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Digital readout over 1/2-inch high on new Royce Model 2-510 Professional CB Mobile Transceiver.


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T902—Do to 15 MHz; single-trace, mono time-base $695**
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T900 Oscilloscopes are simple to use. All have a large, bright (8 x 10 cm) CRT, beam finder, single knob trigger control, delay line to enable viewing of waveform leading edge, automatic selection of TV line or frame display and functionally color-coded control panels. Convenience is also enhanced by a full complement of accessories including 10X probes (included in price), optional scope stand, camera, rain jacket and more...T900 Oscilloscopes are easy to handle and fit into small spaces. They weigh only 15-19 lbs. and measure only 7" x 10" x 19".

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T900 Oscilloscopes are warranted against defective materials and workmanship for one year. There are over 37 service centers and 50 field offices across the U.S. Whenever you need help in the selection, operation, application or servicing of T900 Oscilloscopes your local Tektronix field engineer is available to help you...no extra charge...just extra value.

For a copy of the new T900 Brochure (includes complete specifications), or ordering information write to Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077. For immediate information call your local Tektronix field engineer or Tektronix, Inc. (503) 644-0161 extension 9100.

*Applications and accessories, when applicable, $149.
** Standard equipment. Additional cost: $29.95. 50% deposit required on all orders. 30-day money-back guarantee.
THE METRICATION WAITING GAME

Although Congress has not, as yet, passed a bill dealing with adoption of the metric system in the U.S., the changeover from our present English system is inevitable. After all, about 20% of the world’s population with 70% of world trade uses the metric system. And with good reason! It’s simpler and faster to deal with multiples and subdivisions of 10 than it is with units of 12.

Of course, the U.S. has been “going metric” for many years, although the use of the system has been more of an incursion than an adoption. For example, we employ the metric system for radio wavelengths, electrical measurements, medical prescriptions, and in photography. We even use it for hi-fi pickup tracking force—2 grams, 1 gram, etc.

Comparing the values of one standard with that of another is always awkward. For instance, 1 gram would translate to 1/28 ounce. In a turnabout, 7½ inches per second, a common U.S. tape recorder speed, is equivalent to 19.05 centimeters per second. Clearly, the nice even numbers occur with the standard that is dominant. The equivalent is generally complicated. For international trade purposes, however, many manufacturers “design” metric. That’s why we see many cabinets and enclosures that measure fractionally, such as 14 3/16 inches instead of a nice round 14½ inches. The former measures 36 centimeters on the button!

There are many conversion tables around to compare a value in English to that of metric, and vice versa. Metric conversion calculators are abundant too. Moreover, there are factors to simplify conversion that are as easy as to use (2.54 cm = 1 in., 1 kg = 2.2 lb). But when you get right down to it, one must eventually choose a system to the exclusion of all others so that even numbers predominate. Most countries employed a changeover period from English to metric, with highway signs reading both miles and kilometers, as an example.

The first country to go metric, France, had a 25-year dual system program starting in 1812 before metric became compulsory in 1837. Our defeated U.S. Metric System Bill had a 10-year changeover period. Interestingly, Thomas Jefferson, when Secretary of State, recommended in 1790 that Congress introduce a decimal system. President John Quincy Adams advocated adoption of the metric system in 1821. Congress passed a law in 1866 making the metric system legal; it’s been in use for many years, although the U.S. is the only major industrial nation in the world that uses the outmoded English system of weights and measures!

For a country that is a major participant in world trade, in converting to metric is abhorrent. It means that a product cannot be made for universal distribution. Equally distressing, there is no serious move in our schools to teach upcoming generations the system of weights and measures that must ultimately be adopted.
The diodes used to protect the inputs of the comparator IC are the bad guys. The capacitance of a typical zener diode is many times that of a typical switching diode. With the 1000-ohm value of R1 and approximately 550 pf of capacitance of D1 and D2, there will be very little 10-MHz square-wave signal amplitude available at the comparator's inputs.

Far better results can be obtained if the zener diodes are each replaced with two or three switching diodes connected across the comparator's inputs as shown in my schematic.—W.E. PARKER, Columbus, Ohio

NOTES ON PROGRAMMING PROCEDURE

The 8253 PROM specifications sheet recommends a 390-ohm resistor, as opposed to the 39-ohm value specified in "How To Program Read-Only Memories" (July 1975). The exact magnitude difference between the two values makes the suspicious of the article's procedure.—Mark Coffman, Cincinnati, Ohio

I have a question on one of the steps for programming a PROM (page 30). The note in step 1 states: "NEVER operate S1 when S2 is set to zero." If this is correct, there is no way to blow the fuses.—David Peterson, Edmonton, Alberta, Canada

It has been our experience that most PROM's need a great deal more burn current than is possible to obtain using a 390-ohm resistor. We experimented with a number of PROM's and found that 39 ohms is the optimum burn resistor value. The 390-ohm value failed to give the desired results. (Perhaps the PROM's we had, from several sources, were manufacturer failures, or if most of the PROM's our readers will be able to obtain are in this category.) As for the note in step 1 of the programming procedure, it should read: "NEVER operate S1 when S2 is set to test."

ripple current in filter capacitors

In "How to Design Your Own Power Supplies" (June 1975), no mention is made of the importance of not exceeding the ripple current rating of the capacitor. This factor cannot be ignored, particularly in low-voltage and current source power supplies. Failure to consider the ripple current and its heating effect in the capacitor will severely shorten its life. A. ROMANO, Brooklyn, N.Y.

The author replies that this is a good point to keep in mind if one finds heating in the filter capacitor. The ripple current may be what is causing it. Under normal loads and with full-wave and bridge systems, however, the typical capacitors available to experimenters should not present any problems.

Out of Tune

In "Build a Direct-Reading Logic Probe" (September 1975), in the Parts List, DS1 should be a common-anode unit, not common-cathode.

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POPULAR ELECTRONICS

NOVEMBER 1975

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Page 7
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The field of communications is bursting all over. In Citizens Band alone, estimates predict a growth in equipment sales from $514 million in 1973 to $1.2 billion dollars in 1982! That means a lot of openings in service and maintenance jobs. NRI can train you at home to fill one of those openings...including your FCC license and solid-state 2-way radio service.

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You will learn to service and/or adjust CB equipment...using your own 25-channel Johnson Transceiver and AC power supply for hands-on experience as well as your own personal use.

With NRI's training program, you can learn this important skill easily, at home in your spare time. You get 8 training kits, including your own 3 1/2 digit digital multimeter for digital experiments and precise measurements. You'll learn from bite-size lessons, progressing at your own speed to your FCC license and then into the communications field of your choice.

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The Model RT-824 AM/FM Stereo Tuner has a dual-antenna MOD/FET front end featuring an IF sensitivity of 1.6 µV, a tuned AM section, and a phase-cocked-loop multi-vibrator detector. A wide-linear-scale dial and flywheel tuning are included for easy operation. A riding switch with small spaces is also provided for operation with a flying switch. The Model RT-824 MT was priced at $39.95.

The AM-PX-341 AM/FM Stereo Tuner has a dual-antenna MOD/FET front end. Featuring an IF sensitivity of 1.6 µV, a tuned AM section, and a phase-cocked-loop multi-vibrator detector. Two wide-linear-scale dials and flywheel tuning are included for easy operation. A riding switch with small spaces is also provided for operation with a flying switch. The Model RT-824 MT was priced at $39.95.

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Hewlett-Packard introduces a third scientific programmable:

Now you have three HP pocket programmables to choose from:

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Here's what the new HP-25 offers you:

**Keystroke programmability.** The four-step answer to repetitive problems:
1. Turn the HP-25 on and switch to PRGM;
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4. Repeat step three for each iteration.

You save time, gain precision and flexibility. You can verify formulas or test alternate approaches without sacrificing half a morning.

You do it in plain English. You don't need software or a "computer" language. You don't need prior programming experience.

**Complete programmability.** You can add, check, or change program steps at will. Just use the SST (Single-Step) or BST (Back-Step) key and Display to locate the step you want to check or change, then enter your changes. The HP-25 displays all program steps, so you can always tell at a glance where you are in your routine. HP knows you can't edit in the dark.

The HP-25 even has a PAUSE key that lets you write one-second interruptions into your programs, in case you want to pick up intermediate results or verify the progress of a calculation.

In sum, the HP-25 is a complete keystroke programmable calculator, designed by engineers who've done it before.

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Eight storage registers and 72 preprogrammed functions and operations. All log and trig functions, the latter in degrees, radians or grads, rectangular-polar and decimal hours/hours/minutes/seconds conversions; mean and standard deviations; summations; register arithmetic on data in all registers; an integer/fraction key so you can store two numbers in one register; and all data manipulations.

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- You can evaluate any expression without copying parentheses, worrying about hierarchies or re-structuring beforehand.
- You can solve all problems your way—the way you first learned in Algebra I, the way you now use when you use a slide rule.
- You solve all problems, no matter how complex, one step at a time. You never work with more than two numbers at once.
- You see all intermediate answers immediately; the HP-25 executes each function immediately after you press the function key.
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800-538-7922 (in Calif. 800-662-9662) are the numbers to call for the name of a dealer near you. He'll give you detailed specs, including a list of available accessories, and a "hands-on" demonstration that'll take about 15 minutes. Buy an HP-25, and you'll get them back. Every day you use it.

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Edmund Scientific's electronic calculator (Stock No. 1945) fits in your palm, but has an eight-digit readout with floating decimal, making for arithmetic functions, automatic percentage key, lead zero suppression, and no constant key. The unit runs on two 1.5-V Malory PX 825 camera batteries equal to supplied with calculator. Measures 2.8" x 3.5" x 1.5" x 0.75" and weighs 2 oz (59.8 g). $19.95.

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A digital multimeter from Non-Linear Systems, the Model LM-3, offers three-digit readout and can be operated on either battery or line power (NiCd batteries and charger included). Small enough to be held in one hand, it has four ranges of ac and dc volts and five resistance ranges from 1 kΩ to 1 megohm full-scale. Other features are automatic polarity and automatic zero. The 0.1-mA full-scale input impedance on all ranges, and a 0.33-inch (8.4-mm) LED display. Dimensions are 4" x 2.7" x 1.7" (102.3 x 6.9 x 4.8 cm). $129.00.

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TOK HIGH-PERFORMANCE CASSETTE

A new high-fidelity cassette tape, called Super Avilyn by Tok, is introduced by Tok. Apparently a mix of cobalt, ferric oxide and other proprietary elements. The new tape is said to combine the advantages of ferric and chromium tapes, but overcomes inherent problems in both the straight and hybrid formulas currently available. Headwear is said to be the same as that from Ferro-Cob tape (much lower tan loss of CO2 formulas). According to TKD, the Avilyn tape has better low- and mid-frequency response during equalizing of high-frequency response of chromium tapes. Its FNa is 0.5 to 1.5 better than CO2, and can be used with the standard chromium playback equalization time constant of 70 µs. The tape will retail for $3.95 in C6 format. A C-90 package will be introduced later.

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JAMES MILLER SHIELD DESIGN TIP

"Helpful Hints in the Design of a Magnetic Shield" is a 5-page engineering design tip describing how to shield sensitive devices from interference as well as how to shield devices that cause interference. Thickness and types of shielding materials are discussed, and desegussing procedures are given. Address: James Miller Manufacturing Co., Inc., 150 Exchange St., Masen, MA 02148.

ALTEC ENCLOSURE DESIGN MANUAL

"Loudspeaker Enclosures—Their Design and Use" is a 30-page manual containing data for use in designing and constructing enclosures for Alto loudspeakers. It discusses the function of the enclosure, speaker design theory, various types of enclosures, and how to tune a bass reflex port. Price is $2.00. Address: Altec Corp., 1515 S. Manchester, Anaheim, CA 92803.

NATIONAL CAMERA TOOL CATALOG

The "NC Flasher" (80 pages) includes hard-to-find tools, technicians' supplies, laboratory and workshop equipment, etc. Among new items listed are a low-cost circuit tester, accessories for the "Grabber" test-lead system, and tools and instruments for the photo equipment repair technician. Address: Dept. ORN, National Camera Co., 2000 W. Union Ave., Englewood, CO 80110.

PROJECTOR-RECORDER BELT CATALOG

A reference and catalog from Projector-Recorder Belt Corp. lists over 650 types of belts, wheels, and rubber parts for over 2000 models of audio and video tape players and audiovisual projectors. The company also supplies parts for recording belts and other drive parts. Address: Projector-Recorder Belt Corp., 147 Whitewater Rd., Malden, MA 02148.

WOODCRAFTING CATALOG

A 22-page catalog from Garrett Wade Co. describes their line of hardwood workbenches and tools for all types of woodworking projects, including building speaker and hi-fi equipment enclosures and record cabinets. Tools include those for carving, clamping, mitering, and measuring. Workbenches come in a variety of sizes and styles. Address: Garrett Wade Co., Dept. 16, 302 Fifth Ave., New York, NY 10010.

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W. Belmont Avenue
Chicago, Illinois 60641
Time Smear. Because of the design of most crossover networks, and the nature of the drivers themselves, the separate elements of a multi-way speaker system tend not to respond to an input with equal alacrity. Usually the larger drivers are late, so that an input signal with a steep waveform, like a siren's wave, would come out with its frequency components broken down according to which driver was handling them, and spread out over an appreciable time base. Not long ago someone dubbed this phenomenon "time smear"—definitely my favorite jargon phrase of the year—and it became a serious consideration when some speaker-evaluation schemes. The point is that a number of omnis, most especially the ones with multiple tweeters arranged so that you hear direct radiations from several drivers, can exhibit more time smear than the usual case, because some tweeters will inevitably be nearer or farther than others. And of course, the reflected sound they engender will be correspondingly smeared.

Probably it would be better if speakers didn't have any such anomaly, but since the overwhelming number of drivers produces 3,000-Hz signal, it's appropriate to wonder what audible bad effects it has. That is a subject on which it's hard to find agreement. On a signal (a drum beat, perhaps) that involves together the woofer, midrange, and tweeter(s) in what should be a union response, we're likely to find some frequency smearing lagging considerably behind, which will sound not so good or perfectly all right, depending on whether you're talking to one "authority" or another.

One predictable effect of omni's documentation long ago by Haas, is an increase in perceived loudness. The graph (page 24), which I think has implications for the audible phenomena, indicates that the ear integrates over a time "window" of about 100 milliseconds, so that any
sound of that duration will sound louder the longer it lasts. The delay in the sound that an omni speaker—one of the few logical choices—is capable of producing will sample the performance of the layout of the listening area, with a corresponding expansion of the time the sound lasts at the listener's position. It is to this that I'd attribute some of the bright, open quality (particularly in the high frequencies) that we tend to associate with wide dispersion.

As time smoothes over some frequency bands, there is no logical reason for an omni's being at all inferior to a conventional speaker. There is some evidence—of it quite subjective—for some listeners. I'll lay this down as an interesting example, and leave it at that. Some experienced listeners have reported noting tonal changes when they moved off the axis of a conventional speaker, but that they were relatively minor. All of the various types of speakers are nearly identical, and those listeners who have been most closely associated with the speaker (the trade, for example) have been highly critical of the listener's position. As they move off the axis of a conventional speaker, the sound quality changes, but the change is perceived to be a subjective one, not objective.

More Demo Records. My remarks of some months ago on demonstration records have lured a few more contestants out into the open.

Fulton Electronics, whose products are the FMI Model 80 (consid- ersed by many to be in the top rank of under-$100 speaker systems), also has a small recording operation at its Minneapolis base. Bob Fulton makes records on the way I would if I knew how. Of the five Ark (his label) albums I’ve sampled, none is less than remarkable. One—Choral Music at the House of Prayer (a Minneapolis church, not the British institution)—is unique in my listening experience. No light-voiced Baroque instrument this, but one of the highest-pressure outputs that has you checking the ceiling overhead for nicely chandeliers. In fact, the specifications show the switch to be the largest section of the instrument, which smacks of nineteenth-century excess. Fortunately, the tone of the organ is not hard or piercing, but is almost dominated by the tremendous low-frequency resources—six-16-foot stops and one 32-foot Bourdon. Fulton has gone after these solutions in a way that all but makes you of the heavens. The bass is as substantial as a brick wall, and it just rolls over you without remission. Yet the rest remains in focus. I recommend the delightful Mozart selection for open- ears also; the recording studio is very good.

I could be more enthusiastic about Ark’s Organ Sounds from Mount Zion. The Ark is not the most popular organ in the world. The Oberlin recording is more than adequate in the bass, but of greater interest to me is the upper register, which is very strong yet free of mod- uation effects and plain distortion than I’ve used. I should note that, as of this writing, there is a number of cassettes on the market that are superior in almost every respect but one: the matrix-decoder operation I can’t say, but my impression is that these boxes need all the filtering they can get.

There’s a significant new development in high fidelity that is destined to play a vital role in sound re- production. It is intimately tied in with the piezoelec- tric principle. The piezoelectric ef- fect deals with certain crystal devices that flex when voltages are applied to them. Now, Pioneer has discovered a totally new application of the piezoelectric effect by applying the principle to ultra-thin aluminum coated high polymer film.

By employing this film as a low- mass diaphragm and applying audio signal voltages, the material expands and contracts uniformly generating acoustic energy. For the first time it becomes possible to transform electrical energy into an accurate acoustical equivalent. Such thin-film diaphragms properly mounted are capable of reproducing all music frequencies by means of an electronic control amplifier. The ramifications of this unique refinement of the piezoelectric effect are exciting. Consider such immediate applications as microphones, cartridges, speaker systems and headphones. In a recent demonstration, U.S. Pioneer Electronics Corp., 75 Oxford Drive, Moonachie, New Jersey 07004, West: 13300 S. Es- trella, Los Angeles 90248 / Mid- west: 1500 Greenleaf, Elk Grove Village, Ill. 60007 / Canada: S.H. Parker Co. What you may now own a pair of head- phones, you owe it to yourself to hear the new piezoelectric high polymer transducer head- phones. In fact, compare them with other types. You’ll find a lower level of distortion than has ever been achieved— even at un- precedented volume levels. The experience of listening with these new Pioneer headphones is a revelation. In addition, the open-back design, light weight and soft, snug fitting earpads permit hours of comfortable, private listening. You’ll come away from your Pioneer headphones with a new outlook on other headphones. The Pioneer’s SE-700 and SE-500 headphones don’t. They employ a single-thin-film high polymer piezoelectric diaphragm that reproduces, as shown in Figure 2. Only the diaphragm moves air— and it moves it accu- rately, in exact conformance with the electrical signal ap- plied directly to it. The Pioneer’s new headphones are a revelation in design, invention and performance. The Pioneer’s new High Poly Molecular transducer technology will alter the course of high fidelity.
specialty of Burwen Laboratories, which incidentally manu-
factures a comander recording system and a dynamic
noise filter for playback-only purposes. Burwen’s first rec-
ord (there have been a couple since, I believe) demon-
strates the comander with stunning success. The disc,
Perfectly Clear, presents the East Bay City Jazz Band and
vocalist Jane Campbell in what is said to be a close
approach to traditional New Orleans music making. The
record is a real wonder. There is not a sound on it that
has not been captured with absolute, crystalline precision, and
if it’s fascinating to follow the sharply etched outlines of the
brass timbre into the sinuosity of a virtuoso clarinet.
The banjo is a bit remote (“I luteless,” as the song says), and
the drums are really too far away from the mikes, getting
soaked up by the extremely dead acoustic of the recording
site. But the recording overall has, of course, no tape
noise, and no trace of side-effects that I found too noisy from
the operation of the comander system. Nor is there any print-
through of groove echo. Recorded levels are on the moder-
ate side to accommodate the extreme peaks (which
Burwen claims are there and my scope confirms), but
the pressings is the flattest piece of vinyl I’ve seen in years, and
exceptionally quiet. If your system will tolerate high gain
settings you can blow yourself into chopped liver with this
recording—never louder than a whisper of a noise.
The Burwen record is $10.50 from Burwen Labs, 599
Middlesex Tpke., Burlington, MA 0183.
Ambiphon also sent a newer recording by the Tequila
Mocking Bird Chamber Ensemble. From the name you’d
not expect that the group plays Handel, Vivaldi, and
Pachelbel straight, but that appears to be the case. How-
ever, they attack this material with violin, tuba, and vib-
rhaphone. Question whether the vibes achieve a successful
blend with the violin, but the tuba generally works well.
God knows the bass line is always audible. The recording is
very good. The only thing that keeps it from being excep-
tional is the lack of a big, spacious acoustic and/or spectacu-
lar dynamic range. Ambiphon’s address is: P.O. Box 341,
Kingsbridge Station, Bronx, NY 10463.
In closing, let me announce that CBS Laboratories, now
rechristened as CBS Technology Center, is again offering
its full range of test records, many of them remastered with
new equipment. The CBS series is especially valuable to
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provided along with the more usual sweep tones that re-
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Now, in the black and silver
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unbeatable heavyweight has a
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an transmitter that can really dish it out, with decisive wins over all CB
challenges. Real guts too, with 23 digitally synthesized AM chan-
nels. Powerful —6 watts in, 4 watts out and AM modulation clout.
Everything a champ needs: Audio tone control, push-button DX
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**EXCLUSIVE!**

**The First Motorola/AMI '6800' MPU Computer Project**

**By H. Edward Roberts & Paul van Baalen**

**Features compact size, simplified construction, built-in TTY interface, and low cost.**

Large-scale integration (LSI) has provided many useful IC chips for the hobbyist. One of the latest is devices in the microprocessor unit (MPU), which has made it possible to build microcomputers that are fairly easy to assemble at moderate cost. The most popular MPU's are the 6800 and 8080, due to their reasonable cost and wide availability in computer kits. However, many knowledgeable hobbyists have been looking for a microcomputer built around one of a number of other MPU's available (just as some people would like to try a diesel or steam engine to replace the gasoline motor). Most of these readers have told us they were interested in the Motorola 6800 MPU (for one reason or another). Many also felt that the price of a microcomputer was still too high. Popular Electronics is therefore pleased to introduce the first microcomputer using the 6800 MPU in a design that substantially reduces cost.
Basic System Philosophy. The basic MPU, memory, I/O (input/output), and power-supply circuits in the Altair 680 are located on a single printed circuit board. The addition of a compact power transformer makes this assembly a complete computer system. (Front-panel switch programming can be used, but in the absence of this assembly, PROM's or ROM's must be installed for programming.)

The front-panel assembly contains all the logic needed to reset, halt, or start the processor. Also, any memory cell can be read or written into from the front panel via 16 address and eight data switches. Mounted on the front-panel circuit board is a 100-contact edge connector that permits the main MPU board to plug directly into the front panel, thus eliminating the need for a wiring harness. (In systems that do not use the front-panel assembly, the MPU board automatically starts running at an address specified by either a PROM or a hard-wired patch.) The front panel contains 27 LED's that indicate the state of each switch. As a safety measure, the power switch is located on the back of the cabinet to obviate the possibility of its being accidentally operated during programming.

The basic computer contains 1024 bytes of memory and has provisions for an additional 1024 bytes of PROM or ROM memory. An I/O channel and interface are also included in the basic system. The I/O channel can be configured to interface RS-232 or a 20 mA or 60 mA TTL loop. This means that anyone who can obtain an old five-level Baudot-type Teletype—such as the MOD-19, MOD-19, etc.—can use it as a computer terminal. (Many such Teletypes are available for less than $100 and frequently for as little as $25 nationwide.)

The Altair 680 can be built with either a full-programmability or a "turn-key" front panel. The latter eliminates all controls except resetting the processor. There are a number of applications where this is desirable to eliminate the possibility of having an operator affect the contents of the memory or the computing cycle. An example might be in a sophisticated intruder-detection system where the only control provided for the operator is essentially on/off.

Software. The software associated with the 8800 MPU includes an editor, PROM monitor, and assembler, as contrasted to the editor, assembler, monitor and basic for the Altair 8800 computer.

System Details. The Altair 8800 computer is composed of five sections: MPU and clock, memory, control and indication, I/O port, and power supply.

MPU and Clock. As mentioned earlier, the MPU and clock are the new 8800 LSI chip. Its basic internal arrangement is shown in Fig. 1. The main elements are instruction decode and control, instruction register, data and address registers and buffers, 16-bit index register, 16-bit program counter, 16-bit stack pointer, two 8-bit accumulators, condition code register, and ALU (arithmetic logic unit).

The timing and control inputs and outputs for the 8800 chip are:

Phase 1 and phase 2 clock (p1,p2)—a nonoverlapping 500-kHz square wave at VCC.

Address bus A0 through A15—16 high active outputs that determine address or I/O sections to use.

Data bus 0 through D7—eight high active bidirectional lines for transfer to and from memory and peripherals. Halt signal (RST)—low active input that ceases activity in the computer.

Read/write signal (R/W)—in the high state, signals the memory and peripherals that the MPU is in the read condition; in the low state, signals that the MPU is in the write condition.

Valid memory address (VMA)—signifies external devices (memory and I/O) that the MPU has a valid address on the memory bus.

Data bus enable (DBE)—enables the bus drivers.

Bus available (BA)—indicates machine has stopped and address bus is available.

As shown in block-diagram form.

Fig. 1. Basic internal arrangement of 8800 MPU used in computer.

Data LINE TO BUS

Almost entire computer is assembled on a single large pc board (left). Board at right is for front panel. Boards plug together.

Data LINE TO BUS

Reset (RES)—resets and starts the MPU from a power-off condition. A positive-going edge on this input tells the MPU to begin the restart sequence.

Interrupt request (IRQ)—when low, tells the MPU to start an interrupt sequence (save the registers on the stack, set interrupt mask bit high so no other interrupts can occur, and vector to the interrupt address). This type of interrupt can only occur if the interrupt mask bit in the condition code register is low.

Nonmaskable interrupt (NMI)—essentially the same as the IRQ, except it is not dependent on the condition code register.

The clock is a 2-MHz crystal-controlled oscillator that uses a pair of inverters that drive flip-flops to form a 500-kHz, two-phase clock that is distributed to the MPU, memory, and I/O sections in the computer via inverters and buffers.

Memory. The memory system consists of 1024 words of 8-bit-wide RAM, using 2102-type 1024 x 1-bit devices, and up to 1024 words of PROM, using ultraviolet-erasable 1727 devices. The basic arrangement is shown in Fig. 2. The low-order address bits are fed to both the RAM's and PROM's.

Front Panel. The front panel assembly contains the RUN/HALT switch, with a LED for each switch position, a reset switch with no LED indicator, and the ac power LED indicator (Fig. 3). The 16 address leads and eight data switches each have their own LED indicator. The DEPOSIT, RESET, DATA, and ADDRESS switches are enabled only when the RUN/HALT switch is in the HALT position, at which time, a retriggerable one-shot multivibrator drives the halt input of the MPU low. This, in turn, drives the bus-available (BA) signal high and also conditions the other switches. To view the data in any memory location, the RUN/HALT switch must be placed in the HALT position and the ADDRESS switches set to the required address. The data at that location

Fig. 2. There are eight RAM's (RAM 0 through RAM 7) and four PROM's (PROM 0 through PROM 3) in the computer's memory system.
 There is a major reason for the tremen-

dous success of the various computer

kits on the market is that they are

delivered at a very reasonable cost. One

doesn't have to hunt down the MPU's,

memories, etc., that must be accumu-

lated before embarking on a home

computer project. It appears that OEM

engineers are also spending consid-

erable time in hunting down computer

parts. Cramer Electronics, one of the

top U.S. electronic parts distri-

butors, has decided to enter the com-

puter kit business, with emphasis on

the OEM market.

Cramer is starting with three kits,

separately based on the Intel 8080,

Motorola 6800, and Texas Instruments

TMS5800 MPU's. Each of the kits

shares a common $495 prize tag.

You get a lot for $495: complete
color-coded schematic diagram, RAM

with 1024 (8-bit) bytes, expandable to

65 k bytes, erasable PROM with 1024

(8-bit) bytes; support circuitry, includ-

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and synchronization logic, interrupt

service, DMA controls, etc. The PROM

gives you a program to run at the outset.

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amined, and executed under switch

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HERE COME THE
HOME VIDEO DISCS

How the three leading video disc systems produce sight and sound from a disc resembling the familiar LP record

BY KEN WINSLOW

AFTER several false starts with magnetic tape and optical film and expensive equipment, a practical home-entertainment video playback system that can be used with any TV receiver is on the horizon. RCA, AEG Telefunken, British Decca, Zenith Radio, N.V. Philips, MCA, Thomson CSF, and others have developed video disc systems, that resemble and can be played like an audio disc. More important, the decks and program material are relatively inexpensive compared to tape and optical film systems.

If the developers have their way, we will no longer be tied to network and local station programming. Soon, we'll be able to make our own choices of prerecorded video disc color TV programs. In fact, West Germans can now buy a video disc player from a local retailer. They can also choose from an initial selection of 200 video disc programs.

By the end of 1976, it appears that there will be two incompatible systems (produced by RCA and Philips/MCA) in competition for the U.S. consumer dollar. There is also the possibility that other systems, such as West Germany's Teldec system, will join the battle.

The Video Discs. Similar in physical appearance to and played in essentially the same manner as the 12" LP audio record, the video disc will offer just about every form of entertainment imaginable—from motion pictures to plays and even informational and educational programs. Some manufacturers are busily trying to obtain the rights to current-run motion pictures. One manufacturer (Philips/MCA) plans to provide text—illustrations and print—materials that permit the user to scan or read single pages forward, backward, or at random simply by pressing a pushbutton switch.

Although a video disc might look like an audio disc, the similarity is only superficial. By modern high-fidelity audio recording standards, the transient flow of information bits dealt with is calculated to be 300,000 bits per second. Consequently, LP records have the ability to accommodate a density of about 5,000 bits per square millimeter. The result is a 33⅓ rpm LP disc can easily accommodate 30 to 45 minutes of audio program signal.

The transient information flow required to present a TV picture today is about 100 times more intense than that of sound transmission. A storage medium with the information-density capacity of a video disc would have to offer 100 times more capacity in the same or enlarged surface area for recording the same length (in time) program in video as it does in audio.

An ever-widening variety of dense storage and retrieval techniques and technologies for use with a reasonably sized disc have been demonstrated since 1970. Three leading methods—from RCA, Teldec (Telefunken/Decca), and Philips/MCA—have emerged as of this writing. Because it is the only system currently available, we will take a detailed look at Teldec's pioneering work as an example of the problems faced and as a means for comparing the different solutions to the problems. (Teldec's "TeDo" system, a cooperative effort between AEG-Telefunken and British Decca, first demonstrated its solution to dense storage technology with a working monochrome system in June 1970.)

The standard LP audio disc contains 250 to 350 grooves/radial inch, with information recovery dependent upon a side-to-side (lateral) stylus excursion. Teldec discovered that, by adopting a frequency-modulation carrier-oscillation technique, a single cutting amplitude could be employed during disc mastering to handle the full required frequency range of the video and audio signals within a constant track width. This also permitted the use of an up-and-down (vertical) stylus excursion method for signal information recovery. Teldec was able to almost eliminate the guard space allowance between the tracks, with the result of raising the number of tracks to 3500/radial inch. This gave the needed 100-fold increase in storage capacity from the same surface area used in audio discs, and it made possible a 12" disc.

The problems of TV's high-frequency range and dense information storage encountered in making the recorded video disc are similarly overcome in retrieving the information from the disc. The stylus for an LP can easily respond as mechanical movement at audio frequencies. However, the mass of the stylus of an audio cartridge is too great to permit such response at the much higher TV frequencies. Needless to say, the various companies have solved the problem in their own special ways.

POPULAR ELECTRONICS
Teldec's "Stylus" Player. In the Teldec system, the information is recorded as deformations in the groove track over which a diamond stylus is passed. The stylus tip is in the shape of a sliced runner with a gradual radius on the leading edge (relative to disc rotation) and a sharp trailing edge. During playback, the leading edge glides smoothly along the groove over the deformations without damaging them. As the deformations move under the stylus, they become compressed. The sharp trailing edge of the stylus runner passes over the compressed deformations, causing them to spring back to their original shape. In doing so, the signal on the stylus is registered as a constantly varying pressure. The diamond stylus is rigidly fixed to a piezoelectric element that converts pressure variations into electrical picture and sound signals. The sound, recorded in the same fashion as the video, is recovered as pulses that appear during the blanking interval between horizontal line scans.

Consisting of 30 frames/second (equivalent U.S. standards), Teldec's color TV picture is recorded on the disc with each frame occupying one full rotation of the disc. The disc must rotate at 1800 rpm, which is readily accomplished in synchronization with the power line frequency. Rather than riding on a conventional turntable, the disc is center-positioned on a spindle and is supported on a cushion of air above a stationary platter. Instead of being freely guided by the groove, as with an LP, the video disc's stylus assembly traverses the disc's surface by a simple drum, cable, and pulley arrangement run by the same motor that turns the disc spindle. (The easily scratched disc is not handled by the user.) An automatic mechanism extracts it from the protective envelope and returns it after play when the envelope is inserted into the machine by the operator.

The entire player, with its electrical circuits, is about the size of a large briefcase. It is independent of the TV receiver, providing a modulated r-f sound-and-picture signal on an unused channel through the receiver's antenna terminals. As the system is currently designed, Teldec's video disc has a playing time of 10 minutes.

P/M's Laser Player. Philips/MCA and RCA have taken the video disc considerably further than Teldec has, to date in terms of playing time. Both companies pack greater numbers of grooves to each inch on their discs. Also, both have developed their own unique information recovery transducer systems that are said to be less expensive per hour of use, cause less wear on the disc, and have longer operating lives. Their discs are also designed to be more rugged and easier to handle than are Teldec's.

N.V. Philips and MCA initially pursued separate developments of laseroptical systems but have recently combined their efforts. In March of this year, an impressive demonstration of the joint venture was given. The Magnavox, a subsidiary of North American Philips, is said to be planning to manufacture a U.S. P/M video disc player by the fourth quarter of 1976. The large entertainment conglomerate of MCA will be handling programming and disc mastering and replication for the U.S. market.

The P/M system employs a very precisely controlled laser beam to record information on and recover it from the video disc. In recording, a laser is used to cut minute oblong depressions that represent sound, color, and brightness information. About 0.7-micron wide, the depressions vary by 0.8 to 2.5 microns in length and follow a continuous spiral path. Because of this extremely small size and the fact that the tracks can be spaced less than 2 microns apart, P/M is able to achieve about 13,500 tracks per radial inch. This is almost three times more than is possible with the Teldec approach.

The P/M disc consists of three parts: protective layer, information layer, and highly reflective layer of aluminum.

A laser beam in the player is used as a non-contact optical "reader" to recover audio and video information from the disc. Light from a 1 mw helium-neon laser is focused onto the video disc as a spot 1 micron in diameter. This is reflected back from the aluminum layer through a recovery lens that focuses it on a photo detector. The detector converts the beam into an electronic sound-and-picture signal. The spot of light follows the rotating track and intercepts the depressions that contain the video information. As the light rides over each track depression, the amount of light reflected back is modulated by the depth characteristics of the depressions. A number of different control and servo systems perform various functions to select and preserve accurate spot tracking and focus, to maintain time-base stability in case of unevenness of the disc surface due to irregularities or warping and center-hole eccentricities; and to ignore the accumulation of surface dirt and scratches. The protective trans- parent coating. Since there is no stylus or physical contact with the disc, the P/M player is a "no-wear" system, and the video disc should theoretically last forever.

Philips/MCA player has controls (located on front panel). To left of center is slide-type slow-motion control. Remaining controls on panel are postition.

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The disc rotates at 1800 rpm. As a consequence of the 30-frame/second U.S. NTSC TV system, the disc makes one revolution of 360° for each frame. A radial deflection mirror forms part of the laser beam control system. P/M says that the radial deflecting mirror can easily be made to control the beam during the vertical interval to repeat the same tracks, jump back one or more tracks, or jump forward one or more tracks. Since this occurs during the vertical blanking period of the frame, and provided that not too big a jump is made during this limited time, all manner of still, fixed, and variable slow forward and reverse motion, and random-access effects can be obtained by "playing" the controls. A digital index counter is used to help pinpoint the location of a specific selection or frame.

The disc will be single-sided and will contain a 30 minutes of program material. Company spokesmen say that they will be able to meet the announced price of $500 for the player and still be able to offer the stop/slow/variable-frame display system that the player seems so uniquely able to provide.

As announced, the P/M player will offer modulated R/L pictures and sound signals through the antenna input of any conventional TV receiver. Two separate 20,000 Hz audio output channels will also be provided for feeding into a stereo audio system.

RCA's "Capacitive" Player. In a number of respects, RCA's capacitive-mechanical video disc system falls between the Teldec and P/M systems in terms of storage-density and playing capability. RCA spokesmen say that a calculated choice was made to design a system that offers a player/disc component system that keeps the difficult parts in the factory and the noncritical parts in the home. By using a stylus tracking system, a capacitive-sensing, signal-detection technique, and a 450-rpm disc speed, RCA believes it has struck the best possible balance in manufacturing, reliability, operational simplicity, low purchase/cost, and duration of available playing time. Except for the stylus assembly, the company states that the electrical and mechanical assemblies for the player are largely off-the-shelf items.

Similar to Teldec and unlike P/M, RCA uses a grooved disc that mechanically guides the stylus over the signal track. The grooves are spaced 4.57 microns apart (center to center). There are 5555 grooves per radial inch. The disc itself consists of five layers of material sandwiched together. The vinyl core contains the information slots that vary in length between 0.23 and 1.23 microns. The slots are cut in the master by a high-resolution electron beam in a vacuum chamber. Metallic and styrene coatings are then applied to both sides of the disc. Finally, a layer of oil that increases the life expectancy of both the

**VIDEO DISC SYSTEM COMPARISON CHART**

<table>
<thead>
<tr>
<th>DISC</th>
<th>TELDEC</th>
<th>PHILIPS/MCA</th>
<th>RCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>8&quot;</td>
<td>8.12&quot;</td>
<td>8.12&quot;</td>
</tr>
<tr>
<td>Playing time</td>
<td>10 min</td>
<td>30 min</td>
<td>60 min (2 sides)</td>
</tr>
<tr>
<td>Speed</td>
<td>1800 rpm</td>
<td>1800 rpm</td>
<td>450 rpm</td>
</tr>
<tr>
<td>Tracks/rch</td>
<td>1500</td>
<td>1500</td>
<td>5555</td>
</tr>
<tr>
<td>Information scheme</td>
<td>groove deformations</td>
<td>long longitudinal pits</td>
<td>transverse slots in grooves</td>
</tr>
<tr>
<td>Averge life</td>
<td>100 plays (min)</td>
<td>indefinite</td>
<td>100 plays (min)</td>
</tr>
<tr>
<td>Estimated cost</td>
<td>$4-$10/disc</td>
<td>$2-$10/program</td>
<td>$10/disc</td>
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</tbody>
</table>

**PLAYER:**

<table>
<thead>
<tr>
<th>Type</th>
<th>System type/ transducer</th>
<th>mechanical contact / pressure</th>
<th>no-contact / optical laser</th>
<th>mechanical contact / capacitive</th>
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<tbody>
<tr>
<td>Estimated price</td>
<td>$500</td>
<td>$500</td>
<td>$400</td>
<td></td>
</tr>
<tr>
<td>PICKUP:</td>
<td>Type</td>
<td>diamond stylus</td>
<td>laser</td>
<td>sapphire stylus</td>
</tr>
<tr>
<td>Estimated life</td>
<td>70-100 hours</td>
<td>NA</td>
<td>200 hours (min.)</td>
<td></td>
</tr>
<tr>
<td>Replacement price</td>
<td>NA</td>
<td>NA</td>
<td>less than $10 for stylus / cartridge</td>
<td></td>
</tr>
</tbody>
</table>

NA = Information not available at this writing.
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AFTER an undisturbed 15-year reign, the old "IHFM Standard Methods of Measurement for Tuners" (IHFM-T-100) has been succeeded by the new "Standard Methods of Testing Frequency Modulation Broadcast Receivers." This new Standard (IHFM-T-200 and IEEE Std 185-1975) was produced under the auspices of the IEEE, the IHF, and the EIA. It focuses on some key areas of tuner performance—including stereo—wherein the old standard was inadequate. The old one was developed before stereo FM programming was authorized. Also, it establishes new reference levels for sensitivity, selectivity, and distortion measurements, among others.

Hopefully, this new set of guidelines will enable manufacturers to relate their products' performances more meaningfully, and allow the consumer to make a well-informed decision when he goes to the marketplace.

The Femtowatt. One of the Standard's more important provisions deals with the basic reference level of signal strength. Previously, the microvolt (10^-6 V) was used, but now the femtovolt (10^-15 W) supplants it. Thus, instead of considering the amount of signal voltage developed across the tuner's antenna input, many measurements will be based on the amount of power delivered to the tuner. By definition, an available signal power level of one femtowatt is the reference 0 dBf—not to be confused with its cousin, dB, which expresses something completely different.

But why power? The previous standard was ambiguous about the true amount of signal delivered to the tuner. For example, most signal sources can deliver a higher voltage across an open circuit than across a resistive one, so "open-circuit" microvolts would produce a different result than "terminated" microvolts. Furthermore, tuner inputs are commonly either 75 or 300 ohms, and a standard based on voltage led to a 6-dB hedge due to loading effects. What really determines signal strength is the amount of power that's available, which is related to the voltage by the equation $P = V^2/R$. For example, 10 µV across a 300-ohm input develops $333 \times 10^{-15}$ W, but the same voltage across 75 ohms produces $1333 \times 10^{-15}$ W—an increase of about 4 times, or 6 dB! Some manufacturers might quote the 75-ohm figure, which would apparently give them hotter receivers than those whose sensitivity was rated at 300 ohms. Now that everyone is expected to use the new power rating, specification differences based on type of termination will no longer be exaggerated.

Balanced Tuner Inputs. For each network, $E_p$ is the terminated generator output voltage, usually indicated on a calibrated attenuator. (This works out to be half the open-circuit generator output voltage.)

$E_p$ is the power available to the receiver, so the power loss incurred by the dummy antenna (in dB) is $P_L$. Equations relating these variables are given in each case.

For example, suppose we're measuring the sensitivity of a tuner using the dummy antenna in Fig. 2A. With the "old" IHF procedure, we read the IHF sensitivity when the generator's attenuator read 4.0 µV. The reading would then be divided by 2, since half the voltage was "dropped" across the resistive network. Thus, the "old" IHF sensitivity would be 2.0 µV.

In the new Standard, the 4.0 µV reading is $E_p$, the "open-circuit" voltage. Accordingly, no division is necessary.
portance is the nature of the “quieting slope,” and more specifically, the point where a $SN$ ratio of $50$ dB is obtained. For this reason, the new Standard requires disclosure of the “50-dB Quieting Sensitivity,” expressed in dB(f). The familiar “Usable Sensitivity”—the level of signal resulting in a combined noise and distortion content of $3\%$ (30 dB)—will also be included in dB(f), because the public is familiar with it, and it takes into account both noise and distortion.

Although only residual noise is measured by the “50-dB Quieting Sensitivity” test (the modulating signal is turned off), it is of great interest to determine how much harmonic distortion exists at this point. Therefore, a “Distortion at 50-dB Quieting” spec has been established. The distortion readings for this test and those at higher signal levels must be quoted for three frequencies—100, 1000, and 6000 Hz. Previously, THD was most often quoted at 1000 Hz, but it’s well-known that most audio products exhibit lowest THD content in the mid-range. Hence, the additional measurements will give a more realistic picture of overall performance.

The Committees that collaborated on the Standard felt that 6000 Hz was the highest practical frequency to conduct this test. Harmonics of higher-frequency fundamentals are not only beyond the range of human hearing, but also extend past the upper limit of FM broadcast audio (15,000 Hz).

### Strong Signal Measurements

Tests formerly conducted at high (1000 “terminated” dB(f)) signal levels, such as “Ultimate SN,” “Ultimate THD,” and “Stereo Separation” will now be performed at 65 dB(f). That’s roughly 1,970 “open-circuit” dB(f), or 970 “old HF” (300-ohm) dB(f)—almost the same signal level previously used. Capture ratio is measured in much the same way as before, but the readings must be taken at signal levels of 45 dB(f) and 65 dB(f). The poorer of the two figures must be published as the “rated” capture ratio in dB(f).

### Two Selectivity Specs

“Alternate Channel Selectivity,” which spells out the degree of interference from an FM station 400 kHz away from the desired one, will now be measured at 45 dB(f) (desired signal input), or about 97 “old HF” dB(f).

Now, we have another selectivity spec that must also be published—“Adjacent Channel Selectivity.” The “numbers” are not going to look too good, of course. Obviously, it’s much tougher to suppress signals 200 kHz away than those 400 kHz removed—at least it is when you’re trying to maintain a sufficient bandwidth for low distortion and good phase linearity. But as the public gets used to seeing “Adjacent Channel” figures in the 20-to-30-dB range, this “embarrassment” should fade away. (This concludes Part One. Next month we’ll examine new methods of curve plotting, and look at the new Stereophonic Specifications.)

### Table I. Available Power From Dummy Antennas in Terms of Terminated 50 ohm Generator Output $E_o$

<table>
<thead>
<tr>
<th>Impedance</th>
<th>300 ohms (B,D)</th>
<th>300 ohms (A,E)</th>
<th>300 ohms (C,F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dummy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impedance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dummy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0.55 $\mu$V</td>
<td>1.1 $\mu$V</td>
<td>2.2 $\mu$V</td>
</tr>
<tr>
<td>5</td>
<td>0.97 $\mu$V</td>
<td>1.9 $\mu$V</td>
<td>3.9 $\mu$V</td>
</tr>
<tr>
<td>10</td>
<td>1.7 $\mu$V</td>
<td>3.5 $\mu$V</td>
<td>6.9 $\mu$V</td>
</tr>
<tr>
<td>15</td>
<td>3.1 $\mu$V</td>
<td>6.2 $\mu$V</td>
<td>12 $\mu$V</td>
</tr>
<tr>
<td>20</td>
<td>5.5 $\mu$V</td>
<td>11 $\mu$V</td>
<td>22 $\mu$V</td>
</tr>
<tr>
<td>25</td>
<td>8.7 $\mu$V</td>
<td>19 $\mu$V</td>
<td>39 $\mu$V</td>
</tr>
<tr>
<td>30</td>
<td>17 $\mu$V</td>
<td>35 $\mu$V</td>
<td>69 $\mu$V</td>
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<td>35</td>
<td>31 $\mu$V</td>
<td>62 $\mu$V</td>
<td>125 $\mu$V</td>
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<td>40</td>
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<td>220 $\mu$V</td>
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<td>390 $\mu$V</td>
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<td>2.2 mV</td>
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<td>97 mV</td>
<td>0.19 V</td>
<td>0.39 V</td>
</tr>
<tr>
<td>110</td>
<td>0.17 V</td>
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<td>115</td>
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<tr>
<td>120</td>
<td>0.55 V</td>
<td>1.1 V</td>
<td>2.2 V</td>
</tr>
</tbody>
</table>

$E_o =$ open-circuit voltage

$$R \equiv \text{impedance level}$$

$$\text{dB} = \text{available power for a 1 W reference level}$$

$$= 10 \log (E_o/1)$$

Note: Letters in parentheses refer to dummy antenna configurations shown in Fig. 2.

The Graphic Artist is a visual pattern generator that is designed to use the CRT screen of an oscilloscope as a "canvas" and its electron beam as a high-speed "brush." The real-time three-dimensional display on the CRT screen has all the distinctive geometric beauty and detail of the computer-generated three-dimensional drawings with which we are all familiar. The beam in an oscilloscope is forced to follow two complex, harmonically related signals in producing

THE OSCILLOSCOPE

GRAPHIC ARTIST

BY MITCHELL WAITE

Create exciting, computer-generated, three-dimensional drawings on your oscilloscope

NOVEMBER 1975

A DIM light traces a delicate pattern of geometrical lines on the screen of an oscilloscope. The lines form a rectangle that suddenly tilts back and transforms into a revolving ring of diamonds. You can produce these, plus many more, effects by operating the controls on the Graphic Artist project described here. You can easily make an image rotate in three dimensions, compress and expand, break up into other shapes, or slowly oscillate.
the geometric patterns. Phase-shift networks, working in concert with a simple modulator, in the Graphic Artist add a signal that produces a depth and volume cue for the scope image. If you're into electronic music, you might try feeding the output signal of the Graphic Artist into a stereo amplifying system to hear the tones associated with the on-screen images. Even more interesting, you can feed harmonics from a music source into the Artist's circuit in place of the oscillator signals. This allows you to view the patterns created by harmonically related musical notes.

About the Circuit. As shown in the block diagram in Fig. 1, two almost identical signal channels in the Artist are connected to the vertical and horizontal inputs of an oscilloscope. This hookup results in a CRT trace that is known as a Lissajous figure—a circular-like trace that is proportional to the vertical and horizontal displacement of the scope's electron beam. Each channel in the Artist consists of two oscillators (A and D) that generate square and triangular waveforms. Added to the signals produced by these oscillators is a common modulated signal derived from oscillators B and C. The overall shape of the Lissajous pattern is set by the signals from oscillators A and D. (For example, a simple rectangle results when triangular waveforms make up these signals.) The modulation component is comprised of a variable high-frequency carrier from oscillator C and a variable medium-frequency envelope from oscillator B. The carrier is shifted in phase by +45°. The +45° component is modulated by waveform B in the multiple and summed with the waveform from oscillator A in an adder. Likewise, the -45° carrier is modulated by waveform B but is summed with the waveform from oscillator D. When the phase-shifted components interact in the scope, they form another Lissajous pattern that is perpendicular to the major rectangular pattern, creating the three-dimensional illusion of volume.

Each oscillator can be switched to generate square waves. Depending on which oscillator is switched to square waves, the pattern will either break up into multiple images or change the character of its surface composition. There are three level controls, which tilt or expand the image and change the apparent sizes of the modulating components. The harmonic controls are frequency setting potentiometers that are used to adjust the ratio between the various harmonic signals. The ratios of the signals in turn control the "family" of images you see. To prevent the patterns from revolving on the screen (this occurs whenever the patterns are derived from uncorrelated oscillators), one of the four oscillators is fixed in frequency. The output from this "master" oscillator is used to synchronize

![Fig. 1. Block diagram of Graphic Artist.](image1)

![Fig. 3. Etching and drilling (above) and component (right) guide.](image2)

**PARTS LIST**

<table>
<thead>
<tr>
<th>Value</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R2, R3, R4</td>
<td>4 each</td>
</tr>
<tr>
<td>C1, C2, C3</td>
<td>3 each</td>
</tr>
<tr>
<td>IC1, IC2, IC3, IC4</td>
<td>4 each</td>
</tr>
<tr>
<td>Transistor</td>
<td>1 each</td>
</tr>
<tr>
<td>Battery</td>
<td>1 each</td>
</tr>
</tbody>
</table>

**NOTES**

- The following are available from CalKit, 13925 Bowden St., Glendale, CA 91203: Complete kit, $54.10; kit without components, $52.50; kit without chassis, $49.95; kit without power supply, $45.00. All orders postpaid. California residents, add 6% sales tax.

- Fig. 2. Oscillators are identical except for frequency-determining elements.
the remaining oscillators, forcing them to run at an exact multiple of the sync frequency.

In addition to using the controls on the project, you can also use the vertical- and horizontal-gain controls on the scope to adjust the width and height of the images.

**Circuit Details.** As shown in Fig. 2, the four oscillators are identical except for their frequency-determining elements. Oscillator A is fixed at approximately 50 Hz by R8 and C1. Oscillator B is variable from 60 to 240 Hz. Oscillator C is variable from 300 to 3000 Hz, and oscillator D is variable from 30 to 300 Hz. The oscillators are arranged in a classical comparator-integrator configuration.

Taking oscillator A as an example, IC1A uses R1 and R2 to set the trip point at about 1/2. The output of this comparator connects to integrator IC1B, which in turn, connects back to IC1A's input. When IC1A's output is at -9 volts, IC1B linearly changes C1 through R8. Hence, the output of IC1B is a positive-going ramp. As soon as the ramp reaches Vc, IC1A changes to the positive state and IC1B linearly discharges C1 to initiate a negative-going ramp. When this ramp reaches -Vc/2, IC1A trips to the negative state and the cycle repeats itself.

Potentiometers are used to set the frequencies in the three variable-frequency oscillators by varying the charging currents. The outputs from the comparators (IC1D, IC2B, and IC2C) are symmetrical square waves, while the outputs from the integrators (IC1C, IC2A, and IC2D) are triangle waves. Resistor R10 in fixed-frequency oscillator IC1A/IC1B sets the amplitude of the two waveforms. Level controls are provided for all but oscillator C. Oscillator C has no level control because only one signal need be variable if both signals go to the inputs of a multiplier to cause the output of the multiplier to vary.

The square-wave output from oscillator A is differentiated by C2 and R6 to create a sync pulse. This pulse is fed to the inverting (+) input of IC2B to force oscillator C's operating frequency to be an exact multiple of the operating frequency of oscillator A. To sync the remaining oscillators, the triangle-wave output from oscillator A is attenuated by R4 and R5 and fed to the inverting inputs of IC1O in oscillator B and IC2C in oscillator D. The 60-Hz triangle wave forces oscillators B and D into exact sync. Resistor R7 in oscillator A makes the square and triangle waves in this oscillator equal in amplitude. Switches S1 through S4 provide means for selecting the desired waveforms.

Integrated circuit IC4 is an op amp follower, used here to reduce the source impedance to hopper-type multipliers IC3B and IC3D. In this type of multiplier, a bipolar transistor or JFET is used to switch the op amp between a noninverting (+) and an inverting (-) unity-gain buffer. This switching action results in suppression of the carrier, and the output of IC3B is a balanced four-quadrant signal.

The signal from oscillator C is shifted in-phase by +45° in network C9-R24 and by -45° by network C10-R25. So, the waveform to each JFET (Q1 and Q2) is out-of-phase resulting in a modulated output from the multiplier also being out-of-phase. Networks C5-R16 and C7-R8 provide dc restoration for Q1 and Q2.

The output from multiplier IC3B is summed with the signal from oscillator D in adder IC3C. Finally, the outputs from the two adders are led to the oscilloscope to form the complex Lissajous patterns.

Power is supplied to the Artist by two standard 9-volt batteries (B1 and B2). Capacitor C8 aids in reducing instability in the IC op amps.

**Construction.** The project can be built on either printed circuit or perforated board. The actual-size cutting and drilling guide and components-placement diagram are shown in Fig. 3. After preparing or buying a ready-to-use pc board (see Parts List for supplier), mount the components on it as shown in the placement diagram, paying particular attention to the orientations of the IC's and transistors. Place R1 and R2 on the blank end of the board, terminals pointing away.
the remaining oscillators, forcing them to run at an exact multiple of the syncing frequency.

In addition to using the controls on the project, you can also use the vertical- and horizontal-gain controls on the scope to adjust the width and height of the images.

**Circuit Details.** As shown in Fig. 2, the four oscillators are identical except for their frequency-determining elements. Oscillator A is fixed at approximately 60 Hz by R8 and C1; oscillator B is variable from 60 to 240 Hz; oscillator C is variable from 300 to 3200 Hz, and oscillator D is variable from 300 to 3000 Hz. The oscillators are arranged in a classical comparator-integrator configuration.

Taking oscillator A as an example, IC1A uses R7 and R2 to set the trip point at about $+V_c/2$. The output of this comparator connects to integrator IC1B, which in turn, connects back to IC1A's input. When IC1A's output is at $-9$ volts, IC1B linearly charges C1 through R8. Hence, the output of IC1B is a positive-going ramp. As soon as the ramp reaches $V_c/2$, IC1A changes to the positive state and IC1B linearly discharges C1 to initiate a negative-going ramp.

Triangle wave forces oscillators B and D into exact sync. Resistor R7 in oscillator A makes the square and triangle waves in this oscillator equal in amplitude. Switches S1 through S6 provide means for selecting the desired waveforms.

Integrated circuit IC4 is an op amp follower, used here to reduce the source impedance to chopper-type multipliers IC8 and IC9. In this type of multiplier, a bipolar transistor or JFET is used to switch the op amp between a noninverting (+) and an inverting (-) unity-gain buffer. Transistor Q7 serves this purpose in this circuit.

When the signal in oscillator C goes positive, Q7 conducts and IC8 inverts to an inverting amplifier. When oscillator C goes negative, Q7 starts to cut off, and IC8 becomes a noninverting amplifier with unity gain. This switching action results in suppression of the carrier, and the output of IC8 is a balanced four-quadrant signal.

The signal from oscillator C is shifted-in-phase by $+45^\circ$ in network C9-R24 and by $-45^\circ$ in network C10-R25. So, the waveform to each JFET (Q1 and Q2) is out-of-phase, resulting in a modulated output from the multiplier also being out-of-phase. Networks C6-R26 and C7-R27 provide dc restoration for Q1 and Q2.

The output from multiplier IC3B is summed with the signal from oscillator A in adder IC3A. The output from multiplier IC3C is summed with the signal from oscillator D in adder IC3D. Finally, the outputs from the two adders are fed to the oscilloscope to form the complex Lissajous patterns.

Power is supplied to the Artist by two standard 9-volt batteries (B1 and B2). Capacitor C9 aids in reducing instability in the IC op amps.

**Construction.** The project can be built on either printed circuit or perforated board. The actual-size etching and drilling guide and complete placement diagram are shown in Fig. 3. After preparing or buying a ready-to-use pc board (see Parts List for supplier), mount the components on it as shown in the placement diagram, paying particular attention to the orientations of the IC's and transistors. Place B1 and B2 on the blank end of the board, terminals pointing away from the components, and fasten them in place with loops of wire passed between the batteries. Temporarily set aside the board assembly.

Next, machine the front panel for the six potentiometers, five switches, three binding posts, and a No. 6 machine screw. The last hole should line up exactly with the large hole in the pc board assembly. Mount the pots, switches, and binding posts in their respective locations (see Fig. 4). Pass a 6-32 x 2" machine screw (to support the circuit board assembly) through the remaining hole, slip over its threads a length of plastic spacer, and follow with a No. 6 machine nut. The spacer should be just long enough that, when the nut is in place, about $1/2$ of screw thread is still visible. Label the controls, switches, and binding posts.

Referencing back to Fig. 2 and Fig. 3, finish wiring the project.

**Operation.** The oscilloscope used with the Graphic Artist must have an external horizontal input. Connect test-lead cables from the output binding posts on the Artist to the appropriate inputs on the scope. Set all waveform switches to triangle. Switch on the project and scope.

Set time LEVEL B control fully counterclockwise because oscillator B connects to both multipliers, making LEVEL B zero eliminates the modulated component on the screen. You should now see a simple rectangular or square Lissajous pattern. Adjust the horizontal- and vertical-gain controls on the scope so that, when LEVEL A and LEVEL D controls are set to midrange, the image just fills most of the screen.

Slowly turn up LEVEL B. This adds the modulated waveform to the existing horizontal and vertical traces on the image. You should now have a display similar to those shown in the photos. The next thing we can do is alter the Lissajous "family" by using combinations of the waveform switches. For example, switching WAVEFORM A to the square-wave position and setting WAVEFORM B to the triangle-wave position causes the image to break up into separate shapes. There are 16 combinations for the four waveform switches. Add to this the effects of the six HARMONIC and LEVEL controls, and chances are you will never see the same pattern twice.

After you've familiarized yourself with the operation of the controls (it does take some skill), you might try connecting a pair of stereo headphones to the output channels. The sounds of the four oscillators mixing and adding produces beat notes that are fascinating in themselves. You can even "play" the sounds by twisting the various controls.

Some very different and interesting effects can be produced by running the Graphic Artist in reverse. Take a signal from an external source, such as an electronic organ, and connect it in place of one of the oscillators. You can do this by disconnecting one waveform switch input and connecting your source in its place. Choose your notes to be exact even or odd harmonics of oscillator A, which operates at approximately 60 Hz. The images will appear to stop their motion and their actual shape will depend on the particular waveform of the note being played.
A NYONE who works with modern electronic circuits, whether he is a professional or an amateur, will eventually require a closely regulated variable power supply. While most power supplies are regulated directly from the basic rectifier and filtered dc line, tighter regulation can be obtained by using a pre-regulated approach in the supply's design.

The pre-regulated power supply described here can be built for about $15 more than you would have to pay for a conventionally regulated low-current supply. It employs two inexpensive 705 voltage regulator ICs in a circuit that can deliver 3 to 35 volts dc at load currents up to 3 amperes. The design eliminates the need for massive heat sinks and cooling fans.

How It Works. The power supply's circuit shown in Fig. 1 can be functionally diagrammed as an ac source, rectifier bridge, and two voltage regulators in series. The pre-regulator, by means of IC1, continuously controls the potential at C1 so that the potential across Q1 remains constant. The output regulator (IC2) is a high-performance circuit that is capable of providing 0.1% regulation.

Synchronized to the 120-Hz rectified ac input, pre-regulator integrated circuit IC1 is connected as a time-delayed pulse generator that controls the gate of SCR1 to trigger conduction at the exact point required during each half cycle. The bias voltage applied to the inverting input (pin 2) of IC1 is adjustable via potentiometer R9; it determines the reference level for the supply.

The zener-regulated source at pin 4 of IC1 also supplies current through R14, R15, and R18 to C4 and pin 3 (noninverting input). The current continues to flow until the reference voltage is reached. At this point, IC1 turns on. The resulting square-wave pulse from pin 6 of IC1 is limited to 9 volts by current-sensing resistors R12 and R13, which is sufficient, at the gate of SCR1, to trigger the SCR into conduction.

The RC time constants in the circuit are controlled by the amount of current flowing through Q2, which, in turn, depends on the error voltage present at the wiper of R10A. A voltage divider consisting of R16 and diodes D7 through D10 applies a relatively constant 2.4 volts to the emitter of Q3 so that when the transistor's base goes above 3 volts there will be a voltage drop across R14 and a corresponding change in the RC time constant. Capacitors C5 and C6 stabilize the operation of Q3 to prevent SCR1 from firing erratically. When R10 is rotated counterclockwise, R17 and D13 protect Q3 and D12 from damage.

The method of synchronizing IC1 to the rectified input is graphically shown in Fig. 2. Triggered into conduction by the positive-going voltage, SCR1 cuts off when the gate signal ceases and C4 discharges sufficiently to reduce to a minimum the holding current to the SCR. The diagram also reveals why the secondary voltage from T1 must be greater than would be normal in a conventionally regulated power supply. The SCR cannot conduct until its anode is more positive than its cathode. Simultaneously, a minimum latching current must flow. Also, SCR1 must remain conducting until the energy drawn from C1 by the output load is replaced.

Since the potential across C1 will be 41 volts at maximum output, the 18-volt difference allows the time interval necessary for maximum current. This also means that SCR1 fires only near the peak or on the negative-going side of the waveform. Resistors R1 and R2 are biasers that carry the minimum holding current required by SCR1.

Dual potentiometer R10 establishes feedback to both voltage regulator ICs. (A wire-wound potentiometer is best where the indication requires that the sections will be more evenly matched. So, if an identical voltage were present across each section of the pot, the wiper voltages would be very nearly the same at any setting.) Potentiometer section R10B samples the output voltage and drives IC2 in the proper direction to maintain 3 volts between wiper and ground. The section of the pot samples the voltage across C1 and controls the firing of SCR1, also maintaining 3 volts between wiper and ground.

Since the potential at the counter-clockwise ends of R14 and R10B must be the same, the potential across IC1 is always equal to the input voltage. Therefore, the output voltage is exactly equal to the input voltage, regardless of load. IC2 will continue to conduct as long as the sum of the output voltage and the minimum holding current to the SCR is greater than the 18-volt difference.

C1 will be 6 volts greater than the output because of the action of D12. Any change in the output voltage and/or current will affect the firing-pulse timing at the gate of SCR1, maintaining a constant potential across Q1.

Construction. The easiest way to assemble the power supply is by using a printed circuit board. (See Fig. 3 for actual-size etching and drilling and component placement guides.) Alternately, you can assemble the circuit on perforated board using solder clips and sockets. Whatever method you use, refer to the table in Fig. 3 for instructions on how to interconnect the circuit board assembly and the components.

Fig. 1. Power supply employs two voltage-regulator ICs for super stability.

PARTS LIST

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<thead>
<tr>
<th>Component</th>
<th>Value</th>
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<td>C1-C4</td>
<td>1000-µF, 10-volt electrolytic capacitor</td>
</tr>
<tr>
<td>R1-C10</td>
<td>100,000-ohm, 1/4-watt carbon resistor</td>
</tr>
<tr>
<td>R11-R12</td>
<td>1000-ohm, 1/2-watt wirewound resistor</td>
</tr>
<tr>
<td>D1-D7</td>
<td>1N4148 diode</td>
</tr>
<tr>
<td>Q1-Q2</td>
<td>2N5401 or similar</td>
</tr>
<tr>
<td>IC1-IC2</td>
<td>705 voltage regulator</td>
</tr>
<tr>
<td>CR1-CR2</td>
<td>20V, 1N5819 diode</td>
</tr>
<tr>
<td>CR3-CR5</td>
<td>2N2223 transistor</td>
</tr>
</tbody>
</table>

SEQUENCE OF EVENTS

A. SCR2 fires as C7 charges; C4 then discharges and SCR1 cuts off.
B. D13 limits voltage on C7; SCR2 cuts off and C4 begins to charge.
C. C4 has charged above reference level at pin 2 of IC1, causing the IC to conduct; a trigger pulse at pin 6 turns on SCR1 through C11.
D. SCR1 current decreases as IC1 voltage increases. When voltage across SCR1 is insufficient to maintain about 10 mA current, SCR1 turns off. Note. SCR1 turns on and off at approximately C7 and C11 voltages, when the output load is drawing 3 amperes at 35 volts. With no external load, events C and D occur near the end of the wave as indicated by the unmarked dots.

Fig. 2. Events occur left to right on curve.
Heat sink.

Remaining hole with heat holder through chine components located from foil. Select large-sink assembly.

Components of the mount a front lamp cord.

Q1 of supply that place. Line the SCR1 printed-board components.

There should be a voltage reference. SCR1 fires regularly and the meter indicates 9 volts at TP2. When R10 is rotated fully clockwise, the meter should indicate 41 volts at TP2.

Temporarily short out R5 and momentarily connect a 12-ohm, 120-watt resistor (or an equivalent combination) across the output via BP1 and BP2. If the TP2 reading drops more than 0.2 volt or SCR1 fires intermittently, adjust R9 only enough to correct. Then, with no load connected to the output of the supply, rotate R10 counterclockwise. The reading at TP2 should slowly decrease to 9 volts. If it does not, adjust R9 for a higher voltage at pin 2 of IC1 until it does.

Rotate R10 again and apply the load, compensating for the voltage drop by adjusting R18. There will be some combination of the two adjustments that will permit Q3 to retain control over IC1 throughout the specified voltage and current ranges. To do this, Q3 must always be forward biased. If at any time Q3 does not draw the proper current from R14, it has lost control.

Correct alignment will be achieved when the voltage at the wiper of R10A is the same at any output. As a further test, connect the meter across Q7 and note the voltage change when R10 is rotated clockwise. Any difference would correspond with D12's zener voltage characteristics at bias currents of from 1 to 7mA.

Circuit Operation. As shown in Fig. 1, the Logic Alarm uses a simple 74L86 low-power quiet exclusive-OR gate that receives power from the car's 12-volt line (negative ground) regulated by a 5-volt zener diode. The IC has four separate gates, each producing an output if its two inputs are in opposite states. A gate will not deliver an output if both inputs are simultaneously high or low.

The 74L86 is used because it is a low-power device requiring only 3 mA. It is not a pin-for-pin replacement for the conventional TTL 7488, which requires more current. The 7488 could be used if the circuit is changed to suit the different pin arrangement, the value of R9 is changed because of greater current flow, and a switch is added to turn off the 12-volt supply when not needed.

The outputs of the four gates pass through diode isolators to a solid-state alarm (another low-power device).

For the headlights-on/ignition-off circuits, the inputs of gate A are held high by the supply through R7 and R2. With the headlights off, D1 and D2 conduct, maintaining the stable status of gate A. However, with the headlights on and the ignition off, D3 conducts and input 2 to the gate drops, providing an output from the gate.

The oil-pressure (gate B) and temperature (gate C) circuits are identical. One side of each gate is coupled to the ignition through D4 and D6, respectively so that they are in a high state when the ignition is on. The pressure and temperature sensing signals should also be high when the engine is running. Thus there are no outputs from these gates. When the vehicle is first entered and the ignition is turned on (prior to starting the engine), the oil-pressure and temperature sensors will be "cold," and the alarm will sound. This serves as a sys-tem test. (If the car has instrument-panel lamps for these functions, the Logic Alarm will provide a warning even if one of the lamps fails.)

MODERN cars have warning systems that monitor various conditions in the engine, lights, etc. One such system is the buzzer that sounds when the driver's door is open with the key still in the ignition. There are other conditions that can also be monitored if you install the Logic Alarm described here. These include: leaving the headlights on when the ignition is turned off, leaving the ignition on when the oil pressure is low, and leaving the ignition on when the engine is overheated. (As options, the brake and seat-belt warning light circuits can be monitored.) An extra advantage of the Logic Alarm is that the raucous buzzing of most door warning systems can be replaced by a more pleasing audio tone.

BUILD AN AUTOMOBILE LOGIC ALARM

Simple circuit monitors five electrical points in the car and sounds an alarm when the wrong conditions occur.

BY ROBERT GRATER

Fig. 1. Points to be monitored are connected to exclusive OR gates through diodes.

PARTS LIST

A—Tone generator (Malory Semiconductor SC-43 or similar) D1 to D2—Diode (1N914 or similar) D3—5.5 V, 0.1 W zener diode (NEP ZO-212 or similar)

I.C.—Quad exclusive OR gate (74L86)

R1 to R4—100,000 or 1-W resistor

Misc.—14-pin DIP socket, pc or perforated board, wire for connections, mounting hardware, etc.

Note: The following are available from RGS Electronics, 1360 Charles St., Suite K, Santa Clara, CA 95050 kit of parts including pc board but not Semiconductor $6.35 including postage and handling; pc board alone at $2.50.
Crown
The Known Value...
at an unconditional price...

An honest value isn't hard to find, if you know
as honest supplier. CROWN's reputation for
providing more recorder value for your dollar
is as old as our company. Nothing would ever
cause us to change that.

CROWN recorders offer you day-in, day-
out worry-free reliability, plus brilliant perfor-
mance. Both result from simple, rugged
design, with only a few moving parts. The
CROWN belt drive and massive flywheel
almost completely isolate the capstan drive
from any vibration or hum.

CROWN electronic circuits are carefully
designed for maximum reliability, and elec-
tronic components are thoroughly tested
before assembly. Oversee meters and easy-
to-handle-controls make operation simple.
The result? A professional tape deck, used
to produce quality recordings in many a studio.

Each CROWN transport has undergone
100 hours of testing. Each CROWN record-
er has its own performance report, signed, and
stamped, by a CROWN inspector. And each
CROWN recorder is backed by a one-year full
warranty on parts and labor, and an additional
two-year limited warranty on parts only. We
put the CROWN name on those recorders
prudently—we believe they've earned it.

Why not give our CROWN dealer a call. CROWN
dealers talk about the long-term values of a
CROWN record, and the unconditional price.
It could be the year's best buy.

For more details, consult your local CROWN
dealer or write us for his name. CROWN, Box
7000, Elkhart, IN 46514

Fig. 2. Etching and
drilling guide for pc
board is shown below;
component layout at left.

The +12 volts used to power the
alarm can also be obtained from the
fuseblock. The alarm can be wired
permanently to the supply since the
power consumption is so low. Using
the fuseblock to pick off the various
signals allows the application of con-
venitional automotive snap-in connec-
tors sold at most automotive supply
stores.

The oil-pressure and temperature
pitchoff points can be made as shown in
Fig. 3A, using an insulated connec-
tor.

The circuit from the ignition key
must be located with the voltmeter
and should be at 12 volts as the key
is in the switch. Fig. 3B shows the buzzer
circuit used in the GM type—others
are similar. The buzzer is in the horn
relay enclosure and is pro-
vided through the key switch and door
switch. Remove the wire marked
with an X in Fig. 3B and connect it to
the ignition key sensing.

Construction. The Logic Alarm can
be assembled on a pc board (Fig. 2) or
wired point-to-point on perforated
board. The board assembly can be
connected directly to the ignition
switch through C8. Thus when the ignition
key circuit goes to ground with the key
in, one input is low, causing the alarm
to sound.

Wiring. The headlight sensing point
can be picked up either at the fuse-
block or the headlight switch—or on the
headlight wire using an insulated
connection. Use a dc voltmeter to make
sure that this point is at 12 volts when the
lights are on.

The best place to get at the ignition
circuit is at the fuseblock. Use a dc
voltmeter to locate a circuit that is at
12 volts when the ignition is on.

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Product Test Reports

International Audio Designs is an unfamiliar name in the hi-fi marketplace, but the company's Model B3A dynamic range expander should have a wide appeal for audiophiles who wish to restore some of the dynamism lost in many compressed tape and disc recordings and FM broadcasts. The expander can add up to 15 dB of dynamic range to a recording, and variations are absolutely undetectable while listening to a program.

When Shure Brothers announced a new phono cartridge, you can be sure that it is designed to fill a definite need in the marketplace. The Model M97D has the flat, uncolored sound of the highly respected Shure V-15 Type III at a price most audio designs can afford.

Yamaha, a company well-known for its motorcycles, has only recently had its audio products achieve a telling fame on the hi-fi scene. The company's Model CR-800 stereo receiver does almost everything you could require of a deluxe receiver. It performs more like the most refined separates than like a compact, reasonably-priced receiver.

—Julian D. Hirsch

IAD MODEL B3A DYNAMIC RANGE EXPANDER

Restores dynamics to compressed recorded material.

ABOUT THIS MONTH'S HI-FI REPORTS

The manufacturer's warranty covers defects in material and labor for a period of three years from date of purchase. The retail price of the expander is $275.

Technical Details. The design of the expander must choose the appropriate attack and release time constants, as well as the slope of the expansion curve, to avoid any objectionable artifacts. The attack time must be sufficiently fast to avoid any objectionable artifacts.

The expander is housed in a attractive black plastic case with thick clear plastic and plates. The case measures 12L x 5D x 3H (30.5 x 13.3 x 9.5 cm) and weighs 3 lbs (1.4 kg).

International Audio Designs has recently introduced a novel dynamic range expander whose operating parameters (as well as its physical size) are radically different from those of other expanders we have used. The Model B3A, as with other expanders, is designed to restore some of the program dynamics that are inevitably lost in any compressor/processor recording or broadcast program. The expander is housed in a attractive black plastic case with thick clear plastic and plates. The case measures 12L x 5D x 3H (30.5 x 13.3 x 9.5 cm) and weighs 3 lbs (1.4 kg).

The expander is controlled by a potentiometer that is used to adjust the sensitivity of the expander to the program material. When the control is set to 0, no expansion occurs. When the control is set to its maximum value, the maximum amount of expansion occurs.

An A/B comparison of the car's performance at 40 miles per hour with the factory suspension and the suspension of the expander in action shows a significant improvement in the ride quality. The expander is an excellent addition to the car's suspension system.

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The expander is an excellent addition to the car's suspension system.
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Use as 3 half-wave directors on the high end of the band, and re-responds as a loaded half-wave director on the low end and all band. This results in high gain on all UHF channels, giving the antenna sharper directivity and up to 30% more gain over other high gain UHF antennas.

Typical gain curve with ordinary UHF directors. Note low response on low end of band.

Typical gain curve with Winegard Tri-Linear directors. Note high uniform gain across entire band.

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NOVEMBER 1975
SHURE MODEL M9SED STEREO PHONO CARTRIDGE

Moderately priced, it has "sound" of more costly V-15 Type III.

The new Shure M9SED stereo phono cartridge, falls between the company's top-of-the-line V-15 Type III and its moderately priced Model M9ED. The new cartridge has a pole piece that is similar to Type III, although it is not constructed of lami- nated elements. The design makes possible a lower winding inductance, which results in a flat frequency response that is almost identical to that of the Type III. A low stylus mass of 0.5 mg promises excellent high-frequency "trackability."

The physical appearance of the cartridge is similar to that of the Type III, including an integral swing-away stylus guard as part of the replaceable stylus assembly. The trackability of the cartridge throughout the audio range is such that its nominal operating force of 1 gram is about equal to the Type III operating at 0.75 gram.

The retail price of the Shure M9SED stereo phono cartridge is $99.55.

Laboratory Measurements. We installed the cartridge in the tonarm of a high-quality record player for our tests. Operating the cartridge at a 1 gram-tracking force, we soon discovered that it was able to track very high velocities at low and midrange frequencies on our Cook and Fairchild test records. According to the test record, produced by the German Hi-Fi Institute, the cartridge tracked the record with a 30-micrometer amplitude without distortion at 1 gram. At its maximum rated force of 1 gram, it was able to track the 90-micrometer bend on the record. (Most fine cartridges can track 60 to 70 micrometers, but few can cope with the higher levels.)

High-frequency tracking ability tests using the special 10,000-Hz tone bursts of the Shure TR-103 test record revealed the excellence of the cartridge's high-frequency performance. Tracking distortion was on a par with the best cartridges we have tested. As a more conventional intermodulation-distortion (IM) measurement with the Shure TR-101-recommended 400 to 4000 Hz tones indicated that the IM was only 2% maximum up to 22,000 Hz.

The output from the cartridge at 3.5 cm/second was 4.3 mV/channel. This stylus M9SED's resonance at 20,000 Hz revealed itself as a ringing of several cycles on a 1000-Hz square wave signal from the CBS STR-111 test record.

Initially, we tested the cartridge's frequency response with the periphery cable and tonearm capacitance of the record player (200 pF, which is typical for many players). The response had a peak of about 4 dB at 16,000 Hz. Since Shure recommends a load capacitance of 400 to 500 pF for flatest response, we added capacitance to bring the total to 440 pF and measured the response again. The results was nearly flat, varying +2 dB from 40 to 17,500 Hz and dropping to -4 dB at 25,000 Hz. The resonant frequency was 150 Hz, which is not at all unusual for a tonearm-mount cartridge. Repeated tests on both channels, was better than 30 dB at frequencies below 2000 Hz and gradually reduced to 200 Hz. The response was 174% W 11"x12" x 6 1/4" (45.3 x 29.8 x 15.9 cm) and weighs 31 pounds (14 kg). It retails for $540.

General Description. The relatively short FM dial scale is linearly calibrated at 0.5 kHz intervals. To the left of the scales are the FM zero-center and AM/FM relative signal strength meters, the latter calibrated logarithmically over a 100-dB range. Three red LED's to the right of the scale indicate when the receiver is on, when a station is tuned in, and when a stereo-FM transmission is being received.

The large tuning knob is located to the right of the dial window. All other controls are located on the lower half of the receiver's front panel. Lever switches are provided for controlling receiver power, a 20-dB audio attenuator for temporary level reduction, stereo-in/mono switching, and treble/bass filters. Three-position, center-switched switches are used for the filters.

Here's where the center permits manual adjustment of the center's choice of 25 or 70-Hz cutoff frequency, with a 12-dB/octave slope. When the high-cut filter is in its down position, it introduces a 9-28-dBattenuation beyond 8000 Hz. In the up position, it partially blunts the high audio frequencies to reduce noise on stereo programs.

The center positions of both switches dissable the filters. Many receivers use this setting for "live" or the nominal for FM or AM stereo. As this receiver is new, we find the first we have seen to apply it to all programs.

The bass and treble controls have 11 detented positions. The balance control is a center-detented ring concentric with the volume control. A separate loudness control, also with 11 detented positions, provides bass and treble boost as it lowers the midrange level. It is used in conjunction with the volume control to provide correct low-level volume compensation that is independent of the setting of the volume control. A separate microphone volume control, with an off position, is provided for adjusting the level from a microphone plugged into a jack.

The other controls are rotary switches, operated by bar knobs whose settings can be seen at a glance. One switch is for activating either, both, or neither of two pairs of speaker systems connected to the receiver's outputs. Another is for controlling the level of the 20-dB audio attenuator or the receiver's audio output. The position, the selective sensitivity switch, and the center detent. The first position, the center detent, and the center detent. The first position, the center detent, and the center detent is heard through the speaker systems. Moving it to one position to either side of the center detent permits manual adjustment of the center's choice of 25 or 70-Hz cutoff frequency, with a 12-dB/octave. When the high-cut filter is in its down position, it introduces a 9-28-dBattenuation beyond 8000 Hz. In the up position, it partially blunts the high audio frequencies to reduce noise on stereo programs.

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Heath proudly introduces MODULUS. The totally modular music system that enables you to make it your own. Just what you will, change it when you like. With complete freedom. Without obsolescence. Without fear of becoming obsolete. As you like it. Performance and versatility lies in the choice of separate components, yet with the convenience of an integrated system.

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Put Hum and noise are 80 dB below a 1000 Hz input, 20 mV input even in the highest gain position. A phono preamp with over 94 dB dynamic range. Sensitive, better than a phono preamp. Versatile control center. Special speaker protecting circuitry. Four lighted output meters with 40 dB dynamic range. Sepe- rate bass, treble, and level controls for front and back channels. Master volume control. 21 pushbutton switches that light when activated. They include: output, input (stereo phone, CD-4, aux. tape, tape monitor, dubbing AM and FM); speaker, stereo front channels, stereo (4 channels, SQ, and discrete 4-channel); high filter; low filter; loudness; tone flat, squelch defeat; FM Dolby; and power. Use it as a tuner only, as a driver for your present power amp, as a control center for taping, so good you can even use it as a broadcast station monitor. Kit AN-4026, $59.95.

Expand your MODULUS system with your choice of stereo power amplifiers. Module II is the medium power AA-1505. Module III is the high power AA-1506. 35 or 60 watts, min. RMS, per channel, 8 Ohms. Less than 0.1% distortion from 20-20,000 Hz. Wired to match the Module II Tuner. Input greater than 0.5 mV for AM-4026, $159.95. AA-1506, $179.95.

Choose your model and input Module IV is the FM Dolby module AD-1604 for reduced noise and greater dynamic and broadcast sound range ($39.95). Module V is the CD-4 Demodulator for the spacing sound of CD-4 discrete 4-channel records ($79.95). Module VI is the SQ Di- coder for quadraturephonic separation of matrixed material, full logic and variable bandwidth ($49.95). All are housed inside the tuner/preamp module.

A "Living" music system. MODULUS is designed for you - the way you live - today and tomorrow. It can grow with you, adapt to your changing life style, ties with changing technology. Whatever your desires in music systems, now and later, MODULUS.
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There are antenna inputs for 300- and 75-ohm FM, AM, and VHF-UHF in our experience with receivers and amplifiers.

Laboratory Measurements. The measured performance of our test receiver speaks for itself. In virtually every respect, the receiver far surpassed its published ratings!

With both channels driven into 8-ohm loads at 1000 Hz, the audio outputs clipped at 61 watts/channel. Into 15-ohm loads, clipping occurred at 50 and 41 watts/channel, respectively. The THD at 1000 Hz was below the noise level up to several watts output. It measured less than 0.03% from 0.7 to about 60 watts output. The IM distortion was less than 0.03% from 0.1 to 30 watts, reaching 0.05% at 60 watts output. (The conservatism of the receiver's ratings is illustrated by its rated 45 watts/channel from 20 to 20,000 Hz at less than 0.1% THD.)

At the rated 45-watt output, the distortion was less than 0.03% from 20 to 20,000 Hz, typically measuring less than 0.015%. It was roughly the same at half power and even at one-tenth power did not exceed 0.05% over the full audio range.

The 80-watt power output required an input of 57 mV at the AUX, 1.2 mV at the PHONO, and 1.1 mV at the mic inputs. The respective unweighted S/N figures were 80, 78, and 74 dB, referred to 10 watts. These represent exceptionally quiet conditions, especially through the low-level phono and mic inputs. The phonograph preampl output was at a very high 250 mV, while the microphone preamp output loaded at 700 mV—a new high for our experience with receivers and amplifiers.

The receiver easily handled the one-hour testing period at one-third power before the distortion and power measurements were made. Even more remarkable, it was accidently subjected to 30 minutes of severe overload, driven into hard clipping on both channels, without suffering any damage.

The RF 3rd-order intermodulation was accurate to within ±0.5 dB from 30 to 20,000 Hz. It was affected by cartridge harmonics to about the same extent as most good amplifiers and receivers, with a reduction of output at 15,000 Hz of 1 to 2 dB, depending on the specific cartridge used.

The filters had the rated characteristics, with excellent low-cut action but a gradual high-frequency rolloff that was of little use in this reduction. The tone controls had considerably more range at the low than at the high frequencies, the former with a sliding in-

connect the recording machine to the phone output. (The normally selected program source is not heard in this mode.) Finally, the desired program source is selected by a switch with positions for AUX, two magnetic phono cartridges, FM with and without interstation noise muting, and AM. A headphone jack is located below the microphone jack.

On the rear panel of the receiver are the various inputs and outputs, plus separate preamplifier outputs and main amplifier inputs that permit independent operation of the two receiver sections or insertion of accessories (active equalizer, active cross-over system, etc.). The inputs are normally joined to the output in pairs by an adjacent slide switch. The speaker outputs are insulated spring clips. An if our jack is pushed up the one, but not use with a 4-channel FM adapter. In spite of its nomenclature, it is apparent a detector does not receive stereo signal without deemphasis.

There are antenna inputs for 300- and 75-ohm FM, AM, and VHF-UHF in our experience with AM antenna, plus a pivoted ferrite rod

The AM microphone preamp has a variable sensitivity measured 20.0 V/m. The 50-kHz quieting sensitivity is 3.0 V/m. The stereo switching threshold is above 1000 Hz. The distortion was about 0.015% in both mono and stereo. The FM capture ratio was an outstanding 0.9 dB and the AM rejection was far above average at 70 dB. Similarly impressive measurements were obtained for image rejection (70 dB) and alternate-channel selectivity (88 dB). The 19-kHz pilot carrier leakage into the audio outputs was unmeasurable, being more than 8.5 dB below the 100% modulated program level. The stereo FM frequency response was literally ruler-flat, with a variation of less than ±0.3 dB from 30 to 15,000 Hz. This is especially noteworthy in view of the pilot carrier rejection of the receiver, since most tuners use low-pass filters for rejection to prevent apparent attenuation at 15,000 Hz.

The stereo channel separation exceeded 40 dB from 30 to 750 Hz and 50 dB from 150 to 1500 Hz. It was still a healthy 33 dB at 15,000 Hz.

The AM frequency response was down 6 dB at 140 and 3300 Hz.

User Comment. As the laboratory tests reveal, this is a receiver that involves the use of superlatives. For example, the FM tuner performance comes close to matching that of the $1200 Yamaha Model CT-7000 FM tuner and is far better than what we would expect from a receiver at any price. The convenient FM tuning system features an AFC Circuit that defeats the so-called 'killer knob' and does light the AFSC/SCANLED on the dial when a signal is properly tuned. Releasing the knob permits the AFC to gradually come on, bringing the LED to full brilliance. Although AFC is certainly not needed to correct for drift, which is essentially nonexistent, it makes the tuning procedure simpler than it would otherwise have been.

The dial calibrations were very accurate and easy to read against the Mount-Edison hairline on the movable illuminated plastic indicator. The tuning meter gives a useful indication of relative signal strength, from levels too weak to operate the muting system to the highest that will ever be encountered. All the controls operate smoothly and with positive action, and a total lack of unwanted electrical transients must be experienced to be appreciated.

The FM muting system is one of the best we have used. It had no trace of thumps or noise bursts. As with most stereo receivers, the AM section of the Model CR-800 is below "hi-fi" quality, with the contrast made even more evident by the superb FM performance of the receiver.

We usually take a dim view of loudness compensation systems, which tend to make everything sound boomy and unnatural. However, with the system in this receiver, we make an exception. When the control is set to maximum and the volume is set to the loudest level you expect to use, reducing the loudness control setting preserves a natural frequency balance. At the lowest settings, the compensation becomes rather great. Over most of its range, one is hardly aware of the action of the loudness compensation, which is as it should be.

Obviously, our experience with the Model CR-800 receiver has left us enthusiastic. There are a few other receivers whose quality is similarly above reproach, and we would not attempt to rank them in any order of preference. On the other hand, we can say categorically that we have never used a stereo receiver whose performance surpasses that of the Bearcat. There are CR-680 and 890 and significant respect. Other receivers might be more powerful or have some features lacking in this instrument, but there is no shame in sheer performance and attention to the finest details of human engineering that make it such a satisfactory product.

The Bearcat 101 from Electra offers something new in the way of a scanning FM monitor receiver. Highly advanced, it contains the latest in modern technology, including a sophisticated computer-type digital frequency-synthesis system that eliminates the need for plug-in crystals. The receiver provides scanning of 16 frequencies in the 30- to 50-MHz low-fi, 148- to 174-MHz high-fi, 416- to 450-MHz uhf, and 470- to 512-MHz T uhf Public Safety bands. Included in the coverage is the 146- to 148-MHz segment of the 2-meter Amateur radio band.

Any 16 out of more than 15,000 possible frequencies in these bands can be set up in any order or band combinations or be changed by the user simply by programming them from the front panel.

In operation, the appropriate r-f circuits for each band are automatically tuned for each frequency. This ensures peak performance over the entire range of each frequency.
The JOLT® Universal card is completely new. It's a blank you can use any way you wish, for control panels, T.V. interfaces, keyboards, L.O.G.'s, or any other internal interface logic, because the card's test holes are drilled to accept 14, 16, 24, or 40-pin sockets and have the same form factors as the other JOLT® cards. The single unit price is just $25.

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broad (there are no restrictions as to the band-coverge limits). Each channel can also be set up for automatic switching, one set at a time. In the scan delay or no delay at all at a particular channel.

Among the customary features to be found are LED channel indicators, manual automatic scanning, channel-dis-able, automatic scanning, channel-disable, adjustable squelch, volume control, front-facing speaker, tele-continuous with an antenna, jacks for external antenna and speaker, and terminals for connecting an accessory A kit consists of power con-verter and mounting hardware is available for mobile installations. Oper-ated on a 117-volt circuit line, the receiver draws 30 watts of power.

The receiver measures 7 1/4" X 7 1/2" X 3 1/2" (53 X 18.9 X 9 cm) and weighs 68 pounds (3.8 kg). Suggested retail price is $349.95.

Technical Details. The receiver employs a single-conversion design, to a 117-50 MHz. Selection is pro-vided by a six-pole monolithic crystal filter. High sensitivity, low noise, and good signal-handling capabilities are obtained by use of dual-gate MOSFET's in the r-f and mixer stages for the vhf bands. Uhf-band operation is optimized by a separate r-f and mixer system that uses bipolar transis-tors. IC's are used in the i-f, detector, and jf (including the output) stages. Each band to which the receiver is tuned has its own separate r-f cir-cuit. The circuits are automatically selected according to the frequency for which the working channel is set.

Tuning to each frequency is accom-plished by variable-capacitance diodes that are controlled by the pro-grammed information set up for each position switch. Hence, the sensitivity characteristics are uniform over the entire range for which the receiver can be set.

Our measurements, conducted with 50-ohms across the antenna input terminals, indicated a 20.38 dB sensitivity with a 0.35-ohm-0.4-µV input signal and 1/8-s of 0.75 µV on the lower bands. The sensitivity dropped off somewhat on the uhf bands.

The maximum extension of the tele-scopic whip antenna was 22Vi" (57.2 cm). This is quite short for a 30-50-MHz band. However, the effi-ciency is raised by an antenna-loading network that is automatically switched when in this range is used.

Frequency Synthesizer. Custom-designed MOS and TTL IC's are used for scanning at a rate of about 20 channels per second for the frequency-synthesis system. The synthesizer employs the method in which a standard reference signal is derived from a crystal-controlled master oscillator or clock. The local oscil-lator signal at the receiver's mixer is obtained from a voltage-controlled oscillator (vco). A v-co comparison signal, obtained via a programmable counter-type di-ver-ter system, is compared against the standard reference in a phase-detector, or discriminator. Any discrepancy detected creates an error voltage that shifts the vco frequency to the point where these two signals are locked in phase with each other. This results in the proper vco frequency according to the division ratio programmed for the de-termined channel.

The phase for the switch positions is programmed through a special 'non-volatile' memory system that retains the information even after power is removed from the receiver. Therefore, no reprogramming is ever necessary, unless channel frequencies are to be changed.

User Comment. The receiver is ini-tially programmed at the factory for 16 national frequencies. Reprogram raration from a choice of 6000 people-pre-signed Public Safety frequencies is easily accomplished by referring to the manual provided with the receiver. Tables in the manual indicate the re-quired operations for each frequency.

The logic for scanning is as follows: You push a READY switch, set all channels switches to their down position, and place the channel switch to the LED indicators to the channel number to be pro-gammed. Then, you push a particular channel switches as indicated in the tables for the desired frequency. (The only switch that is not pro-gammed is the one for the particular channel that can also be pro-gammed at this time.) Following this, you momentarily depress an ENTER-mentary-contact switch. Then, by phasing the receiver's switch to its up position, and placing the channel switches up for only those channels you want to scan, the receiver is pro-grammed to selectively scan.

Manual or automatic scanning is selected and controlled by a separate level switch. With manual scanning, any one channel can be kept open after the automatic scanning is resumed. There is no priority order.

The two-meter Amateur frequencies are entered in the manual's tables in multiples of 5 kHz, so the receiver's selectivity is broad enough to allow reception of local re-petition. However, using this table in-puts only two holes in the side of the set that line up when the instrument is on.

Our measured selectivity indicated a 10-kHz adjacent-channel rejection of better than 60 dB. Operationally, with the 148- to 174-MHz assigned channels at 15-kHz multiples, while a two-meter vician attempting to make a contact in our local police transmitter (located some 2½ blocks away) produced only 20% of the desired signal. It was apparent that no sig-nificant problems should be expected operating in this band.

Best signal efficiency is obtained from the use of an external antenna. The receiver is designed for a single plane designed for the particular fre-quency band you plan to use. How-ever, we appreciated good signal reception using only the whip antenna supplied with the receiver at our third-floor in-put location from signals originating 40 or so miles away.

The output power from the audio section was 2 watts, with 3% distortion from a 1200-Hz sine-wave signal. At 3 watts output, the distortion rose to 10%, and the waveform exhibited slight clipping. Audio intelligibility from the front-facing speaker was good to excel lent.

LECTROTECH MODEL BG-10 COLOR GENERATOR

Battery-powered, miniature generator for field servicing.

There isn't even a power switch per se. To apply power, a mechanical lock-set mechanism at the generator's case must be squeezed, while the bottom of the case is being slid off to a leaf switch when the case is opened, closing the contacts. When the case is shut, the cam disengages and opens the leaf switch. A direct LED on the control panel comes on. The locking mechanism prevents the case from accidentally opening and running down the batteries, while a mechanical stop prevents the bottom half of the case from sliding all the way out.

The test leads for the generator are permanently in. They are virtually invisible. You can move them away to fit into a small well in the instrument's case. Since it is necessary to be ready to open the case to get at the test leads, power comes on automatically and the instrument is ready to use. The r-f oscillator in the instrument is factory tuned to Channel 4. It can, how- however, be adjusted with a tuning switch to tune to any other TV Channel 3 or 5 if preferred. Access to the tuning slug is provided through a hole in the side of the case that line up when the instrument is on.

User Comment. This miniature color generator can do virtually every-thing the full-sized instruments can do. The major advantage to the se-rvice technician is that it is not as much as the full-sized color generator of five years ago, but that it is smaller, cheaper, and will fit in a boxy caddy without taking up vital space for other supplies and tools.

We used it on a number of service calls and can honestly report that it was a great convenience in terms of getting it to the job and performance on the job. The fact that this is a battery-powered instrument was greatly appreciated, since an ac outlet is often not available.

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Calculators chips for other circuits

U
dicous and relatively inexpensive, calculator IC’s (popularly called “chips” by engineers) are suitable only for the assembly of pocket and desk calculators. Right?

Wrong! More and more circuit designers are using these devices in noncalculator applications and, while unlikely as it may seem, one day they may be used almost as extensively in other type of equipment as they are in calculators today. Some calculator chips have such powerful capabilities, in fact, that a number of original equipment manufacturers are considering their use in specialized instrument and control systems in place of minicomputer subsystems and expensive microprocessors. One industry executive has predicted that by 1977 not less than 20% of the total calculator chips manufactured will be used in commercial equipment and systems rather than in conventional calculators.

Calculator chips can be used to assemble computers; specialized types of watches and clocks; laboratory, industrial and service test equipment; medical instruments; process monitors, communications equipment; surveillance and security systems; and automotive, appliance, and industrial controls. Under development and scheduled for early release (if not on market by the time this appears in print) is a miniature combination calculator wristwatch. This is of one class of noncalculator applications, an easily duplicated counter circuit featuring a calculator IC as given in Fig. 1. Abstracted from Calculator Chip Makes A Counter (application note AN-110) published by the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051), this is the simplest of seven circuits featured in the 6-page publication. The other circuits include a higher speed counter, an “up-down” counter and a combination counter/calculator.

Suitable for either PC or CRT board assembly, the counter circuit requires only a type MMS736 calculator IC, a type DMY7492 digit driver, a type HAA1166 six-digit LED display, three spot switches, and a 6.5-to-9.5-volt dc power source, such as a standard 9-volt transistor battery. Capable of handling counts of up to 999,999, the circuit’s average maximum counting rate is approximately 60 Hz, but the actual maximum rate may range from as low as 40 Hz to as high as 150 Hz due to IC chip tolerances. It can be actuated by a pushbutton, mat, or red switch, by magnetic relays, by a microswitch, or by any of a number of contact arrangements. Therefore, it is suitable for a wide variety of practical applications. Depending on the type of counter control switch (S3), the counter can be used, typically, for inventory control, production line counting, recording game scores, or for counting the number of customer entries or leaving a store or business office.

The counter function is achieved simply by using the calculator chip to add “1” repeatedly. This is accomplished by interconnecting the chip’s terminals (K3 and D4) which initiate the “addition” step through an external counter switch, S3. In practice, the operator first clears the circuit by depressing CLEAR switch ST, then enters “1” into the counter by closing the start switch S2. From this point, each closure of the counter switch causes “1” to be added to the total count up to the display’s maximum capability.

By definition, a computer is a device or system capable of solving problems by accepting and returning data, performing prescribed operations on that data, and supplying and/or storing the results of those operations. If the capability of accepting and returning a planned program of operations is added to a calculator chip, then, in effect, the calculator/programmer combination becomes a basic computer.

Not too long ago, a programmable calculator required documentation yet it often took from 6 to 9 months to complete the reader. This was because the “Benchmarks” family of calculator chips are inexpensive, the number of required components and support parts, provides extremely simple interfacing to external devices and has excellent documentation.

Our kit combines the M6800 processor with the MIKBUG® read-only memory (ROM). This ROM contains the program necessary to automatically place not only a loader, but also a mini-operating system into the computers memory. This makes the computer very convenient to use because it is ready for you to enter data from the terminal keyboard the minute power is turned “ON”. Our kit also provides a serial control interface to connect a terminal to the system. This is not an extra cost option as in some inexpensive computers. The system is controlled by an ASCII coded terminal that you may wish to use. Our CT-1024 video terminal is a good choice. The control interface will also work with any 20 Ma. Teletype using ASCII code, such as the ASR-33, or KSR-33. The main memory in our basic kit consists of 2,048 words (8117ES) of static memory. This eliminates the need for refresh interrupts and allows the system to operate at full speed at all times. Our basic kit is supplied with processor system, which includes the M6800 ROM, a 128 word static scratch pad RAM, and clock oscillator bit rate divider; main memory board with 2,048 words, a serial control interface, power supply, cabinet with cover and complete assembly and operation instructions which include test programs and the Motorola Programmers Manual.

If you have a Motorola 6800 chip set, we will sell you boards, or any major part of this system as a separate item. If you would like a full description and our price list, circle the reader service number or send the coupon today. Prices for a complete basic kit begin at only $450.00.

Southwest Technical Products is proud to introduce the M6800 computer system. This system is based upon the Motorola MC6800 microprocessor unit (MPU) and its matching family of support devices. The 6800 system was chosen for our computer because this set of parts is currently in our opinion the "Benchmarks" family for microprocessor systems. It makes it possible for us to provide you with a computer system having outstanding versatility and ease of use.

In addition to the outstanding hardware system, the Motorola 6800 has without question the most complete set of documentation yet made available for a microprocessor system. The 714 page Application Manual for example contains material on programming techniques, system organization, output/input techniques, and more. Also available is the Programmer's Manual which details the various types of software available for the system and provides instructions for the programming and use of the unique interface system that is part of the 6800 design. The M6800 system minimizes the number of required components and support parts, provides extremely simple interfacing to external devices and has excellent documentation.

Southwest Technical Products Corp., Box 32040, San Antonio, Texas 78284

By Lou Garner

The Computer System You Have Been Waiting For

A BENCHMARK SYSTEM—Using the MOTOROLA M6800 benchmark microprocessor family.

Fig. 1. In this six decade counter circuit (from a National Semiconductor Application Note), a calculator IC and a digit driver control an LED readout. Depending on the type of counting switch used, the circuit has many different applications.

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November 1975

Circle 48 for free information card

Popular Electronics
several LSI chips to provide the necessary calculation, memory and programming functions, keyboard input, and result, a programmable calculator can be assembled with only three IC's, a LED display, an appropriate keyboard, a dc power source, and a few small components.

National's five new MM5760 single-chip circuit, the MM5762 business and financial calculator, the MM5763 statistical calculator, the MM5764 international conversion calculator, and the MM5765 calculator programmer. All four calculator chips provide standard arithmetical functions. In addition, the MM5760 offers a complete set of log and trig functions, while the MM5763 provides a single-key computation of present and future value of compound interest, deposit or sinking fund amounts, payment or loan installments, and sum-of-the-digits calculations. The MM5763 includes linear correlation and regression, y-intercept, mean and standard deviation, summation of X or Y values, and related statistical functions. The MM5764 is designed to provide automatic conversions of length, volume, area, or temperature between two different measuring systems, such as British and metric. Finally, the MM5765 programmer chip, used in conjunction with any of the calculator chips, can provide computational programs of up to 102 steps. All of the circuits in the new series feature automatic display cutoff to conserve battery power, halving zero suppression, power-on clear, and a low battery signal display (when used with a suitable digital driver).

Reader's Circuits. Suitable for use in electronic music synthesizers, waveform generators, operational control sequencers, and similar projects, the circuits illustrated in Figs. 2 and 3 were submitted by reader Frank J. Canova, Jr. (725 Myrtle Ave., Green Cove Springs, FL 32043). Each circuit is capable of delivering a repetitive series of different output voltage levels when triggered by a chain of pulse signals from a logic “clock” circuit or relaxation oscillator. Both circuits utilize readily available 7400 series digital logic IC's and both are designed for operation on standard 5-volt negative-ground dc sources. As shown in Fig. 2, a 7473 dual J-K flip-flop, IC7, and 7403 quad 2-input positive NAND gate, IC2, are used to provide four output voltage levels in sequence when a pulse train is applied to the circuit’s input terminal. Each output voltage is preset (or programmed) by adjusting a potentiometer (R7 to R4) in series with one of the four NAND gate output terminals and the dc source voltage through a 330-ohm resistor. The flip-flops are inter-connected to form a binary counter.

The sequence starts with pins 8 and 13 of binary counter IC1 “high” driving only the top NAND gate on and shifting R1 to ground. At this point, the output voltage, established by the voltage division between the common 330-ohm resistor and R1, is somewhere between 0 and 4 volts (approximately), depending on R7’s adjustment. When the first input pulse is applied, the input flip-flop changes state, with pin 12 (IC1) going “high,” pin 13 “low.” The top NAND gate is switched off, the second NAND gate on, and R2 is connected to ground, changing the output voltage to a level determined by R2. In a similar fashion, the next pulse causes both flip-flops to change state, with pins 13 and 9 of IC1 high and the third NAND gate switched on, all others off, and changing the output voltage to a level determined by R3. Finally, the fourth input pulse switches pin 12 (IC1) high, driving only the last NAND gate on and delivering an output voltage established by R4. The next pulse causes both flip-flops to change state and re-establishes the original conditions, starting a new cycle.

The circuit in Fig. 3 is arranged in somewhat similar fashion, but utilizes a type 7490 decade counter and a type 7445 (or 74145) BCD-to-decimal decoder/driver to provide ten adjustable output levels. Again, separate potentiometers, R1 to R10, are used to establish each output voltage level.

Standard components are used in both designs. The potentiometers are 1500-ohm linear-taper types and can be either conventional knob-controlled units or screwdriver-adjusted trimmers, depending on the circuit’s intended application. The fixed resistors are half-watt types. Any standard input and output connectors can be used. A low-noise shielded coaxial type is preferred. For optimum performance, the circuit(s) should be powered by 5 volts.
a well-regulated 5-Volt dc supply, with additional filtering provided on each circuit board to prevent possible cross-coupling. Frank recommends a 100-µf electrolytic capacitor shunted by a 0.1-µf plastic film or ceramic type, as close to the IC power terminals as is practicable.

Neither lead dress nor component layout are critical, but soldering to the IC leads should be done with a 30-watt soldering pencil. Beginners may prefer to provide sockets for the IC's. Either pc or perf-board construction is satisfactory.

The completed circuit(s) can be used in any of a variety of applications, depending on the type of equipment involved and the frequency of the input drive signal, as well as upon the adjustment of the individual potential-meter to optimize the output voltage levels. If used with a music synthesizer, for example, the programme output signal could serve to control voice (voltage controlled oscillator), vct (voltage controlled filter), or gain circuits, eg a combination of these. The 10-step version (Fig. 3) is preferred for function generator applications. Here, the circuit can serve to create virtually any waveform that can be approximated by ten distinct voltage levels. As a general (but not inflexible rule) lower frequency drive signals are used in sequencer and music synthesizer applications, higher frequency signals up to the kHz and lower MHz range for waveform generation. An input drive signal of at least two volts amplitude is required for positive operation.

R & D Tidbits. While it may not be the ultimate answer to the nation's energy crisis, the semiconductor solar cell is certainly the simplest device currently available for converting sunlight into electricity. The chief limitations to its widespread use in the past have been its comparatively high cost and relatively low efficiency. However, both of these limitations may become less critical as the result of recent scientific breakthroughs, and the solar cell might well become a serious challenger in the energy race.

A new type of solar cell promising high efficiency at low cost has been developed by a research team at NASA's Jet Propulsion Laboratory in Pasadena, California. The new solar cell—called a CMOS, for Anfracta-

channel 141 is a fully synthesized 3-channel AM transceiver offering full legal transmit power. Maximum control on your fingertips: Noise blanker switch • Automatic noise limiter switch • Gain control • PA control • Delta tune • Illuminated RF meter • transmit indicator light • Plug-in microphone. Operates on 12V DC (+) or 12V ground. Suggested retail price $189.95.

See your distributor today.

**Our new cartridges will turn your good record player into a great record player.**

Perhaps you've tried to track your records at the lowest advertised setting for your elliptical stylus. In the hope of optimizing performance and reducing record wear. But few footpath threats can be met at those settings. And big crescendos are simply fuzzy. Bland for a better player? No. Get a better stylus.

We have concocted a new approach. A stylus shape that contact's the groove wall, to spread tracking force over a greater vertical area. The Shihata stylus. It safely tracks your records at up to 2 grams while maintaining response to 40,000 Hz, offering great stereo separation, and reducing record wear... even compared with an ellipti-

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Measuring 16 x 20 mm, the image sen-
sor is the largest single chip device
ever made.

Finally, in fulfillment of another of the predictions made in last January's column, the LEAA (Federal Law
Enforcement Assistance Administra-
tion) has contracted for the develop-
ment of a personal fitness monitor—
essentially a wristwatch-sized solid-state instrument that will
instantaneously tell its wearer his pulse rate,
temperature, blood pressure, and other critical information, with a built-in
alarm to warn the user if his bodily
signs have reached a dangerous level.

Device/Product News. In addition to
its new calculator and programmer
chips, discussed earlier, the National
Semiconductor Corporation has re-
cently introduced a number of other
devices which should be of interest to
serious experimenters, students, en-
gineers, and hobbyists, including a
new display driver, a 12-bit successive
approximation register, and a new
pair of line drivers.

Combining the best features of both
CMOS and bipolar technologies, National's new line drivers, types MM88C29
and MM88C30, can operate on 3 to 15
volts, provide a noise immunity of (typ-
ically) 45% of the power supply, have
an on resistance of only 20 ohms, and
are capable of delivering 80 mA.

Both devices are offered in 14-pin
Epoxy-B or ceramic DIP's. The
MM88C30 is a dual differential
line driver that also performs the dual
four-input AND or the dual four-input
NAND function.

An all-electronic solid-state tuning
system designed primarily for TV sets
has been developed by the National
Institute of Technology, Corp. (New York, NY). Dubbed Omega, the new tuner fea-
tures an MNOS-repeatable memory CMOS D/A converter, and ion-
implanted logic. It is approximately
equivalent to the size of comparable
electromechanical tuners. In opera-
tion, a metal-nitride-oxide semi-
conductor (MNOS) memory digitally
stores all the tuning information
needed for each TV channel, retaining
the memory for up to 10 years, even
with power removed. When the
operator selects a station, information
in the MNOS memory for that channel
is coupled to a 14-bit CMOS D/A con-
verter, developing a corresponding
analog voltage, which can then be ap-
plied to a Varactor diode to tune in
the selected station.

Two new npn power transistors,
types 2N4645 and 2N4646, have been
announced by RCA's Solid State Divi-
sion (Box 3200, Somerville, NJ 08876).
The new devices are complements of
pnp types 2N6487 and 2N6488, re-
spectively, and, as such, are useful in
complementary-symmetry circuits
for audio-frequency linear amplifier
applications, as well as in linear
modulators, servo amplifiers, and
operational amplifiers. The 2N4645
is a 100-volt, 40-watt device with a do-
beta of 15-150 measured at 1.5 A col-
lector current, while the 2N4646 offers
the same dissipation rating and beta
range, but at 120 volts. Both types
nonloare supplied in hermetic
JEDEC type TO-96 packages.

Correction. In our September col-
umn, we erroneously listed a 416-72
Data-book from Unitec as being free
for the asking to anyone who wishes
to obtain a copy. This book is available
only to Unitec's customer list as recom-
ended by the company's Sales and Reprersentative Staffs. We
unfortunately regret any inconvenience our error has caused.

Mini-Scan is the pocket scanner that works a week on just 4 penlight cells.

A breakthrough we call "mind-
miser circuitry" makes it possible... and it's actually 2½ to 5 times more
efficient than any other pocket scanner we tested! Just 4 alkaline penlight cells power it for a full
week, 8 hours a day, on a tough 50-50 duty cycle (50% full volume, 50% squelched). And its perform-
ance is bred from our experience in public safety two-way radio... so it also gives you the crisplest, clearest
messages possible. Just $119.95 with built-in ferrite antenna
(batteries, crystals and optional
driver antenna extra.)

*Test results gladly supplied on request.

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POPULAR ELECTRONICS

November 1975

1. At (A) is a typical voice signal. Voice peaks are high, but average level of speech is low.
2. (B) is the signal modulation a carrier such that result has strong peaks but no average modulation level.
3. Two methods of compression: audio not r-f.
MODULATOR doesn't put of the and ion: audio time, is degree TO use DRIVER and AMP is voltage, strong signal have been the AUDIO AMP, "flexible" two methods and this AUDIO AMP. As a case, in the RF circuitry of the transceiver, thus requiring some "surge." In general, r-f cleaners are more complex and expensive than compressors, because of the strict filtering requirements. But in terms of what the CB'er wants most, increased "talk power," r-f systems are superior to audio ones. For a given amount of speech processing, say 20 db, r-f clipping will increase the signal-to-noise ratio at the receiver by 8 db for example. This will improve the S/N by about 5 db, or just under one S unit. Audio r-f compression will both give an S/N about one db better than an unprocessed signal.

Transmitter Requirements. In order to get the most out of a speech processor, the transmitter must be designed along certain guidelines. Most important of these concerns the type of tubes or transistors used in the driver and power amplifier stages. Since the average modulation level is a lot higher, these devices will be handling much more power most of the time. This means they run hotter, and must be able to dissipate the extra heat generated. Otherwise, thermal effects will reduce the performance of the device. Further, the power supply that supports these active devices must be "stiff," since the average power demand will be a lot higher. This means that larger filter capacitors, higher current rectifiers and voltage regulators must be used. Some compact chassis may require a cooling fan to move more air around heat-generating components. And, of course, inboard cleaners will necessitate the use of stringent filtering and shielding techniques.

All this adds to the cost of producing a CB rig. Is it worth it? From on-the-air listening experience, speech compressors can do an impressive job of normalizing signal levels. Using 8-db (6.3 times) signal boost can make that marginal contact a solid one!

Intelligibility. But coping a message easily is not just a question of signal levels. How clean the received signal is can be just as important. If we compare the original modulating waveform (Fig. 1A) to the unprocessed, modulated carrier (Fig. 1B), we can see that the envelope of the waveform is a good replica of the voice signal. The processed signals (Figs. 4 and 6) contain envelopes which are distortions of the original, inevitably, any speech processing introduces a certain amount of distortion. In most cases though, you'd find that the processed version is still quite recognizable—and more intelligible—than the original.

Most speech processors available to CB'ers are audio compressors, whether they are built-in, add-on accessories, or packaged inside an optional microphone. As we've already seen, clipping is more effective, especially when the r-f method is used. As more and more CB'ers learn the advantages of speech processing, more effective methods will be included in new transceivers. It's a safe bet that if you'll hear an increasing number of properly clipped signals on the air!
WHAT TO LOOK FOR IN A SHORTWAVE RECEIVER

TIPS

I’ve not too early to start hinting for a new shortwave receiver for Christmas. But unless you pick it up today, you may be disappointed. Choosing the best new receiver is not an easy task — it’s one of the hardest decisions you’ll ever make. The right choice is not too early on

A shortwave receiver is only one part of the listening experience. It’s like choosing a car: it needs to be comfortable, reliable, and able to cope with the unpredictable conditions of DXing.

You’ll want to read the manual carefully and follow the instructions for installation and operation. This will help you avoid potential problems and take full advantage of the receiver’s features.

Remember that a shortwave receiver is an investment that can last you for years. So take your time and make the right choice.

More on RCI Radio Canada International's DEDICATED TO ENGLISH-LANGUAGE SHORTWAVE BROADCASTS FOR NOV/THRU FEB. by Richard E. Wood

To: Eastern North America

<table>
<thead>
<tr>
<th>TIME-EST</th>
<th>TIME-CACT</th>
<th>STATION</th>
<th>QUAL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>London, England</td>
<td>5.500 GHz (S-STORY), 5.450 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>Times, Altonia</td>
<td>5.460 GHz, 5.160 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>USA, Washington, U.S.A.</td>
<td>5.460 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>Mawana, Canada</td>
<td>5.500 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>Mawana, Australia</td>
<td>5.450 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>Peking, China</td>
<td>5.666 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>Singapore</td>
<td>5.668 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>HCIR, Dabo, Ecuador</td>
<td>5.745 GHz, 5.745 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>Stavanger, Norway</td>
<td>5.765 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>Oslo, Norway</td>
<td>5.895 GHz</td>
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<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>Voz, Engeland</td>
<td>6.190 GHz</td>
</tr>
<tr>
<td>03:00-12:30</td>
<td>11:00-12:30</td>
<td>MCRI, Quem, Ecuador</td>
<td>6.215 GHz</td>
</tr>
</tbody>
</table>

* The frequency listed is the one used for the primary broadcast. Secondary frequencies may also be used for backups or special programs.

** There may be slight variations in the broadcast schedule due to propagation conditions or other factors.
SOFTWARE TOOLS

N O MATTER how small the computer, even the most dedicated programmer will rapidly become bored with the keyboard.

Some hobbyists use a Teletype as there are several older models on the market at reasonable prices. Even with a Teletype, though, you need some software to convert those key- stroke codes into something meaningful in memory. If you can’t afford a Teletype, you can almost always use an un- coded keyboard. These are frequently on the surplus market for less than $25.00.

A terminal is important, but it is only one tool in the computer hobbyist’s kit. Once you’ve written a program and gotten it into storage, you ought to use the cassette interface (HIT) described in September’s column. With this tool, you have to “button in” the program bit-by-bit only once. After it is in stor- age, you can write it out to be taped and read in the next time you want it. Of course, if your only storage medium is RAM, you’ll lose the mem- ory contents when you turn the com- puter off, so it’s a good idea to copy the latest version of a program out to tape as a backup.

With a reasonably large storage medium in RAM, you’ll have to reenter the tape reading routine laboriously through an editor when you want to make changes, some of which may be traumatic and complex. One of the best ways to avoid much of the incon- venience is to provide a small monitor. A monitor is just another computer program, but it is assumed to consist of a terminal (or a separate keyboard), with binary notation. For these characters specifying the bit patterns to put into memory. The simplest monitor has three basic commands: Load, Dump and Go. A command is a single letter typed at a time when the monitor is not otherwise engaged in some activity. Typical commands are single letters like “L” for Load, “D” for Dump and “G” for Go. When you type in “L” you are directing the program to accept keyboard input and load it into memory. “D” means you want to display data from the tape and then execute that data. Such a read-in program is usually somewhat larger and more powerful, so it is recommended (perhaps using the bootstrap program as a subroutine), which make up an even larger and more sophisticated program. The effect, then, is to use one group of records to read the next group in, thus “pulling” the program in by its own bootstraps.

Using a Monitor. The ability to pre- serve a program for later recall is im- portant, but it doesn’t solve two major nuisances: (1) you have to get the program bit-by-bit the first time; and (2) every time you make an error in the program, you have to key in the changes, some of which may be traumatic and complex. One of the best ways to avoid much of the inconvenience is to provide a small monitor. A monitor is just another computer program, but it is assumed to consist of a terminal (or a separate keyboard), with binary notation. For these characters specifying the bit patterns to put into memory. The simplest monitor has three basic commands: Load, Dump and Go. A command is a single letter typed at a time when the monitor is not otherwise engaged in some activity. Typical commands are single letters like “L” for Load, “D” for Dump and “G” for Go. When you type in “L” you are directing the program to accept keyboard input and load it into memory. “D” means you want to display data from the tape and then execute that data. Such a read-in program is usually somewhat larger and more powerful, so it is recommended (perhaps using the bootstrap program as a subroutine), which make up an even larger and more sophisticated program. The effect, then, is to use one group of records to read the next group in, thus “pulling” the program in by its own bootstraps.

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Hobby Scene

By John McVaugh

"STEREO" HEADPHONE SOUND

Q. My stereo headphones don't sound "stereo", but rather like two separate sound sources. Why not?

A. "Stereo" headphones have two electrically and acoustically separate channels. Loudspeakers, on the other hand, have a certain amount of acoustical "crosstalk" or blending between them. The circuit shown will electronically introduce the appropriate amount of crosstalk (in both amplitude and phase) to make the headphones sound "stereophonic" rather than "binaural". Be sure to use non-polarized capacitors. If you can't find the required values, use smaller capacitors, paralleling them until the desired capacitance is reached.

When a positive voltage is applied at the input, the output starts to swing positive. Current then flows from the op amp output through D8, the meter, D6, R1, and R2 to ground. This current generates a positive voltage at the inverting input of the op amp. When it reaches the same level as the voltage on the noninverting input, the op amp stabilizes and the meter remains at some upscale indication (which can be adjusted by R2).

When a negative voltage is applied to the noninverting input, the output of the op amp becomes negative and the circuit is through R2, D1, D7, M1, and D5. This current produces a negative voltage at the inverting input, and when it reaches the same value as that at the input, the op amp is stabilized. The meter once again settles at an upscale indication. In both cases, the current flows in the same direction through the meter.

Capacitor C7 is used to smooth any voltage fluctuations across the meter - especially when the meter is measuring low-frequency ac. Such voltage integration removes flutter from the meter movement and keeps it at zero. The voltage difference between the two inputs to the op amp is measured in millivolts so the positive-to-negative transition is very sharp. With some accurately known dc (either polarity) applied to the input, R2 can be adjusted to give the correct indication on the meter.

The feedthrough capacitors should be Allen-Bradley CL003-HA503P units or equivalent. If the problem persists, it will be necessary to shield the lamp housing with fine-mesh screening. Ground both the screening and lamp base (if metal).

LED ZERO BEAT DISPLAY

Q. Is there any visual means of detecting when I have "zero-beat" my vfo and a received signal?

A. If your receiver has an S meter, you can adjust for zero beat while watching its needle. As the two frequencies approach each other, the needle will swing back and forth more and more slowly. At zero beat, the needle will hold one position. The circuit shown will also give a visual display of zero beat. When the vfo has come within 25 Hz of the signal's carrier, the LED's will alternately flicker. At zero beat, neither LED will light up. The circuit can also be used as a polarity checker for dc applications. When the top input terminal is positive, LED1 will glow, while LED2 turns on when the bottom input terminal is positive. Select R to limit LED current to a safe value, or use a voltage divider.

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IC Breadboards

Breadboarding IC projects is a common practice and many commercial boards are available. However, an inexpensive substitute can easily be made in a pinch. Using 0.1-in. (0.25-cm) grid P-pattern board as a template, drill holes in a piece of perforated board to accept the pins of a 14- or 16-pin dip. Clip the pins to two rows of small clips (V-T-32A or similar). Place extra clips along board edges for use as tie-points. Install push-in ferrule clips at each corner to elevate the board. Several sections can be secured to a larger board for convenient mounting and subsystems. A strip of masking tape along the terminals permits mark- ing wires for pin numbers and functions to be made. —Raymond F. Arthur, New Kensington, PA

Home-Made Adapter Lets You

To use an ohmmeter to measure a car's dwell time, a 1543 or similar diode must be placed in series with the meter's "hot" lead. The easiest way to install the diode is to house it in an adapter that can be quickly connected and removed from the test setup. This eliminates the need to modify the ohmmeter. To make the adapter, first accept the barrel-type plug of the battery screwdriver. The next step is to enlarge the barrel of a standard short-barreled test prod just enough to permit the tip jack to be screwed tightly into it. After prethreading the barrel, solder one lead of the diode to the tip jack (which leads depend on the position of the voltmeter at the time of testing). Then pass the other jack and the car's electrical ground. Use an insulated spacer and finish assembling the adapter. —Paul E. Griffith

Battery Eliminator For TV/FM

If you're tired of replacing R1, the 1.5-Volt battery supply, and a 2000-μF capacitor smooths out the dc. Since the forward voltage drop across a silicon diode is about 0.7 V, connecting two of them in series from the dc supply to ground provides a voltage drop of nearly 1.5 volts R1, a common cathode resistor is composed of 28-ohm, 2-watt resistors in parallel. All diodes D1 and D2 are approximately equal. The electrolytic capacitor ought to have a 15-mFD value. —Donald Wallace, Appoquinimink, VA

Tracing Fault Patterns

Etching simple printed-circuit boards from pc blanks can be very easy if you use masking tape to trace the resist pattern on the copper surface of the blanks, completely with broad masking tape, taking care not to overlap the tape or to leave gaps between each strip. Then trace the outline of the foil pattern on the etching and drilling guide, using a sheet of carbon paper between the tape and the guide. Carefully cut out the tape from the areas to be etched using a sharp knife or razor blade. Then apply resist using the "dial" method from the masking tape. When the etch resist is dry, score it with a razor blade where it touches the tape. After the remaining tape is removed, the board is ready to be etched. —Antony Barake, Quebec, Canada

An Impressive Lamp Dimmer

If you want more than one light-level output from an incandescent bulb, this circuit is useful. What's more, it can lengthen bulb life considerably, while saving you money on electric bills and make expensive three-way bulbs and dimmers unnecessary. When the power switch is turned to the on position the diode allows only positive half-cycles of the ac power to flow through the bulb. In the off position, the bulb behaves normally. See to use an appropriately rated diode (both PH and forward current) for the power consumption (in watts) of the light bulb. —Bill Drisko, Topsfield, MA
THE LIGHT-ACTIVATED SCR

HE SCR has been around for some time, and most of us have used them in a variety of circuits. There’s one SCR, however, that doesn’t get much experimenter use. It’s the one in LASCR (Light Activated Silicon Controlled Rectifier).

Lots of the parts dealers now sell LASCR’s at bargain-basement prices. Depending on the voltage rating, you can buy good quality units at prices less than 50¢ to about $1.75. Not bad for a component with lots of practical uses.

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