of about 0.1 volt rms maximum at the input (pin 5) of *IC1*. This can also be accomplished by carefully listening to the receiver while adjusting *R1* in the transmitter until the sound just distorts and then backing off a little.

Because a single transmitter/receiver system will suffice for a monophonic sound system or for one channel of a stereo system, a second receiver and transmitter will be required for stereo sound over the wireless medium. In this case, one transmit/receive system would be tuned to 100 kHz and the other to 200 kHz. You can also use a pair of transmit/receive systems for the rear channels in a 4-channel system to avoid running cables all over your listening room. Again, you would use a different carrier frequency for the different channels.

One final note: Although we have mentioned using carrier frequencies of 100 kHz and 200 kHz for a two transmit/receive system, this spacing needn't be 100 kHz apart. For most purposes, a 40-kHz spacing will do, while still providing maximum frequency response from the system. ◈

AN INTRODUCTION TO RADIO ASTRONOMY

Yerkes Observatory photograph

Get into this fascinating new hobby with a simple homebrew telescope system.

BY DAVID HEISERMAN

RADIO astronomy has changed our understanding of the universe. Behind this new science is an electronic, rather than an optical "eye," called the *radio telescope*. It was the radio telescope that first brought to our attention the existence of quasars, pulsars, and galaxies that seem to disappear at the very brink of space and time.

Shortly after World War II, radio astronomy became a serious science. The wartime effort brought tremendous advances in communication and radar receivers and antennas that had the bandwidths, low noise levels, and high gain characteristics required for radio astronomy. Professional astronomers seized the opportunity to explore the universe by studying the radio signatures of planets, stars, and galaxies. The amateur astronomer, however, has shown uncharacteristic shyness toward radio astronomy.

Part of the amateur's reluctance to get involved in radio astronomy has been the lack of budget-priced "viewing" equipment. Though this may have been an obstacle in the past, vhf and uhf equipment and devices are now readily available for amateur use.

In this article, we will discuss radio astronomy in general terms to introduce amateur optical astronomers and non-astronomers to this fascinating and relatively new hobby. We will discuss what a radio telescope is and how to listen to the cosmos with a simple homemade telescope.

Tuning In the Stars. The stars that fill the nighttime skies with their twinkling blue-white light visible to the human eye emit electromagnetic energy in the visible spectrum. It is to these that the optical astronomer aims his telescope. Many large objects in space also emit electromagnetic energy at longer wavelengths, in the shf, uhf, and even vhf portions of the radio spectrum. Obviously, no optical telescope allows the human eye to view these wave-lengths. For these, you need a radio telescope.

The real impact of radio astronomy has not come from matching up light and radio waves from visible stars. Most of the stars visible to the human eye generate relatively low amounts of energy in the radio spectrum. In contrast, the most powerful radio sources outside our solar system include distant galaxies, dense star clusters, and remnants of exploded star systems.

Consequently, a simple backyard radio telescope can (and does) readily respond to colliding galaxies on "the other side of the universe," though it cannot detect radiation from well-known stars like Vega and Sirius. Furthermore, a simple radio telescope can pick up radiation from sources that are optically obscured by clouds of gas and dust, a condition that exists when an optical telescope is turned toward the center of the Milky Way galaxy. Also, radio telescopes can "see" through clouds, air pollution, and high ambient light at night and can be used for daylight "viewing."

The universe is literally alive with white-noise radio "static." Every hot object—which includes stars, galaxies, etc.—emits broadband radio energy that has an intensity roughly proportional to its temperature. As illustrated in Fig. 1, this kind of *thermal* radiation rises in intensity through the vhf and uhf parts of the radio spec-

Figures 1, 2, and 3 are from the author's book "Radio Astronomy for the Amateur," published by Tab Books, Blue Ridge Summit, PA.

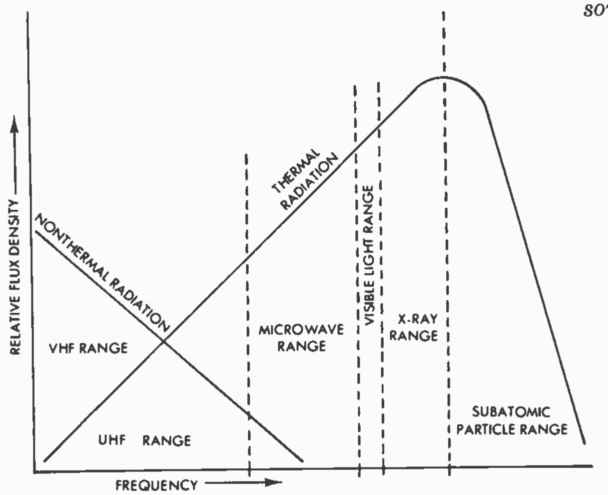


Fig. 1. Relative intensity of thermal and nonthermal sources across the spectrum.

trum. It reaches a peak just beyond the visible wavelengths.

There are also nonthermal sources of radio noise in space. Most such sources are created by high-velocity electrons whipping through intense magnetic and gravitational fields that surround most stars and galaxies. Note from Fig. 1 that the intensity of nonthermal radiation is highest at the low end of the vhf radio band.

Many radio sources in space generate noise that is both thermal and nonthermal. The significance of this is that an amateur astronomer has the option of observing the sources anywhere across the radio spectrum. Some sources, however, tend to generate larger doses of radio energy at one end or the other of the spectrum. The sun and Jupiter are classic examples of predominantly nonthermal sources of radio energy.

The sun is our most powerful radio source. While it generates much high-frequency thermal radiation, intense nonthermal signals from sunspots and solar flares make it an excellent subject for the novice radio astronomer. The planet Jupiter is the next strongest radio source. Since it is rather cold, its thermal radiation is negligible (as far as amateurs are concerned). Jupiter's powerful gravitational field, however, sweeps gigantic swarms of electrons through the planet's upper atmosphere, creating noise that can be heard easily on a radio telescope (as low as 21 MHz).

There is a third class of radiation, known as the 21-cm hydrogen line, that is of special interest to radio astronomers. Hydrogen atoms make up an overwhelming majority of all the matter in the universe. They radiate a "resonant" energy at a constant frequency of 1.428 GHz. Anywhere there is hydrogen, this radiation is present. Hence, professional radio astronomers have keyed most of their research to the 21-cm band. Unfortunately for amateurs, 21-cm equipment with the proper specifications is either too elaborate or too expensive—or both—for the average amateur's budget. Until microwave equipment becomes available with more suitable specifications at a lower cost, there is little an amateur radio astronomer can contribute at 21 cm. Even so, there is a lot for the amateur astronomer to see at the lower vhf and uhf frequencies.

The most fruitful working range for amateur radio astronomers is in the vhf and uhf bands where nonthermal and thermal sources have about the same energy levels. The technology is fairly well established in this range, and few professional radio astronomers have done work here.

The Radio Telescope. From a block-diagram point of view, a radio telescope is little more than a directional antenna, wideband receiver, and some type of recording/readout device. Adding a device for aiming the antenna and calibrating the receiver complete the picture.

Whenever a radio source in space enters the antenna's beam pattern, the readout device registers a gradual increase in noise signal level. The signal in most cases is pure white-noise static. As the source passes through the center of the beam, the readout device will show a peak noise level. Then, the noise level drops off as the object moves away from the antenna. The

TABLE 1—ANTENNA AND MOUNTING CHARACTERISTICS

	Advantages	Disadvantages
Antenna:		
Multi-element beam (YAGI)	Moderate to high gain; relatively simple construction; many impedance-matching options	Narrow bandwidth; polarized in one plane
Beam array	High gain; any linear polarization possible; many impedance-matching options	Mechanically awkward; requires great deal of working space
Single helix	Inherently wideband; circular polarization; moderate gain; responds to circular or any plane polarization	Mechanically awkward in vhf range; polarized in one "sense" (left- or right-handed).
Helical array	Inherently wideband; high gain; responds to linearly or circularly polarized signals	Mechanically awkward in vhf range; "sense" conscious.
Parabolic reflector	Extremely directional; high gain	Very difficult to build
Mounting:		
Fixed	Simple construction	Not steerable in any plane
Altitude	Relatively simple construction	Azimuth is fixed
Altazimuth	Fully steerable	Relatively complicated construction; awkward in lower vhf range; works in horizon coordinates
Equatorial	Fully steerable; work in celestial coordinates	Complicated construction

TABLE 2—RECEIVER CHARACTERISTICS

Receiver Type	Advantages	Disadvantages
Shortwave communications	High gain; suitable converters and preamplifiers available	Narrow bandwidth
Commercial FM	Good gain; wideband; low noise	Restricted to 88-108-MHz
Custom-designed homemade	High gain; wide bandwidth; low noise	Requires know-how to build and align
TV tuner	Readily available; wide bandwidth	Low gain; poor noise figures

stronger the radio source, the higher the peak signal response.

Anyone familiar with communication systems will find the purpose of each element in a radio telescope system rather obvious, but a brief summary is in order. The antenna picks up radio signals from remote sources. The antenna mounting steers the antenna to the point in the skies from which the signal originates. The receiver then tunes, amplifies, and detects the signal. Finally, the recording system displays or records the results. The special requirements imposed on these common system components, however, require further discussion.

The antenna, for example, must have a higher power gain than is normally required for communication purposes, and it must be highly directive. Only antennas with gain figures in excess of 10 dB are worth considering for serious radio astronomy work. The major lobe should have a width of no greater than 30° between the half-power points. By the same token, the bandwidth of the antenna should be 2 MHz or more.

Although parabolic antennas seem to be the hallmark of professional radio astronomy, they are not the best choice for amateur astronomers, especially newcomers. Considering both practical and theoretical features, a tuned multi-element beam antenna is the best all-around choice for a vhf radio telescope system, while a quad helix array performs better in the uhf range. Table 1 summarizes the advantages and disadvantages of antenna systems in the light of amateur radio astronomy.

Most amateur radio astronomers find that they spend considerable time and effort designing, building, and debugging the antenna and antenna mounting system. While receivers and recording devices with the necessary specifications are available commercially, the antennas are not. The ultimate success or failure of a radio astronomy system rests heavily on the quality and proper selection of an antenna system, making the extra time and effort very worthwhile.

As far as the receiver is concerned, it must have high gain, low noise, good stability, and wide bandwidth. These particular requirements are almost self-contradictory, and run-of-the-mill radio construction projects seldom meet them. Fortunately, there are some ready-made systems that can do the job.

Any wideband radio receiver that has a sensitivity of 5 μV or better is suitable for amateur radio astronomy work. Shortwave communication receivers can be used, provided they have a sensitivity on the order of 0.5 μV to make up for their narrow predetection bandwidth. Commercial FM receivers work rather well in a vhf radio telescope system because most of them have good sensitivity figures and a wide predetection bandwidth. (Incidentally, there is no need to disable the FM detector or limiter stage to get satisfactory results from an FM receiver. The receiver passes wideband noise whenever there is no carrier present.)

It is tempting to try using a uhf TV receiver to work the uhf end of the radio astronomy spectrum. However, while TV receivers have the required bandwidth, they have intolerably low sensitivity figures. The wideband characteristic never quite makes up for the poor sensitivity, and any attempt to use a TV receiver is bound to produce disappointing results. Table 2 compares the various types of receivers available.

The data readout or recording device, the final stage in the system, can be as simple as a voltmeter or as complex and expensive as a chart recorder. In any case, it must provide information with reasonable precision and reliability. Table 3 lists the relative advantages and disadvantages of three types of recording devices.

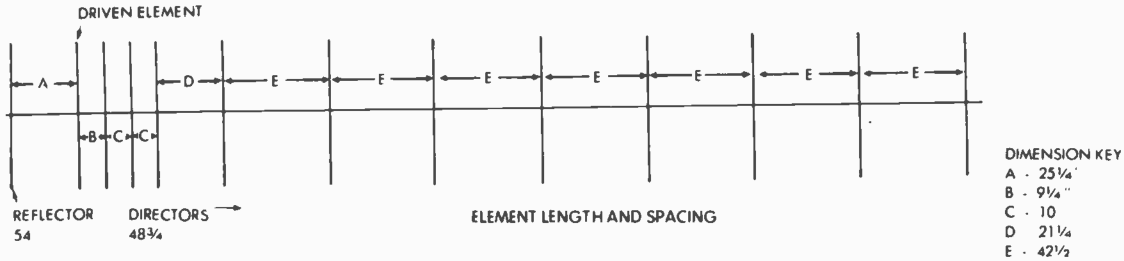
Few amateur radio astronomers can resist the temptation of listening to the hissing signals from the cosmos through a loudspeaker. With the notable exception of signals from Jupiter, radio signals from space are not very exciting to hear. A loudspeaker is nevertheless a popular kind of auxiliary "readout" device for amateur radiotelescopes.

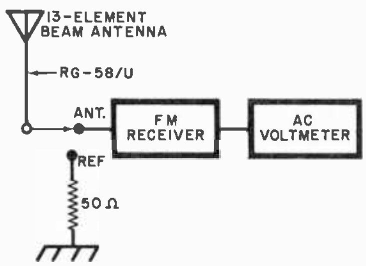
The basic specifications for simple radio telescopes are summarized in Table 4.

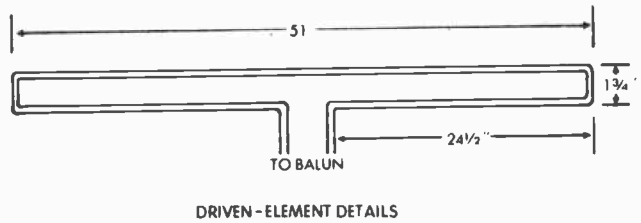
TABLE 3—RECORD/READOUT DEVICE CHARACTERISTICS

Monitor Device	Advantages	Disadvantages
Voltmeter	Readily available	Requires constant attention during recording sessions
Chart recorder	Requires little or no attention during recording sessions; provides permanent record of raw data	Initially expensive
Tape recorder	Requires little or no attention during recording sessions; provides permanent record of raw data; can be used for other purposes	Data must be transcribed

Getting Started. Doing anything really useful with a radio telescope requires at least a nodding acquaintance with basic astronomy. A radio astronomer must be able to aim his antenna at a particular target or know what sources are passing through the







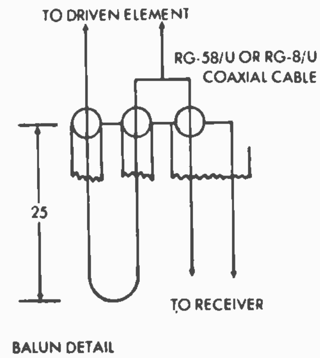


Fig. 2. Block diagram (left) and details for a 13-element beam antenna (above) for a 110-MHz radio telescope described in text.

lobe pattern of his antenna at a given time. So, he must be able to read star maps and interpret prediction tables. However, an experimenter doesn't have to be familiar with astronomy to set up a simple telescope and get it working.

The 110-MHz radio telescope system illustrated in Fig. 2 can be assembled for about $30, assuming you already have an FM receiver and a voltmeter. A beginner can assemble this system, use it to spot a couple of radio sources, and finally determine for himself whether or not he wants to learn more about astronomy and build another system suitable for more extensive projects.

Although most of the time and money involved in this 110-MHz system goes into building the antenna and its mounting, there is really nothing unusual about it. It is a standard 13-element yagi array cut for a center frequency of 110 MHz. The elements can be made from heavy aluminum wire and mounted on a boom made up of 8′ (2.5-m) long sections of 1½″ (3.8-cm) diameter aluminum tubing. Mount the boom assembly on a standard 2″ (5.1-cm) diameter steel mast to raise the balance point of the boom about 16′ (5 m) above ground level. Experimenters who are uncertain about construction techniques for this type of antenna should look up further details in *Radio Astronomy for the Amateur* by this author (TAB Books, Blue Ridge Summit, PA 17214). This book also contains all the information you'll need to get seriously into radio astronomy on an amateur level. Alternatively, you can consult a recent edition of *The ARRL Antenna Book* for antenna construction tips.

Fix the antenna mounting so that it always aims the boom due south. The boom must be mounted so that it can be adjusted in altitude (pivot up and down). Use a length of RG-58/U coaxial cable to carry the antenna signal to the input of a moderately good FM receiver. An impedance-matching transformer can be used to match the 50-ohm impedance of the antenna/cable to the 300-ohm impedance of the antenna input circuit on most FM receivers. (The matching transformer isn't absolutely necessary for trial runs.) Then, connect a voltmeter that has a 1- or 1.5-volt ac range across the receiver's speaker output terminals. The meter will now register the system's output noise level.

A switch at the antenna input on the receiver can be used to replace the antenna with an equivalent-value load resistor. Since the resistor generates a negligible amount of noise, any noise detected by the voltmeter while the resistor is in the circuit represents the receiver's inherent noise level. Switching the antenna back into the system will always cause a rise in the noise level. The increase in noise level represents the signal level present at the antenna.

The sun is usually the best subject for trying out a new radio telescope, mainly because it is so easy to find and is such a powerful radio source. To check out this simple system, adjust the altitude of the antenna so that it points directly at the sun when it crosses the celestial meridian (an imaginary line that runs from directly overhead down to the southern horizon). Make this initial adjustment about two hours before the crossing is to occur.

All readings described here were taken with the receiver tuned to 110 MHz, as determined with the aid of an r-f signal generator. The treble control on the receiver was set to maximum and the afc switch to off. The volume control must be set for full audio gain while taking readings, but it can be turned down at other times if the hiss-

TABLE 4—BASIC SPECIFICATIONS FOR SIMPLE RADIO TELESCOPE

Parameter	Minimum	Nominal	Excellent
Antenna gain	10 dB	15 dB	20 dB
Receiver sensitivity	5 μV	1 μV	0.5 μV
Receiver bandwidth	100 kHz	2 MHz	6 MHz

Note: *Minimum* is capable of detecting signals from sun, Jupiter, Cassiopeia A and galactic plane; *nominal* and *excellent* are capable of working at least five sources outside solar system.

ing sound becomes a nuisance.

Switch to the resistor and note the voltmeter reading. If possible, use the meter's zero-adjust control to set the meter pointer to zero. If this isn't possible, set the pointer for the lowest possible reading and note it on a sheet of paper. Now, switch to the antenna and note the new reading. Subtract the previous (reference) reading from the new reading to obtain a fairly good estimate of the background noise being picked up by the radio telescope.

Take both readings in a similar fashion at 30-minute intervals over a period of four hours or so. Always note the time and difference between readings. When the experiment is completed, the data should show a distinct rise in the noise levels as the sun passes through the beam pattern.

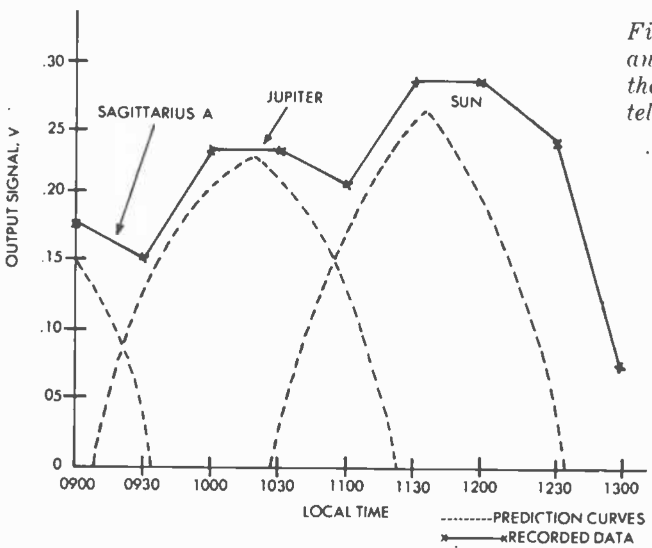


Fig. 3. Results of an experiment with the 110-MHz radio telescope system.

Illustrated in Fig. 3 are the results of a four-hour recording session identical to that described above. The plotted data (solid lines) show signals arriving from three different sources: Sagittarius A, Jupiter, and the sun. Sagittarius A, a powerful radio source representing the center of our galaxy, was just moving away from the antenna when the session began. Jupiter then moved into the beam, followed by the sun. Three powerful radio sources are not always lined up in this way, so an experimenter shouldn't be disappointed if his data shows only a single response representing the sun.

Our simple 110-MHz system is capable of detecting signals from at least seven different radio sources of extraterrestrial origin. These include: the sun, Jupiter, Sagittarius A, Cassiopeia A, Taurus A, and Virgo A. Electronics experimenters who are unfamiliar with the locations of the constellations listed here can seek the aid of an experienced amateur astronomer.

Our simple radio-astronomy system has a secondary application as a bonus. It makes an excellent system for FM DX'ing. ◈

BUILD A $25 HIGH-FREQUENCY VOLTMETER

Measures up to 90 volts from dc to beyond 20 MHz.

BY THOMAS H. SEAR

There has long been a need for an inexpensive, easy-to-use bench instrument that could measure the voltage levels of signals at frequencies into the MHz range. Now, for less than $25 you can build a broadband voltmeter that accurately measures from dc to frequencies over 20 MHz at amplitudes up to 90 volts in five overlapping voltage ranges.

The heart of this meter is a thermal converter similar to the type used in professional instruments to perform voltage calibrations to frequencies of 1 GHz. The converter is essentially a straight wire heater, which is connected in series with the current to be measured, and a thermocouple that measures the mid-point temperature of the heater. The thermocouple generates a dc voltage that is approximately proportional to the square of the current. (Fig. 1).

The important characteristic of the thermal converter is that its response is relatively independent of waveform and frequency variations. The unit used in this voltmeter is designed to operate between dc and 10 MHz with excellent accuracy and up to 65 MHz with only a 3% error. To get accurate results at, say, 65 MHz, a more sophisticated construction of the converter would be required.

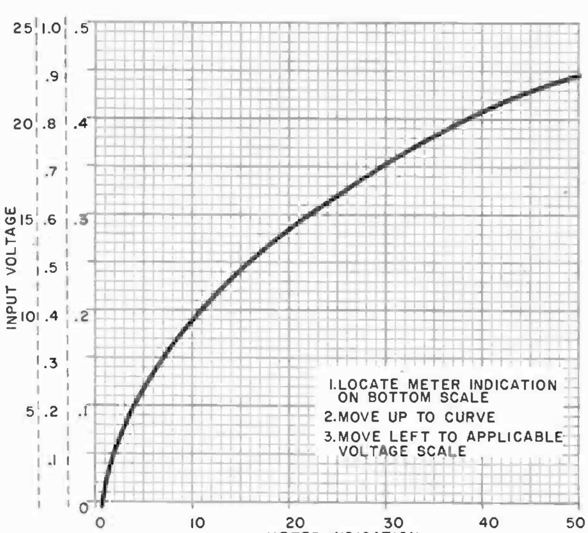


Fig. 1. Output of thermal converter varies with the square of the input. Use this curve to calibrate meter.

How It Works. As shown in Fig. 2, *R1* through *R4* make up a voltage divider, with values selected to limit the voltage across *TC1*, the thermal converter, to 0.45 V. The dc output of *TC1* is connected to the noninverting input of operational amplifier *1C1*, which is connected as a dc amplifier. Resistors *R5* and *R6* determine the gain of *IC1*, whose output drives *M1* a 50-μA meter. Potentiometer *R7* is used to calibrate the circuit and the meter, while *R8* is adjusted to set the zero point of the meter movement.

Construction. With the exception of the circuit involving the input voltage divider and *TC1*, where r-f signals may be present, and all leads should be kept as short as possible, there are no special precautions to be observed in wiring the voltmeter. However, it is advisable to keep the r-f and dc portions separated as much as possible to avoid pickup.

The IC and resistors can be mounted on perforated phenolic board, with the five connectors, meter, switch, and two potentiometers on the front panel of a suitable enclosure. The resistors in the voltage divider are standard 5% units, *R1, R3,* and *R4* being made up of two resistors either in series or parallel, to obtain the required value. The closer you can come to the required value, the better the accuracy of the meter. A precision resistance measuring bridge can be used to get even better accuracy.

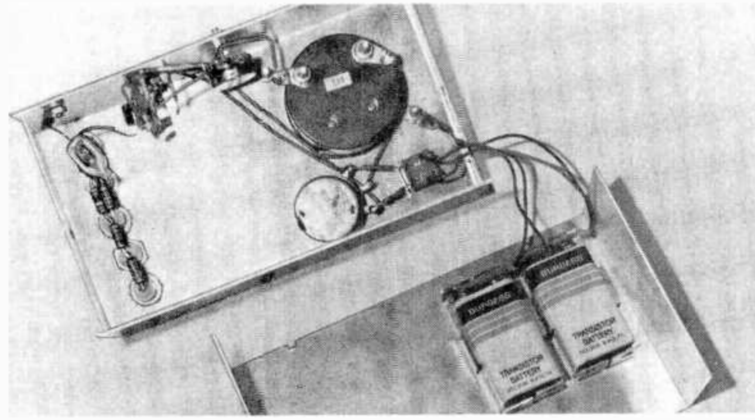


Photo of prototype shows layout of components.

Calibration. Before turning on the power, be sure that the meter needle is at its zero mark, using the mechanical zero adjustment on the meter itself if necessary. Set *R7* to its center position, turn on the power *(S1), and* wait a few minutes for the circuit to stabilize. Then adjust *R8* to set the meter pointer to zero.

Because *TC1* is a thermal device, it will generate a slight output due to the ambient temperature. It will also indicate above zero following each measurement until it returns to the ambient temperature. For this reason, *R8* should not be used to adjust the zero after each measurement. Use *R8* only after the temperature has stabilized for 5 or 10 minutes.

With the power on and the meter zeroed, connect a known dc voltage to the appropriate input jack. The 22.5-volt input (*J2*) is recommended because calibrating on that range will distribute the voltage divider errors more evenly. Wait about 10 seconds for *TC1* to stabilize. Then adjust *R7* to obtain the correct meter reading as determined by the graph in Fig. 1. The calibration will be as good as the degree to which the input voltage is known. (Three fresh 1.5-volt dry cells will provide a calibration voltage very close to 4.8 volts.)

PARTS LIST

B1,B2—9-volt battery
IC1—709 op amp
J1 to J5—BNC female connector (Amphenol UG-1094/U or similar)
M1—0-50-µA meter (Radio Shack 22-051 or similar)
R1—13,500-ohm, ½-W, 5% resistor (select 56,000 and 18,000 ohms in parallel)
R2—3600-ohm, ½-W, 5% resistor
R3—720-ohm, ½-W, 5% resistor (680 and 39 ohms in series)
R4—90-ohm, ½-W, 5% resistor (68 and 22 ohms in series)
R5—1000-ohm, ½-W, 5% resistor
R6—1-megohm, ½-W, 5% resistor
R7—250,000-ohm miniature potentiometer
R8—50,000-ohm potentiometer
S1—Dpst switch
TC1—Thermal converter (Best Products, Ltd., Model S-7. Available from Best Electrics Div., 1211 E. Denny Way, Seattle, WA 98122 at $10.30 each, plus postage.)
Misc.—Battery holder (2), suitable enclosure (LMB 138), knob (2), mounting hardware, etc.

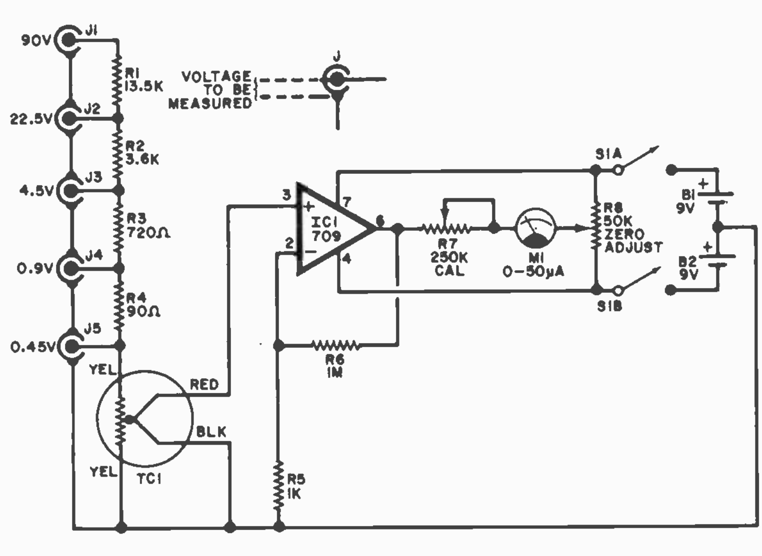


Fig. 2. Schematic of the voltmeter. Select and combine resistors to obtain proper values given in Parts List.

Caution. Although the circuit is conservatively designed to protect *TC1*, the device can be easily damaged by excessive current. Even brief currents of 5 mA or more in the input divider circuit can burn out *TC1*.Always start measurements using the 90-V range and move down to the lower ranges only if the meter indication is 5 divisions or less. Never connect a voltage to an input jack when you know the voltage is higher than the range for that jack. Also, never change the amplitude or frequency of the input signal without first reducing it to zero since transients could damage the thermal converter.

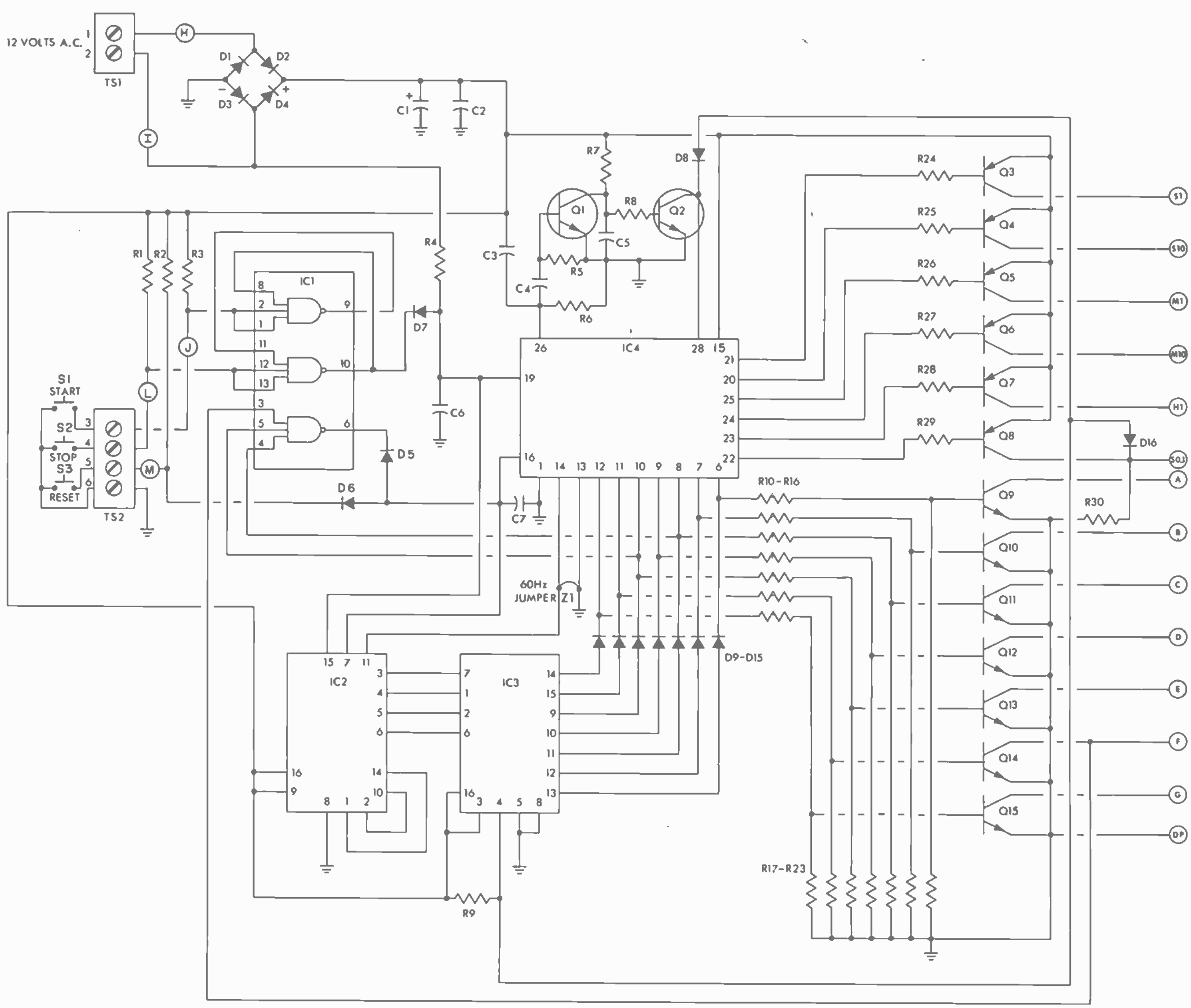
Use. Always remember to allow the voltmeter to warm up for a few minutes.

Keep in mind that the meter's repeatability may be an order of magnitude better than most instruments to which you may compare it. To avoid confusion, set this meter to a reference indication and then compare it to another instrument. This voltmeter is very sensitive in the upper third of the scale, and a small voltage change that may not be noticed on a conventional multimeter can amount to several divisions on this meter. ◈

A DIGITAL STOPCLOCK FOR SHORT AND LONG EVENT TIMING

Times events to 10 hours in 0.1-second intervals.

BY MICHAEL S. ROBBINS



WOULD you like to know precisely how long a recording session runs; how long it takes to make one lap around the track; or how long that new amplifier has been cooking on the bench? Here is a new six-digit stopclock that can do it—counting and displaying elapsed time up to ten hours by tenths of a second.

The heart of the stopclock is the new National Semiconductor MM5309 PMOS integrated circuit. It is identical to the MM5311-5314 series of clock IC's with one important exception. The "hold" pin has been replaced by a "reset" pin, which allows all of the counters to be reset to zero. This means that all of the on-chip counters can be reset to zero as required in a stopclock.

In this project the 5309 is used with three other IC's to provide 0.1-s counting with stop, start, and reset controls. Power is provided by a 12-volt transformer, and either 60- or 50-Hz line power can be used. Although the 5309 has outputs for either a 12- or a 24-hour display, in this case we use only a 10-hour display with the initial zero blanked and the sixth digit used for displaying tenths of a second. (For example, the display is 9:00:00:0 instead of 09:00:00.0.)

Later in this article, we will describe some practical circuits to use in actuating the stopclock for timing different types of events.

How It Works. As shown in Fig. 1, the output of *IC4* is in a multiplex seven-segment format, with each LED display turned on for one-sixth of the display cycle. The seven segment lines coming from *Q9* through *Q15* carry the segment information to all six digits (*DIS1* through *DIS6*), while the six digit-enable lines coming from *Q3* through *Q8* turn on the digits one at a time. The display cycle occurs at about a 1000-Hz rate, so that any display flicker is not noticeable.

Transistors *Q1* and *Q2* function as an interdigit blanking generator to prevent segment ghosting or afterglow. All segments are shut off for an instant before the digits are switched.

Since *IC4* counts in seconds, *IC2* and *IC3* are required to provide a 0.1-s count. The first section of *IC2* divides the 60-Hz line frequency down to 10 Hz, while the second section counts the 10-Hz pulses and delivers a BCD output. The count is repetitive, going from zero through nine. The reset line of *IC2* (pin 7) is connected to the reset line of *IC4* (pin 16) to insure that the two IC's count in synchronism after both are reset.

To display the output of *IC2*, the BCD signal must be converted to a seven-segment format. This is performed by *IC3*. To eliminate the need

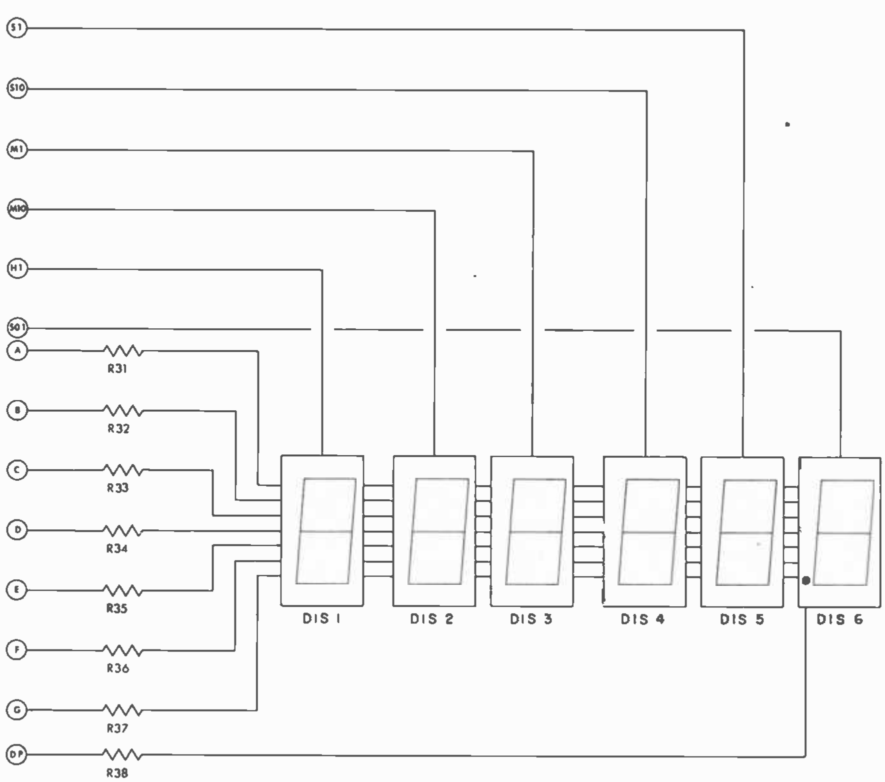


Fig. 1. Complete schematic of stopclock is shown above and on opposite page.

PARTS LIST

C1—2000-µF, 16-volt electrolytic capacitor
C2,C5—0.1-µF, 20-volt disc capacitor
C3—0.02-µF disc capacitor
C4,C7—0.01-µF disc capacitor
C6—0.002-µF disc capacitor
D1 through D4—1N4001 rectifier diode
D5 through D16—1N914 switching diode
IC1—CD4023AE (RCA) or MC14023CP (Motorola) integrated circuit
IC2—MC14566CP (Motorola) integrated circuit
IC3—MC14511CP (Motorola) integrated circuit
IC4—MM5309 (National) integrated circuit
DIS1 through DIS6—Seven-segment LED display (Litronix DL747 or similar)
Q1,Q2,Q9 through Q15—2N5172, MPS5172, or MPSA20 transistor
Q3 through Q8—2N4403 transistor
The following resistors ¼ watt, 10%:
R1,R2,R3,R30—1000 ohms
R4,R6,R7—100,000 ohms
R5,R17 through R23—10,000 ohms
R8,R9—470,000 ohms
R10 through R16—2000 ohms
R24 through R29—470 ohms
R31 through R37—120 ohms
R38—270 ohms
S1,S2,S3—Normally-open spst pushbutton switch
TS1—Two-lug screw-type terminal strip
TS2—Four-lug screw-type terminal strip
Misc.—Chassis box; printed circuit boards (2); 74 Molex Soldercons or one 28-pin, two 16-pin, and one 14-pin IC sockets; 2 small L brackets (optional); four spacers; four rubber feet; red acrylic display filter; machine hardware; hookup wire, solder; etc.
Note: The following are available from Caringella Electronics, Inc., P.O. Box 727, Upland, CA 91786: etched and drilled main pc board No. DSC-1PC for $7.95; etched and drilled display board No. DSC-1APC for $6.95; complete kit of parts, including cabinet, hardware, etc., No. DCS-1K for $74.95 plus $2 shipping. California residents, please add 6% sales tax on all items. There are no kits available for the circuits shown in Fig. 4.

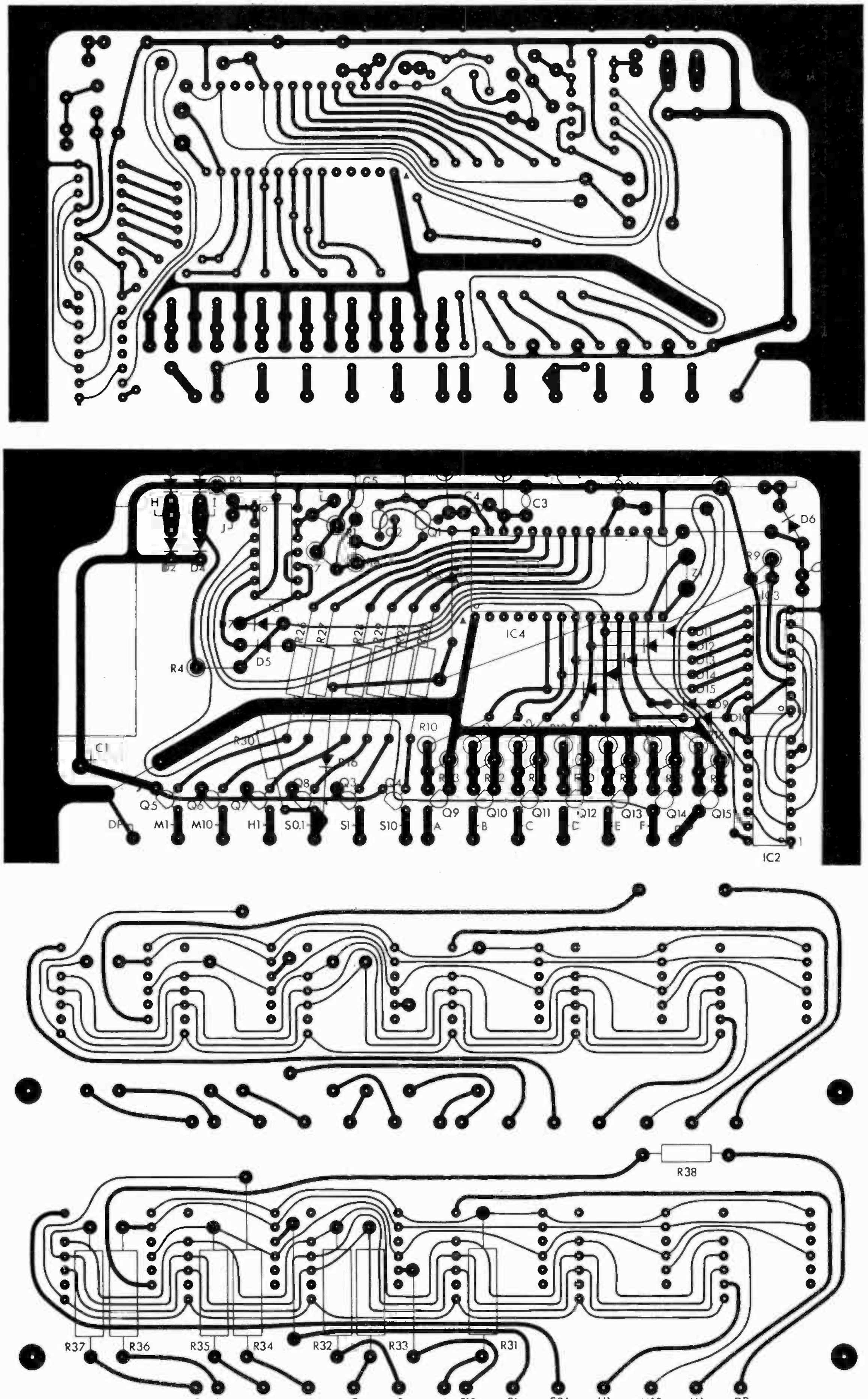


Fig. 2. Etching and drilling guides with component layout diagrams for the two pc boards.

for additional transistors to drive the 0.1-s display (*DIS6*), the outputs of *IC3* are connected through *D9* through *D15* to the outputs of *IC4*. Since *IC4* is off due to the leading-zero blanking interval when it would normally display the 10's of hours, this time slot can be used for the 0.1-s display. Thus, the H10 output of *IC4* is used to turn on and off *IC3* and enable *DIS6*.

Now, what happens when the H10 10's of hours display is supposed to be on as it normally would be after a 9:59:59 count? Without *IC1*, *DIS6* would display a random character. One NAND gate in *IC1* is used to detect this random digit and reset *IC2* and *IC4* to zero. In this manner, the stopclock is reset 0.2 second after the 10:00:00 count pulse, thus producing an effective timing range of 9:59:59.9 counts.

The other two gates in *IC1* are connected as an RS latch to turn on and off the time base. Operating *S2* causes pin 9 of *IC1* to drop to zero. Diode *D7* is then forward biased, preventing the ac signal from reaching *IC2* and *IC4*. Operating *S1* raises pin 9 to about 12 volts and effectively removes *D7* from the circuit, allowing the ac timing signal to reach the counters, and the count changes every 0.1 second.

Jumper Z1 between pins 13 and 14 of *IC4* causes the input sections of *IC2* and *IC4* to divide by six for use on the 60-Hz power line. For 50-Hz operation, no jumper is needed.

Construction. The stopclock is best assembled on two printed circuit boards, the etching and drilling and component placement guides for which are shown in Fig. 2. The circuit is split between the main and display boards as shown by the two sections in Fig. 1.

Leaving installation of the IC's until last, wire the main board as shown, taking care to properly orient the filter capacitor, diodes, and transistors. Note in Fig. 3 that some resistors mount upright. Install Molex Soldercons® or regular IC sockets in the locations for the IC's, but don't install the IC's just yet.

Next, wire the display board as follows. First install and solder the resistors into place on the *foil* side of the board. Trim away excess lead lengths. Then install and solder into place the displays, *DIS1* through *DIS6*, on the *blank* side of the board. Interconnect the two boards with lengths of hookup wire connected between similarly labelled pads on both boards. Solder 5" (12.7-cm) lengths of hookup wire to the pads identified in Fig. 2 by the letters H through L.

Fasten the display board to the main board with two small L brackets, threaded spacers, and machine screws; and mount another pair of spacers at the back of the main board. Then mount the entire assembly inside the chassis box, via the spacers, with four machine screws and lockwashers. Glue a red acrylic filter behind the front panel of the chassis box over the display "window." Then mount *TS1* and *TS2* on the rear panel of the box and *S1*, *S2*, and *S3* on the top.

Connect and solder the free ends of the wires coming from holes H and I to the lugs of *TS1* and the free ends of the J, K, L, and M wires to lugs 3, 6, 4, and 5, respectively of *TS2*. Solder 5" lengths of hookup wire to each of the lugs on *TS2* and wire them to the switches as shown in Fig. 1. Label *TS1* 12 VOLTS AC and lugs 3 through 6 on *TS2* STOP, START, RESET, and GROUND, respectively. Then label switches *S1*, *S2*, and *S3* STOP, START, and RESET, respectively.

Practicing the usual precautions for handling MOS devices, install the IC's in their respective locations via the Soldercons or sockets. Make certain that you orient them properly. (On the case of each IC is a dot for easy identification of pin 1.)

Operation and Use. When power is first applied to the stopclock, random numbers will be displayed. Depressing RESET switch *S3* resets all displays to zero. When START switch *S1* is momentarily closed, the stopclock should begin counting at a 0.1-s rate and the *DIS6* digit should be a blur. Let the stopclock run for a few minutes. Then hit STOP switch *S2*. The display should immediately grind to a halt and remain locked onto the last count after releasing *S2*.

To be of any use as an events timer, the stopclock must be stopped and started in a manner that produces meaningful information. The simplest approach would be to use the switches on the top of the cabinet to initiate the count and stop it. For remote operation, an identical set of pushbutton switches can be connected to *TS2* (paralleling *S1*, *S2*, and *S3*) via a cable. The best way by far of tripping and stopping the count is to let the event being timed operate the stopclock.

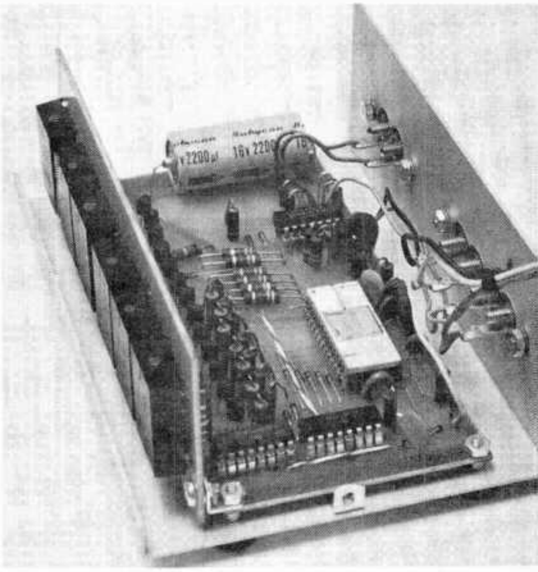
Bear in mind that each of the three circuits operated by the pushbutton switches in Fig. 1 is held at +12 volts by *R1*, *R2*, and *R3*. To enable an input, the bottom ends of these resistors must be connected to ground. Therefore, any external switching device connected to *TS2* must have an on resistance of less than 100 ohms and an off resistance in excess of 10,000 ohms. In the momentary-on condition, the external switching device must be capable of handling 12 mA of current.

As shown in Fig. 4A, relay contacts operated by some remote device can be used to trip any one or more of the *S1*, *S2*, *S3* functions. The circuit is closed by applying energizing power to the relay coil. If the relay is a latching type (mechanical or electrical), some means must be provided to open its contacts after each closure.

Optoelectronic couplers make ideal interfaces for the stopclock whenever the controlling circuit is at a different voltage from that used in the timer's circuit or has potentially damaging spikes. An optoelectronic coupler consists of a light source (usually a LED) and a light sensor (usually a phototransistor) facing each other in a light-tight case. The source and sensor are electrically isolated from each other. The Motorola 4N28 optoisolator, one of the more common types available, is shown connected to *TS2* on the stopclock in Fig. 4B. A separate optoisolator circuit can be used on each of the START, STOP, and RESET inputs. Each is separately tripped by momentarily applying a dc voltage to the source circuit.

The circuit in Fig. 4C can be used to

Fig. 3. Photo of internal layout. Note some resistors are vertical.



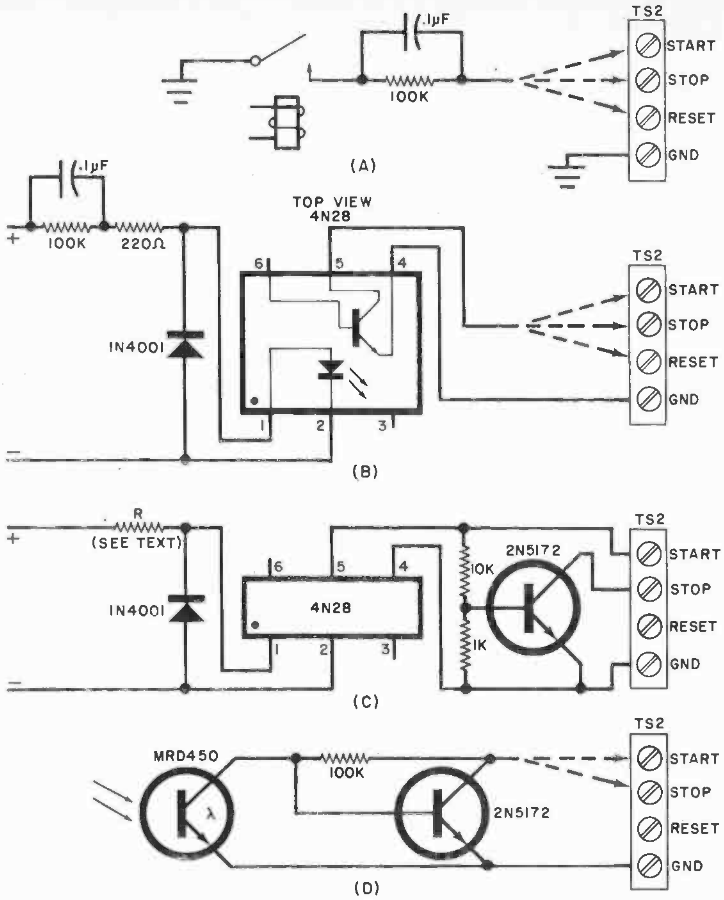


Fig. 4. Stopclock can be operated by a relay (A); an optoisolator (B and C); or a phototransistor (C).

measure running (or on) times. Resistor *R* should be selected to limit the current through the diode to about 40 mA. For example, to measure the running time of a battery-powered cassette recorder that has a 12-volt dc motor, the value selected for the resistor in ohms is equal to (V−1.2)/A, where V=12 volts and A=40 mA. In this case, R=270 ohms. The circuit connects across the tape recorder's motor.

The length of time it takes a vehicle (including toy trains and cars) to traverse a prescribed distance is often of interest. Light-beam tripping is a convenient way of starting and stopping the count. The circuit for accomplishing this is shown in Fig. 4D. Almost any type of light source, including an ordinary flashlight, can be used in this scheme. Depending on the distance between the light source and phototransistor, it may be necessary to use lenses to focus the beam. (Lenses may not be necessary in timing toys unless the distance is more than a few inches.) Although a Motorola MRD450 phototransistor is specified in the diagram, the value of the resistor can be adjusted to allow the circuit to accommodate just about any other phototransistor. ◈

THE PROGRAMMABLE MUSIC BOX PART 2

How to add 256 words of memory, plus music box applications.

BY MITCHELL WAITE AND LARRY BROWN

In Part 1 of this article, we discussed the circuit and construction procedure for the basic programmable music box, which contains a 40-note static memory system. This month, we will describe a 256-word memory add-on that greatly expands the programmability and playing time of the music box.

Because the music box uses an unaddressed shift register for storage, increasing the size of the usable memory is simple. The add-on memory system is built around three dual 256-bit shift registers. The entire memory circuit can be assembled on a small printed circuit board and connected to the music box by a multiconductor cable.

About the Circuit. The complete schematic diagram of the memory extender is shown in Fig. 1. Note that a 16-conductor cable is used to connect the memory module to the main music box circuit board. This cable carries all the required power, clock and input/output data. (Power is obtained from the music box.)

The clock signal from the music box board is fed to *Q1, Q2,* and *Q3,* which shape the leading edge of the clock signal to match the requirements of memory chips *IC1, IC2,* and *IC3.* All three IC's are clocked simultaneously. Information is stored when the RECIRC input is disabled.

The data on input lines *I1* through *I6* changes with instructions from the music box. The memory is clocked once for each change. Output lines *O1* through *O6* feed the stored data back to the music box when a tune or melody is to be played.

Construction. In Fig. 2 are shown the actual-size etching and drilling and component placement guides for the memory extender module. Wire the board as shown, reserving installation of the IC's for last. Mount and solder into place IC sockets or Molex Soldercons[8] at the IC locations. Then connect the leads on one end of a length of 16-conductor cable to the pads labelled 1 through 16 on the memory module. Remove *IC1* from the basic music box, and solder the free ends of the cable to the same numbered pads in *IC1*'s location on the main circuit board which is located inside the music box.

Next, exercising the usual precautions for handling MOS devices, install *IC1, IC2,* and *IC3* in their sockets on the memory board. Check to make sure that all IC's, transistors, and

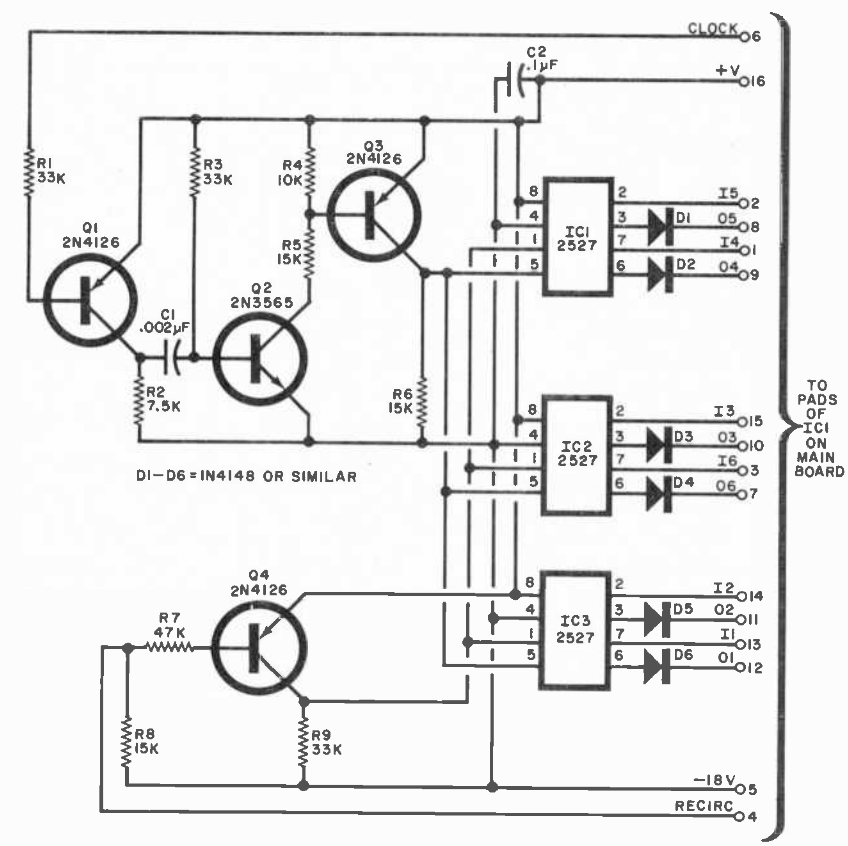


Fig. 1. Schematic of the memory extender. Numbered terminals are connected to main board in music box.

PARTS LIST

C1—0.002-µF, 100-volt Mylar capacitor
C2—0.1-µF, 50-volt Mylar capacitor
D1 through D6—1N4148 or similar diode
IC1 through IC3—2527 dual 256-bit shift register IC (Signetics)
Q1,Q3,Q4—2N4126 or similar transistor
Q2—2N3565 or similar transistor
The following resistors are ¼ watt, 5%.
R1,R3,R9—33,000 ohms
R2—7500 ohms
R4—10,000 ohms
R5,R6,R8—15,000 ohms
R7—47,000 ohms
Misc.—Printed circuit board; sockets or Molex Soldercons for IC's; 16-conductor cable; hookup wire; machine hardware; solder; etc.
Note: The following items are available from Cal Kit, P.O. Box 877, Sebastopol, CA 95472: Complete kit of memory extender module parts, including drilled and solder-plated pc board, flat 16-conductor cable, and mounting hardware, No. MC1-6 for $54.00. IC1, IC2, and IC3, No. MC1-8, for $43.00; three IC sockets, No. MC1-11, for $3.00; pc board No. MC1-7 for $8.00; telephone interface kit No. MC1-5 for $11.00. All items shipped postpaid and insured. California residents, please add 6% sales tax.

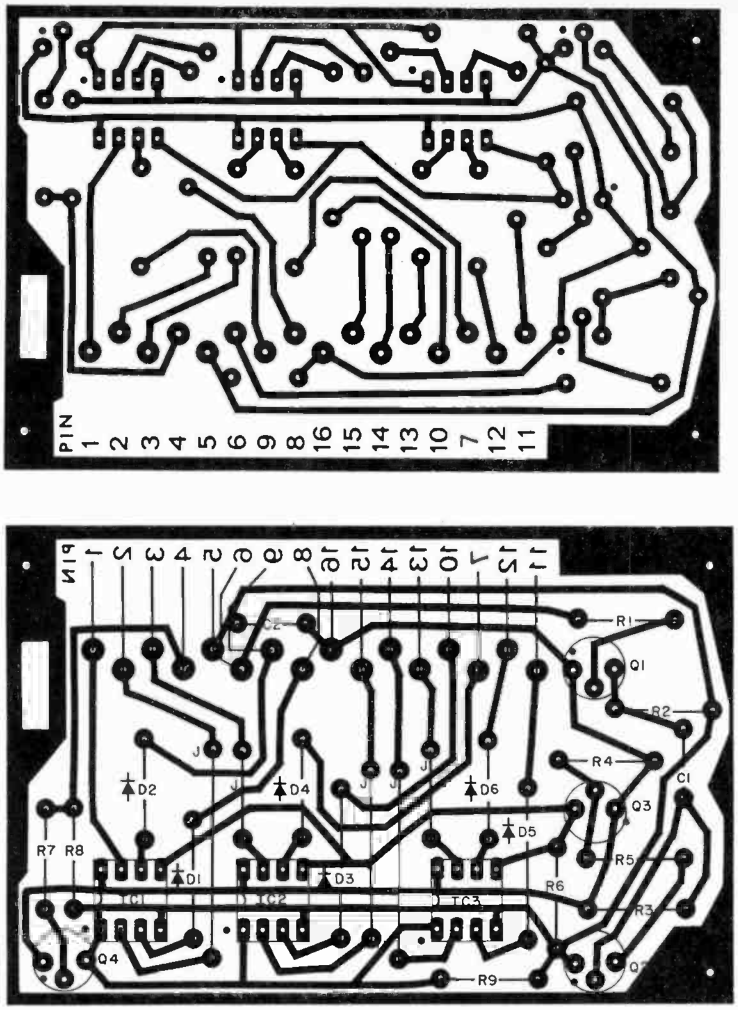


Fig. 2. Etching and drilling guide (top) and component layout.

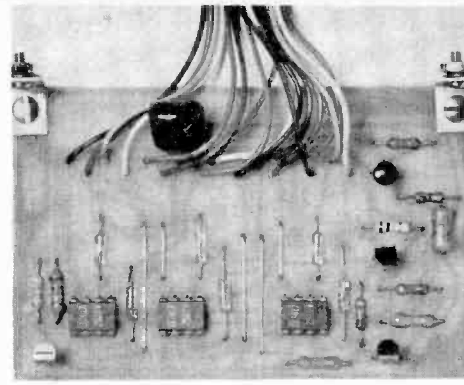


Photo of memory extender board.

diodes are properly oriented. Turn over the circuit board and check all soldered connections. Reflow the solder around any connection that appears questionable. Finally, check the board's conductor pattern against the etching and drilling guide in Fig. 2, particularly between the closely spaced IC pads, for solder bridges.

Power requirements for the memory module are significantly greater than those for the original 40-note memory. If you decided to use battery power for the original music box, it will be necessary to use a heavier-duty battery when the memory extender is added. Switch to an Eveready No. 276 or RCA No. VS306 heavy-duty 9-volt battery, which should provide about 60 hours of useful life.

Operation. A set of programming forms can simplify writing and storing melodies in the music box, regardless of which version you build. Note that the addition of the memory extender module does not alter the manner in which the music box is programmed and played. It simply provides an expanded memory.

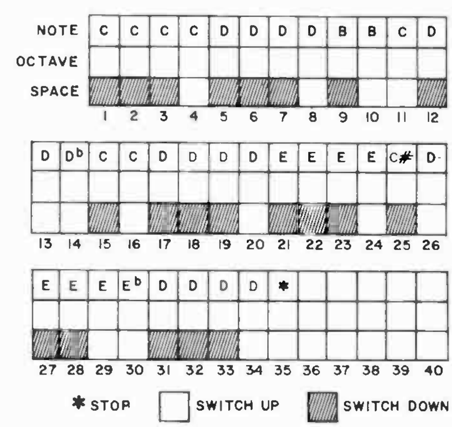
You can make your own programming form by laying out three horizontal rows of boxes numbered from 1 to 40 for the 40-word memory or from 1 to 256 when the memory extender is used. Label the top row NOTE, the middle OCTAVE, and the bottom SPACE. For simplicity, leave the OCTAVE and/or SPACE (remove) squares for each note blank if neither switch is to be depressed during programming and shade in the boxes where the switch or switches are to be closed.

As an example of programming, let us use the first two measures of "Call Me Irresponsible." In sheet music form, they would look like this:

"Call Me Irresponsible" by Sammy Cahn and James Van Heusen. Copyright © 1962 & 1963 by Paramount Music Corp.

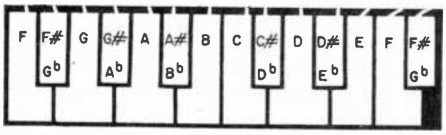
First, record each note above its symbol. Next, determine the duration of the shortest note. In our example, there are two half notes, one quarter note, four eighth notes, and a quarter note. This means that a memory "word" is worth one eighth note, the shortest note in the brief melody. A quarter note will then require two words of memory, a half note four words, and so on.

Determine how many words of memory each note requires and write this number beside the note's letter. In our example, "call" and "me" are half notes. Since a half note is the same duration as four eighth notes, the first number is a 4. The next note is for "ir. . ." (first syllable in "irresponsible"), which is a quarter note, or two eighth notes long. So, note B has a 2 after it. Continue to do this to all notes until you have used up the melody or run out of memory.



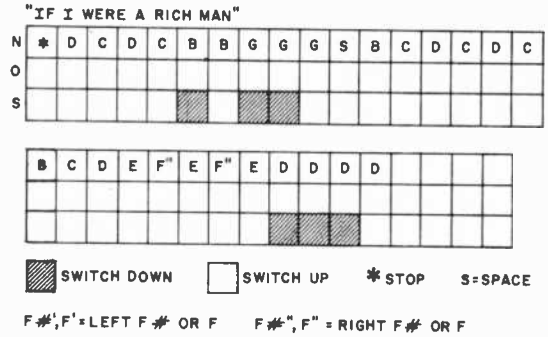
Program for "Call Me Irresponsible."

Now, determine where the spaces are to go. The first entry, C, is a half note. Since it requires four words to create a half note, the first three words have no space between them, which means the spaces should be removed by operating the SPACE REMOVE switch on the Music Box. To prevent the last word from running into the next note, your programming form should have a



Keyboard of the music box.

Program for "If I Were A Rich Man" from "Fiddler on the Roof."



blank in the SPACE row. You indicate this on your sheet music by entering a 3 after the "C4" entry. The entry "C43" is now interpreted as note C with four words of memory required and the first three spaces removed. Continue to calculate where to remove spaces for the rest of the notes in the melody. If a note is to be in the upper octave, indicate this by underlining the entry on the sheet music form.

In our example, the curved line between the two D notes on the scale forms the "spon" (of "irre*spon*sible"), which means that the two notes are run together. Therefore, you must remove a space from the first D note.

All that remains now is to enter the data onto your programming form. We will use only the first note (C43) to illustrate how this is done; all other entries on the form are made in a similar manner. In the top row, enter a C in boxes 1 through 4. Since the note is not in the upper octave, leave blank the first four blocks in the second row. You want to remove the spaces between only the first three eighth notes, which means you have to fill in the first three boxes in the bottom row.

Programming this note is a relatively simple procedure. Touch the programming probe to the C key, press the SPACE REMOVE switch and hold it, press the WRITE & STEP switch three times, release the SPACE REMOVE switch, and press the WRITE & STEP switch once again. Proceed to the next note. Programming form for another tune is shown above.

Applications. With the memory extender added to the music box, some interesting programming possibilities are possible. You can, for example, write a long melody into the memory. Alternatively, you can write several shorter tunes, which can be played on demand by touching the keyboard probe to the START key or having a doorbell switch close the same circuit. If each tune starts with a "stop" code, only one melody will play each time the start circuit is activated.

Another way you can use the music box, in either version, is to program the tune you want and accompany it on another instrument or by singing the tune. This approach is better than using a tape recorder because the playback rate of the music box can be increased or slowed down *without changing the pitch*. (Any time you change the speed of a tape recorder, you also change the pitch.)

You can even use the music box as a variable-speed metronome, with or without accented beat. With a little imagination, it can be programmed to play the rhythm accompaniment to your music.

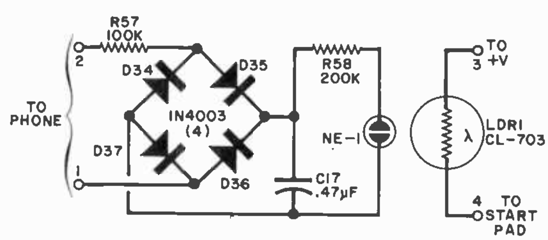
To use the music box as an unusual replacement for a conventional doorbell or chime system, locate and disconnect the doorbell's pushbutton switch leads at the transformer. Connect these two wires to the main circuit board in the music box via pads 36 (+V) and 35 (start). You can then feed the output of the music box to a power amplifier to obtain attention-getting volume.

If local laws permit, you can build the music box/telephone interface shown in Fig. 3. The actual-size etching and drilling guide and components placement diagram for this circuit are shown in Fig. 4. The telephone interface detects the 20-to-90-Hz ringing voltage that normally operates the phone's bell and uses this voltage to strike (ionize) neon lamp *I1*. The lamp is optically coupled, via a light-tight shield, to light-dependent resistor *LDR1*. The LDR is connected to the main board via pads 35 and 36. When the ringing signal occurs, the music box triggers on until the receiver is lifted off the hook or the ringing stops. Because the circuit has a high series resistance, it will not interfere with normal telephone operation. And the optical coupling eliminates any danger to the telephone system by accidental hookup of the power supply to the ac power line.

If you are a radio amateur, you can program short Morse code messages, such as a CQ followed by your call letters. By using a relay in the collector of the audio output circuit, you can key a transmitter.

You can wire two music boxes so that one clock controls both to allow you to play two-note chords in real time. If you have an electronic music synthesizer, you can use the output lines of the music box to drive the synthesizer's control circuits, creating some interesting sequences not possible with a conventional keyboard.◈

Fig. 3. Schematic for a telephone interface to go with the music box.



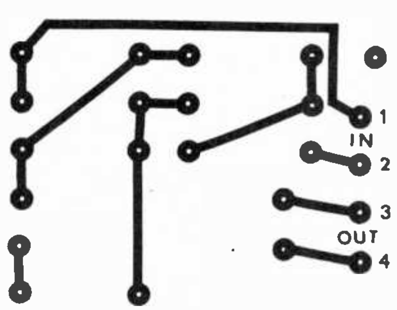
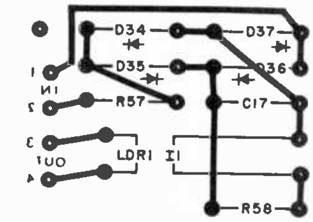


Fig. 4. Etching and drilling guide and component layout for the telephone interface.



I²L A New Transistor Logic Family

New techniques provide high speed with low power requirements.

BY WILLIAM D. HAFFNER

IN A seemingly endless quest for ever smaller and faster circuits, semiconductor researchers have developed a number of different transistor logic families. Among those that have already made their splash are: direct-coupled transistor logic (DCTL), resistor-transistor logic (RTL), resistor-capacitor transistor logic (RCTL), diode-transistor logic (DTL), transistor-transistor logic (TTL), and most recently metal-oxide semiconductor (MOS) and complementary-symmetry MOS (CMOS) logic.

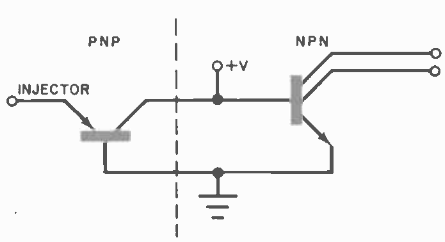


Fig. 1. The npn transistor is an inverter; the pnp serves as a current source as well as load.

Now, a promising newcomer has been added to the list. It goes under the name integrated injection logic, or I²L. Said to be as much as two years ahead of the previous state of the art, it employs the same proven manufacturing process as used for TTL. The IC's have high packaging density, have speeds approaching TTL, and consume only about a hundredth of the power of equivalent TTL devices.

Injection logic achieves its high performance by reducing a logic gate to a single complementary transistor pair as illustrated by the basic gate in Fig. 1. The vertical (npn) transistor operates as an inverter, while the lateral (pnp) transistor serves as both the current source and load. By contrast, a typical TTL gate requires six or eight transistors and must have source or load resistors.

When the I²L gate is formed on silicon, both transistors are merged into the area of a single multiple-emitter transistor. This eliminates space-consuming device isolation, which, in addition to the absence of resistors, accounts for I²L's circuit density. That density can be up to 100 times greater than is possible with TTL. For example, as many as 3000 logic gates, or 10,000 bits of memory, can be packed on a single I²L chip. The table compares several of the more important parameters for I²L and TTL devices.

Perhaps the most revolutionary attribute of I²L technology is its versatility. Furthermore, I²L circuits can easily interface with other circuits. It enables the designer to put both digital and analog circuits on the same chip. Because it uses thoroughly proven manufacturing techniques, it is low in cost and lends itself to the full range of microcircuit applications.

Evolution of I²L. The advantages of I²L came from shrinking DCTL, shown in Fig. 2, into a compact equivalent structure. The input circuit consists of three transistors in parallel. If one or more of these transistors is conducting, they act as short circuits, preventing current from flowing through the load gates. When all input transistors are cut off, current flows through the load gate transistors. This circuit action produces the common NOR logic function.

COMPARISON OF TTL AND I²L DEVICES

Parameter	I²L	TTL
Packing density	120-200 gates/mm2	20 gates/mm2
Gate delay	25-250 ns	10 ns
Power dissipation (per gate)	6 nW - 70 µW	10 mW
Supply voltage	1 - 15 V	3 - 7.3 V
Logic voltage swing	0.6 V	5 V
Current range	1 nA - 1 mA	2 mA

By replacing the three load resistors with an active current source, I²L simplifies the rather bulky DCTL. Then, the transistors with connected bases are replaced with a multiple-collector (npn) transistor. This is easy to do because all of the DCTL transistors have a common grounded emitter. In most I²L gates, a simple pnp transistor

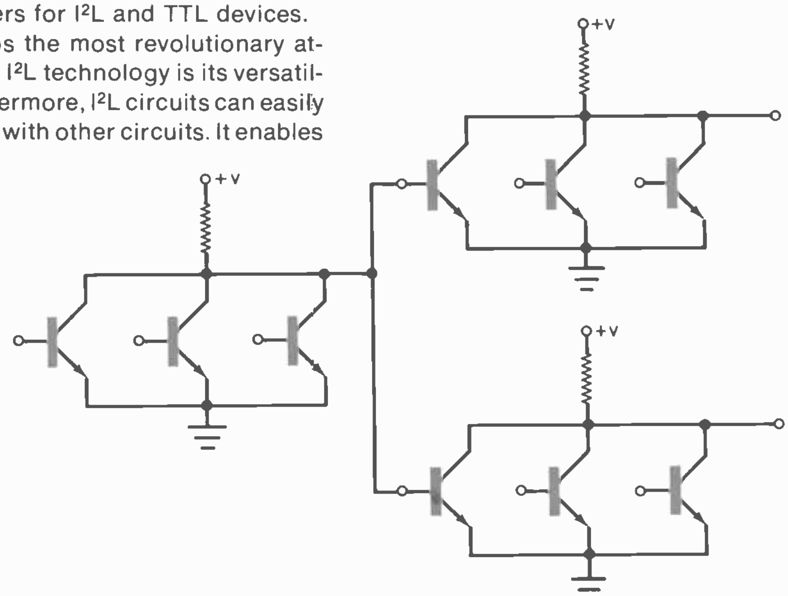


Fig. 2. A DCTL circuit which can be made smaller using I²L.

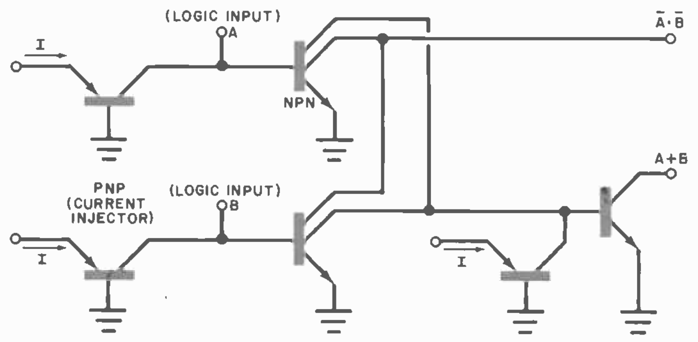


Fig. 3. A simple NAND gate using integrated injection logic.

serves as the active current source by injecting minority carriers into the emitter of the npn transistor. A light source can be used for injection in electro-optical applications.

The refinement of the DCTL gate results in the complementary transistor pair shown in Fig. 1. It can be seen that the base current of the npn transistor is common to the collector of the pnp current source, while the base of the current source is common to the emitter of the npn transistor. The emitter of the pnp transistor, called the injector, is common to all I^2L gates on a chip.

The circuit shown in Fig. 3 is an example of the simplest version of an I^2L NAND gate. Positive NAND logic is implemented by using the multiple-collector npn transistor as an inverter. Positive NOR logic can also be performed by OR'ing the I^2L gate outputs.

The npn transistor is normally biased on (low output) by the current-injector pnp transistor, which is connected between the base of the npn transistor and the external current source. Switching action is accomplished by steering the injector current. This is done by controlling the input voltage, V_{BE}, to the gate. A low input voltage of less than V_{BE} (750 mV) pulls injector current out of the input through the on, or low, output of the driving gate. Thus, deprived of its base current, the npn transistor cuts off and the output goes high. This NAND circuit is converted to NOR logic by wiring the outputs as shown in Fig. 3.

Device Construction. Because of the common elements described above, the entire I^2L gate takes up the space of a single multiple-emitter transistor when laid out on silicon. Here's how this is done:

The high density of I^2L is due in large part to its simplicity and economy of design. The n+ region in Fig. 4 serves as a common ground plane to interconnect all grounded-emitter transistor gates on the chip. The n region above the n+ region is both the emitter of the vertical (npn) transistor and the base of the lateral (pnp) transistor. The two p regions serve as the base of the npn transistor and also as the collector of the pnp transistor. The two n+ regions are the multiple collector of the npn transistor. Finally, metallized connectors are added to provide interconnection between the gates. Notice that the pnp transistor is integrated into the npn transistor. It doesn't exist as a discrete component, yet it can supply injection current for a series of npn gates.

The result of this manufacturing technique is the smallest component size of any current IC manufacturing technology. The I^2L gate is less than one-tenth the size of conventional TTL or CMOS gates. Even the latest LSI forms of TTL gates occupy four times as much space as the I^2L gate.

Two Types. Although I^2L is a young technology, two different versions are already in production. One is the isolated variety that uses a reverse-biased pn junction for component isolation. Since this completely isolates adjacent devices, it is used in I^2L chips that contain mixed functions. Such functions as LED drivers, memory decoders, current regulators, op amps, comparators, oscillators, and TTL or ECL devices can be combined on a single monolithic chip. Texas Instruments has in production an isolated I^2L digital watch chip that measures ⅛" (3.2 mm) on a side and contains logic, timing, and display drivers. The chip is approximately 25% smaller than the typical MOS versions. This chip is being used in a digital watch made by Benrus. An advantage of I^2L in this application is that cost can be reduced by using crystals operating at 4 MHz. This is not possible when using CMOS.

Also on the market is a 100-ns medium-performance TI RAM (74S209) with I^2L gates as the memory and TTL circuits as peripheral interface elements.

The second type of device in production is the nonisolated I^2L chip, used in very complex digital IC's. Isolation is not required because all circuits on the chip are I^2L devices. Consequently, higher functional density is achieved when compared to isolated I^2L chips. The first LSI digital circuit built with nonisolated I^2L technology is the Texas Instruments SBP0400 4-bit microprocessor. This chip has more than 1450 gates in a single 40-pin IC package. To date, it is the most complex standard bipolar chip in production. It has features that could be duplicated only by using 30 to 40 small- and medium-scale TTL IC's.

A Look Into the Future. As impressive as today's I^2L devices are, even better ones are coming. Right now on the way are DVM circuits, high-frequency counters, digital tuners, read-only memories (ROM's), control logic for calculators, touch-control and linear circuits for radio and TV, and circuits for telephone touch-dialing systems.

Intensive research and development continues to increase the speed of experimental devices. For example, researchers at IBM's Semiconductor Development Laboratories in West Germany are using Schottky-diode clamps on I^2L outputs to decrease gate delays. They estimate that speeds faster than 5 ns will be obtained in the near future. ◈

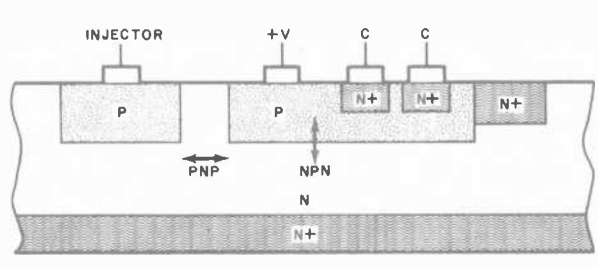


Fig. 4. Simplified diagram shows how I^2L is constructed.

ENVELOPE GENERATORS & SEQUENCERS FOR ELECTRONIC MUSIC

Shaping tones or notes and determining combinations or order.

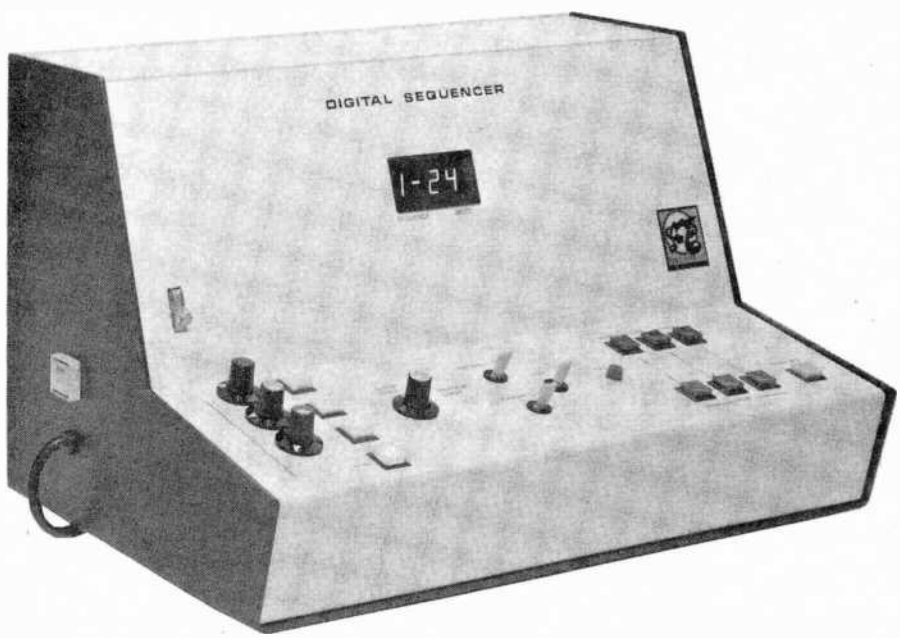
BY DON LANCASTER

ANY electronic music system needs some means for specifying the shape and sequence of the tones or notes produced. The equipment to accomplish this can range from an extremely simple keyboard-controlled on/off manual to elaborate sequential attack/sustain/decay generators and on up to complete digital computer synthesis sequencing that specifies everything about the notes and their time order.

Any device that shapes the individual notes is called an envelope generator or ASD (attack/sustain/decay) controller. If some circuitry is determining what tones or notes are to follow in a given combination or order, we call it a sequencer. Sequencers can operate on fixed rhythm and chording patterns, on random patterns from a composer circuit (as "teach-and-learn" devices), or as part of an elaborate computer system that bases what it will do on a set of compositional guidelines.

We have already seen in previous articles on electronic music that, if we obtain a waveform that represents the amplitude-versus-time of a desired note, all we must do is route it through a keyer or vca to let it modulate either a basic frequency reference or a complex tonal structure. Either way, we eventually end up with a tone whose frequency and amplitude components are specified throughout its duration. So, where does the initial envelope waveform come from and how do we generate it?

Oberheim Electronics DS-2 Digital Sequencer



Envelope Generation. In Fig. 1 are illustrated some of the things we might want to build into a single note or tone. For the sake of simplicity, assume that the frequency structure of the tone will remain constant for the tone's duration. (If it does not, simply use more of the same techniques, routing some of the envelope commands to filters instead of to keyers or vca's.) This leaves us with the basic amplitude shape shown. Now, let us examine the individual parts of our note.

ATTACK is the initial rise time of the note. It usually ranges from a few to several hundred milliseconds. Attack waveforms often have a rising exponential, while linear and capacitor charging waveforms are more often used in electronic music since they are much simpler to generate. With the exception of horn blips, the exact changes in the total attack time do not usually have a profound effect on the final tone structure.

HORN BLIP is a characteristic single or double implusive "blip" that often appears in a horn voicing, giving it the characteristic "bite" of the trumpet and other brass instruments. It is often obtained electronically by summing a brief impulse wave shape with the normal envelope waveform.

PEAK VALUE is the maximum amplitude, often reached at the end of the

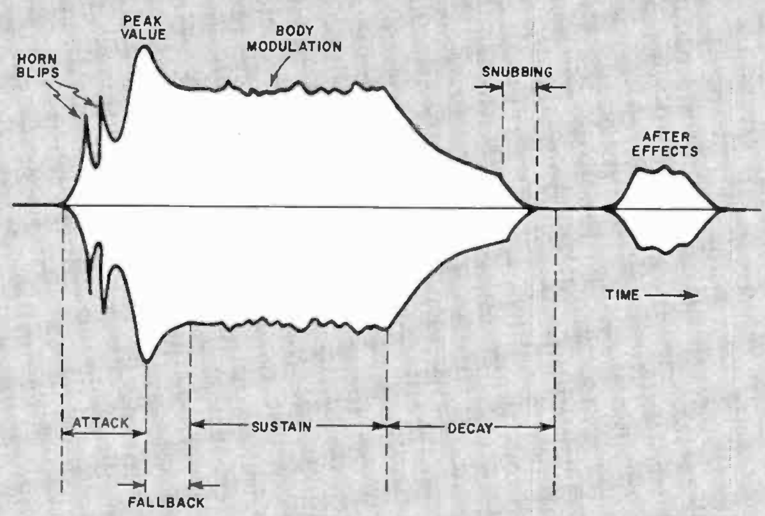


Fig. 1. Envelope of a note showing various characterists.

attack period. Some traditional instrument imitations—particularly the English horn—have a two-value attack in which much of the initial amplitude is rapidly reached. This is followed by a much slower rising response to the peak value.

FALLBACK is the portion of the waveform from peak level down to zero or some intermediate level. Many voices—particularly percussion—drop rapidly from a peak to some intermediate level as initial transients and other high-frequency effects rapidly die down. A classic example of this is a bell that gives an initial loud "clang," followed by a long drawn out pure bell tone. Fallback is essential for most percussion voices, particularly in piano synthesis.

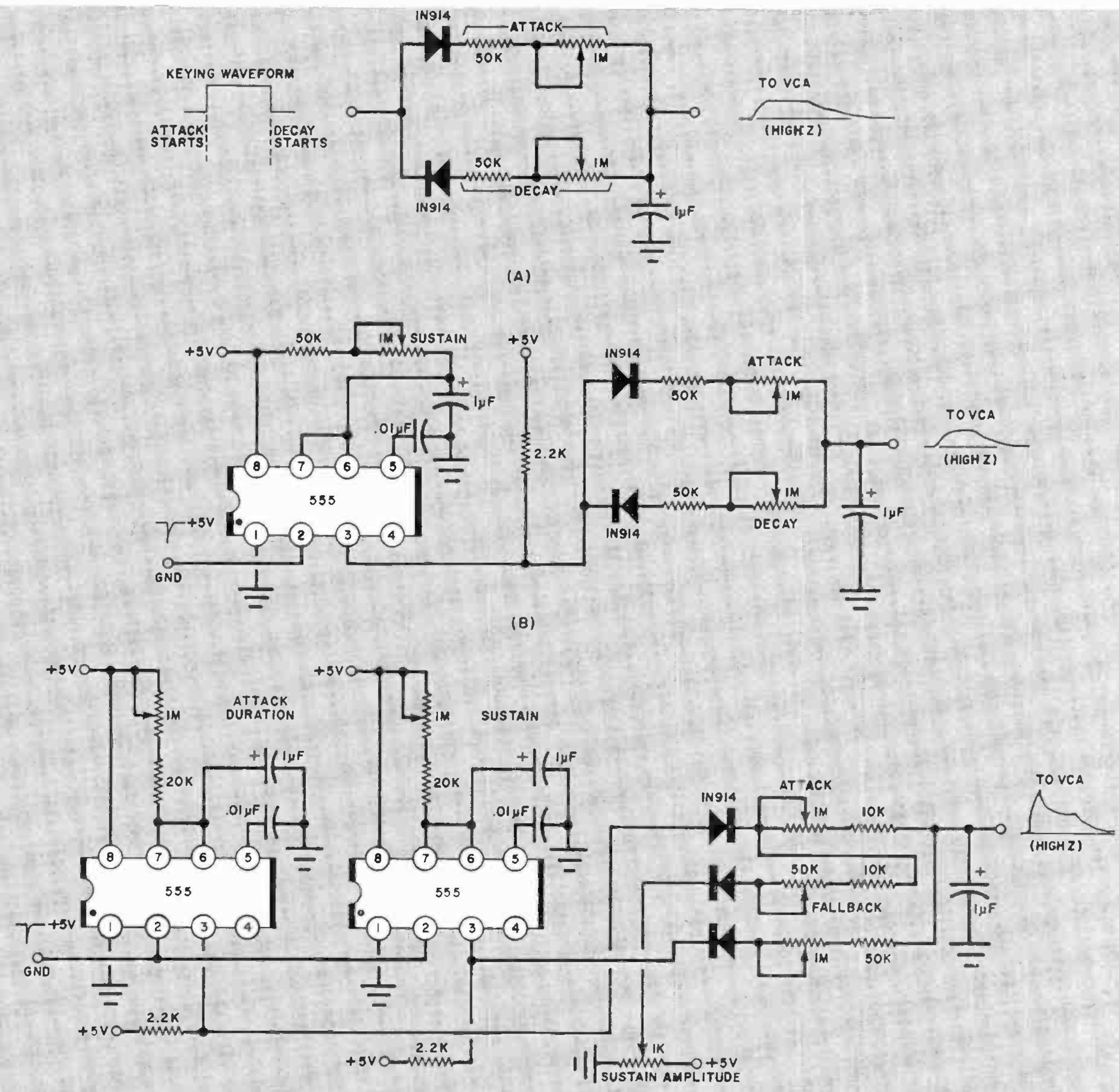


Fig. 2. At (A) is simple attack/sustain/fallback/decay circuit controlled by musician. Circuits (B) and (C) perform same function but are controlled by monostable oscillators.

SUSTAIN is the dwell period during which a note remains at relatively constant amplitude. It can be very short in duration or missing altogether in a percussion note. In fact, a percussion can be redefined as a note with a short or missing sustain time that is not under the immediate control of the musician. If the musician can hold the note for a controlled time, we have a non-percussion voice.

BODY MODULATION is any additional amplitude effect that is added to the note during the sustain period. A deep 6- or 7-Hz tremolo characteristic of piccolo or flute voice is one possibility. Another is the addition of random noise variations to break up an "exactitude" (electronic sound). In traditional instruments, this might take the form of wind noise, bowing noises, etc. At the other extreme, we could use all random noise for the body of the note, as is the case with some percussion effects. As the noise is filtered more and more, the greater the degree of filtering, the more it will appear as a pure tone. Hence, with either filtering or randomizing techniques, we can obtain anything from a purely random hiss to a pure "code practice oscillator" tone. The most musical of the effects are obviously between these limits.

DECAY is the drop-off at the end of the note. In reality, the decay is almost always exponential in form, although higher-frequency components often drop off at exponential rates that are different from those for the lower-frequency components. Decay times range from a fraction of a second to several seconds and are usually much longer than the attack times. (This can be reversed in electronic circuits to yield a "tape played backwards" type of effect.)

Since the decay is the last thing to occur in a note, and since it is relatively long in duration, obtaining the best waveform possible here is very important. A true exponential decay (or—better yet—several of them working on different harmonic components) must be used. A linear decay approximation will sound unreal. A truncated decay will sound even worse. And a decay that does not quite go to zero will produce note feedthrough and background noise. Fortunately, the normal RC discharge of a capacitor is a simple exponential decay, although you must be sure the level to which you are discharging represents the zero-amplitude point of your keyer or vca without truncation or feedthrough.

SNUBBING is a truncation technique that is used when you want to purposely terminate the decay cycle early. This snubbing most often crops up when you are synthesizing the release of a piano key. A snubbing waveform is usually nothing but a sudden speeding up of the decay time constant, causing a very rapid (but usually a non-zero) decay.

AFTER EFFECTS can be reverberation, echo, or any of a number of special effects. They are normally generated separately with the aid of a reverberation or tape-delay technique.

If we examine all of the characteristics wanted in a note, we can see that we need an attack/fallback/sustain/decay waveform as our basic envelope generation technique. Onto this, we can add such things as horn blips, noise modulation, snubbing, and echo effects to increase the range of total variations at our command.

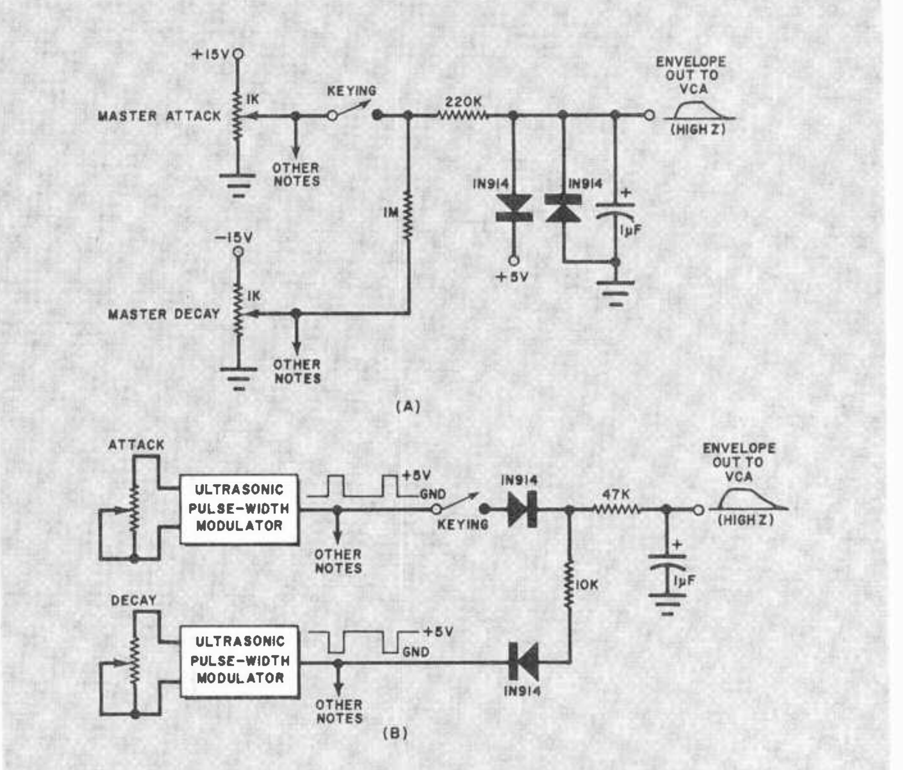


Fig. 3. Circuit (A) has two master controls for attack and decay; (B) uses ultrasonic pulse-width modulation.

Now, let us turn to some simple circuits that will do the job.

Envelope Circuits. Three simple attack/sustain/fallback/decay circuits are shown in Fig. 2. Circuit (A) is a simple attack/sustain/decay that is under the control of the musician, while circuit (B) performs the same functions but this time is controlled by a single monostable oscillator (555). By overlapping the attack and decay times, we can get a percussion voice with zero sustain.

Circuit (C) has added to it a second monostable oscillator to provide complete control of attack/fallback/sustain/decay shaping. All three circuits are based on charging a capacitor with one resistor that sets the attack time and a second resistor to discharge the capacitor and set the decay time. In circuit (C), a second resistor also discharges the capacitor at the end of the attack period but shuts off automatically whenever the remaining capacitor voltage drops below the sustain amplitude value. You can also vary circuit (C) to permit sequential operation of the monostable oscillators with the first controlling attack, a second fallback, a third sustain, a fourth decay, a fifth snubbing, and so on.

All three circuits shown in Fig. 2 can be only lightly loaded, which means that they can be connected to a keyer or vca that has a high input impedance, on the order of more than 3 megohms. A simple voltage follower, FET follower, or emitter follower circuit can be added as required for a

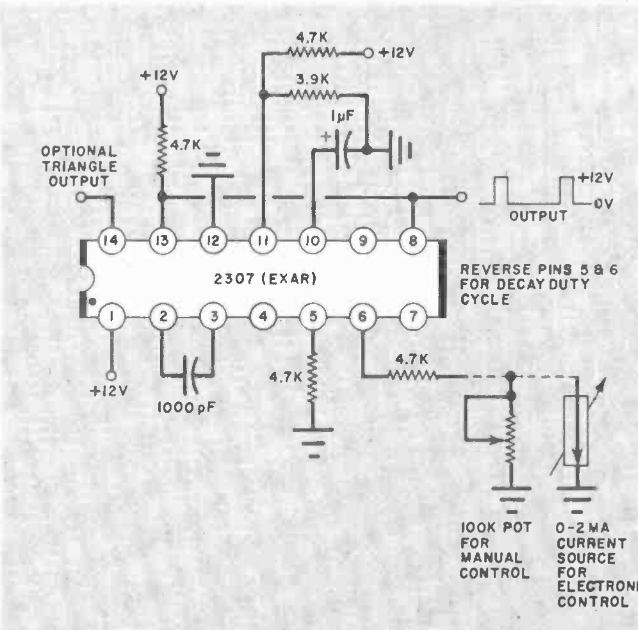


Fig. 4. Typical pulse-width modulator. Two are needed for complete control of all keys.

lower impedance keyer or gain control circuits.

Each of these circuits must have its attack and decay times set separately. The problem now is how to obtain polyphonic operation so that only one or a very few controls set the overall attack for all notes simultaneously, while a second group of controls is assigned to the decay function. Two possible approaches are illustrated in Fig. 3, one of which is a brand new and very powerful technique.

In circuit (A) is a MASTER ATTACK for all the notes and a MASTER DECAY control that serves all notes in a polyphonic instrument. Keying charges the output capacitor in the positive direction, increasing the volume of the vca until a potential slightly greater than 5 volts is reached. At this point, the positive clamping diode goes into conduction and limits the capacitor voltage to a maximum amplitude value. Releasing the key discharges the capacitor, eventually clamping at ground potential at the note's end.

For long attack and decay times, the charge rate is exponential (actually one minus the exponential on the charge cycle and the exponential on the discharge cycle). However, as either the attack or decay times are shortened, the charging rates become more linear. This would be objectional but for the fact that the linear rates are associated with the shorter times and are thus difficult to notice. Nevertheless, this is an extremely simple and useful polyphonic circuit.

The better technique is shown in circuit (B). This technique is called ultrasonic pulse-width modulation (UPWM). It is fully polyphonic, can be controlled by digital logic or some other easy means, and provides true exponential decay characteristics that are instantly variable, even from a remote location, over a wide range.

The trick to this circuit's operation is to rapidly switch resistors inside and outside the charging circuit. A 47,000-ohm resistor appears as a 47,000-ohm resistance when current is flowing through it. Reduce the current to zero, and the resistor behaves like an infinite resistance. Pass current through it for one-tenth the steady-state current time, and the resistor would appear to have a value of 470,000 ohms, which most conveniently gives us the ability to remotely control dozens or even hundreds of resistors (and the resulting attack and decay times) simultaneously.

To accomplish the above, we have two pulse sources whose duty cycles are controlled by potentiometers or control voltages. These operate at ultrasonic frequencies, charging and discharging the envelope capacitor in very small steps. The slope of each step is set by the charging or discharging resistor, while the total height of each step is set by the ratio of the on to the off times of the modulator. Since each step is a tiny fraction of a decibel in height, and since there are many thousands of them during the evelope generation period, the net result is the same as if the capacitor were charged and discharged.

A typical pulse-width modulator is shown in Fig. 4. While the IC costs about $4 (from EXAR Inc., 750 Palomar Ave., Sunnyvale, CA 94086), only two are needed for complete control of all keys, with low-cost diodes doing the actual switching. In this setup, the attack waveform is routed through the keyboard's contacts. If this is objectionable, a CMOS logic gate or analog switch can be substi-

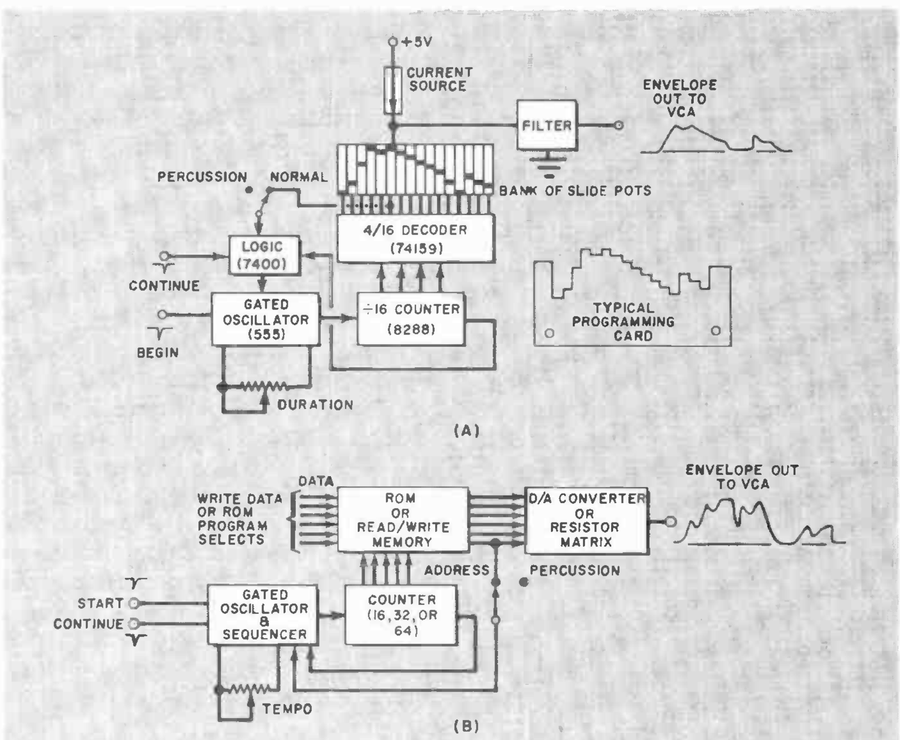


Fig. 5. Output of binary counter is shaped by programmed pots in (A). In (B), pots are replaced by digital memory.

tuted as the control element, since the signal is really a digital waveform up to the diodes. This technique can easily be extended to include fallback, percussion, and other effects.

Purely digital techniques can also be used for generating the envelope, but as of now, their added complexity limits them to monophonic instruments or, at best, to a time-shared or priority hierarchy in an instrument. Two typical digital circuits are shown in Fig. 5.

In circuit (A), we use an input time reference from a start/stop oscillator to count out 16 counts of a binary counter. Each count is decoded and routed to a slide-type potentiometer. Using slide pots, you can "draw" the waveform you want and set the total duration with the frequency of the time references. You can let the circuit go completely around for a nonpercussion voice. Releasing the key then continues the cycle. So, when you press a key, you generate the first five levels of the envelope. It then sticks in, say, position 5 for as long as the key is held down. On releasing the key, the note will continue through the decay cycle. As with most envelope schemes, some type of memory, usually a sample-hold or a digital latch, is essential if the key's frequency is to be remembered after the key is released.

The main advantage of the slide-pot scheme is its extreme versatility, especially since you can generate all manner of envelope shapes that are unreal or extremely difficult to generate with a traditional instrument. These include echo, multiple bursts, reverse attack, etc. One limitation of this scheme is that you really should use more than 32 slide pots, and another is that the tolerance of the pots can be rather restrictive as you are setting each slider to a slightly different value from its neighbor.

Programming the circuit is quickly accomplished with a plastic program card, first homing the sliders and then using the card to set them to the desired values. Once your favorite envelopes are chosen, you can install fixed resistor matrices that can be switched into the circuit in place of the pots in either preset or stop fashion.

Circuit (B) replaces the analog slide pots with a purely digital memory. For initial setups and experiments, you can use a read/write or random-access memory (RAM). For performance and concert use, a read-only memory (ROM) can be used to rapidly select any of a number of fixed envelopes.

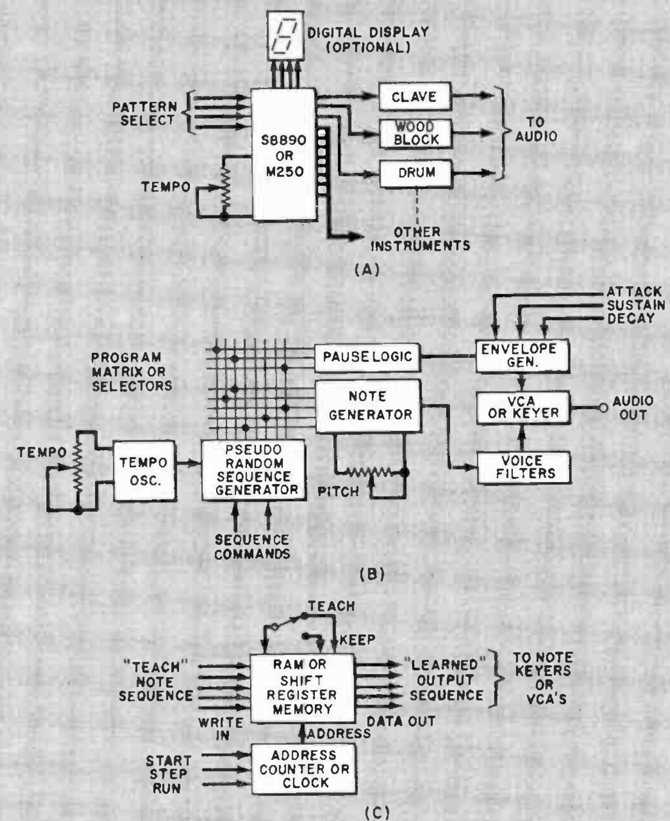


Fig. 6. Sequencer techniques: (A) has rhythm generator; (B) generates random patterns; (C) is teach/learn device.

Sequencers. Three popular sequencer techniques are shown in Fig. 6. A sequencer governs the order and combinations the notes follow, rather than the shape of each individual note. Technique (A) has a rhythm generator or sideman. An early version of these circuits appeared in POPULAR ELECTRONICS as the "Drummer Boy" (July 1971). Today, you can do the whole thing with a single S8890 IC from American Microsystems, Inc. (3800 Homestead Rd., Santa Clara, CA 95051) or the M250 IC from SGS-ATES (435 Newtonville Ave., Newtonville, MA 02160). The IC's are available at about $25 in unit quantities. Both IC's generate the combination rhythm patterns for rhythm accompaniment and are available in a standard pattern (traditional rhythms) as well as in custom patterns at much higher cost. Electrically, the IC's operate in much the same manner as circuit (B) in Fig. 5.

Circuit (B) in Fig. 6 is a composer/synthesizer that employs a pseudorandom sequencer to generate random tone patterns. These patterns are combined with program selectors and pause selectors to generate hundreds of thousands of tonal sequences, and at around $50 cost much less than most synthesizers. One such random-pattern generator was the "Psychtone I" that appeared in this magazine as a construction article in February 1971 and is still available in kit form from Southwest Technical Products Corp., 219 West Rhapsody, San Antonio, TX 78216.

Circuit (C) in Fig. 6, a variation of circuit (B) in Fig. 5, is a teach/learn sequencer. A commercial version called the Model DS-2 is available from Oberheim Electronics (1549 Ninth St., Santa Monica, CA 90401). Teach/learn devices of this type can employ either RAM's or shift-register memories. One good choice for experimenters would be the Signetics hex 32- and hex 40-bit shift registers (2518 and 2519), particularly since they are beginning to appear on the so-called "surplus" market for as little as 25¢ each. Brand new IC's directly from the factory are currently selling for less than $5 and form the basis for many teach/learn music experiments. ◈

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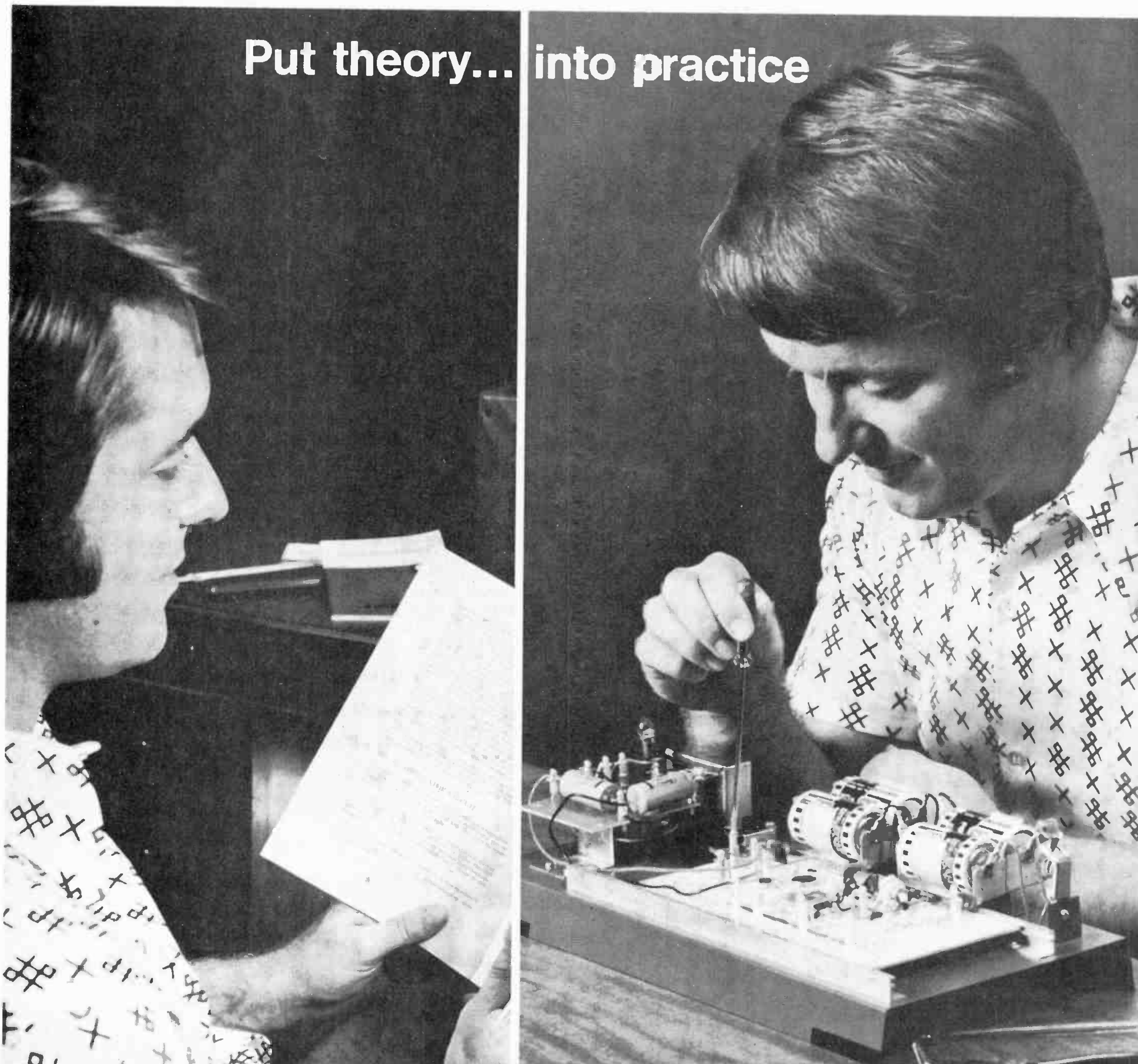

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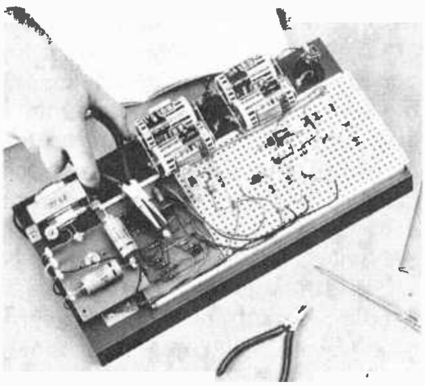

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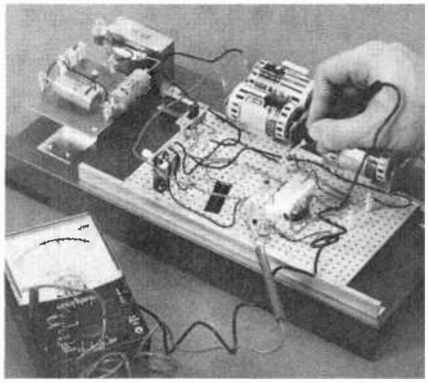

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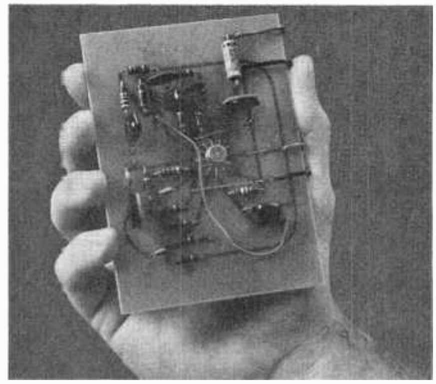

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CIRCLE NO. 12 ON FREE INFORMATION CARD

Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

The British Industries Co. Model 980 Multiple Play Manual Record Player is, to our knowledge, the first successful adaptation of a belt drive to an automatic record changer. This electronically controlled player offers almost every design and operating feature one could desire, plus a high level of performance, at a reasonable price.

Pickering's PP-1 preamplifier equalizes and amplifies the output of a magnetic cartridge, delivering a signal suitable for the high-level input of any amplifier or receiver. It makes it possible to use a second record player with amplifiers not equipped with two magnetic-cartridge inputs, as well as up-dating an older amplifier which was originally designed for use with ceramic cartridges.

—Julian D. Hirsch

B•I•C MODEL 980 MULTIPLE PLAY MANUAL RECORD PLAYER

Automatic turntable with belt drive.

HIRSCH-HOUCK LAB REPORT

At the top of the British Industries Co. line of "Programmed Multiple Play Manual Turntables" is the Model 980. It may well be the first belt-driven automatic changer.

The turntable's 12" (30.5-cm) nonferrous platter is belt-driven to operate at either 33 1/3 or 45 rpm by a 24-pole synchronous motor. This low-speed motor, operating at 300 rpm (which corresponds to 5 Hz), places most of the rumble frequencies below the audible range. In contrast, the usual four-pole motor revolves at 1800 rpm, which puts the rumble frequencies at a very audible 30 Hz.

Mounted in its walnut base, with dust cover in place, the record player measures 17 1/16"W × 14 11/16"D × 7"H (43 × 37 × 18 cm). The basic turntable retails for $199.95, while an optional walnut base and dust cover are priced at $16.95 and $9.95 respectively.

General Description. For single-play operation, a short spindle that rotates with the record goes into the center of the platter. When operating in the multi-play mode, this spindle is replaced with a taller automatic spindle. Unlike other record changers, this player does not depend on the automatic spindle to lift or support the record stack while a record is being dropped to the turntable. A post just outside the rim of the record helps do the supporting. The spindle contains only a slim rod that pushes the bottom record off the ledge of the support. Only a slight force is required for this action, well within the capabilities of the belt-drive system.

The tubular tonearm is mounted on needle-bearing gimbal pivots, with a rotating elastically mounted counterweight. A scale on one of the gimbal rings is calibrated from 0 to 4 grams at 0.25-gram intervals for setting stylus tracking force. Separate levers are provided for setting the tracking force and antiskating compensation. Normally set to coincide, both levers can be moved in a single operation. If desired, however, they can be set separately.

Unlike other cartridge shells with which we are familiar, this one does not plug or slide into the tonearm. A four-pin plug on its side mates with a connector on the tonearm, with a single nut locking it into place. A screwdriver adjustment tilts the entire shell for the correct vertical tracking angle. (A plastic jig is supplied for setting the correct stylus overhang for minimum stylus tracking error.) At the end of the shell is a small sliding lever that is used for setting the vertical angle for single or multiple play. For multiple play, the angle is set for the center of a maximum six-disc stack.

The record player's operating controls are grouped on a panel along the right side of the motorboard. At the rear is a lever that is used for modifying the antiskating compensation for conical and elliptical styli. Next is the cueing lever that operates the cueing system whose action is damped in both directions. A small knob near the base of the tonearm lets the user adjust the damping for a descent of from one to three seconds. The speed-select control is a slide lever.

A slide-type "programming" lever comes next. Because this record changer does not employ the center spindle to sense the presence or absence of records to control the automatic changing mechanism, it must be preprogrammed for the number of discs in a stack or for the number of times a single disc is to be played. The control has positions for OFF, MAN, and 1 through 6, the last for the number of discs in the stack or the number of times a single disc is to be played. The final control is labelled CYCLE.

The player's motor drive and control system employs a stable oscillator that generates a 60-Hz drive that is independent of power-line frequency and voltage. A small knob at the left front of the system's base permits the platter's speed to be trimmed by ±3%. Stroboscope markings under the platter can be viewed through a window on the motorboard. There are separate markings for 50- and 60-Hz power-line feeds and for both operating speeds.

In the single-play mode, a disc is placed on the platter with the short spindle, the programming control is set to position 1, which starts the platter rotating, and the CYCLE button is lightly touched. The pickup automatically indexes for a 12" diameter when the speed selected is 33 1/3 rpm or for 7" diameter when the speed is 45 rpm. After the disc has been played, the tonearm automatically returns to its rest post and the player shuts off. For straight manual operation, or if a nonstandard combination of record size/speed is involved, the programmer control is set to MAN, which starts the platter rotating, and the tonearm is positioned by hand. The only automatic operations in the manual mode are tonearm return and system shutoff.

For multiple-play operation, the automatic spindle is inserted and a stack of up to six discs is loaded onto it and the side support post. The programmer is set to the number of discs loaded, and the CYCLE button is pressed. This button, incidentally, requires only 90 grams of operating force and a travel of just 1/16" (1.6 millimeters).

Laboratory Measurements. For our tests, we inserted a good-quality phono cartridge into the player's tonearm shell. The tonearm resonance was at 8 Hz at about a 7-dB amplitude, which is an indication that the tonearm's mass is compatible with the majority of today's high-compliance cartridges.

The calibrations on the tracking force dial were exact, within the 0.05-gram resolution of our force gauge, and the force did not change by any detectable amount from the first to the last disc in our ½" high stack. The tracking error of the tonearm was as low as we have ever measured on a pivoted tonearm of comparable dimensions. Between radii of 2.5" (6.35 cm) and 6" (15.84 cm), the maximum error was less than 0.3°/in. At the inner radius, it was essentially zero. The tonearm and cable wiring capacitance was 120 pF, which is slightly higher than desirable, but usable with CD-4 cartridges.

Similar to most antiskating systems we have used, this player's system had to be set about 1 gram higher than the tracking force for optimum compensation. This is not a critical adjustment, and for most purposes the indicated settings should prove satisfactory. The cueing system operated smoothly, with no outward drift during tonearm descent. The rate of descent was adjustable over a range from 2.5 to 4 seconds.

The operating speeds were exact when the stroboscope pattern was stationary. They did not vary by any appreciable amount when the line voltage was changed over a 100-to-135-volt range. At 95 volts, the speed slowed by an insignificant 0.3%. The vernier (speed-trim) range was from +4.3% to −2.9% at 33 1/3 rpm and from +3.8% to −3.4% at 45 rpm. There was a very slight drift in speed during the first half hour or so of operation, which was barely detectable on the stroboscope.

The unweighted rms wow and flutter were each 0.03% to 0.04% at both speeds. The unweighted rumble was −32 dB, essentially in the horizontal plane. The ARLL audibility weighting yielded a very good −61-dB figure. The change cycle in automatic operation required 12 seconds, which is about average for record changers.

User Comment. The problems that a pure belt-driven system presented to designers of record *changers* in the past have obviously been overcome in this model. As a result, its wow, flutter, and rumble specifications are astonishingly good for a changer, being in a class with many of the fine single-play turntables.

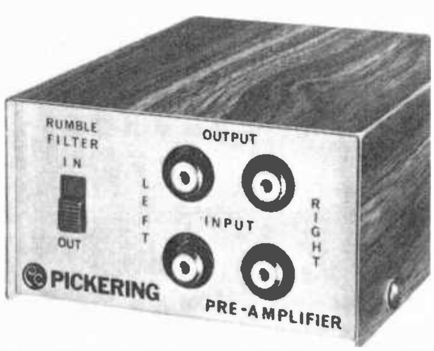
Operating the changer is different in at least one respect from others we have examined, however. For example, lacking a spindle sensor to control the changing mechanism, one must count the number of discs in a stack and "program" the player. Also, for those who like to switch cartridges for, say, playing records singly or automatically, there's a mechanical hassle involved in the use of a tiny securing nut.

Other, more expensive changers have special features that justify their prices, but in basic performance parameters—the ones that affect what you hear—the Model 980 takes a back seat to none. Equally important, this performance is obtainable at a moderate cost.

CIRCLE NO. 80 ON FREE INFORMATION CARD

PICKERING MODEL PP-1 PHONO PREAMPLIFIER

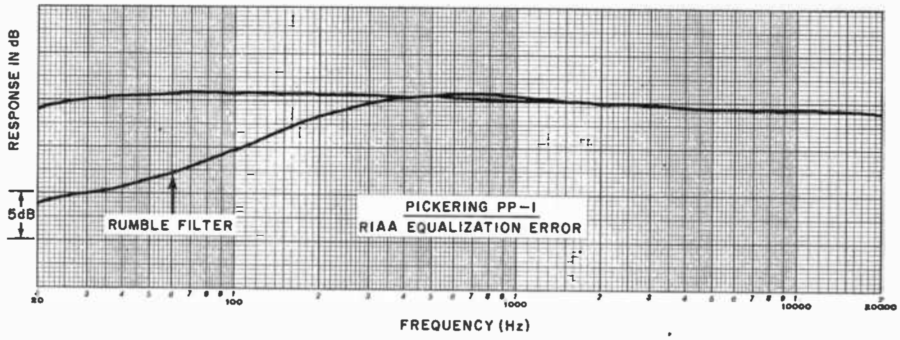
Updates low-cost music systems for use of magnetic cartridge.



HIRSCH-HOUCK

The Pickering Model PP-1 phono preamplifier is designed for use in upgrading low-cost music systems by permitting the replacement of ceramic cartridges with magnetic units. The type of record player equipped with a ceramic cartridge, of course, does not have the equalizing preamplifier needed for a magnetic cartridge. In most cases, however, the tonearm of the record changer will accommodate a standard magnetic cartridge with ½-in. (12.7-mm) centers. The preamp can also be used to connect a second record player to an amplifier equipped for only one magnetic-cartridge input.

General Description. The self-powered preamp measures 4⅜"D × 3½"W × 2"H (11.1 × 8.9 × 5.1 cm). Its two input jacks accept the signal cables from the record player's cartridge, while a pair of shielded cables (not furnished) go from the preamp's



output jacks to the AUX inputs of an amplifier. Because no power switch is provided on the preamp, the line cord should be plugged into a switched convenience outlet on the amplifier.

The specifications of the preamp are limited to the fundamental characteristics of a phono preamp. The input impedance of 47,000 ohms matches all current stereo cartridges. The gain at 1000 Hz is 38 dB, and the RIAA equalization is rated to be within ±2 dB of the ideal characteristic from 30 Hz to 15,000 Hz. The S/N is stated as being at least 60 dB, and crosstalk between channels at better than 60 dB down.

A rumble filter is included in the preamp in the expectation that many systems in which it will be used will have inexpensive record changers whose relatively high rumble cannot be reproduced by a ceramic cartridge but might prove troublesome with a magnetic pickup. The filter is rated to provide at least 15 dB attenuation of rumble frequencies.

The retail price of the Pickering Model PP-1 preamp is $29.95.

Laboratory Measurements. With a 10-mV input producing a 1-volt output, the measured 1000-Hz gain of the preamp was 40 dB. The maximum undistorted output was 2.5 volts, which suggest the advisability of using relatively low-output magnetic cartridges (ones with, say, no more than a 5-mV output level) to minimize distortion from preamplifier overload on loud recorded passages.

The crosstalk at 1000 Hz was −64 dB. The S/N ratio, referred to 1 volt output, was a good 69 dB (unweighted). It improved to 72 dB when the rumble filter was switched in, which reduced the small amount of power-line hum in the output. With IEC "A" weighting, corresponding to the subjective effect of the noise, the S/N was an impressive 77 dB, with or without the filter. The distortion was too low to be measured accurately at most usable output levels, being submerged in the low hum and noise output. At 2 volts output, the 1000-Hz THD was an insignificant 0.05 percent.

The RIAA equalization was better than ±1 dB from 20 Hz to 20,000 Hz. The rumble filter began to roll off the response below 300 Hz, with the −3-dB point at 170 Hz. It reached a maximum attenuation of 10 dB at frequencies below 40 Hz. Unlike many phono preamps, the equalization of the PP-1 was virtually unaffected by the inductance of the phono cartridge. Whatever the cartridge extracts from the disc will be passed on intact to the amplifier.

User Comment. We found that the preamp does a fine job in its intended application. We connected the preamp to the AUX inputs of our regular hi-fi amplifier and used an Ortofon Model M15E cartridge (quite a bit higher in quality than would normally be used in such a conversion) for our listening test. The results were first rate, sonically indistinguishable from the performance of the cartridge through the usual PHONO inputs.

TRAM XL AM CB TRANSCEIVER

Mobile rig has excellent noise limiting and modulation control.

The Tram XL mobile AM CB transceiver measures a compact 6.3"D × 5.5"W × 2"H (16 × 14 × 5 cm), yet delivers "big" performance on all 23 channels using crystal-controlled frequency synthesis. Good receiver sensitivity and selectivity, excellent automatic noise limiting (anl), an easy-to-read meter, operation at full legal power with clean modulation, and an unusually good automatic modulation control (amc) system are its attributes.

Other features are: adjustable squelch, PA operation, built-in speaker, external-speaker jacks, microphone, theft-deterrent mobile mounting hardware, 12-volt positive- or negative-ground power system, zener-diode voltage regulation, reverse-polarity protection, and line filter.

The transceiver retails for $159.95.

The Receiver. An unusual aspect of the double-conversion receiver used is the absence of an r-f input amplifier preceding the first mixer. However, good sensitivity is still obtainable, as indicated by our measurement of 0.55 µV for 10 dB (S+N)/N at 30% modulation with a 1000-Hz test tone. This is close to the average generally achieved with receivers that are equipped with an r-f amplifier. Without the amplifier, chances of signal overloading are minimized. The result is that the XL's receiver section has better signal-handling ability than is usually the case. Good image rejection, measured at 62 dB, is achieved by two loosely coupled tuned circuits at the input and the transmitter antenna matching network. Protective diodes are provided in the receiver's input.

The intermediate frequencies are

7.8 MHz and 455 kHz. A 7.8-MHz bandpass circuit between the two mixers aids unwanted signal rejection, which measured 60 dB over most of the range. As often occurs in this type of conversion and synthesis, a spurious response can be produced by a signal near 30 MHz. The rejection factor for this "image" was 36 dB. Rejection of the 7.8-MHz i-f in the 455-kHz stage was 60 dB.

Selectivity is obtained through the use of a ceramic filter. Adjacent-channel rejection was nominally 53 dB, and the overall response, including that of the receiver's audio section, was 350 to 3300 Hz.

A single diode is used for detection and agc. The agc, applied to the two mixers, held the audio output to within 7 dB with a 20-dB r-f input change at 1 to 10 μV and to 12 dB with a 60-dB input change at 10 to 10,000 μV.

The meter does double duty as a signal-strength and transmitter-output indicator. Readings of about S9 were obtained with input signals of 50 to 100 μV. The thermistor-stabilized squelch was adjustable for thresholds of 0.35 to 550 μV.

A series-gate anl follows the detector. The audio section of the receiver consists of three stages that end with a class-B amplifier stage, which provided a measured output of 3 watts at 6% distortion into an 8-ohm load using a 1000-Hz test tone.

The Frequency Synthesizer. A conventional frequency-synthesis system is employed in the transceiver. It utilizes 10 crystals, six of which are in the 11.8-MHz region and the remainder in the 7.5-MHz region. Pairs of crystals are used to create the local oscillator signal at the first mixer to generate the 7.8-MHz i-f when combined with a given CB channel signal. A 7.345-MHz crystal is used for heterodyning at the second mixer to produce the second i-f.

The Transmitter. On transmit, the synthesizer's output is combined with a 7.8-MHz crystal-controlled signal to produce the on-channel carrier. The carrier is filtered against spurious responses by a triple-tuned bandpass circuit. The rest of the transmitter consists of a conventional r-f amplifier, driver, and power amplifier system. A multi-section pi network minimizes harmonics and matches the output to 50-ohm transmission-line/antenna systems. The r-f output measured 4 watts when the transceiver was powered up from a 13.8-volt supply.

The audio section of the receiver, used for modulating the collectors of the driver and power amplifier stages, is preceded by a speech amplifier that is automatically switched in when the rig is on transmit.

The amc in this transmitter differs from the usual compression system. The collector and emitter leads of a transistor are connected across the speech amplifier's input. A dc control voltage, obtained by sampling the modulating voltage through a voltage-doubler system, is applied to the transistor's base. When the modulating voltage rises above the level required for 100% modulation, the resulting dc control voltage reduces the collector-emitter resistance of the transistor, causing it to reduce the speech input level. It thus acts as an automatic volume control that compensates for excessive speech levels as needed to prevent overmodulation. The result is extraordinarily good amc performance.

Raising the microphone input level 20 dB above that required to produce 100% modulation maintained a clean sine wave at full modulation, without clipping or negative-peak crossover. Under these conditions (20 dB compression), the distortion with a 1000-Hz test tone was only 5% and adjacent-channel splatter was down 55 dB. With a 2500-Hz tone, it was 40 dB down, and with voice modulation, it was 60 dB down. Using a 400-Hz tone, most CB transceivers have high distortion products, but with the XL, even with 20 dB of compression, the distortion was only 8.5%.

Referred to 1000 Hz, the audio response was 475 to 5000 Hz at the 6-dB points. A 2-dB rise occurred at about 2000 Hz. The frequency tolerance of the transmitter was within ±150 Hz at 80° F (27.3° C).

User Comment. The transceiver is built into a tough Cycolac plastic case. Miniature slide switches are provided for CB/PA mode selection and activating and deactivating the anl. The channel selector knob is easy to grip. Aside from having white position indicators, the VOLUME and SQUELCH controls also have tabs that let the user "feel" as well as see their positions. Although the edgewise meter movement isn't large, it's well-illuminated and has a pointer that's easy to see.

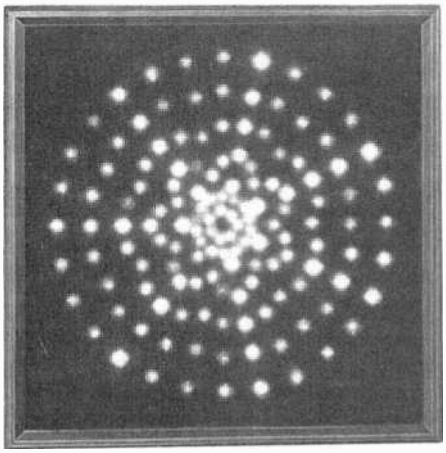
The speaker is mounted facing up, which can present a problem for under-the-dash mounting. However, an external speaker can be used.

The fine performance of the transceiver is evident from our test results. We especially liked the ability of the amc system to deliver a clean, fully-modulated signal without splatter over a wide range of voice levels —even when we shouted directly into the microphone.

The effectiveness of the anl was equal to or better than that of many noise-blanker/anl systems. At least 60-dB attenuation of high impulse-noise peaks was measured with no noticeable vehicle ignition noise and only a non-interfering trace during weak-signal conditions.

HEATHKIT MODEL TD-1006 4-CHANNEL COLOR ORGAN KIT

New approach provides unusual effects.



Though the popularity of the color organ declined somewhat a few years ago, it is back again in a form that promises to put it at the top of the audio-visual field once more. The Heathkit Model TD-1006 takes a sharp departure from the display format that was adopted by manufacturers a number of years ago. Instead of randomly positioning a number of colored lamps, the TD-1006 employs a balanced geometric pattern that seems to pulsate, explode in a fireworks display, and pinwheel as the music goes through the octaves and runs through a wide decibel range.

For want of a better descriptive, the Model TD-1006 is a "picture" color organ. Four channels of colored lights and their driving circuitry are housed in a walnut-grained vinyl-clad cabinet that measures 22¾" square × only 4½"D (57.8 × 57.8 × 11.4 cm) and weighs 18 pounds (8.2 kg). The system can be hung on a wall or stood on the floor or on a shelf. Retail price of the kit is $79.95.

General Description. The color organ is built around a conventional amplifying system whose output goes to four bandpass filters. The center frequencies of the filters are roughly 80, 350, 1000, and 3000 Hz. Each bandpass filter's output goes through a separate rectififer circuit to an SCR that, in turn, drives the channel's respective colored light string. Red lights are used in the lowest-frequency channel, followed by blue, green, and amber lamps as the frequency goes up.

The drive signal for the color organ is taken from across the speaker terminals or the speaker output of an amplifier or receiver. The system's 5000-ohm input impedance is designed to have only a minimal loading effect on the driving amplifier. To obtain the full 25-dB dynamic range from the color organ, an input signal level range of 1 to 28 volts is required.

The color organ has its own built-in power supply. The colored lamps consist of strings of miniature Christmas tree lights that require up to 117 volts of drive potential, which is controlled by the SCR's.

There is only one external control on the color organ. This is the power on/off switch that is ganged with the SENSITIVITY control. Inside the cabinet, on the main printed circuit board assembly, are eight more trimmer controls, two assigned to each channel (string of colored lights).

Externally, the color organ resembles a flat, square speaker system. Its front panel, behind which is located the display board, is covered with a black fine-mesh fabric. Directly behind the fabric is a lensed clear plastic sheet. The lamps are set into clear plastic "flower buds" that spread the point-source illumination out into a star-like pattern. Tiny lenses in the clear plastic sheet and the mesh fabric have a further effect on the dispersion of the light from the individual lamps. (The fabric also prevents the back-scatter of the light from within the color organ and limits the amount of ambient room lighting that can enter the display.)

There are 35 of each color lamps in the color organ's display, adding up to a total of 140 point sources of light when the system is driven by a wide-spectrum signal. The lamps are arranged in a star-burst pattern whose radials alternate in color. The display's density is greatest at its center, where a single circle of red lamps is located. The center is the only circle that has a single color. All outer circles have two or more colors of lamps.

Assembling the Kit. Assembly of the matte-black display board consists of mounting eight wood blocks and the hardware for securing the power supply and main pc board assemblies. Then the strings of lamps are plugged into the hole matrix. The lamps must be individually removed from their bases during installation and replaced immediately thereafter. Since these are series-string lights, each must be checked out before proceeding to the next string. (If one lamp in a string is burnt out or not making contact, none of the lamps in the string will come on.)

Next comes the gluing of the black fabric to the clear plastic sheet. Since the fabric must be stretched during this procedure, the task might have proved difficult. However, Heath thoughtfully provides not only the glue for the job, but the clamps to hold the fabric taut as well.

Mounting the components on the two printed circuit boards takes up the next portion of the assembly procedure. Neither board is crowded, which greatly simplifies wiring. This done, the rest of the work is mainly mechanical. All told, it took us some six hours to assemble the kit, working from the well-written and excellently illustrated assembly manual.

After allowing the color organ to "burn in" for the recommended period of time, we proceeded to the adjustment steps. Less than a half hour later, we were ready to put the color organ into our music system.

User Comment. Although we had gone through the fad era of the color organ and had been sated the way so many other people were, we were pleasantly surprised when we first turned on the new Heath color organ and played some music while watching the display. After living with it for several months, we find this color organ's effect as refreshing as it was the day we first turned it on.

One must see the TD-1006 perform to really appreciate it. As the frequencies in the music change and the signal level rises and falls, the starburst pattern of lights explodes, pinwheels, pulse-beats and throbs, expands outward and folds back on itself. Transients are captured in a nova-like display, and when all the lights are on and flickering with the rise and fall in signal level, there is a jewel effect.

While the color organ responds to all types of music, it appears to have an affinity for the pure tones of the synthesizer whose psycho-visual effects can be "mind blowing." With classical and most modern (not rock) music, the effect is highly appealing. So far, our favorite selection is Tomita's synthesizer arrangement of "Pictures at an Exhibition" (RCA), which has a number of special passages that appear to bring out the color organ's full effects.

Viewing conditions are best maximized when room lighting is low and not aimed directly at the display. Also, the best effect is achieved when the display is viewed head-on; the further off-axis you get, the more blurred the display becomes. (This isn't surprising, considering the double lensing system used.)

Most amplifiers and receivers capable of developing a few watts of output power (assuming a signal level of some 15 or more volts) will drive the color organ. One type of receiver that shouldn't be used is AM. Since the color organ uses SCR's to control the lamp strings, every time the SCR's go through zero crossing they generate noise that can be picked up by the standard AM receiver.

CIRCLE NO. 90 ON FREE INFORMATION CARD

SENCORE MODEL CR31 CRT TESTER & RESTORER

Versatile, easy-to-use TV service instrument.

TV PICTURE tube testers and restorers are among the most valuable instruments a TV service technician can own—whether he is a full-time shop owner or a part-timer. The expenditure for such an instrument can be quickly recovered, and its profit-making potential is great. Furthermore, the service technician can operate in a more professional manner when he uses a CRT tester/restorer. The new Sencore Model CR 31 "Super Mac" is in the Cadillac class of CRT tester/restorers. What it offers are versatility, simplified operation, a choice of "safe" and "last resort" CRT restoration steps, and high accuracy. Self-contained in a luggage-type case, the CR 31 measures 12¼"H × 11"W × 7"D (30.6 × 27.5 × 17.5 cm) and weighs 13¼ lb (5.9 kg.). Price is $395.00.

General Description. The inside cover of the CR31 contains 15 CRT plug-in sockets that enable one to make tests on virtually any CRT, color or black-and-white, including the RCA 110°, 17" Trinitron and GE's Quadline. There is also mounting space for a handful of extra sockets, which will be made available by the manufacturer when new CRT's are released.

The electronic portion of the instrument is in two parts: "CRT & Circuit Tester" and "Beam Builder." Depressing a rocker switch illuminates the section chosen. Testing a CRT starts with the left section. "CRT & Circuit Tester." Moving its rotary function switch to LINE VOLTS gives the user the ac volts reading on a big 6" × 4½" color-coded meter. If the TV receiver is operating on line voltage below its minimum requirement, a

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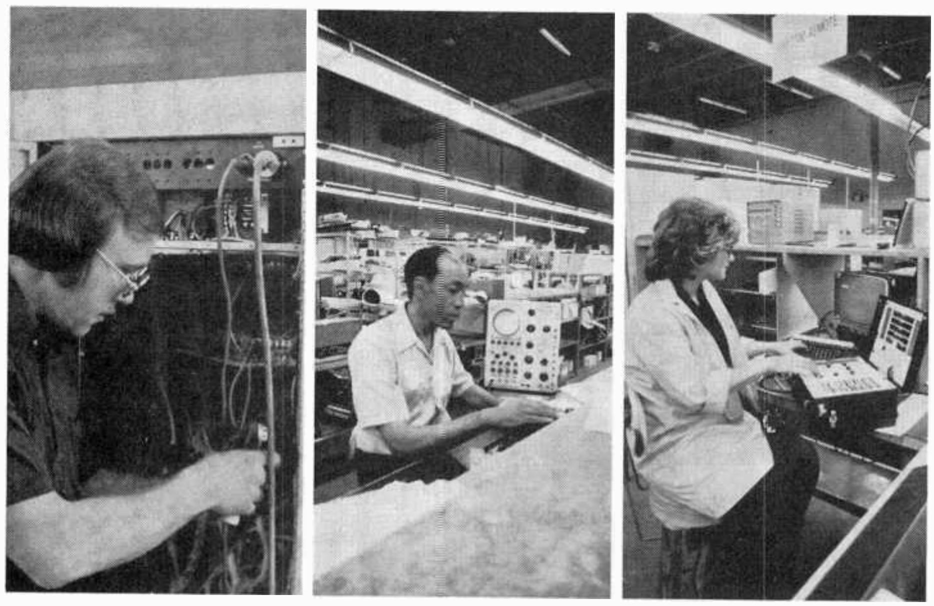

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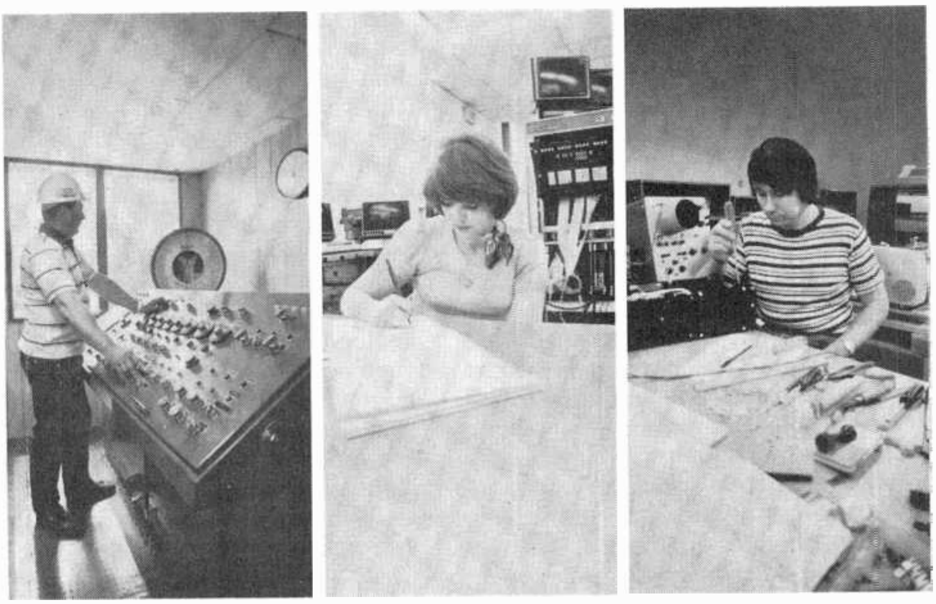

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CIRCLE NO. 21 ON FREE INFORMATION CARD

step-up transformer can be tried. Focus and high-voltage tests can be made via a built-in 10-kV probe and, if required, a 50-kV adaptor probe. The TV receiver can be plugged into the instrument's convenient front-panel ac outlet. Determining that the above is satisfactory, tests on the CRT itself can be started. (The foregoing can be bypassed, of course, if the CRT's heater doesn't light up.)

Using a handy 36-page set-up booklet stored in the case's compartment gives rapid access to all the information needed to test and rejuvenate CRT's. This includes listings of CRT types with instrument settings for filament voltage, bias, voltage range for focus and HV, and plug-in socket number. After attaching the proper socket to the CRT and connecting the CR31's coupling to it, you're ready to start. Setting FILAMENT VOLTAGE from 0 to 14 volts and "fine tuning" it with a FILAMENT-SET control, you simply turn the function switch to HEATER-CATHODE SHORT and read the meter, followed by a CONTROL-GRID SHORT test. If a short is indicated, you can flip the main selector switch to the BEAM BUILDER position. This mode is used to clear G1 shorts. Depressing a pushbutton discharges a high-voltage capacitor between the cathode and G1. This can be done to any of the three guns in a color picture by depressing R/B&W, G or B buttons.

If the CRT passes the foregoing test, you need simply move the rotary switch to GUN BALANCE while in the CRT & CIRCUIT TESTER mode. Here, each gun's G2 control is adjusted so that the meter pointer hits the same indicated line on the meter, providing the lowest emission level. Switching to EMISSION gives a direct meter reading that shows good, bad or ? for each CRT gun, measuring true beam current at maximum emission.

If emission isn't satisfactory, you've got five cracks at improving it. Firstly, there are two REJUVENATE positions in the BEAM BUILDER mode. These positions accelerate the beam current and/or increase filament voltage temporarily to bring new emitting material to the surface of the cathode. Even if you hold the pushbutton down, the system will discharge and, therefore, not allow you to use excessive rejuvenation. (You might also try raising filament voltage in delayed steps and testing for emission to see if an improvement is noted, which is a sixth option). If all three CRT guns show poor emission, then you can try RESTORATION. The CR 31 offers three CRT restoration choices. The AUTO CYCLE position applies a constant dc voltage between the cathode and the control grid for about four seconds (a screw-driver adjustment permits this time to be increased or decreased), then removes the voltage for about 2 seconds. The cycle is repeated three times while the pushbutton is depressed. Two MANUAL RESTORE positions are also available, where the user controls the amount of time the system is working. In MANUAL 1, maximum cathode current is limited to 100 mA, whereas in MANUAL 2, current is limited to 150 mA. The latter is a last-resort method.

Restoration is actually the reactivation of the electron-emitting properties of the CRT cathode, so that it can emit large quantities of electrons to eliminate degradation due to slight amounts of gas within the tube.

If emission is satisfactory, a LIFE TEST is made. This lowers the filament voltage so that you can estimate how much life is left in the old CRT by observing meter readings. An AUTOMATIC TRACKING test is made next, in the CRT & CIRCUIT TESTER mode. This test is accomplished without any additional balancing or settings by simply moving the function switch to AUTOMATIC TRACKING and noting whether the meter indicates good or bad. Using a Sencore-patented circuit, emission information for each color gun is stored and compared on the basis of the industry 1.5:1 ratio standard. If the tracking reads "Bad," then the color picture will either be too green, too blue, or too red, depending on which gun's emission is too low; black-and-white pictures on color receivers also display tinges of color if tracking is poor.

User's Report. The CR31 "Super Mac" was in our hands for a few months. Testing a myriad of CRT's with it, we found it to be as complete a CRT tester and restorer as one could hope to use. We brightened up a host of formerly low-brightness pictures, removed a G1 short, and vastly improved tracking on many other color TV receivers. (In instances where all guns could not be equalized, adjusting the set's screen-grid controls did the trick). In one case, we ruined a CRT using the CR31's MANUAL 2 restoration, but this tube was gone to begin with. In another instance, however, we "saved" a similar defective CRT. Also, we were unable to correct one CRT with a G1 short, deducing, therefore, that it was a mechanical problem. So out of nine cases, we restored six CRT's to satisfactory condition, and detected one receiver where the fault wasn't with the CRT (it was HV trouble).

The instrument was especially easy to use. The test steps are made in logical order, the number of settings is minimal, and test results are garnered most efficiently. We especially liked the automatic tracking feature, which didn't require any calibration. The wide choice of rejuvenate/restore operations, running from ultra-safe to risk, was most welcome too.

About the only negative comments we could find to make about the CR31 is that it's not tiny and lightweight, and it costs a lot of bucks. But its size and weight can be handled without trouble and is well worth carrying along because, unlike other instruments, it can generate income that you would otherwise never earn. Even testing a CRT and showing a customer the results on the big meter is an important plus in your favor. Insofar as cost is concerned, you get what you pay for. And the CR31 has it all.

With over 10 percent of all TV problems reported to be due to the big tube, having an accurate CRT tester and restorer is an important asset to a TV service technician. Though it might initially seem as if the technician will lose money by restoring a defective CRT to good operating condition, it can actually make money for the servicer. Most TV men offer to refund part or the whole of a CRT restoration bill when called to eventually replace it with a new CRT. Thus, there's assurance that the business will eventually come to the servicer in the end, not to mention other service calls for the satisfied customer and new ones for neighbors. It's clear then, that if you're going to stay in the TV business, it pays to own a CRT tester and restorer.

One has to be sure to forewarn a customer that there is a risk involved before undertaking CRT restoration. Just as with a medical operation, there's always a chance that something will go wrong. But without undertaking such correction, a new CRT would be needed. Happily, the CR31 offers many "safe" restoration tests, with only one holding the high risk of final ruin. However, the customer has nothing to lose at this point anyway.

Solid State

By Lou Garner

PROPHECIES FOR NEXT YEAR

IF YOU'RE a newcomer to these pages, let me explain that I like to play an annual guessing game with the electronics industry, predicting what new semiconductor products will be introduced during the coming year, price trends, and technical innovations. While, over the years, my record has been pretty good, the game is doubly difficult during periods of recession or inflation, because manufacturers may delay the introduction of new products, waiting for more favorable markets; and what, normally, would be price cuts may become a matter of simply holding to current prices.

Having made my excuses, let's see how well I did with the predictions made in last January's column. As many of you may recall, I predicted:

● *A price breakthrough on solid-state imaging devices,* and the possible introduction of a low-priced solid-state video camera. On target! The construction of such a camera from an inexpensive kit was described in this magazine in the February, 1975 issue ("Build CYCLOPS," by Terry Walker, Harry Garland and Roger Melen).

● *The development of personal health monitors for patients subject to sudden attacks or seizures.* Score a partial. While I envisioned a device about the size of a hearing aid, the LEAA (Law Enforcement Assistance Administration) placed a contract for the development of such a device about mid-1975. The LEAA contract calls for a device about the size of a wrist watch that provides a readout of pulse rate, body temperature and blood pressure. It is intended to inform law enforcement officers of possible physical problems that might interfere with the performance of their duties during periods of stress. Since the instrument is being developed under government contract, it may be some time before comparable commercial instruments are available.

● *Digital electronic watches in the range of $50 to $60.* Another bull's-eye! Not only are a variety of watches available in this price range, but, by watching for sales or going to a discount house, you might be able to pick up a nice digital electronic watch for less than forty dollars.

● *A digital MPG (miles-per-gallon) meter for automotive applications.* Zero on this one! Despite the continuing energy shortage and the ever-increasing cost of gasoline, no manufacturer has introduced such a product as of the present writing. One firm (SpaceKom, Inc., Box 10, Goleta, CA 93017) has been offering an analog solid-state MPG meter for some time. While standard vacuum gauges can be used, under some conditions, to estimate gas mileage, a true digital MPG meter for the average motorist awaits future development "back at the drawing board."

● *A low-cost electronic calculator designed specifically for the children's market.* Right on! Announced mid-1975 and designed to appeal to children as well as adults with a sense of humor, *Mickey Math*™ features a colorful picture of cartoon favorite Mickey Mouse® arrayed in a sorcerer's costume. Furnished with an illustrated instruction booklet written for the younger set, the instrument is a full four-function, algebraic logic calculator with a floating decimal and six-digit readout. The instrument is offered mail-order by the JS & A National Sales Group (4200 Dundee Road, Northbrook, IL 60062).

● *An increasing variety of multipurpose consumer and office electronic products.* Another winner! Space limitations prohibit a listing of all the new products introduced during the year, but among the more interesting were Garrett's "Incredible Time Machine." Designed for desk use, it combines in one instrument a signal alarm, digital calendar with memory (for special days), full-function calculator, digital stopwatch/timer and a digital electronic clock. The "Time Machine" was merchandised by The Gallery (a division of the Amsterdam Co., Amsterdam, NY 12010).

● *The development of low-cost portable electronic games,* based on calculator technology. Reluctantly, a miss. In my opinion, calculator devices could be used in the creation of a variety of both children and adult games which combine skill with chance (or luck, if you prefer). Apparently, the industry doesn't agree because, unless I've missed an announcement, no such games have been offered to the general public.

● *The development of a high-output or high-intensity LED.* On target again! Several semiconductor manufacturers have introduced high-output LEDs. Data Display Products (5428 W. 104th St., Los Angeles, CA 90045), for example, offers a number of LED's with a brightness comparable to that of incandescent lamps (typically, 50 mcd for red, 35 mcd for amber,and 16 mcd for green). Some of the units have built-in resistors and are based so that they can be used as direct replacements for corresponding incandescent pilot bulbs.

● *The development, although not necessarily the commercial production, of solid-state energy control centers for homes and offices.* Score another bullseye! Actually, sophisticated solid-state energy control systems have been available for large scale applications for several years, as mentioned succinctly by reader Charles R. Morford (of Honeywell, Inc.) in last May's *Letters* section. Mr. Morford, in fact, chided me slightly for my prediction. While efficient, however, such systems are expensive and their use is limited, for practical purposes, to large commercial operations. What I had in mind was an effective control center for the average home or small office as a substitute for, say, a conventional bi-metallic electromechanical thermostat. Happily, a major semiconductor manufacturer has developed just such an instrument. Although not yet in commercial production, the unit utilizes a solid-state temperature sensing IC, an SCR, a triac, and several diodes, and *is intended* for use as a direct replacement for conventional thermostatic controls.

Things to Come. Having missed a couple of my predictions for 1975, I suspect that either my crystal ball has a hairline crack or that there is a defective PROF (programmable read only future) IC in the support circuitry. Despite my qualms, here goes for 1976:

● *The introduction of additional special-purpose calculators utilizing nonvolatile memories* (similar to the one used in the Mostek CheckMaster™). Perhaps it might be a calorie counter for weight-watchers, a perpetual inventory unit for stores and manufacturers, or a mileage/trip expense calculator for travelers and business men.

● *Digital electronic watches retailing for less than $25.00*—despite continuing protestations from industry officials that the "electronic watch market will not follow the path of the calculator market." Where there's a market, there's a way, and Timex, among others, has demonstrated that there is a market for inexpensive watches.

● *More so than in previous years, 1976 should be the year of the programmable calculator, with an expansion in the variety of types offered, a general drop in prices, and the possible use of nonvolatile memories to retain programs.* Today's programmable pocket calculators fall into two categories: those with volatile program memories and those which use accessory devices, such as magnetic cards, to store entered programs. I feel there is a need for a programmable calculator with an *integral* nonvolatile memory. I mean one which will retain an entered program until deliberately erased or modified, even if the unit is switched "off," and which *does not* rely on external accessories.

● *The introduction of pocket calculators featuring internal access connectors or jacks.* Considering the overall capabilities of pocket calculators, the addition of I/O (input/output) connectors would greatly increase their versatility. Such jacks would permit their use as counters, for example, or permit data to be recorded on accessory equipment. In addition, an output jack would permit a pocket calculator to be used as a portable control unit for various types of electronic instruments or as an input device for computers and microprocessors.

● *The development of higher density memory chips.* Considerable work is already in progress in this area, with several firms reporting positive results. Utilizing a combination of ion implantation and electron-beam lithography techniques, IBM's Research Division, for example, has already achieved a ten-fold increase in the packing density of LSI memory chips on an experimental basis. The IBM process permits the fabrication of memory chips with a storage density of *five million bits* per square inch.

● *The use of microprocessor IC's in automotive applications, at least on an experimental basis.* With its powerful computational and control capabilities, the microprocessor is a "natural" for monitoring such things as spark intensity, air/fuel ratio, engine speed, oil pressure, oil, coolant, atmospheric and engine temperatures, atmospheric pressure, relative humidity, exhaust characteristics, and engine loading, making automatic adjustments to achieve optimum overall performance. Such units also could serve to monitor critical areas and to alert the driver to possible danger or the impending need for repairs.

● *A substantial drop in the prices of microprocessor and memory IC's.* This will occur despite a continuing inflationary trend. As the costs of microprocessors and memory chips drop, these devices will become increasingly popular for experimenter and hobbyist projects. There should be a corresponding drop in the prices of minicomputers, whether factory-assembled or in kit form.

● *The introduction of a moderately priced thermoelectric module for the experimenter and hobbyist market.* The response to our discussion of TE modules in last February's column was so great that we feel sure that some progressive manufacturer will recognize the market possibilities of a moderately priced device. Chances are the device, when offered, will carry rather broad "specs," as did the early experimenter's transistors.

Readers' Circuits. If reader response is any criteria, LED flasher circuits continue to be very popular with experimenters and hobbyists. Among recent contributions is the dual flasher circuit in Fig. 1. Submitted by Ferdi Baler (1551 A. Day Ave., San Mateo CA 94403), the circuit features a type 74123 TTL dual monostable multivibrator, *IC1*, and is designed for operation on a standard 5-volt dc source.

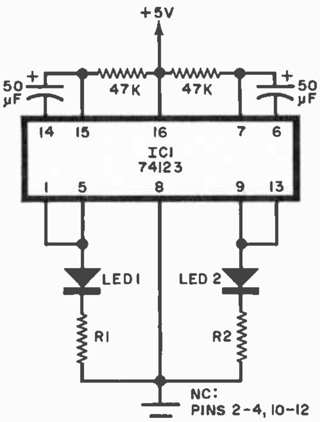


Fig. 1. Dual LED flasher circuit. Several of these can be cascaded for sequential flashing.

The circuit's flashing rate is determined by the two RC time constants, and different capacitor values may be used, if desired, to adjust the rate to meet individual requirements. The resistors are ¼- or ½-watt types, the capacitors 5-to-10 volt electrolytics. Select current-limiting resistors R1 and R2 (generally 100 to 400 ohms) to produce equal brightness in both LED's.

According to Ferdi, his design differs from previously published circuits in that several of the flashers may be cascaded for special effects. Simply open the connection between pins 1 and 5 and, instead, connect pin 5 of the first IC to pin 1 of the next, continuing to the last IC and finally completing the loop by connecting pin 5 of the last IC back to pin 1 of the first. With this arrangement, the various LED's will flash *in sequence*, with on-times proportional to the R-C time constants in each stage. Cascaded multi-stage flashers may be used in direction indicators, advertising displays, and in similar applications.

One of our overseas readers, Yves Soussi (15 parc de Bearn, 92210, St. Cloud, France), contributed the touch-switch circuit in Fig. 2. It is designed to switch a standard ac load, such as a lamp, fan motor, or display actuator, on or off each time a pair of conductive terminals is touched lightly. The circuit is of particular interest because it utilizes an IC in conjunction with a variety of discrete semiconductor devices—a transistor, triac, and diode.

In operation, *IC1*, a dual "D" type flip-flop, provides two functions. Half of the IC serves as a monostable circuit, actuated by impulses received from the touchplate, while the other half acts as a divide-by-two counter. The counter

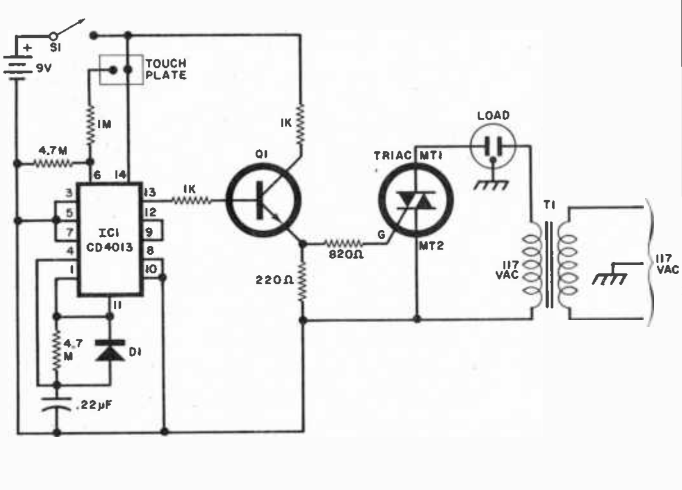


Fig. 2. Touch-switch circuit uses an integrated circuit in conjunction with discrete devices.

circuit furnishes base current to *Q1* which, in turn, supplies a gate signal to the triac, switching ac power through the load. Basic circuit power is furnished by a 9-volt transistor battery, with load power supplied by an ac line.

Yves has specified standard, easily available components in his design. The IC is a COS/MOS type CD40-13 (RCA), *Q1* a 2N2222 general-purpose npn transistor, D1 a 1N647 or 1N914 diode, and the triac an SC 142 (GE). In practice, almost any sensitive gate triac can be used with the control circuit, provided its current rating is adequate for the external load. Actually, *S1* may be omitted, if desired, for the control circuit's current drain is quite low. The touchplate is a hand-assembled unit consisting of a small piece of insulating material, such as perf board, and a pair of small conductors, such as metal thumb tacks, copper strips, machine screws, or nail heads.

The circuit's layout and lead dress should not be overly critical but, of course, good wiring practice should be observed. The standard precautions applying to MOS type devices should be followed when wiring the IC in place to avoid damage. For safety's sake, the isolation transformer must be used between the circuit's ac terminals and the power line.

Device/Product News. If you're working with equipment using nickel-cadmium batteries, you'll find it worthwhile to investigate the ICM7201 low-battery-voltage indicator. Manufactured by Intersil, Inc. (10900 N. Tantau Ave., Cupertino, CA 95014), the device is a monolithic IC comprising four npn transistors and seven internal resistors. Assembled in a 4-lead TO-72 case, the ICM7201 is designed to switch an external LED *on* whenever its source voltage drops below 2.9 volts, the recommended warning level for a rechargeable 3-cell nickel-cadmium battery, thus alerting the user that a recharge is needed.

RCA's Solid State Division (Box 3200, Somerville, NJ 08876) has announced the commercial availability of a new microprocessor family featuring CMOS technology. Included in the family are the CDP1801 CMOS 8-bit microprocessor, a "Microkit" hardware support kit, microprocessor manuals, and software development packages. The CDP1801's low power requirements (60 mW typically at 2 MHz) and broad supply-voltage tolerance (3 to 15 volts dc, unregulated) makes it particularly appropriate for automotive and portable equipment applications. The full-voltage version is available at $56.00 each in unit quantities, while a special 5-volt version, type CDP1801C, is offered at $40 each in small quantities (1 to 99).

If you are considering assembling your own calculator, keep in mind the DS8864 display driver introduced recently by the National Semiconductor Corp. (2900 Semiconductor Drive, Santa Clara, CA 95051). A LED-to-MOS interface device that includes a battery-condition sensing circuit, the DS8864 requires only 900 to 1200 μA drive current, yet contains nine independent digit drivers designed to sink up to 50 mA from a common-cathode LED display operating in a multiplexed mode. The unit's built-in battery-condition sensing circuit turns on the decimal point of the left-most digit when the battery voltage drops below 6.5 volts. The DS8864 is supplied in a 22-pin Epoxy-B DIP. The only other components needed for a complete calculator are a 22-position keyboard, a spst switch, a 9-volt battery, a MM5738 calculator IC, and an NSN-98A 9-digit LED display unit. ◈

Test Equipment Scene

By Leslie Solomon

MAKING GOOD USE OF NOISE

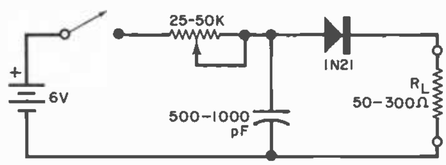
IF YOU ask a typical electronic hobbyist or service technician to list the electronic problems that give him the most difficulty, there is a good chance that circuit noise will be somewhere near the top. Most of us consider noise the bane of our existence. We can determine that it exists in a circuit; but the problem is to find a cause and a remedy.

In discussing noise, the first thing to do is define what we're talking about. There are a number of sources of this troublemaker, among them is *thermal agitation*, a result of the random motion of molecules. This motion occurs in all matter that is at a temperature above absolute zero. Such noise is independent of frequency and is proportional to the absolute (°K) temperature. (Remember those cryogenic devices used in deep space antennas?) The noise is also proportional to the resistive component of the impedance across which the thermal agitation is produced and the bandwidth (the wider you open the window, the more dirt comes in).

A second type of noise is *shot noise*, which is a result of uneven cathode emission in vacuum tubes, or *recombination noise* in many types of semiconductors.

The list of noise sources goes on and on, but the result is always unwanted noise. To keep the noise down, many circuit designers use "low-noise" resistors in the front end of the circuit. (Keep in mind that everything that shows up in the first stage is amplified in later stages—internal noise as well as the desired signal.) A similar design device is to use FET's (which have no real recombination noise) in the front end instead of bipolar transistors.

Using Noise in Testing. There is, actually, a bright side to the noise problem, despite what you might think about the unwanted intruder. Are you aware that noise makes a dandy tool in testing? A circuit that deliberately generates noise is shown below. It generates a controllable (by the potentiometer) amount of noise (the same as the hiss you hear when a receiver is not tuned to a station) just about evenly distributed across the r-f spectrum.



Essentially the circuit is a forward-biased diode whose fluctuating current is generated across a load resistor. The value of the load resistor is the same as the input impedance of the receiver or other device being tested. To use the circuit to determine the noise level of a receiver (for example), start by connecting an audio-frequency voltmeter, which has a decibel scale, to the receiver's audio output terminals.

Connect the noise generator, with the power off, to the receiver antenna terminals making sure that the load resistor you choose is the same as the receiver input impedance. Turn the receiver on with the agc off. Then set the r-f and audio gain controls to obtain a clearly identifiable dB indication on the meter. (Be sure you are not tuned to a station.) This will be the reference noise level. Turn on the noise generator and adjust its potentiometer to get a just-perceptible increase in the hiss level. Note the ratio of the two meter indications.

This approach, though not allowing the measurement of the actual noise level due to the diode being used, will allow you to compare the noise levels of two receivers. It will also allow you to "fine tune" the receiver's front-end circuits. Then, if necessary, you can replace noisy resistors or transistors to get the best noise level (the largest number of dB on the output voltmeter when the noise generator is on) out of the receiver.

Pruning an Antenna. R-f noise can also be used to prune an antenna for maximum efficiency. In this case, a noise bridge is used and the procedure will be of interest to CB'ers who want to get the most out of their limited transmitter power. Many people have worked on their antenna with an SWR bridge to get conditions as good as possible, but they still can't get a 1:1 ratio.

There are several commercial noise bridges available, usually consisting of a wide-band r-f noise generator to drive a bridge. The bridge then compares an unknown impedance (in this case the antenna) against a calibrated potentiometer. The receiver is then used as a tunable null indicator to determine when the antenna is really matched to the desired frequency.

With the noise bridge driving the antenna, all you do is tune the receiver for the deepest null and read the antenna impedance off the calibrated potentiometer dial. Now you can determine whether the antenna is cut for the desired frequency and what the impedance really is. Armed with this information, you can then hack and chop until your antenna is on the button and doing a good job. In this way, whip antennas can be matched to mobile rigs to improve transmission range.

A noise bridge can also be used to check noise levels in audio equipment and see if resistor and/or transistor replacements would improve audio quality. ◈

COMING UP IN THE FEBRUARY Popular Electronics

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Computer Bits

By Jerry Ogdin

INTERRUPTS AND REAL-TIME

HOBBYIST applications of computers fall into two general categories: intellectual pursuits and practical uses. In intellectual pursuits, simplicity is generally the keyword and all the unessential details are stripped away to reveal the underlying simplicity. In practical (real) applications, however, we can't afford that luxury, and it is in these useful areas that the realities of "real time" operation strike home.

In any computer, the instructions are sequentially executed until the specific goal is accomplished, and all this happens without regard to the onward march of time. However, once you are forced to write a program that must finish within some limited amount of time, you are in the "real time" domain. A computer program to read thermostats once every fifteen minutes is not difficult at all. But a program that is required to shut off a valve when water reaches a certain level must be very short, unless you want to risk a flood.

In real-time programming, it is generally not too difficult to write a program that can perform the required work in the allotted time and produce the requisite output signals. What is difficult is sensing the external conditions so that the program can be activated. Ideally, the real-time program can be made to sit in a loop, sampling some input signal until the appropriate event occurs to activate the rest of the program and produce (hopefully) the appropriate response (see Fig. 1). However, this simple scheme limits the computer to handling one and only one chore at a time. The major virtue of a computer is its ability to do many things and do them all fast. It seems a shame, then, to limit the entire computer to continuously executing one sequence of input testing instructions.

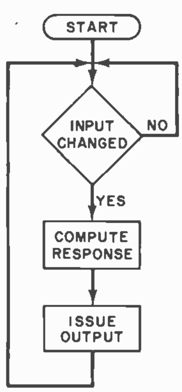


Fig. 1. Real-time looped program.

If you want to install a computer in the basement to monitor and control many of the sub-systems in the house (heating and air conditioning plant, burglar and fire alarm system, night lights, and a small diskette file that holds your family financial records, for example), you will need to "service" a wide range of input signals. Any of these signals can arrive at any random time, and unless you can afford to ignore some of them it is important that you create a hardware and software combination that is foolproof. This can be done with the *interrupt* circuitry of the computer or microprocessor.

An interrupt is a special kind of external signal that notifies the computer to pause in its current task, do something else for a while and then resume the interrupted task. For example, if you are reading a newspaper and the phone rings (you answer, talk, hang-up and resume reading the newspaper), you've been interrupted. Similarly, when the computer is executing a program to compute and generate some output, we should design the hardware and software to be interruptable. Then, when some new external stimulus comes along (via the interrupt hardware), the currently executing program is suspended and the interrupt-servicing software is activated. When the interrupt service subroutine is finished, it will cause the interrupted program to be reactivated.

An elegantly simple interrupt system is used in the popular Intel 8080A microprocessor. As shown in Fig. 2, the external signals are applied to an input called INT (interrupt). When the computer is about to fetch the next

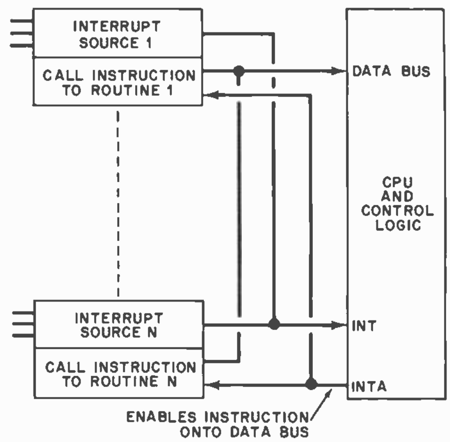


Fig. 2. Diagram shows how the interrupt works in the 8080A.

instruction in sequence, it senses the INT condition and does two things: it issues an interrupt acknowledgement signal (INTA) which allows the external hardware to supply an instruction to the CPU instead of the memory; and it inhibits the incrementing of the internal program location counter. Otherwise, instruction execution proceeds normally.

The interrupting equipment is then responsible for supplying the CPU with an instruction in the 8080's architecture. The interrupting hardware places an eight-bit instruction on the data bus whenever the interrupt acknowledge signal (INTA) appears. This instruction is a subroutine call which causes the current program location counter contents to be pushed onto the stack in memory and is the first step in the process called "preserving the state of the program." After the subroutine call instruction preserves the interrupted program's next-instruction address, it places a specified address into the program counter; that is the address of the interrupt servicing program. At this point, the interrupt servicing program may not modify anything in the computer or memory without tampering with the execution of the interrupted program.

When any program is in execution, part of the status of that program is in the CPU's registers. The contents of the program location counter and the accumulator and the flag bits are all important. If any of these is changed from outside the program, then the program's correct execution is nearly always prevented. The interrupt servicing program must preserve this part of the interrupted program's status, and in most computers there are instructions that allow the state to be preserved by copying the CPU registers into memory (Fig. 3). It is this particular operation that the 8008 is unable to perform without some extra outside hardware. The 8080, however, has a set of instructions for preserving the state of the computer; for example, the PUSH instructions save the relevant information in the stack. The 6800 microprocessor automatically preserves the entire state of the CPU on the stack whenever an interrupt is sensed.

memory. The execution of a subroutine return instruction will cause the interrupted program's program location counter to be restored. The interrupted program then continues as if nothing had happened.

There is a potential problem that arises at the interface between the real-time interrupt servicing program and the non-real-time "background" software. There is a part of each routine, called the "critical section" where confusion may reign unless some care is taken. Imagine the worst possible case: the interruptable program is interrupted just at the instant that it is about to examine the interrupt counter. In most computers, the counter must be fetched up from memory into a CPU register to be examined and decremented and then re-

```
;  INTERRUPT SERVICE ROUTINE
;  (INTERRUPT #7)
           ORG     56
;  COMES HERE TO SERVICE INTERRUPT AUTOMATICALLY
           PUSH    PSW        ;  PRESERVE STATE
           PUSH    B          ;  OF INTERRUPTED
           PUSH    D          ;  PROGRAM
           PUSH    H
;  INTERRUPT SERVICE ACTIONS HERE
           LXI     H,COUNT
           INR     M
           POP     H          ;  RESTORE STATE
           POP     D
           POP     B
           POP     PSW
           EI                 ;  RE-ENABLE INTERRUPTS
           RET                ;  GO BACK
```

Fig. 3. Routine to allow state to be preserved by copying the CPU registers into the memory.

After the interrupted program's state has been preserved, the interrupt servicing program performs its work. Generally, the minimum amount of work is accomplished. The longer the interrupt servicing program takes, the more likelihood there is that some other interrupt will be lost. The absolute minimum is to record the fact of the interrupt somewhere in memory. Each time the interrupt occurs, a specific location in memory is incremented by one; and, whenever the interruptable softwear gets time, the counter is examined and the appropriate actions are taken. The interruptable software then decrements the counter by one to account for the action taken.

After the interrupt servicing routine is finished, the entire state of the computer is restored to the conditions that existed *prior* to the interrupt. The registers of the CPU are restored from

stored to memory. This sequence must not be interrupted. If it can be interrupted, you may not get the expected results. The best way to avoid this problem is to prevent the interrupts from being serviced while the interrupt counter is being examined or modified (Fig. 4). There are instructions in all computers that can be used to disable and then re-enable interrupts.

The interrupt then, is basically a hardware trick to allow us the illusion of having two or more different cooperating computers sharing a common memory. It is important not to let the interrupt service routines do too much as they may be difficult to debug if they are complex, and the effects of the bugs may be obscure and seemingly unrelated. If the interrupt service routines are simple, they will be easy to "prove" correct without

```
           (Interruptable)                      (Interrupt Service)
                 .
                 .
                 .
           (assume counter = 5)
           accumulator ← counter;
                                                preserve state of computer;
Interrupt strikes here                          counter ← counter + 1 ;
                                                restore state ;
           accumulator ← accumulator - 1 ;
           counter ← accumulator ;
           (counter = 5!)
                 .
                 .
                 .
```

Fig. 4. Instructions can be used to disable and then re-enable interrupts.

much ado. Interrupts, like any other riches, can be overindulged; so resist the impulse.

We Get Letters. Since we introduced the HIT (Hobbyist Interchange Tape) system in our September 1975 column, we have received a considerable amount of mail concerning it. There are a number of such cassette systems, each manufacturer using his own scheme. At a November meeting in Kansas City, Mo., an effort was made to establish a standard format. Looks like a 1200/2400-Hz system will be adopted. We'll keep you posted on the future developments.

The HIT format was not suggested as a computer industry standard, but as a simple, low-cost, easy-to-implement system for hobbyists so that they could exchange data and programs. In fact, one supplier of OEM kits (Cramer Electronics) has its software recorded in the HIT format, and a HIT interface is included in their kits.

News Items. AMD announced an OEM price reduction on its 8080A (to below $30), and Intel followed suit. Then, Texas Instruments announced its 16-bit 9900. Not due until March, the 9900 operates at about the same speed as the 8080, but will probably cost about $50. When price reductions start on the OEM level, they eventually sift down to the hobbyists.

Hobbyist Clubs. Information on computer hobbyist clubs continues to come in. In addition to the ones listed below (to which we will add from time to time), check out your local high schools and universities. Many of them have clubs which were formed by students, with outsiders generally welcome to join.

California

Homebrew Computer Club, 193 Thompson Sq., Mountain View, CA 94043.

Sacramento Minicomputer Users, Box 741, Citrus Heights, CA 95610.

San Diego Computing Society, c/o Gary Mitchell, Box 35, Chula Vista, CA 92012.

Southern California Computer Society, Box 987, S. Pasadena, CA 91030.

UCLA Computer Club, 3514 Boelter Hall, UCLA, Los Angeles, CA 90024.

29 Palms Area, Sgt. Wesley B. Isrigg, Box 3558, C&E Schools M.C.B., 29 Palms, CA 92278; or Sgt. Stanley E. Herr, 13-C Copper Dr. M.C.B., 29 Palms, CA 92278.

Colorado

The Digital Group, Box 6528, Denver, CO 80209

Illinois

Chicago Users Group, c/o Robert Swartz, 195 Ivy Lane, Highland Park, IL 60035.

Massachusetts

Boston Area, c/o John Vullo, 21 Sunset Ave., N. Reading, MA 01864.

Minnesota

Bit Users Assoc., Resource Access Center, c/o Richard B. Koplow 3010 4th Ave. So., Minneapolis, MN 55408.

Southeast Minn. Amateur Computer Club, 2122 NW 17 Ave., Rochester, MN 55901.

New Jersey

Amateur Computer Society of N.J., 72 S. Railroad Ave., Staten Island, NY 10305.

Ohio

"Universe Unlimited" Users Group, c/o John E. Kabat, 11918 Forrest Ave., Cleveland, OH 44120.

Oklahoma

Oklahoma City Club, 2412 SW 45th, Oklahoma City, OK 73119.

Pennsylvania

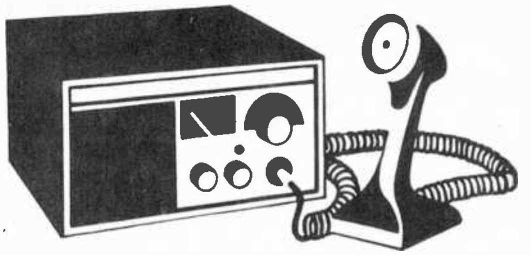
Pittsburgh Area Computer Club, c/o Fred Kitman, 400 Smithfield St., Pittsburgh, PA 15222

Texas

Texas Computer Club, c/o L. Walker, Rt. 1, Box 272, Aledo, TX 76008.

Canada

Canadian Computer Club, c/o G. Pearen, 861 11th St., Brandon, Manitoba, Canada R7A 4L1. ◈



CB Scene

BY SHERMAN P. WANTZ

HOW TO USE CB RADIO "BUZZ" WORDS..

INTERSTATE truckers, abetted by a growing number of mobile and base station operators, meet each day, on Citizens Band (CB) channel ten. They use a colorful—often cryptic—language to communicate with one another.

The glossary below has been developed to help CB newcomers interpret the special terms used most frequently on the interstate highway channel and elsewhere in the CB Class D frequency spectrum. Save this list and add new terms and meanings to it as they develop among the truckers.

Using CB jargon correctly is interpreted by some as a mark of sophistication. Anytime you cannot remember the "proper" term to use, however, plain old everyday English will do. Even on channel ten.

TERM	MEANING	TYPICAL USE
Back	Over	Back to you.
Back door	Rear of vehicle	I'm watching your back door (protecting you from being overtaken unawares by police).
Back down	Drive slower	Smokey's ahead. Better back it down.
Back out	Stop transmitting	I'm going to back out of here.
Barefoot	CB set output signal not additionally amplified.	I'm running this rig barefoot.
Base station	CB set operated from a fixed location	I'm operating here from my base station.
Beam	Type of directional antenna	I've got my beam on you now.
Big switch	Turn off CB set	I'm going to pull the big switch.
Big 10-4	Acknowledged with enthusiasm	That's a big 10-4.
Bleeding	Interference from a nearby CB channel	A local (station) is bleeding all over you.
Break	I'd like to interrupt	Break, break.
Breaker	One who interrupts	Go ahead, breaker.
Catch	Talk to	We'll catch you later.
Chicken coop	Weigh station for trucks	The chicken coop is closed.
Clear	Out, final transmission	We're clear

TERM	MEANING	TYPICAL USE
Come again	Repeat your last transmission	Come again?
Comeback	Return call	Thanks for the comeback.
Come on	Over, invitation to transmit	What's your twenty? Come on.
County mounty	Sheriff's deputy	Two county mounties are parked under the bridge.
Covered up	Interferred with	You were covered up that time
Cut the coax	Turn off CB set	I'm going to cut the old coax now.
Bodacious	Shamelessly strong	You've got a real bodaacious signal up here.
Ears	CB set	Got your ears on?
Eighteen wheeler	Truck and trailer	How about that northbound eighteen wheeler?
Eights (eighty-eights	Goodbye (from amateur radio 88's meaning "love and kisses.")	Threes and eights to you.
Eyeball	Face-to-face meeting	Can we get together for an eyeball?
Feed bears	Pay a fine for speeding to highway patrol	I can't afford to feed any bears.
Final	Last transmission	I'll turn it over to you for your final.
Flip flop	Trucker's return trip	We'll catch you on the flip flop.
Four wheeler	Automobile	You've got a southbound four wheeler.

TERM	MEANING	TYPICAL USE
Getting out	Being heard	Just wanted to see if I was getting out.
Good buddy	Salutation used by truckers	What's the smokey situation, good buddy?
Gone	Final transmission, or going to switch to another channel?	We're gone.
Green stamps	Money paid in fines for for traffic violations	I'll back her down. I don't have any more green stamps.
Hammer	Truck's accelerator	There aren't any smokies ahead so let the old hammer down.
Handle	Operator's assumed name	The handle here is "Bikini Watcher."
High gear	Use of transmitter power amplifier	See if my signal changes when I shift into high gear.
Holler	Call	I gave you a holler, but you didn't come back.
Home twenty	At home	I'm at my home twenty right now.
How about?	Calling	How about that "Bikini Watcher" one time?
Landline	Telephone call	I'll give him a landline and pass the info.
Lay an eye on	See	Can you lay an eye on me yet?
Linear	Extra power amplifier used to increase CB transmitter output	Are you using a linear or are you running barefoot?
Local yokel	City police officer	There's a local yokel northbound on the move.
Mail	Overheard conversation	I've been sitting here reading the mail
Mercy.	Aah. Pause. Speech habit have no particular meaning	Mercy, that's a big ten-four.
Mile markers	Small signs along interstate highways	The smokey is located at the 142 mile marker.
Mobile	CB set mounted in a vehicle	I'm talking from my mobile.
Modulate	To talk with	I think I modulated with you last week.
Move	In motion	That smokey is on the move.
Negative	No	That's a negative.
Negative contact	station being called failed to respond	Negative contact. I'm gone.
Negative copy	Did not hear response by the station called	Negative copy. We're by.
Negatory	No, negative	Ne-ga-tory (said slowly for added emphasis).
One time	For a short contact	Calling that "Bikini Watcher" one time.
On the side	Standing by (listening) on the channel	We'll be on the side.

TERM	MEANING	TYPICAL USE
Over shoulder	Behind	If you're at the truck stop I'm over your shoulder.
Peanut butter in ears	Not listening to CB set	Guess he's got peanut butter in his ears.
Putting on	Strength of signal	What kind of a signal am I putting on you?
Radio check	Reception	Give me a radio check, please.
Read	Hear	I read you loud and clear.
Rig	CB set	What kind of a rig are you using?
Roger	I acknowledge	Roger on that.
Scatterstick	Vertical antenna with ground plane	I'm using a scatterstick at the moment.
Seventy-three	Best regards (amateur radio term	Seventy-threes and hope to catch you later.
Shout	Call	Thanks for the shout.
Ski, short skip	Atmospheric conditions that permit contacts greater than line-of-sight distances.	Sorry. Those short skip stations have you covered up.
Smokey-the-Bear, smokies	Highway patrol troopers	A smokey is on the move, heading east.
SWR	Standing wave ratio	This antenna gives me a two-to-one SWR.
Taking pictures	Radar operated speed indicator	The smokies are taking pictures.
Ten-four?	Do you understand?	Is that a ten-four?
Ten roger	I acknowledge	That's a ten roger.
Tijuana taxi	Police car	I've got a Tijuana taxi in sight.
Thermos bottle	Tanker truck	I'm pushing the white thermos bottle.
Threes	Seventy-three, best regards	Threes to you.
Throwing	Transmitting	What kind of a signal am I throwing at you?
Trip	Strong signal	You're making a fine trip down here.
Twenty	Ten-twenty, location	What's your twenty?
Walked all over	Overpower by a stronger signal	Come again. Somebody just walked all over you.
Wallpaper	Postcard acknowledging a two way contact	Give me your twenty and I'll send you some wallpaper
Wall-to-wall	Loud and clear	I'm hearing you wall-to-wall.
Wrapper	Paint job on car	That northbound smokey is in a plain white wrapper.
XYL	Ex-young lady, wife	How's your XYL?
YL	Young lady	I met your YL at the last eyeball.

Art's TV Shop

By Art Margolis

THE BEWILDERING BRIGHTNESS

JONATHAN, my next door neighbor, was waiting in my driveway as I pulled up in the service van after a busy day at the shop. I honked to my wife to start dinner. Lea looked out the window, saw Jonathan and nodded knowingly. I was going to have to help him out again before I ate.

Jonathan blurted as I stepped out of the truck, "Art, I want to show you something. It will only take a minute." I smiled, but my stomach was growling.

I followed him into his basement where he had set up his workbench. On the table was a new modular Zenith TV with the back off. Its shipping carton lay nearby. Jonathan is an accountant, but he enrolled in a home-study TV service course as a leisure pursuit. He was supplementing the course with my advice, usually before dinner.

He said, excitedly, "The TV came from the school today. It's a honey!" I looked it over. It was the 19FC45 chassis. I had installed and worked on quite a few of them recently.

His voice saddened, "I began the checkout and I must be doing something wrong—it doesn't do what the book says it should."

"Let's take a fast look," I said, trying to console him. I plugged in the cheater cord. The sound came on, and the high-voltage circuits crackled to life. The raster's brightness gradually increased. I noticed there was a slight bloom to the picture so I adjusted the brightness control. There was definite expansion at higher levels of brightness. At low levels, the raster lost its blooming quality and filled the screen properly. "Is that the trouble?" I asked. "The picture is blooming somewhat. It's supposed to stay the same size at all brightness levels.

He pulled out the instruction manual and examined it. "Yeah, you're right. That's the trouble. It's blooming, but that's not what I meant."

I looked at him quizzically. He went on, "I was doing Experiment 9. When I got to the BRIGHTNESS LIMITER adjustment, my results didn't agree with the manual."

"Run through it again," I said.

He nodded and began the numbered sequence. First he pulled the cheater out. Then he disconnected the i-f cable from the i-f strip, and attached his voltmeter across a 3-watt resistor near the flyback. He plugged in the cheater again and the receiver came alive. "Watch this," he said turning the BRIGHTNESS LIMITER control. The meter needle held still. "The voltage is supposed to vary," he moaned, "and be set at 1.7 volts."

My stomach was snarling for food, but I couldn't resist the puzzle. I took the instruction manual and opened to the foldout schematic (Fig. 1).

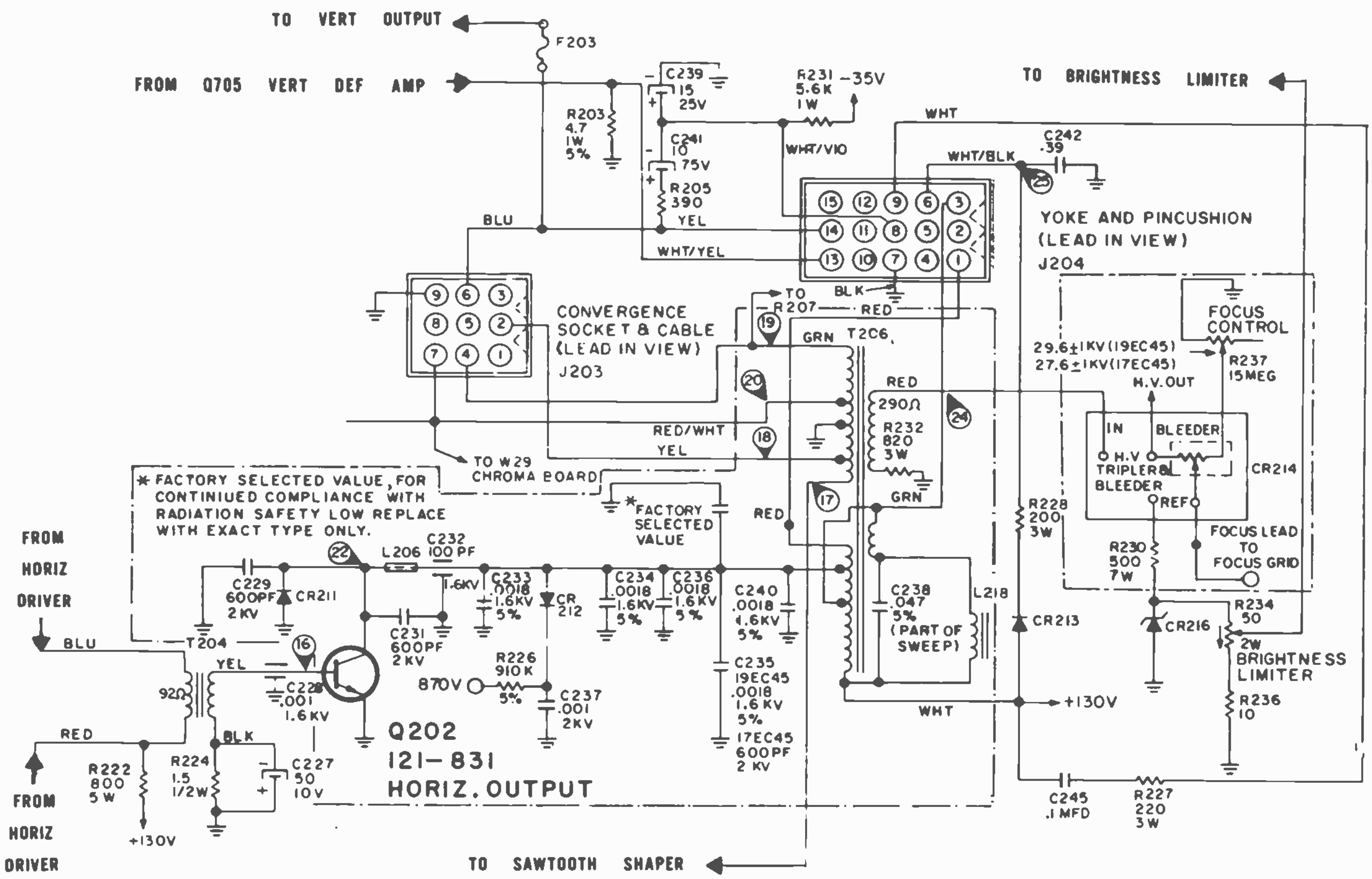


Fig. 1. Brightness limiter controls.

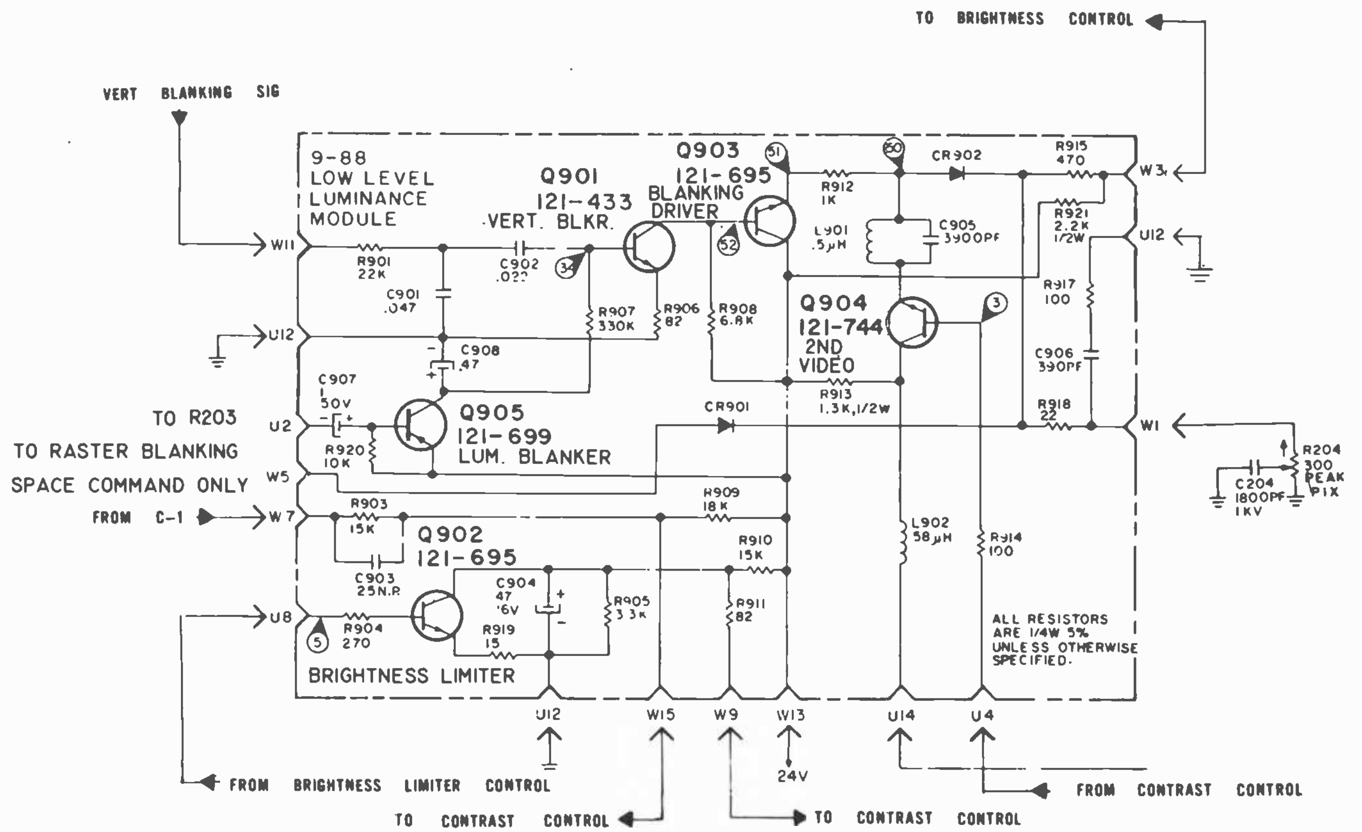


Fig. 2. Schematic of luminance module.

The 3-watt, 820-ohm resistor, *R232*, was connected from the bottom of the tertiary flyback winding to ground. The desired voltage drop (1.7 V) occurs when the proper amount of current passes through the flyback winding. This monitors the amount of beam current. Too much current would cause the high voltage to drop, producing the "blooming" effect.

The BRIGHTNESS LIMITER control is connected to the voltage tripler with a zener diode through a 500-ohm, 7-watt resistor (*R230*). This trio picks off a positive pulse and transmits it through a 270-ohm resistor on the LUMINANCE MODULE (Fig. 2) to the base of the brightness limiter transistor.

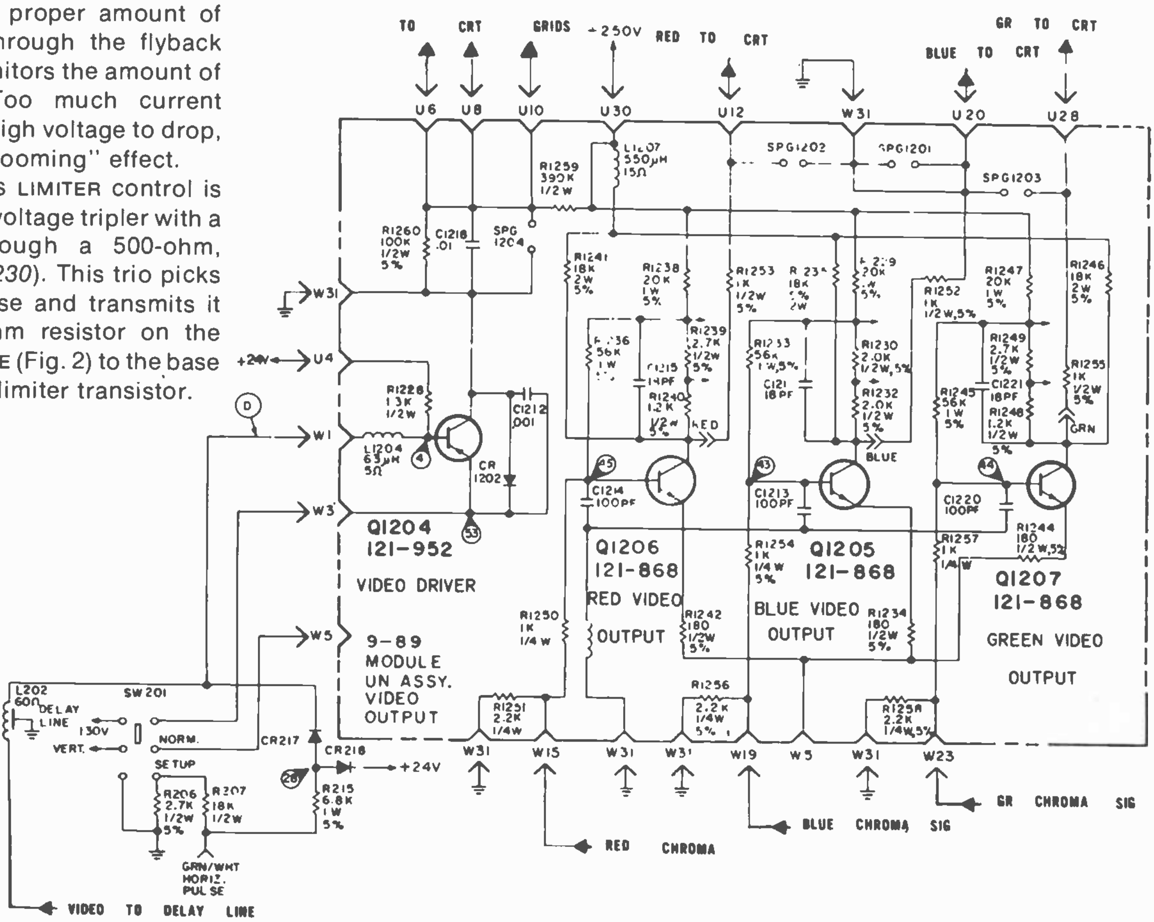


Fig. 3. Video output module.

This transistor amplifies and inverts the pulse which is then fed to *C904*, a 47-μF filter capacitor. The latter changes the pulse to a smooth dc voltage, which is fed through the CONTRAST control to the base of *Q904*, the second video amplifier.

The luminance output of *Q904* is coupled to the base of *Q1204*, the video driver (Fig. 3) through the DELAY LINE (*L202*). This transistor drives the emitters of the three chroma outputs (*Q1205, Q1206, Q1207*).

When the outputs of the three chroma stages are low, the CRT cathode voltage goes positive and cuts off the electron beams. If the color outputs are high, the beams flow toward the control grids. In this way, the level of conduction of transistor *Q902* produces the brightness limiting.

I said to Jonathan, "Bring in my module caddy." He disappeared, and while he was gone, I turned on his scope and connected the probe to the base of *Q902*. The positive pulse from the BRIGHTNESS LIMITER control should have appeared, but there was nothing there. Jonathan returned.

I opened the caddy. As luck would have it, I didn't have the luminance module. Instead, I pulled out my bundle of jumper leads. I've found that working on these modular TV's demands a lot of them!

Removing the luminance module from its prongs, I attached a jumper from each connector on the module to the module's chassis-mounted connector pins. Then I made sure I connected the jumpers to the correct points.

Since I had no pulse on the *Q902* input, I disconnected the jumper from the *U8* connector pin. Then I turned on the receiver, and touched the probe to the BRIGHTNESS LIMITER control wiper. The pulse was there! The scope indicated that its amplitude was about 2 V (p-p) as it should be.

That meant the flyback circuit was good. As a double check, I reconnected the jumper. The pulse was gone again! Something in the luminance module was killing the pulse.

I explained to Jonathan what I had discovered, who was quickly jotting down notes. He had been watching the technique with the jumper cables carefully, and now knew that trick of the trade.

He examined the schematic carefully. I recognized something of my way of doing things as he intoned, "The prime suspects are thus *Q902, R904, C904, R919* and *R905*, in that order. Right?"

"Right," I answered. "I have to eat now, so check them out yourself." As I left with my module caddy, he had his nose buried in the circuit.

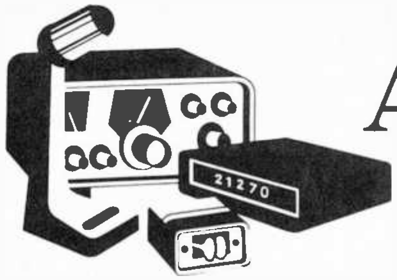
Dinner was going great when Jonathan burst in the back door. I quickly put a hunk of steak in my mouth thinking that I would have to run back to his basement—the week before he had fried a power transformer!

He held a little transistor in his palm. "Recognize *Q902*? It was shorted, base to collector. The control's working perfectly now. No more blooming!"

I nodded and cut another piece of steak. He looked annoyed, "Come on back and I'll show you."

Meanwhile Lea brought out a tax form she was having trouble with. "Jonathan," she started.

He held up his hand, "I'm sorry Lea, but it will have to wait till later tonight, after I eat." ◈



Amateur Radio

By Herbert S. Brier

SLOW-SCAN TELEVISION

THE DREAM of long-distance amateur video communication was made practical by Copthorne MacDonald's article "A New Narrow Image Transmission System" in *QST* (August and September 1958). "Cop" developed a system of transmitting TV signals requiring the same bandwidth as an ordinary SSB voice signal, opening up the possibility of DX TV work on the hf amateur bands. As a result, you can now tune around the bands and hear a number of raspy "slow-scan" (SSTV) signals, especially around 3.84, 7.22, and 14.23 MHz.

Slow Scan Vs Fast Scan. Predictably, the fundamental difference between conventional fast-scan and slow-scan TV lies in the rates at which their pictures are "taken" and "developed." A fast-scan camera splits the incident image into 525 narrow horizontal lines, scans them all in 1/30th of a second, and repeats the entire procedure 30 times a second. The position of the scan point is controlled by the horizontal and vertical sweep circuits within the camera. The varying amount of light reflected from the televised object causes the photosensor in the camera tube to generate a proportional voltage signal.

This signal modulates (usually AM) the carrier, and is recovered by the video detector in the TV receiver. It is then used to control the intensity of the electron beam striking the phosphors on the picture tube's face. At the same time, the position of the beam is controlled by the sweep circuits in the receiver, which are locked in step with those in the camera by sync pulses.

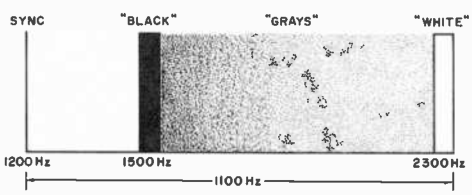


Fig. 1. Frequencies of audio tones determine shading on SSTV picture.

Although the beam does not stay at any one part of the picture screen for more than a small fraction of a millisecond, the compound's lasting phosphorescence or "persistence," together with the response of the human eye, enables us to see an "even" picture.

Slow-scan cameras and picture tubes act in much the same way, but at a much more relaxed pace. In this scheme, an image is scanned from top to bottom in eight seconds! Also, it is broken down into only 120 lines, and the repetition rate is seven frames per minute.

As the bandwidth of an information channel is directly proportional to how many bits are handled in one time unit, SSTV signals take up a tiny slice of the spectrum when compared to fast-scan channels (6 MHz each). In fact, the "bit rate" (the rate at which units of information are sent) is so slow that it's practically impossible to send it by conventional AM. "Cop" elegantly solved the problem by frequency modulating an audio subcarrier, which in turn "amplitude modulates" the transmitter. As shown in Fig. 1, the standard subcarrier frequency is 1200 Hz. Black is at 1500 Hz, and 2300 Hz represents white. Sync pulses appear between 1200 and 1500 Hz (blacker than black), thus they do not appear in the received picture. Only 1100 Hz of bandwidth is required!

Due to their short "persistence," fast-scan cameras and picture tubes can not be used in SSTV work. The illuminated portions at the left of one line would fade before those on the right were "developed." Consequently, a longer lasting "glow" is needed, which is accomplished by a CRT with a P7 phosphor. When P7 is struck by an electron beam, it glows brightly. But as the beam moves on, the original glow disappears and is replaced by a fainter afterglow that persists for many seconds. A discernible image will remain on the tube for about two minutes.

Equipment Requirements. To get started in SSTV, you'll first need a receiver capable of receiving SSB signals (usually no problem) and an SSTV monitor. This can be a commercial, ready-to-operate unit (there are several on the market), or a home-brewed unit. If you replace the P1- or P4-phosphor CRT in an oscilloscope, you'll have the nucleus of a monitor. A converter that processes the audio output of the receiver into a form usable with the scope can be fairly easily built.

Something new on the slow-scan scene are scan converters, which use A/D and D/A converters, digital memories and shift registers to generate a picture compatible with a standard home TV receiver. They are generally available with raw video and/or modulated (Ch. 2 or 3) r-f outputs. They also allow the use of fast-scan surplus closed-circuit cameras in your SSTV pursuits. Although the units are fairly expensive, they will be attractive to many newcomers to SSTV because the cost of a special slow-scan monitor is eliminated. Coupled with home TV receivers, these converters can produce higher-quality images than those on conventional slow-scan monitors. Further, they usually have "freeze" modes which will store and/or display a received picture as long as power is applied.

To transmit slow-scan images, you will need a video sensor, a modem, and an SSB transmitter. The sensor may either be a vidicon coupled with an electromechanical shutter device, or a flying spot scanner (the less expensive approach). The modem converts the video and sync information into audio tones which modulate the transmitter. If you're lucky enough to have a scan converter, a standard Vidicon or CCD camera can be used. For more information, consult the sources listed in the box.

What's happening on SSTV? Hundreds of U.S. and Canadian operators are working each other and the world regularly near 14.23 MHz. Don, W9NTP, recently returned from a long trip on which he carried SSTV gear. He worked many U.S. amateurs from Easter Island and other exotic points. Barry Goldwater, K7UGA, on his trip to Southeast Asia, plugged SSTV

SSTV INFORMATION SOURCES:

"Slow-Scan Television Handbook," by Don Miller, W9NTP, and Ralph Taggart, W8DQT. $3.00, 73 Inc., Peterborough, NH 03458.

"Specialized Communications Techniques for the Radio Amateur," $3.00, ARRL, 225 Main St., Newington, CT 06111

Robot Research, Inc., 7591 Convoy Ct., San Diego, CA 92111.

Summer Electronics & Engineering Co., Box 572, Hendersonville, TN 37075.

Venus Scientific, Inc., 399 Smith St., Farmingdale, NY 11735

equipment into existing SSB rigs and was quite active for a while.

License Requirements. One potential roadblock to getting started in SSTV below 28.5 MHz is the necessity of having an Advanced or Extra Class license. This is one *more* reason to upgrade! Generals can use SSTV above 28.5 MHz, and Tech's can engage in this type of work on their phone frequencies above 50 MHz. There is quite a contingent of SSTV'ers on 114 and 220 MHz in the Los Angeles area.

Incidently, because SSTV modulating signals are actually audio tones, pictures can be recorded on an ordinary tape or cassette recorder.

Novice Roundup. The 1976 ARRL "Novice Roundup" will occur between 0100 GMT, January 31, and 2359 GMT, February 8. Operating a maximum of 30 hours during this period, Novices work everyone, and other amateurs work only Novices. U.S. and Canadian stations exchange RST and their ARRL sections. Others substitute country for section. A complete two-way exchange earns one point. Total score equals the number of contact points (after duplicates are deleted!) plus the highest speed shown on the contestant's ARRL Code-Proficiency certificate multiplied by the number of sections and other countries worked. Complete rules and score sheets are available from ARRL, 225 Main St., Newington, CT 05111, on request accompanied by a stamped, self-addressed envelope.

Amateur License Courses. The Indianapolis American Red Cross Amateur Radio Club, 10th and Central Aves., Indianapolis, IN, will sponsor a General Class license course starting January 12, 1976. The course will be held every Monday between 7:30 and 10:00 p.m. Everyone 16 years or older or who holds a Novice license is eligible for the course. Instructor is John Jacobs, Jr., WB9KSZ, assisted by Robert Foot, K9KGJ. The LREC Amateur Radio Club, 2814 Empire Ave., Burbank, CA 91504, also starts its new General Class course, January 12, after the conclusion of its last Novice session. Bill Welsh, W6DDB, is the instructor. ◈

Hobby Scene Q&A

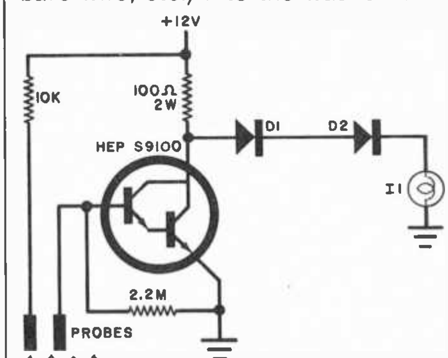
By John McVeigh

WINDSHIELD-WASHER ALARM

Q. ***Is there a circuit which will let me know when the windshield washer fluid in my car is running low?***

—R. Claudet, Tannersville, NY

A. This circuit will do the job. Insert the two metal probes (pin plugs, stiff bare wire, etc.) into the washer fluid



reservoir, leaving tips about 1 inch (2.5 cm) above the bottom. Install indicator *I1* (which can be a 53 pilot bulb, a Sonalert or a buzzer) at a convenient viewing angle. When the fluid level drops below the probe tips, the lamp will light. Diodes *D1* and *D2* can be common 1-A power supply rectifiers. The alarm will work with water and most detergent solutions.

DOUBLE-SIDED PC BOARD BLANKS

Q. ***I have been unable to find a source for double-sided pc board blanks. Any ideas?***

—David Greenwood, Allison Park, PA

A. There are a number of sources which cater to the hobbyist. Two that we know of offhand are:

Techniques, Inc.
235 Jackson St.
Englewood, NJ 07631

GC Electronics (Calectro)
400 S. Wyman St.
Rockford, IL 61101
(or through local Calectro dealers).

This is by no means an exhaustive list. Check with electronics stores in your area, and scan the ads in Electronics Market Place each month in this magazine.

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Electronics Library

BASICS OF ELECTRICITY AND ELECTRONICS

by Matthew Mandl

This revised work (formerly *Fundamentals of Electric and Electronic Circuits*) provides updated coverage of electronic theory, related equations, symbols, abbreviations, and associated data. Chapters are devoted to atoms and electrons; basic electrical units; series and parallel circuits; principles of magnetism; dc and ac measurements; RLC (simple and complex) circuits; resonance; transformers and coupling; polyphase ac and pulse-shaping circuits; and an introduction to tube and solid-state electronics. Many illustrations, examples, and problems are included.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. 388 pages. $15.95 hard cover.

TELEVISION TROUBLESHOOTING

by Clyde N. Herrick

State-of-the-art television servicing is presented here for those with a basic knowledge of radio theory and basic servicing procedures. General principles of circuit function (and malfunction) are stressed throughout. In the area of chassis analysis, component identification, and circuit tracing, the illustrations supplementing the text facilitate an understanding of the subject matter. Specifics of circuit behavior, with examples from commercial products, illustrate the practical troubleshooting methods required. Test and measurement techniques are explained and illustrated for each subdivision of troubleshooting methodology.

Published by Reston Publishing Co., Box 547, Reston, VA 22090. 230 pages. $14.95 hard cover.

NORTH AMERICAN RADIO-TV STATION GUIDE (TENTH EDITION)

by Vane Jones

Nearly 10,000 stations (all the active radio and TV broadcasters in the US, Canada, Mexico, and the West Indies, according to the publisher) are listed in this volume. Stations are listed in three ways—by geographical location, frequency (or channel), and call letters. Important statistics, such as power (day and night for AM stations), antenna heights (for FM stations) and time-sharing with other stations are given. Network affiliations are noted, as well as educational and FM stereo stations.

Published by Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, Ind. 46206. 192 pages. $4.95 soft cover.

Operation Assist

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

Wurlitzer Model 1015 Juke Box, Serial 2344, made in Canada in 1930. Schematic diagram and/or operating manual. Bob Found, 12-12 9115-92 Avenue, Fort Saskatchewan, Alberta, Canada T8L 1A6.

E.H. Scott Model SLR-F 5-band receiver covering 80-550 kHz and 1.9-24.0 MHz. Serial 2238. Schematic and/or service annual. Raymond Scott, 422 Grafton Ave., San Francisco, CA 94112.

Operadio Model NB1325 Battle Announcing Equipment (1945). Schematics or any other information. Bob Macias, 4401 NE 15th Way, Ft. Lauderdale, FL 33334.

Wurlitzer Model 140B Electric Piano. Schematic. Richard Brush, 1965 E. 3375 St., Salt Lake City, UT 84106.

Stromberg-Carlson Model 1121, Series 12 receiver. Schematic and speaker coil impedances, and any other information. Edward Heimbach, RD 5, Box 169, Stroudsburg, PA 18360.

De Vry Tech. Inst. Scope/VTVM in same cabinet, model no. unknown. Need schematic, parts list, and power transformer. Alan Getz, 148 Camden Ave., S. Plainfield, NJ 07080.

De Vry Projector Model 439. Manual and parts. Fabian Bourge, Box 626, Vinton, LA 70668.

Lafayette Model HA-230 four-band receiver. Schematic and alignment information. Jim Wilkins, 6215 Lone Oak Dr., Bethesda, MD 20034.

Superior Instruments Model 450 Tube Tester. Schematic. S.W. Hawkinson, 6106 Lillywood Ln., Knoxville, TN 37921.

Weston Tubechecker Model 798 Type 5B. Schematic. Tracy LaVere, 13902 La Pat #16, Westminister, CA 92683.

Hammarlund HQ 145A receiver. Schematic. John Nelms, 521 Parkview, Richardson, TX 75080.

General Electric Model W300B portable intercom. Schematic. Gary Jackson, 1514 So. Ferdinand, Seattle, WA 98108.

Ameco Model SNLT noise limiter and squelch unit. Schematic. Charles Cerami, 66 Olympic Terrace, Irvington, NJ 07111.

Zenith Model 5808 cabinet "Long Distance Radio" Serial No. S576805. **RCA** Model K 80 cabinet radio. Schematics and any helpful information. Dave Faverty, 177 Haven Road, Elmhurst, IL 60126.

Sun Model SS-1 Auto Timing Unit. Service manual. Don Brown, 216 West Vally Parkway, Escondido, CA 92025.

Precise Development Corp. Model 300 Oscilloscope. Schematic, operations, and calibration data. Bert Goodrich, 886 Juniper Ave., Sherwood Park, Alberta, Canada T8A 2C7.

Chicago Tube and Set Tester Model 532 by Chicago Industrial Instruments Co. Instruction manual. Terrie Frane, Box 111, Owen, WI 54460.

Friden Flexowriter Model F10. Schematic and/or remote control jack connections. J. Marcomm, Box 82, Brice, OH 43109.

National Model NC 77X general coverage receiver with chassis marks 64 4838 and 64 0946. Schematic and/or service information. Richard H. James, Box 5289 T.E., Bradenton, FL 33507.

Montgomery Ward Airline receiver, TRF circuit, tubes: 3 No. 24A 1 No. 27A, 2 No. 45, 1 No. 80. Need schematic and model no. Charles D. Prater, Edna, KY 41419.

Collins Model 17L-8A aircraft transmitter, serial no. 2344. Maintenance and operations manual. David Moody, 4305 South St., Terre Haute, IN 47802.

Aiwa tape recorder Model TP-730. Need motor or source for same. John Holevac, 301 W. Lead St., Bessemer, MI 49911.

Experimenter's Corner

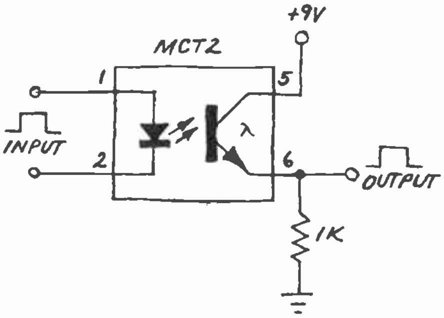
By Forrest M. Mims

USING AN OPTOISOLATOR

OPTOISOLATORS are ideal for solving many noise and high-voltage isolation problems in electronic circuits. Until fairly recently, their prices have been rather high for experimenter use. But now some real bargains are available from a number of electronic parts dealers, such as those who advertise in the back of this magazine.

An optoisolator is a relatively simple device, consisting of a light source and a light sensor housed in a light-tight package in such a manner that their active elements face each other. While the source is always electrically isolated from the sensor (in the low kilovolt range), the two are optically coupled in such a manner that a signal activating the source will trigger the sensor.

Most optoisolators use a gallium-arsenide (GaAs) infrared emitter for the light source and a silicon detector. The latter can be a photodiode, light-activated SCR (LASCR), photosensitive FET, photo-Darlington, or, most commonly, a phototransistor. The housing for the two elements that make up the optoisolator is usually a semiconductor package, with the common IC DIP configuration predominating.



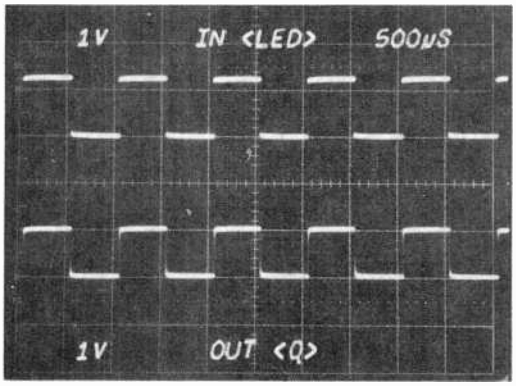


Fig. 1. An arrangement for coupling one signal to another with an optoisolator is shown at right above. The scope photo at right is typical of input and output pulses for the circuit.

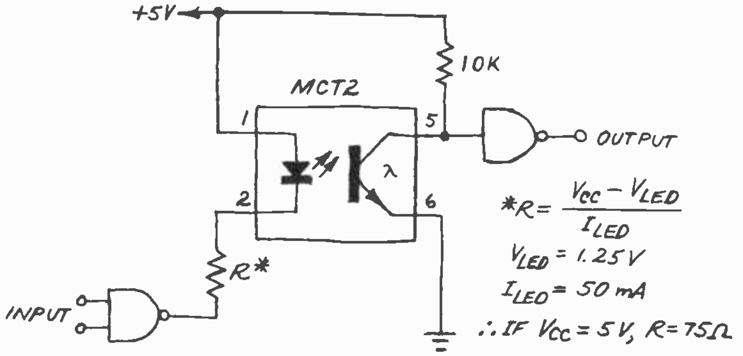


Fig. 2. One way of coupling circuits with an optoisolator.

Simple Couplers. A simple arrangement you can use to isolate an analog or pulsed signal to be coupled from one circuit to another is shown in Fig. 1. The circuit can use any phototransistor optoisolator. (I used a Motorola MCT2, but any similar device can be substituted.) The photograph in Fig. 1 illustrates a pair of typical input and output pulses for the circuit. I calibrated the 4-volt, 1-kHz square-wave output from the scope to pulse the LED in the optoisolator and monitored both sides of the MCT2 to obtain this photo. Notice that the base of the transistor is not used. This is the case with most phototransistor optoisolator circuits, even though manufacturers usually make the base available for special applications such as external biasing.

There are dozens of ways to couple optoisolators to RTL and TTL circuits. A typical circuit for this is shown in Fig. 2. The various manufacturers who make optoisolators (Texas Instruments, Monsanto, Litronix, Fairchild, etc.) all include this and many other basic hookup schemes in their spec sheets, so there's no need to go into details here. Just remember to include a current-limiting resistor between the drive circuit and LED side of the optoisolator. If you omit this resistor, excessive current might be pumped through the LED, causing damage.

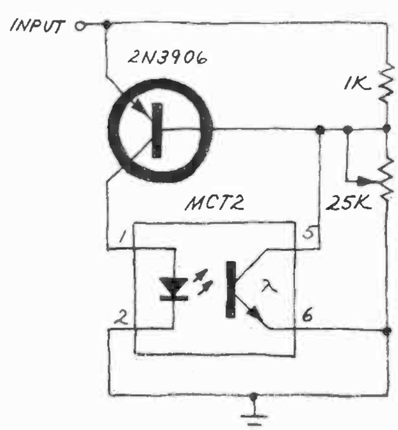


Fig. 3. This optoisolator circuit exhibits negative resistance.

Negative-Resistance Circuit. A circuit you won't find in anyone's spec sheet is the unusual optoisolator negative-resistance configuration shown in Fig. 3. This novel circuit was dreamed up by Japanese engineers Haruo Takahashi and Yasuo Kitahama and first published in the April 1974 *IEEE Journal of Solid State Circuits* ("An Optronic Negative Resistance

Circuit"). Here's how it works. The transistor in the isolator is normally cut off, but an applied voltage causes a small current to flow through the outboard transistor and the LED. As the input voltage increases, the LED turns on and triggers the isolator's transistor into conduction. The circuit exhibits negative resistance because it begins to conduct only above a certain voltage threshold at the input.

Relaxation Oscillator. If you've ever built a neon-lamp flasher circuit, you already know that you can make a simple relaxation oscillator by connecting a resistor and capacitor to a negative-resistance component. The circuit in Fig. 4 shows how this is done with the optoelectronic negative-resistance circuit. Operation begins with the capacitor charging through the 10 k resistor until the negative-resistance circuit switches on. At this point, the capacitor discharges through the circuit and the system resets to the off state to repeat the cycle.

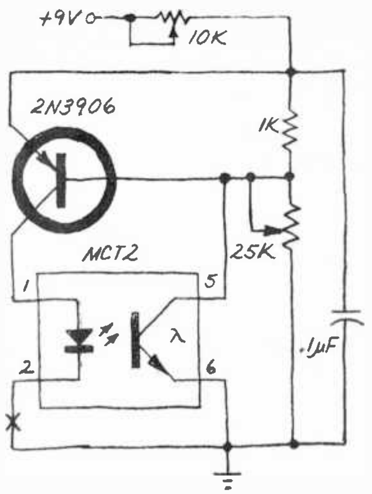


Fig. 4. Relaxation oscillator.

For best results, start with the component values specified in Fig. 4. After you get the circuit working, you can experiment with different capacitor values to change the oscillation range of the circuit. With the values shown, I measured a freqency range of about 3 to 8 kHz with the potentiometer adjusted for a resistance of about 5 k. Changing the capacitor's value to 1 μF caused the freqency range to drop to between 120 Hz and 1.8 kHz.

You can monitor the operation of this circuit with a scope connected across the LED and/or a 1 k resistor inserted between the emitter of the isolator's transistor and ground. The waveforms I obtained are shown in Fig. 5. Alternatively, you can connect a miniature 8-ohm speaker at point "X" to make the oscillator's tone audible.

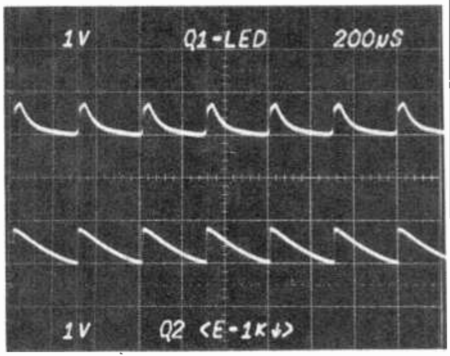


Fig. 5. Waveforms for Fig. 4.

Parting Comment. So far, we've examined only one particular optoisolator, but there is a wide range of other useful gadgets that include electrically isolated emitters and detectors. These source-sensor pairs, as they are usually called, can be used for limit switches, object detectors, position sensors, reflectance sensors, and many other applications. I haven't seen any of these source-sensor pairs on the surplus/hobby market yet. ◈

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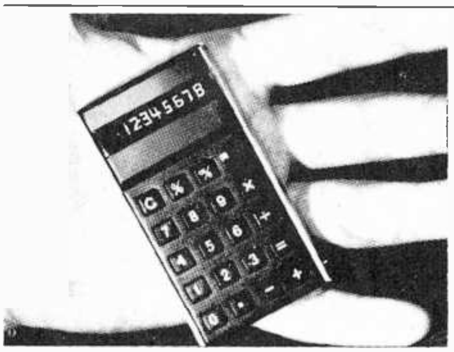

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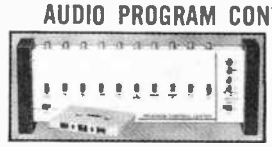

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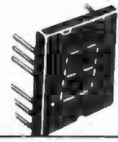

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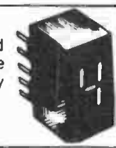

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Built-in phototransistor adjusts intensity of display.
Gold tone — with adjustable mesh strap.

$99.50
+$1.50 Shipping & Handling
Usual 10% Discount Applies

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		7491	.97
		7492	.71
7400	$ .14	7493	.60
7401	.16	7494	.94
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
7485	1.10	74197	.89
7486	.40	74198	1.79
7489	2.48	74199	1.79
7490	.59	74200	5.90

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301	Hi perf op amp	mDIP	.29
307	Op AMP (super 741)	mDIP	.26
308	Micro Pwr Op Amp	mDIP	.89
309K	5V 1A regulator	TO-3	1.35
310	V Follower Op Amp	mDIP	1.07
311	Hi perf V Comp	mDIP	.95
319	Hi Speed Dual Comp	DIP	1.13
320	Neg Reg 5.2, 12, 15	TO-3	1.04
324	Quad Op Amp	DIP	1.52
339	Quad Comparator	DIP	1.58
340K	Pos. V reg. (5V, 6V, 8V, 12V, 15V, 18V, 24V)	TO-3	1.69
340T	Pos. V reg. (5V, 6V, 8V, 12V, 15V, 18V, 24V)	TO-220	1.49
370	AGC/Squelch AMPL	DIP	.71
372	AF-IF Strip detector	DIP	2.93
373	AM/FM/SSB Strip	DIP	.53
376	Pos. V. Reg	mDIP	2.42
380	2w Audio Amp	DIP	1.13
380-8	.6w Audio Amp	mDIP	1.52
381	Lo Noise Dual preamp	DIP	1.52
550	Prec V Reg	DIP	.89
555	Timer	mDIP	.89
556A	Dual 555 Timer	DIP	1.49
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562	Phase Locked Loop	DIP	2.48
565	Phase Locked Loop	DIP	2.38
566	Function Gen	mDIP	2.25
567	Tone Decoder	mDIP	2.66
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710	Hi Speed Volt Comp	DIP	.35
723	V Reg	DIP	.62
739	Dual Hi Perf Op Amp	DIP	1.07
741	Comp Op Amp	mDIP	.32
747	Dual 741 Op Amp	DIP	.71
748	Freq Adj 741	mDIP	.35
1304	FM Mulpx Stereo Demod	DIP	1.07
1307	FM Mulpx Stereo Demod	DIP	.74
1458	Dual Comp Op Amp	mDIP	.62
1800	Stereo multiplexer	DIP	2.48
3900	Quad Amplifier	DIP	.35
8038	V contr. osc	DIP	4.95
8864	9 DIG Led Cath Drvr	DIP	2.25
75150	Dual Line Driver	DIP	1.95
75451	Dual Perepheral Driver	mDIP	.35
75452	Dual Peripheral Driver	mDIP	.35
75453	(351) Dual Periph. Driver	mDIP	.35
75491	Quad Seq Driver for LED	DIP	.71
75492	Hex Digit Driver	DIP	.80

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5261	1024 bit RAM	2.69
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8223	Programmable ROM	3.69
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MM5739	9 DIG 4 funct (btry sur)	5.35
MM5311	28 pin BCD 6 dig mux	4.45
MM5312	24 pin 1 pps BCD 4 dig mux	3.95
MM5313	28 pin 1 pps BCD 6 dig mux	4.45
MM5314	24 pin 6 dig mux	4.45
MM5316	40 pin alarm 4 dig	5.39

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MV10B	Red TO 18	$ .22
MV50	Axial leads	.18
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	Jumbo Vis. Red (Clear Dome)	.22
ME4	Infra red diff. dome	.54
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MAN2	Red alpha num .32"	4.39
MAN4	Red 7 seq. .190"	1.95
MAN5	Green 7 seg. .270"	3.45
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MAN8	Yellow 7 seq. .270"	3.45
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MCT2	Opto-iso transistor	.61

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4000A	$ .26	4017A	1.19	4066A	.89
4001A	.25	4020A	1.49	4068A	.44
4002A	.25	4021A	1.39	4069A	.44
4006A	1.35	4022A	1.10	4071A	.26
4007A	.26	4023A	.25	4072A	.35
4008A	1.79	4024A	.89	4073A	.39
4009A	.57	4025A	.25	4075A	.39
4010A	.54	4027A	.59	4078A	.39
4011A	.29	4028A	.98	4081A	.26
4012A	.25	4030A	.44	4082A	.35
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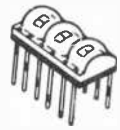

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7808-16c	7475-65c	74161-99c
7410-16c	7476-39c	74163-1.19
7413-49c	7483-85c	74164-1.89
7420-16c	7490-69c	74165-1.49
7427-24c	7492-75c	74174-1.29
7430-16c	7493-75c	74175-1.39
7437-39c	7495-75c	74181-2.75
7438-35c	7496-75c	74192-1.25
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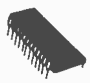

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WITH SPECS

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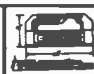

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SN7402N	.21	SN7454N	.41	SN74154N*	1.25
SN7403N	.16	SN7459A	.25	SN74155N	1.21
SN7404N*	.16	SN7460N	.22	SN74156N	1.30
SN7405N	.24	SN7470N	.45	SN74157N	1.30
SN7406N	.45	SN7472N	.39	SN74160N	1.75
SN7407N	.45	SN7473N*	.37	SN74161N	1.45
SN7408N	.25	SN7474N*	.32	SN74163N*	1.35
SN7409N	.25	SN7475N*	.59	SN74164N	1.65
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SN7417N	.43	SN7488N	3.50	SN74174N	1.95
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SN7425N	.43	SN7493N*	.57	SN74181N	3.55
SN7426N	.31	SN7494N	.91	SN74182N	.95
SN7427N	.37	SN7495N	.91	SN74184N	2.30
SN7429N	.42	SN7496N	.91	SN74185N	2.20
SN7430N	.26	SN74100N*	1.00	SN74187N	6.00
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SN7437N	.47	SN74121N*	.45	SN74191N	1.50
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SN7439N	.25	SN74123N*	.70	SN74193N*	.99
SN7440N	.21	SN74125N	.60	SN74194N	1.45
SN7441N	1.10	SN74126N	.81	SN74195N	1.00
SN7442N	1.08	SN74132N	3.00	SN74196N	1.25
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SN7444N	1.10	SN74142N*	4.00	SN74198N	2.25
SN7445N	1.10	SN74143N*	4.50	SN74199N	2.25
SN7446N	1.15	SN74144N*	4.50	SN74200N	7.00
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CD4007	.25	CD4040	2.45	74C73N	1.50
CD4009	.59	CD4042	1.90	74C74	1.15
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CD4013	.47	CD4049	.79	74C151	2.90
CD4016	.56	CD4050	.79	74C154	3.00
CD4017	1.35	CD4051	2.98	74C157	2.15
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CD4020	1.49	CD4060	3.25	74C161	3.25
CD4022	1.25	CD4066	1.75	74C163	3.00
CD4023	.25	CD4069	.45	74C164	3.25
CD4024	1.50	CD4071	.45	74C173	2.60
CD4025	.25	CD4081	.45	74C193	2.75
CD4027	.69	74C00N	.39	74C195	2.75
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LM301CN*	3/1.00	LM381N	1.79	LM2111N	1.95
LM302H	.75	LM382N	1.79	LM2901N	2.95
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LM307CN	.35	NE531H	3.00	LM3905N	.60
LM308H	1.00	NE536T	6.00	LM5556N	1.85
LM308CN	1.00	NE540L	6.00	MC5558V	1.00
LM309H	1.10	NE550N	.79	LM7525N	.90
LM309K	1.25	NE553	2.50	LM7528N	2.20
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LM319N	1.30	NE567H*	1.25	75451CN	.39
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LM320K-5	1.35	LM703CN	.45	75453CN	.39
LM320K-5.2	1.35	LM709H	.29	75454CN	.39
LM320K-12	1.35	LM709N	.29	75491CN	.79
LM320K-15	1.35	LM710N	.79	75492CN	.89
LM320K-5	10.50	LM711N	.39	75494CN	.89
LM324N	1.80	LM723N	.55	RCA LINEAR	
LM339N	1.70	LM723H	.55	CA3013	1.70
LM340K-5	1.95	LM733N	1.00	CA3023	2.15
LM340K-12	1.95	LM739N	1.29	CA3035	2.25
LM340K-15	1.95	LM741CH*	3/1.00	CA3039	1.35
LM340K-24	1.95	LM741CN*	3/1.00	CA3046	1.15
LM340T-5	1.75	LM741 14N	.39	CA3059	2.46
LM340T-6	1.75	LM747H	.79	CA3060	2.80
LM340T-12	1.75	LM747N	.79	CA3080	.85
LM340T-15	1.75	LM748H	.39	CA3083	1.60
LM340T-24	1.75	LM748N	.39	CA3086	.59
LM350N	1.00	LM1303N	.90	CA3089	3.25
LM351CN	.65	LM1304N	1.19	CA3091	8.25
LM370N	1.15	LM1305N	1.40	CA3123	1.85
LM370H	1.15	LM1307N	.85	CA3600	1.75

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

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	$2.95

ALL THREE HANDBOOKS $6.95

★ JAMES JANUARY SPECIALS ★

Astrisk Denotes Items On Special For This Month

Special Requested Items

RC4194	Dual Track V reg	$ 5.95	N8T97	$ 3.00	MK5007	$10.95	MC4044	4.50
RC4195	± 15V Track Reg	3.25	4024P	2.25	8263	5.95	LM3909	2.25
F9368	Decoder	3.95	2513	11.00	8267	2.75	MM5320	19.95
LD110/111	DVM Chip Set	28.00	2518	7.00	8288	1.15	74279	.90
CA3130	Super CMOS Op Amp	1.49	2524	3.50	8826	3.00	4072AE	.45
MC1408L7	A/D	9.95	2525	6.00	8880	1.35	4511AE	2.50
F3341	FIFO	8.95	2527	5.00	7497	5.00	4136	2.50

WE'LL BE HAPPY TO QUOTE ON YOUR SPECIAL PARTS —

OPTO ELECTRONICS

XCITON
LITRONIX
MONSANTO

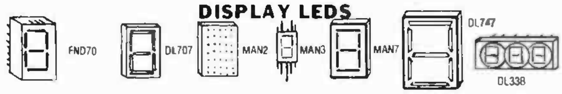
DISCRETE LEDS

R - RED
G - GREEN
Y - YELLOW
O - ORANGE

.125" dia.		.185" dia.		.190" dia.	
XC209R	5/$1	XC526R	5/$1	XC111R	5/$1
XC209G	4/$1	XC526G	4/$1	XC111G	4/$1
XC209Y	4/$1	XC526Y	4/$1	XC111Y	4/$1
XC2090	4/$1	XC5260	4/$1	XC1110	4/$1

.200" dia.		.200" dia.		.085" dia.	
XC22R	5/$1	XC556R	5/$1	MV50	
XC22G	4/$1	XC556G	4/$1	.085" dia. Micro	
XC22Y	4/$1	XC556Y	4/$1	red led	
XC220	4/$1	XC5560	4/$1		6/$1

DISPLAY LEDS



TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	COMMON ANODE	.270	$1.95	MAN 74	COMMON CATHODE	.300	$1.50
MAN 2	5 x 7 DOT MATRIX	.300	3.95	DL707	COMMON ANODE	.300	$1.50
MAN 3	COMMON CATHODE	.125	.39	DL747	COMMON ANODE*	.600	1.95
MAN 4	COMMON CATHODE	.187	1.95	DL750	COMMON CATHODE	.600	2.49
MAN 7	COMMON ANODE	.300	1.50	DL338	COMMON CATHODE	.110	1.95
MAN 7G	COMMON ANODE-GREEN	.300	2.50	FND70	COMMON CATHODE	.250	.50
MAN 7Y	COMMON ANODE-YELLOW	.300	2.50	FND503	COMMON CATHODE	.500	1.75
MAN 72	COMMON ANODE	.300	1.50	FND507	COMMON ANODE	.500	1.75

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

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

SOLDERTAIL STANDARD (TIN)

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

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$ .70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
				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 ASST.

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

ALL OTHER RESISTORS FROM 2.2 OHMS 5.6M AVAILABLE IN MULTIPLES OF 5 ea
5-25 PCS: .05 ea. 30-95 PCS: .04 ea. 100-495 PCS: .03 ea. 500-995: .027 ea.

14 PCS. POTENTIOMETER ASSORTMENTS

ASST. A 2 ea 10 OHM-20 OHM-50 OHM-100 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

$9.95 Per Asst.

Each assortment contains 14 pcs of 10 turn pots. All pots are available in single unit quantities $.99 ea.

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	3021 567T	3071 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

74LS00 TTL

74LS00	.39	74LS55	.39	74LS151	1.55
74LS02	.39	74LS73	.65	74LS153	1.89
74LS03	.39	74LS74	.65	74LS157	1.55
74LS04	.45	74LS75	.79	74LS162	2.25
74LS05	.45	74LS76	.65	74LS163	2.25
74LS08	.39	74LS83	2.19	74LS164	2.25
74LS10	.39	74LS86	.65	74LS181	3.69
74LS13	.79	74LS90	1.25	74LS190	2.85
74LS14	2.19	74LS92	1.25	74LS191	2.85
74LS20	.39	74LS93	1.25	74LS192	2.85
74LS26	.49	74LS95	2.19	74LS193	2.85
74LS27	.45	74LS96	1.89	74LS194	2.25
74LS28	.49	74LS107	.65	74LS195	2.25
74LS30	.39	74LS112	.65	74LS257	1.89
74LS32	.45	74LS132	1.55	74LS260	.55
74LS40	.49	74LS136	.65	74LS279	.79
74LS51	.39	74LS138	1.89	74LS670	5.95

DPST
C & K ROCKER SWITCH
$0.69 Dim: 1" x 1" x ¼"

They are rated at 125 Vac @ 5A. They are excellent in applications such as Microcomputer Panel Switches

MINATURE TOGGLE

DPDT				PART	1	2-9	10-29	30-99
	ON	OFF	ON	221	3.05	2.65	1.97	1.76
	ON	NONE	ON	223	2.80	2.25	1.80	1.61
	ON	OFF	ON	121	2.38	1.95	1.43	1.30
	ON	NONE	ON	123	2.06	1.65	1.21	1.10

PUSH BUTTON

SPDT – SERIES PB, PB1
Maintained Action Switch
Push To Make Contact, And Push Again To Reverse Action
Momentary Action Switch
Normally Open or Normally Closed. (For N.C circuit use terminals 2 & 1; for N.O. 2 & 3; for N.C and N.O. 1,2 &3)

Model Number	1 Each	2-9	10-29	30-99
PB-123	$2.35	$1.95	$1.47	$1.30
PB-126	$2.35	$1.95	$1.47	$1.30

5 AMP RATINGS

THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY
SF = Front Mount SR = Rear Mount

Part No	Description	Price
SF 12	Single Pole 10 Position	$2.50
SR 12	Decimal	3.00
SF 21	10 Position BCD only	2.50
SR 21		3.00

Ordering: Order desired switch or switches and add necessary accessories for your particular application.

SERIES SF Front Mount Assembly | SERIES SR Rear Mount Assembly

ACCESSORIES Part No.	Description	Price	ACCESSORIES Part No.	Description	Price
SF EP	End Plate (Pair)	$.50	SR EP	End Plates (pair)	$.50
SF DP	Divider Plate (each)	.40	SR DP	Divider Plate (each)	.40
SF BB	Blank Body (each)	.40	SR BB	Blank Body (each)	.40
SF HB	Half Body (each)	.40	SR HB	Half Body (each)	.40

6PDT SWITCH
HIGH QUALITY P.C. TYPE **69 ea.**
PUSH BUTTOM SWITCHES
FOR INSTRUMENT APPLICATIONS
¼" x ¼" x 3¼" .69¢ each

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
FN2415	5 $1.00	2N3711	5 $1.00	2N5086	4 $1.00
2N2484	4 $1.00	2N3724	$ .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			C106B1SCR	2 $1.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10pf	.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

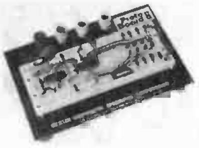
+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.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

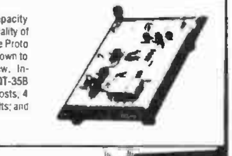
Axial Lead					Radial Lead				
.47	50	.15	.13	.10	.47	25	.15	.13	.10
1	50	.16	.14	.11	.47	50	.16	.14	.11
3.3	50	.15	.13	.10	1	16	.15	.13	.10
4.7	25	.16	.14	.12	1	25	.16	.14	.12
10	25	.15	.13	.10	1	50	.16	.14	.11
10	50	.16	.14	.12	4.7	16	.15	.13	.10
22	25	.17	.15	.12	4.7	25	.15	.13	.10
22	50	.24	.20	.18	4.7	50	.16	.14	.11
47	25	.19	.17	.15	10	16	.15	.13	.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	220	16	.23	.17	.16
2200	16	.70	.67	.55	470	25	.31	.28	.26

CONTINENTAL SPECIALTIES $15.95



PROTO BOARD 6

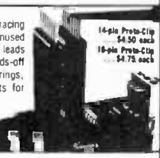
The PB-6 lets the user test and build circuits without soldering or patch cords, all interconnections between components are made with common #22 AWG hook-up wire. This quality breadboarding kit inludes 630 component tie points at less than 2.5¢ each. It measures 6" long by 4" wide. Designed specially to Breadboard Microprocessor Circuits. **$15.95**



PROTO BOARD 100

A low cost, big 10 IC capacity breadboard kit with all the quality of QT sockets and the best of the Proto Board series . . . complete down to the last nut, bolt and screw. Includes 2 QT-35S Sockets, 1 QT-35B Bus Strip, 2 5-way binding posts, 4 rubber feet, screws, nuts, bolts; and easy assembly instructions

$19.95



Bring IC leads from pc board for fast signal tracing and troubleshooting. Inject signals. Wire unused circuits into boards. Scope probes and test leads lock onto Dynagrip Inset (see circle) for hands-off testing. Plastic construction eliminates springs, pivots. Non-corrosive nickel/silver contacts for simultaneous low resistance connections.

PC-14, 14-pin Proto Clip, $4.50 ea.
PC-16, 16-pin Proto Clip, $4.75 ea.
PC-24, 24-pin Proto Clips, $8.50 ea.

CALCULATOR CHIPS AND DRIVERS

MM5725	8 DIGIT 4 FUNCTION	$1.98
DM75491	SEGMENT DRIVER	.79
MM5736	6 DIGIT 4 FUNCTION	1.95
DM75492	DRIVER FOR 5736	.89
MM5738	8 DIGIT 5 FUNCTION	2.95
DM8864	DRIVER TYPE 1	2.00
DM8865	DRIVER TYPE 2	1.00

CLOCK CHIPS

MM5311	6 DIGIT W/BCD	$4.95
MM5312	4 DIGIT W/BCD	4.95
MM5313	6 DIGIT W/BCD	4.95
MM5314	6 DIGIT CLOCK	3.95
MM5316	ALARM CLOCK	4.95
CT7001	CAL/CLOCK CHIP	5.95

DIGITAL WATCH READOUT

FOR USE WITH WATCHES, OVMS, COUNTERS, ETC. $1.95

HP-5082-7300

HP 5082-7300
.3" Dot Matrix type numeric readouts with decoder/driver/latch built on the chip. Only 8 bins (BCD in, DP Latch +5v, ground).
HP 5082 7300 **$5.95**

HP 5082 7304
+1 version of 7300 **4.95**

1¼" x 1½" XFMERS P.C. Mount

That were designed for clock type applications. 110 Vac primary @ 60 Hz
Secondaries: 8-10 Vac @ 300 mA-200 mA
50 Vac @ 30 mA-50 mA
Excellent for miniature power supplies & gas discharge displays

SPECIAL $.99

1/16 VECTOR BOARD

0.1" Hole Spacing P-Pattern

	Part No.	Length	Wideth	Price 1-19	Price 20-49
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 02XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

VECTOR WRITING PENCIL

Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire, fed off a self-contained replaceable bobbin, onto component leads or terminals installed on pre-punched "P" Pattern Vectorbord®. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire. **$9.50 ea.**

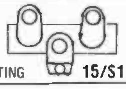
REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg. 3	(Green)	$2.40
W36-3-B-Pkg. 3	(Red)	$2.40
W36-3-C-Pkg. 3	(Clear)	$2.40
W36-3-D-Pkg. 3	(Blue)	$2.40

9V BATTERY CLIP

STANDARD CLIP FOR USE WITH 9V TRANSISTOR BATTERIES WITH 4" LEADS **9/95 ea.**

TERMINAL STRIPS



THREE TERMINAL STRIPS, WITH CENTER TERMINAL USED FOR MOUNTING **15/$1.00**

AMP TERMINAL PINS

TERMINAL PINS FOR MOUNTING COMPONENTS ALSO PERFECT FOR USE WITH BOARD CONNECTORS AND SUBASSEMBLIES **$1.00/100 PCS.**

MICROPROCESSOR COMPONENTS

JAMES ELECTRONICS IS PROUD TO ANNOUCE, FOR THE FIRST TIME EVER, TO THE ELECTRONIC HOBBIEST . . FROM AMERICAN MICRO DEVICES.

8080A $39.95

8080 AND 8008 SUPPORT COMPONENTS

8224 CLOCK GENERATOR USED TO GENERATE TWO PHASE CLOCK NEEDED BY THE 8080 $12.95

8228 SYSTEM CONTROLLER GENERATES A SYSTEM DATA BUS AND CONTROL SIGNALS FOR MEMORY $21.25

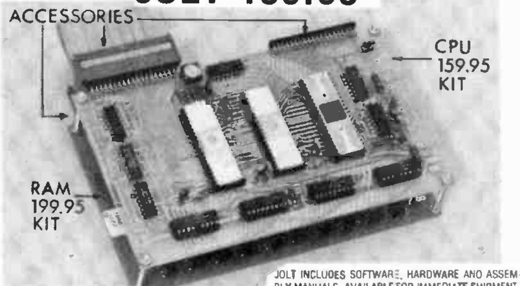
74LS138 DECODER PERFECT FOR DECODING THE THREE 8008 STATE LINES INTO 8 USEABLE LINES FOR ADDRESS LATCHING $3.98

8212 8 BIT INPUT OUTPUT PORT DIRECTLY INTERFACES WITH THE 8080 TO PROVIDE I/O INTERFACE $5.75

	CPU'S	
8008	8 BIT CPU	$19.35
8080	SUPER 8008	39.35
4040	4 BIT 8080	39.35
	SR'S	
2504	1024 DYNAMIC	$9.00
2518	HEX 32 BIT	7.00
2519	HEX 40 BIT	4.00
2524	512 DYNAMIC	3.50
2525	1024 DYNAMIC	6.00
2527	DUAL 256 BIT	3.95
2529	DUAL 512 BIT	4.00
2532	QUAD 80 BIT	3.95
2533	1024 STATIC	7.95
3341	FIFO	6.95
74LS670	16X4 REG	3.95
	UART'S	
AY-5-1013	20K BAUD	$6.95
	ROM'S	
2513	CHAR. GEN.	11.00
7488	RANDOM BITS	3.50

	RAM'S		
1101	256X1	STATIC	$2.25
1103	1024X1	DYNAMIC	6.95
2101	256X4	STATIC	6.95
2102	1024X1	STATIC	2.95
2107	4096X1	DYNAMIC	19.95
2111	256X4	STATIC	7.95
7010	1024X1	MNOS	29.95
7489	16X4	STATIC	2.49
8101	256X4	STATIC	7.95
8111	256X4	STATIC	7.95
8599	16X4	STATIC	3.49
91L02	1024X1	STATIC	2.95
74200	1024X1	STATIC	6.95
93410	256X1	STATIC	1.75
5262	2048X1	DYNAMIC	2.95
	PROMS		
1702A	2048	FAMOS	15.95
5203	2048	FAMOS	14.95
8223	32X8	BIPOLAR	3.00
74S287	1024	STATIC	7.95

JOLT 159.95



JOLT INCLUDES SOFTWARE, HARDWARE AND ASSEMBLY MANUALS. AVAILABLE FOR IMMEDIATE SHIPMENT. $159.95 in kit form . . . $249 assembled.

The JOLT system consists of a set of modular microcomputer boards which can be used singly or tied together to produce any desired microcomputer system configuration. The minimum system is one CPU board, which alone constitutes a viable computer system complete with central processor, I/O, interrupts, timer, read-write memory, and a complete software debug monitor in read-only-memory.

JOLT SYSTEM DESCRIPTION

JOLT RAM Card — Fully static 4,096 bytes of RAM with 1 microsecond access time and on-board decoding. Hardware and assembly manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $199.95 kit . . . $265 assembled.

JOLT Power Supply — Operates at +5, +12 and −10 voltages. Supports JOLT CPU, 4k bytes of RAM and JOLT I/O card — or, CPU and 8 I/O cards. Manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $99.95 kit, $145 assembled.

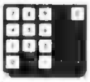
JOLT Accessory Bag — Contains enough hardware to connect one JOLT card to another. Such necessary items as flat cable, connectors, cord spaces, hardware, etc. AVAILABLE FOR IMMEDIATE SHIPMENT. $39.95.

JOLT I/O Card (Peripheral Interface Adapter) — 2 PIA LSI chips, 32 I/O lines, four interrupt lines, on-board decoding and standard TTL drive. Fully programmable. Manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $95.50 kit . . . $140 assembled.

JOLT Universal Card — Same size (4¼" x7"), same form factor as other JOLT cards. Completely blank, drilled to accept 14, 16, 24 or 40 pin sockets. Used for additional user memory or I/O control panels, TV interfaces, keyboards, LEDs, or other interface logic. AVAILABLE FOR IMMEDIATE SHIPMENT. $24.95

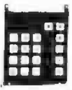
JOLT +5V Booster Option — Fits onto JOLT Power Supply card. Supports CPU, 16k bytes of RAM — or, CPU and 8k bytes RAM and 8 I/O cards — or, CPU and 4k bytes RAM and 16 I/O cards. Manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $24.95

MULTIPURPOSE KEYBOARDS



MULTIPURPOSE KEYBOARDS
20 Keys — Touch Tone

No schematic needed. Calculator use or re-arrange (pop off) key tops. For touch tone or any control application. This unit may be cut apart for smaller units. **$2.95**



This unit was originally intended for calculator type applications but can be applied to a variety of other types of units such as microcomputer interface, digital channel controlling, digital input to a frequency synthesizer, and even touch tone applications. The unit is composed of 16 very low bounce keys of the SPST type and one SPST slide switch. Numbers are white, Clear and Decimal are blue and all other keys are orange on a black background. **$2.49**

WIRE WRAP WIRE

AWG	COLOR	25 FT. MIN.	50 FT.	100 FT.	1000 FT.
30 AWG	WHITE	$2.10	$2.75	$3.50	$24.00
30 AWG	YELLOW	2.10	2.75	3.50	24.00
30 AWG	RED	2.10	2.75	3.50	24.00
30 AWG	GREEN	2.10	2.75	3.50	24.00
30 AWG	BLUE	2.10	2.75	3.50	24.00
30 AWG	BLACK	2.10	2.75	3.50	24.00

STANDARD WIRE

AWG	COLOR	25 FT MIN	50 FT	AWG	COLOR	25 FT MIN	50 FT
16	RED	$3.80	$5.05	24	RED	$1.55	$2.05
18	GREEN	$3.25	$4.30	26	GREEN	$1.45	$1.90
20	WHITE	$7.55	$3.40	28	WHITE	$1.25	$1.65
22	BLACK	$1.90	$2.55	30	BLACK	$1.25	$1.65

TO ORDER SPECIFY GUAGE COLOR AND FOOTAGE (25 FOOT MINIMUM)

6' 2 CONDUCTOR POWER CORDS 125V @ 5A

3/1$

THREE CONDUCTOR POWER SUPPLY CORDS

NUMBER	LENGTH	AWG	O.D.	RATING	COLOR	PRICE
17236	6	18(41X34)	.265	1250W 10A-125V	BLACK	Special .99 ea.
17237	6	18(41X35)	.253	1250W 10A-125V	GREY	1.25
17238	8	18(41X34)	.265	1250W 10A-125V	BLACK	Special .99 ea.
17239	8	18(41X34)	.253	1250W 10A-125V	GREY	1.30
17000	4	18(41X34)	.253	1250W 10A-125V	BLACK	.59

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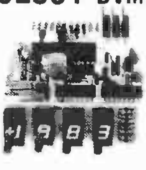
JE SERIES KITS

JE801 DVM



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.

$39.95 Per Kit printed circuit board

JE803 PROBE

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.

$9.95 Per Kit printed circuit board

JE804, JE805 SUPPLIES

THE JE804 AND JE805 ARE POWER SUPPLIES MOUNTED ON A 1¼ x 3" PC BOARD. THEY ARE AVAILABLE IN ±5@ 300 mA, ±6 @ 250 mA, ±12 @ 100 mA. SPECIFY VOLTAGE WHEN ORDERING.

JE804 IS A POSITIVE SUPPLY
JE805 IS A NEGATIVE SUPPLY

$9.95 per kit

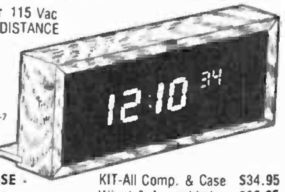
JE700 CLOCK

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip. $19.95

12 or 24 Hour
115 VAC—
$19.95 per kit.

WALL OR TV DIGITAL CLOCK

12 or 24 Hour 115 Vac
25' VIEWING DISTANCE



6 Digit
LED DISPLAY
(4) DL747 (2) MAN-7

WALNUT CASE 6" x 3" x 1"

KIT-All Comp. & Case $34.95
Wired & Assembled $39.95

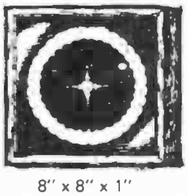
JE010 CALC.

- 5 Functions
- 8-digit — business logic
- Floating decimal or fixed two-place add mode output (selectable)
- Automatic markup/discount on percentage calculation
- Automatic constant calculations
- General calculations
- Chain calculations
- Repeat operations
- True credit balance
- Addressable Memory

$12.95

OPTIONS
115 VAC Transformer $4.95 each
6 each "N" Alkaline Batterys $2.50 lot

ELECTRONIC ROULETTE



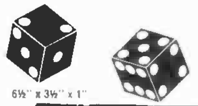
Complete kit with all components case and transformer.

115 VAC

8" x 8" x 1"

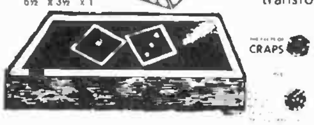
A 56 page book on the facts of Roulette included. **$29.95 Per Kit**

ELECTRONIC CRAPS



Complete kit with all components case and transformer.

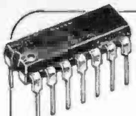
6½" x 3½" x 1"



115 VAC

A 56 page book on the facts of Craps included. **$19.95 Per Kit**

CIRCLE NO. 28 ON FREE INFORMATION CARD



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8080A $69.50	**2102 $3.50**
MICROPROSSOR 0-70°C 480 ns Clock Period	1024 Bit Random Access Memory 500 ns Typical, 1000 ns Max Access Time

INTEGRATED CIRCUITS — TTL, CMOS, LINEAR & MOS

7400	24c	7451	22c	74155	77c	4018	$1.44	4518	$1.28
7401	24c	7453	22c	74156	77c	4019	58c	4520	$1.28
7402	24c	7454	22c	74157	68c	4020	$1.56	4527	$2.00
7403	24c	7460	22c	74160	$1.19	4021	$1.42	4528	90c
7404	24c	7470	34c	74161	$1.11	4022	$1.18	NE536T	$3.25
7405	24c	7472	34c	74162	$1.19	4023	24c	NE540L	$2.04
7406	24c	7473	31c	74163	$1.19	4024	96c	NE553L	$1.87
7407	24c	7474	31c	74164	$1.28	4025	24c	NE554L	$1.87
7408	24c	7475	51c	74174	$1.09	4026	$1.67	NE555V	48c
7409	24c	7476	34c	74175	$1.02	4027	64c	NE556A	88c
7410	24c	7480	68c	74180	77c	4028	$1.04	NE560B	$3.83
7411	24c	7482	68c	74181	$2.13	4029	$1.36	NE561B	$3.83
7412	24c	7483	68c	74182	85c	4030	50c	NE562B	$3.83
7413	24c	7485	$1.11	74190	$1.45	4033	$1.67	NE565A	1.45
7414	$1.02	7486	31c	74191	$1.45	4034	$3.34	NE566V	$1.28
7416	24c	74S89	$2.13	74192	$1.19	4035	$1.36	NE567V	$1.36
7417	24c	7490	48c	74193	$1.11	4040	$1.60	uA709CA	43c
7420	24c	7491	77c	74194	$1.11	4041	90c	uA709CV	43c
7421	24c	7492	48c	74195	$1.11	4042	82c	uA710CA	36c
7425	65c	7493	48c	74279	56c	4043	67c	uA711CA	37c
7426	24c	7494	77c	8T97	95c	4044	67c	uA723CA	60c
7428	43c	7495	85c	75150	$1.40	4046	$2.35	uA741CV	43c
7430	24c	7496	77c	4000	24c	4049	52c	uA747CA	68c
7432	43c	74100	$1.24	4001	24c	4050	52c	uA748CV	41c
7433	31c	74107	31c	4002	24c	4051	$1.44	MC1456V	$1.00
7437	24c	74121	36c	4006	$1.50	4052	$1.44	MC1458V	51c
7438	24c	74122	43c	4007	24c	4053	$1.44	MC3302P	85c
7440	24c	74123	78c	4008	$1.17	4060	$1.67	LM309K	$1.80
7441	$1.11	74125	39c	4009	64c	4066	90c	LM324N	$1.28
7442	61c	74126	39c	4010	64c	4071	26c	uA7805CU	$1.25
7443	61c	74132	73c	4011	24c	4072	26c	uA7806CU	$1.25
7444	61c	74141	94c	4012	24c	4073	26c	uA7808CU	$1.25
7445	61c	74145	$1.16	4013	50c	4075	26c	uA7812CU	$1.25
7446	77c	74150	$1.36	4014	$1.58	4081	26c	uA7815CU	$1.25
7447	77c	74151	85c	4015	$1.17	4082	26c	uA7818CU	$1.25
7448	85c	74153	77c	4016	50c	4502	$1.26	uA7824CU	$1.25
7450	22c	74154	$1.36	4017	$1.26	4511	$1.60	2102B	$3.50

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XAN82	YELLOW	C.A.	XAN682	YELLOW	C.A.
XAN74	RED	C.C.	XAN674	RED	C.C.
XAN54	GREEN	C.C.	XAN654	GREEN	C.C.
XAN84	YELLOW	C.C.	XAN684	YELLOW	C.C.

SILICON TRANSISTORS

EN918	21c	$17.85/C	MPS3638A	16c	$13.60/C	PM4888	16c	$13.60/C
MPS930	16c	$13.60/C	2N3640	21c	$17.85/C	2N5089	16c	$13.60/C
MPS2222A	16c	$13.60/C	MPS3641	16c	$13.60/C	2N5129	21c	$17.85/C
MPS2369A	16c	$13.60/C	MPS3643	16c	$13.60/C	2N5133	21c	$17.85/C
MPS2712	16c	$13.60/C	2N3645	21c	$17.85/C	2N5134	21c	$17.85/C
MPS2907A	16c	$13.60/C	MPS3646	16c	$13.60/C	2N5137	21c	$17.85/C
2N3055	99c	$85.00/C	2N3904	16c	$13.60/C	2N5138	21c	$17.85/C
MPS3392	16c	$13.60/C	2N3906	16c	$13.60/C	2N5139	21c	$17.85/C
MPS3393	16c	$13.60/C	2N4124	16c	$13.60/C	2N5210	16c	$13.60/C
MPS3394	16c	$13.60/C	2N4126	16c	$13.60/C	2N5457	52c	$44.20/C
MPS3395	16c	$13.60/C	2N4401	16c	$13.60/C	PN5964	16c	$13.60/C
2N3563	21c	$17.85/C	2N4403	16c	$13.60/C	MPF102	48c	$40.80/C
MPS3565	16c	$13.60/C	2N4410	16c	$13.60/C	MPSA13	40c	$34.00/C
MPS3638	16c	$13.60/C				C106B1	55c	$50.00/C

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— Radial Lead —			— Axial Lead —			— Axial Lead —		
			1ufd/50v	11c	$ 7.70/C	47ufd/25v	17c	$11.20/C
1ufd/50v	8c	$ 5.40/C	2.2ufd/50v	12c	$ 7.80/C	100ufd/16v	17c	$11.20/C
2.2ufd/50v	8c	$ 5.40/C	3.3ufd/35v	12c	$ 7.90/C	100ufd/25v	20c	$13.30/C
3.3ufd/50v	8c	$ 5.60/C	3.3ufd/50v	12c	$ 8.30/C	100ufd/50v	29c	$19.70/C
4.7ufd/25v	8c	$ 5.40/C	4.7ufd/35v	12c	$ 7.90/C	220ufd/16v	20c	$13.30/C
10ufd/25v	8c	$ 5.70/C	10ufd/16v	11c	$ 7.70/C	220ufd/25v	29c	$20.00/C
10ufd/50v	10c	$ 6.60/C	10ufd/25v	12c	$ 8.30/C	330ufd/16v	29c	$20.00/C
22ufd/25v	9c	$ 6.10/C	10ufd/50v	14c	$ 9.60/C	330ufd/25v	32c	$21.60/C
22ufd/50v	12c	$ 8.50/C	22ufd/16v	12c	$ 8.30/C	470ufd/16v	32c	$21.60/C
100ufd/6.3v	9c	$ 6.30/C	22ufd/25v	13c	$ 8.70/C	470ufd/25v	37c	$25.40/C
100ufd/16v	11c	$ 7.30/C	33ufd/16v	12c	$ 8.50/C	1000ufd/16v	39c	$26.60/C
100ufd/25v	13c	$ 9.20/C	33ufd/25v	14c	$ 9.60/C	1000ufd/25v	56c	$38.20/C
			47ufd/16v	14c	$ 9.60/C	2200ufd/16v	62c	$42.00/C

DISC CAPS

100pf/500v	4c	$ 6.09/2C	.01ufd/500v	6c	$ 8.55/2C
220pf/500v	4c	$ 6.09/2C	.01ufd/50v	3c	$ 4.05/2C
470pf/500v	4c	$ 6.09/2C	.022ufd/25v	3c	$ 7.73/2C
1000pf/500v	4c	$ 6.22/2C	.047ufd/25v	5c	$ 4.73/2C
2200pf/500v	4c	$ 6.22/2C	.1ufd/25v	8c	$10.57/2C
4700pf/500v	4c	$ 5.41/2C			

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6 AMP SPST N.O. CONTACTS

5 V. Coil	$1.70	$125/C
6 V. Coil	$1.70	$125/C
12V. Coil	$1.70	$125/C
24V. Coil	$1.70	$125/C

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1N4148	40c/10	$3.50/C	1N4004	70c/10	$5.95/C
1N4001	64c/10	$5.50/C	1N4005	82c/10	$7.05/C
1N4002	66c/10	$5.61/C	1N4006	90c/10	$7.73/C
1N4003	68c/10	$5.78/C	1N4007	99c/10	$8.59/C

½ WATT ZENER DIODES

1N5226B	3.3v	15c	$11/C		1N5236B	7.5v	15c	$11/C	
1N5227B	3.6v	15c	$11/C		1N5237B	8.2v	15c	$11/C	
1N5228B	3.9v	15c	$11/C		1N5238B	8.7v	15c	$11/C	
1N5229B	4.3v	15c	$11/C		1N5239B	9.1v	15c	$11/C	
1N5230B	4.7v	15c	$11/C		1N5240B	10v	15c	$11/C	
1N5231B	5.1v	15c	$11/C		1N5241B	11v	15c	$11/C	
1N5232B	5.6v	15c	$11/C		1N5242B	12v	15c	$11/C	
1N5233B	6.0v	15c	$11/C		1N5243B	13v	15c	$11/C	
1N5234B	6.2v	15c	$11/C		1N5244B	14v	15c	$11/C	
1N5235V	6.8v	15c	$11/C		1N5245B	15v	15c	$11/C	

HARDWARE

2-56 1/4 Screw	99c/C	$7.20/M
2-56 1/2 Screw	99c/C	$7.65/M
4-40 1/4 Screw	55c/C	$3.60/M
4-40 1/2 Screw	60c/C	$4.05/M
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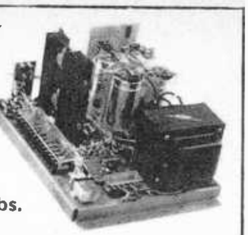

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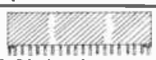

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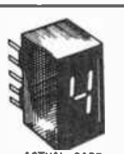

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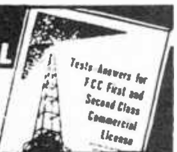

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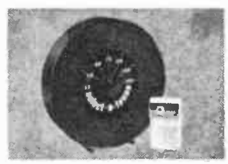

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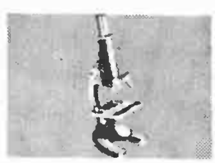

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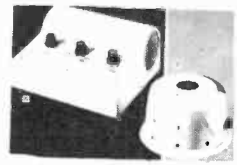

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Happily, the lowest-priced Dual, the 1225, is the perfect example of Dual's basic design concept: to build every turntable with more precision than you are ever likely to need.

The 1225 is a fully automatic, single-play turntable with multi-play facility. Its vernier-adjustable, low-mass counterbalanced tonearm can track flawlessly at as low as one gram. Stylus pressure is applied exactly as in every Dual, around the vertical pivot and perpendicular to the groove, maintaining perfect balance in all planes. Anti-skating force is also applied exactly as in every Dual, with separate calibrations for conical, elliptical and CD-4 styli.

Other features the 1225 shares with all other Duals include pitch-control and cue-control damped in both directions. The hi-torque motor maintains speed within 0.1% even when line voltage varies as much as 20%, and the hefty 3½ lb., 10⅝" platter provides effective flywheel action to minimize the audible effect of any speed variation.

The newest Dual, the 510, is a single-play turntable with a unique semi-automated tonearm. A mechanical sensor indicates when the tonearm is positioned precisely over the lead-in groove of a 12" or 7" record. The tonearm remains suspended over the record until lowered by the cue-control; it cannot be dropped accidentally. At the end of play, the tonearm is automatically lifted by the cue-control and the motor shuts off.

In all other respects, the 510 is essentially the same as other full-sized Dual models. The 8¾" tonearm is mounted in a newly designed four-point gimbal suspension, and the dynamically-balanced cast platter is driven by an 8-pole synchronous motor via a precision-ground belt. Pitch is variable over a 6% range (a semitone) and can be conveniently set to exact speed by means of a built-in illuminated strobe, read directly off the rim of the platter.

Now all you need decide is which way you want Dual precision: automatically or semi-automatically. (And whether you will ever want to play two or more records in sequence.)

Dual 1225

Dual 510

Dual 1225, less than $140, less base. Dual 1226, similar but with cast platter and rotating single-play spindle. Less than $170. Dual 1228 with gimballed tonearm, synchronous motor, illuminated strobe, variable tracking angle, less than $200.

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