Preview: Panasonic’s Four-Head Video Recorder
Guide To Floppy-Disk Formats
Computerized Tune Player With Expandable Memory

PE EXCLUSIVE:
Microprocessor Product Development System
The man, the wi
1. The NTS/Rockwell AIM 65 Microcomputer A single board unit with on-board 20 column alphanumeric printer and 20 character display. A 6502-based unit 4K RAM, expandable. 2. The NTS/KIM-1 Microcomputer A single board unit with 5 digit LED display and on-board 24 key hexadecimal calculator-type keyboard. A 6502 based microcomputer with 1K RAM, expandable. 3. The NTS/HEATH H-89 Microcomputer features floppy disk storage, "smart" video terminal, two Z80 microprocessors, 16K RAM memory, expandable to 48K. 4. The NTS/HEATH GR-2001 Digital Color TV (25" diagonal) features specialized AGC-SYNC muting, filtered color and new solid-state high voltage tripler rectifier.
of the first key is stored in IC2. This puts a full 8-bit number on the input side of the 4016 gates IC3 and IC4. If the CPU is in the LOAD mode, the pressing the INPUT button will load the binary value of the two keys previously pressed into the program memory. This is accomplished by pin 2 of IC5 pulling the DMT IN line low, causing the contents of the data bus to be directly loaded into the memory location specified by the register 0 in the CPU. The CPU will acknowledge the DMT by issuing a high on SCI. This is used to reset flip-flop IC5. The INPUT switch is also connected to the EF4 line.

The hex keyboard also can be used to input data during a program. It is configured to respond to a 6C instruction. The RUN, LOAD and RESET buttons are connected to three NAND gates of IC17. These gates are flip-flops that apply the appropriate logic levels to the CLEAR and WAIT lines which control the CPU mode. The WAIT switch will cause the CPU to pause. It is arranged so that the pause will only occur between TPA and TPH to insure that valid data and addresses are displayed when the WAIT is issued. The single-step mode allows the operator to execute the program one step at a time, observing the STATE codes, q line, data and address lines, as well as the action taken by external relays and components, etc. Jumper J1 can select the stopping point during the single-step mode. If J1 is connected A to C, then the program will stop only in a FETCH cycle. If J1 is connected B to C, the stopping point will be each machine cycle at the trailing edge of TPA. You may want to try this initially to get a better understanding of the CPU operation. However, eventually you will probably connect J1 to HALT only in the FETCH mode.

Remember to consult the timing diagrams that interpret the contents and meaning of the ADDRESS and DATA bus signals.

**Slow-Step Clock.** Formed from IC19, the speed of the stepping or toggling clock is controlled by R3. Hold the STEP toggle button depressed, and adjust R3 for the clock speed desired.

**Test Procedure.** To test the combination of the product and programming boards, install the six 1K bank-select jumpers (IA to G). This will locate the 1K memory at 0000 hex. Connect the input ports so that jumper 1 connects from terminal A to EF1 and jumper 2 between A and B, selecting instruction 6. Connect the output port jumper 3 A to B, the 1K memory-select jumper 4 A to B. Jumper 5 is not required at this time. Install the following jumpers on the programming board: J1 A to C, J2 B to C. Now connect an 8-volt dc supply between the 8-volt input and ground on the product board. Use the circuit shown in Fig. B. Apply the power with no ICs installed. Check the output of the 7805 regulator Q2 on the product board. The voltage should be ±5 volts, ±5%. If not, correct the problem before proceeding.

Remove the power, install the ICs, and plug the programming board into the product board. If you are using an Elf II to program the product board, remove the 1802, 2102's and the 1861 video chip. (The 1861 will interfere with the I/O port allocation unless you use your giant board to reallocate I/O instructions to IC4 and IC5 on the product board.

When power is applied, the 7-segment displays should light up. With the latch switches up, press the RESET button. The RESET LED should be on, as well as SCI, FAIL, PAUSE, and LEDs should be off. Press the LOAD button. The RESET LED should go off. Enter a 7 on the hex keyboard, followed by a B, then depress the INPUT button. The display should read 0000 7B, indicating that a 7B is located at memory location 0000. Now input 7A, followed by a 3A and 00. The display should read 0000 31. This program first turns the Q light on, then turns it off and BRANCHES back to the beginning, running in a loop.

Now press RESET, followed by the EXECUTE RUN button. Both the RESET and PAUSE lights should go on, indicating that both the WAIT and CLEAR lines on the CPU are high or that the CPU is in the RUN mode. The Q light should glow. It is being turned on and off by the program. Now press the PAUSE button. The Q light should stay on, the RESET go off. The program can now stop at any point in the loop. Remember, it stops in any machine cycle, so it may stop in a FETCH or EXECUTE.

Depress X again. The program will start up where it left off. Try a few times, noting that the program stops only at address 0000 through 0003 and that the Q, SCF, and SCF LEDs may or may not be on. Try to estimate where the CPU has stopped. Now depress the S (STEP) button. Then depress E, holding the T (TOGGLE) button down. Rotate R3 until you can follow the program.

Note that the addresses displayed are one step ahead of the action on the data bus display and the Q LED. This is because the single-step stops at the beginning of a FETCH, while the data display and the Q LED are indicating the previous machine EXECUTE cycle. Refer to Fig. 4 and follow the timing diagram through the single-step mode.

Examine memory, press RESET, LOAD and P (Memory Protect). Remember to release the SINGLE-STEP button. Now, pressing INPUT will allow you to
step through your program. Pressing and holding the TOGGLE button will allow you to review it at a rate determined by R3. The M button is not used at this time. Provisions have been made to add a system monitor which will be activated with this button. To test the I/O ports, write a small program such as those in Fig. 9 using them.

Construction. Assembly of the development system is basically straightforward, but because of the complexity of the circuitry, use of pc boards is virtually a necessity. The boards are double-sided and very difficult to make, and their purchase is recommended. Because of their size, the foil patterns are not given here. The patterns and component layout guides may be obtained by sending a self-addressed 8-inch by 10-inch envelope with two units of postage to Editorial, Dept. MP, Popular Electronics, One Park Ave., New York, NY 10016. Several of the ICs are MOS devices and require the standard handling precautions.

Once you have assembled and checked out your development system, you will be well on your way to proficien-

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A N AUTOMOTIVE battery works very hard, especially when cranking the engine, and if you have a plethora of electrically operated accessories that often draw more power than the unaided alternator can deliver, it may not have a full charge to work with. Even a battery that loads most of the time may age to the point where it can no longer start the engine on a cold day, so it's a good idea to check your battery's health now and then.

Numerous tests can be made on a battery, and all of them give some indication of its condition. But none is as conclusive as checking its performance under load. To do that you need a professional battery tester, an inexpensive version of which you can build, as described in this article.

The Circuit. The battery tester, shown schematically in Fig. 1, assumes the test current to be 200 amperes at 12 volts. (To determine appropriate load current, refer to the box.) Using Ohm's Law and assuming a 12-volt battery, you can readily see that load resistor R2's value would have to be a very low 0.06 ohm ($R = \frac{E}{I} = \frac{12\text{ volts}}{200\text{ amperes}} = 0.06\text{ ohm}$). Furthermore, its power rating would have to be a whopping 2400 watts ($P = IE = 200\text{ amperes} \times 12\text{ volts} = 2400\text{ watts}$). Clearly, you're not going to find a resistor with these ratings in your local electronics parts store. Fortunately, however, you can fabricate your own power resistor from available inexpensive materials.

Continuing with our example of 12 volts and 200 amperes, you'll need about 12 feet of \(\frac{3}{8}\)-inch wide, 0.025-inch thick steel banding strap (used to cinch wooden packing cases) to fabricate R2. Connect the strap in series with an ammeter that can handle at least 2.5 amperes across a variable power supply capable of delivering up to 1 volt at more than 2 amperes. Adjust the power supply for a 2-A output and measure the voltage across the load. If it is over 0.12 volt, trim the strap until it equals 0.12 V.

Turn off the power supply and disconnect the test setup. You've now determined the length of steel strap to use for a 0.06-ohm load resistor. (You can use the same test setup to determine the length needed for any other battery voltage/power ratings simply by changing the voltage or/and current to the appropriate values in the formulas that are provided in the box.)

You're not likely to find a switch that can handle 200 amperes in an electronic parts store, but a conventional 12-volt automotive starter solenoid (K1 in Fig. 1) will fill your need. Operating current for the solenoid is controlled by normally open pushbutton switch S1.

Meter M1, resistors R3 through R6,
and diodes D1 and D2 make up a 0-to-6-volt dc voltmeter. When connected in series with 10-volt zener diode D3, this meter circuit becomes an expanded-scale 10-to-16-volt dc voltmeter. Diode D2 protects the meter against reverse polarity, while diode D1 protects against overvoltage when the meter is connected in proper polarity.

When selector switch S2 is set to POLARITY, LED1 glows green if the tester is connected to the battery in proper polarity, red when the connection's polarity is incorrect. Note that Fig. 1 shows and the Parts List specifies an integrated red/green LED assembly for LED1. If you wish, you can replace this with discrete red and green LEDs, connecting them into the circuit as shown for the integrated unit.

Construction Hints. As shown in Fig. 2, the best way to mount the steel strapping that makes up the load resistor, R2, is on a ¼-inch plywood board, using No. 6 metal—not plastic—spacers and machine hardware. Start by drilling a ¼-inch hole spaced ¼-inch in from each end of the strapping.

Next, drill two rows of ¼-inch holes through the board, spacing the rows about 8 inches apart and the holes within each row about 1 inch apart. Then mount a metal spacer at each hole location with a 6-32 × 1” machine screw, placing a large flat No. 6 washer under the head of each screw. Mount another large flat washer on top of each spacer with a 6-32 × ¼” machine screw.

Mount the starter solenoid at the right rear of the plywood board and fasten one end of the steel strapping to one of its terminals. Then route the strapping back and forth from spacer to spacer. (The washers prevent the strapping from slipping off the spacers.) Fasten a large L bracket to the free end of the strapping with ¼-inch hardware. Then secure the L bracket and one- and two-lug terminal strips to the wood base with ¼-inch round-head wood screws.

For the front panel, you will need a sheet of 16-gauge aluminum. Trim it to the width of the plywood base. Then, if possible, bend a 90° lip, about 1 inch wide, along the panel’s bottom edge (alternatively, use three large L brackets) and drill three or four ¼-inch holes along the length of the lip to permit mounting the panel to the plywood base.

Machine the panel and mount on it the meter movement, integrated LED assembly (or discrete LEDs), switches, and two-three-lug terminal strips. This done, mount the panel to the top front of the plywood base with ¼-inch-long roundhead wood screws.

Wire the circuit as shown in Fig. 1. Note that separate #24 wires are used as voltage sensors and are run in parallel with the large #4 cables that carry the actual current. The #24 wires are used to measure the voltage at the battery before any voltage drops in the cable resulting from the high-current flow through R3. When installing the #24 wires, route them along the #4 cables and use either lacing cord or tape to bind wire and cable together. Finish the assembly by attaching large Mueller clips or jumper-cable clamps to the free ends of the #4 cables.

Use. To use the tester, connect the two Mueller clips (or clamps) to the battery/charger system (at the battery’s terminals) in the vehicle you wish to test and set S2 to POLARITY. If the LED glows green, the tester is properly connected, but if the LED glows red, reverse the connections to the battery.
NOW SET $2 TO VOLTAGE, the meter should indicate between 10 and 13 volts. Press and hold LOAD switch $1 for no longer than 5 seconds (the limit because as R2 heats up, from the current flowing through it, its resistance increases) and note the meter indication. A fully charged battery should indicate 10 volts or more.

Release $1 but leave $2 set to VOLTAGE. Start the vehicle's engine. The meter's pointer should now swing up-scale to a point between 13 and 15 volts as the vehicle's charging system comes into play. If you obtain abnormally low readings at any time, try fully recharging the vehicle's battery and repeat the tests. If the condition still persists, the battery is most likely bad.

You should periodically "load test" your vehicle's battery, say, once a month. Regular testing will help you keep track of the battery's condition and can also indicate preventive maintenance steps to keep it delivering maximum current for as long as possible. Periodically clean the battery terminals and connectors and, unless yours is a sealed, "no-maintenance" type, check the liquid level in each cell often and add distilled water where necessary.

### SELECTING A LOAD

Battery testers used by professionals have built-in load resistors specifically selected for testing a range of typical automotive battery power-delivery capabilities. As a general rule, load-resistance values are calculated from a simple formula that states that the load resistor should draw half of the battery's maximum current during a voltage measurement. Since automotive batteries are usually rated in volts, rather than current-delivery capability, it is necessary to first convert to current before you can calculate the load resistance.

Using the standard power formula \( P = IE \)

where \( P \) is rated battery power, \( I \) is unknown battery current, and \( E \) is battery voltage, we obtain \( I = E/P \). Now, let's assume the battery is rated at 12 volts and 4800 watts. First, we divide the power rating by 2 obtaining 2400 watts. Plugging these values into the formula, we get \( I = E/P = 2400 \text{ watts}/12 \text{ volts} = 200 \text{ amperes} \).

Now, use Ohm's Law to calculate the resistance of the load: \( R = E/I \), where \( R \) is load resistance, \( E \) is battery voltage, and \( I \) is test current (calculated above). Continuing our example, we obtain \( R = 12 \text{ volts}/200 \text{ amperes} \), or 0.06 ohm. Therefore, for a typical 12-volt, 4800-watt automotive battery, the load resistance should be 0.06 ohm at 2400 watts.

Using the procedure described above, you can calculate the required load resistor's parameters for any battery voltage/power ratings.
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(Continued on page 85)
The circuit uses three ICs: the microprocessor, an eight-input NOR gate, and an optional EPROM.

**PARTS LIST**

- C1—2200-µF, 16-V radial-lead electrolytic
- C2—220-µF, 25-V radial-lead electrolytic
- C3—1000-µF, 10-V radial-lead electrolytic
- C4—10-µF, 15-V radial-lead electrolytic
- C5, C6—0.1-µF disc capacitor
- C7—240-pF disc capacitor
- D1, D2, D3—IN4000 series, 1-A rectifier
- D4, D5, D6—1N4148 switching diode
- D7, D8—4.7-V, 1-W zener (1N4732 or similar)
- D9—12-V, 0.5-W zener (1N963 or similar)
- IC1—AY-3-1350 (General Instrument)
- IC2—CD4079BE 8-input NOR-gate
- IC3—EPROM (see text)
- R1, R2, R3, R6, R7, R9, R20, through R24—10 kΩ
- R4—1 MΩ
- R5, R18—33 kΩ
- R6—1.8 kΩ
- R10, R11, R25—100 kΩ
- R12—10-kΩ vertical potentiometer
- R13—47 kΩ
- R14—1.5 kΩ
- R15—10-kΩ horizontal potentiometer
- R16—180-Ω, 1/2-W, 10% resistor
- R17—330-Ω, 1/2-W, 10% resistor
- R18—47Ω
- R26—2.2 MΩ horizontal potentiometer
- R27—250-Ω, five-section dip switch
- R28—250-Ω, five-section dip switch
- S1—Eight-section dip switch
- S2—Five-section dip switch
- S3, S4, S6, S7—Spst normally open push-button switch
- S5—Part of S2
- SPKR—Miniature loudspeaker
- T1—12-V, 1-A transformer
- Misc.—PC board, sockets, etc.

Note 1: The following are available from Bullet Electronics, Box 401244, Garland, TX 75040: complete kit of parts, less IC3, SPKR, and switches, for $23.50. Also available separately: drilled, plated, and silk-screened pc board for $5.00; AY-3-1350 IC (IC1) for $12.00; B-section and S-section dip switches for $2.00.

Note 2: Master Music, P.O. Box 448, Mt. Vernon, MO 65712 will supply the following items: sample music 2708 EPROM with more than 800 notes of popular music for $12.50; 2708 EPROM music albums with 1024 bytes containing 25 selections (more than 500 tunes available; write for information) for $15.00; sample music 2716 EPROM with more than 1600 notes of popular music for $27.50; double music albums in 2716 s for $32.00.
and, by using the appropriate address, play any tune in the ROM's "catalog."

Circuit Description. As shown in Fig. 1, the Super Music Maker project consists basically of three ICs: IC1, the microprocessor/synthesizer chip; IC2, a 4078 CMOS eight-input NOR gate; and IC3, an optional EPROM (erasable programmable read-only memory) into which an "album" of tunes is programmed. The remainder of the circuit includes an audio amplifier for driving a small speaker (or the input of a power amplifier) and a power supply.

During program execution, IC1 sets its address lines at pins 10 through 17 to 00. Closing the EXT ROM-enable switch (part of DIP switch S1) initiates the following sequence. When all lines are at logic low, the output of IC2 goes high and sends $Q^7$ into conduction. In turn, $Q^7$ applies a ground to the tune address lines through $D_4$ and $D_5$. The output of IC2 is also applied to enable pin 20 of IC3, where a logic high turns off this IC and presents a high impedance on the IC's I/O lines at pins 9 through 11 and 13 through 17. This allows the address data to be read from the same lines on which the EPROM's information appears. The tune address is then read and stored by IC1. On the next cycle, $Q^7$ cuts off and enables IC3. If IC1's internal tunes are selected, IC3 is disabled by pull-up resistor R21 on enable pin 20 and $Q^7$ conducts continuously.

During operation, IC1 tests for the presence of external PROM IC3 by going to address location 377 octal and testing for octal 125. If the proper code is sensed, an internal flag in IC1 is set. The tune address lines are interrogated and then that particular memory location in IC3 is played. If no PROM is sensed, IC1 plays the internal tune at the preset tune address. The program then tests for the "next tune" switch closure; if it senses it, IC1 steps to the next tune and plays it. This operation works in either the internal or external tune mode, permitting all tunes in IC1 and IC3 to be played. (Note that the chimes cannot be played when IC3 is selected.)

TEMPO control R26 sets the speed at which IC1 plays the notes, while PITCH control R15 sets the reference frequency. The waveform at pin 26 of IC1 is one quarter of the oscillator frequency; it can be varied over a two-and-a-third octave range, from 50 kHz to 250 kHz, with the PITCH control.

Dual in-line package (DIP) switches S1 and S2 provide the letter/number address selectors required for addressing a given page of tunes in IC1 and IC3. Also part of S1 is the EXT ROM-enable switch, and S5 is part of S2. Normally open spst switches are used for reset and next tune switches S3 and S4 and optional door-chime switches S6 and S7. Finally, switches F and G at pins 22 and 23 of IC3 are part of S1.

The audio amplifier section, at the lower right in Fig. 1, consists of a pair of Darlington circuits, Q3/Q4 and Q5/Q6. With the arrangement shown, the circuit's output has a certain amount of exponential decay, which gives it an organ-like sound. By eliminating the Q5/Q6 circuit and jumpering the 12-volt line, as indicated by the dashed line, to the top terminal on the speaker, output volume can be increased, but the tones will have faster attack and decay times, producing a sound more like a piano. If you wish, you can soften this tone by installing optional capacitor CX.

Programming External Memory. The system is designed to use either a 2708 (1K X 8) or, with a few simple modifications, the newer 2716 (2K X 8) EPROM. Since IC1 can address only 256 bytes at a time, however, the higher-order address bits must be manually switched to play all the memory by closing the F and G toggles in S1. Each 256-byte block comprises a "page" of memory (see Fig. 2 for details on how to select individual pages), which means that a 2708 has four pages and a 2716 has eight pages of memory. Since the frequency and duration of each note are defined by an eight-bit code, a 2708 four-page ROM can accommodate a combination of 1024 notes and rests, while an eight-page 2716 ROM can accommodate 2048 notes and rests. The only limitations here are that no single tune can contain more than 256 notes and rests, and no page can have more than 25 different tunes.

The 2708/2716 series of EPROMs are static memory devices that can be programmed, erased, and then reprogrammed numerous times. Widely used in the computer industry, they are supplied by several major manufacturers at prices that make them relatively inexpensive for nonvolatile memory. The EPROMs are programmed ("blown") by selecting an address location and applying a 24-volt pulse to the desired program pin. Articles on building and using devices to program EPROMs with tunes of your choice have appeared in Popular Electronics (see August 1980). If you have the capability to program EPROMs, you can use the programming charts in Fig. 3 as a guide. The three least-significant bits (LSBs) in Chart A define the length.

**Fig. 2. Page-select settings for S1. Shaded area is used only for the 2716.**

<table>
<thead>
<tr>
<th>G</th>
<th>F</th>
<th>H</th>
<th>Page Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
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<td>3</td>
</tr>
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<td>0</td>
<td>6</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

**Fig. 3. Chart A (above) gives the length of each note. Chart B (right) defines the actual music pitch. Codes 377 and 376 cannot be used as "rest" codes.**

<table>
<thead>
<tr>
<th>Name</th>
<th>Frequency (Hz)</th>
<th>Octal</th>
<th>Binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>175</td>
<td>00</td>
<td>000000</td>
</tr>
<tr>
<td>#</td>
<td>185</td>
<td>01</td>
<td>000001</td>
</tr>
<tr>
<td>G</td>
<td>196</td>
<td>02</td>
<td>000010</td>
</tr>
<tr>
<td>#</td>
<td>208</td>
<td>03</td>
<td>000011</td>
</tr>
<tr>
<td>A</td>
<td>220</td>
<td>04</td>
<td>000100</td>
</tr>
<tr>
<td>#</td>
<td>233</td>
<td>05</td>
<td>000101</td>
</tr>
<tr>
<td>B</td>
<td>247</td>
<td>06</td>
<td>001110</td>
</tr>
<tr>
<td>C</td>
<td>262</td>
<td>07</td>
<td>001111</td>
</tr>
<tr>
<td>=</td>
<td>277</td>
<td>10</td>
<td>010000</td>
</tr>
<tr>
<td>D</td>
<td>294</td>
<td>11</td>
<td>010001</td>
</tr>
<tr>
<td>E</td>
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<td>12</td>
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</tr>
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<td>F</td>
<td>330</td>
<td>13</td>
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<td>#</td>
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<td>14</td>
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<td>G</td>
<td>370</td>
<td>15</td>
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<td>392</td>
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<td>011110</td>
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<td>G</td>
<td>417</td>
<td>17</td>
<td>011111</td>
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<tr>
<td>A</td>
<td>440</td>
<td>20</td>
<td>100000</td>
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<td>#</td>
<td>466</td>
<td>21</td>
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</tr>
<tr>
<td>B</td>
<td>494</td>
<td>22</td>
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</tr>
<tr>
<td>C</td>
<td>523</td>
<td>23</td>
<td>100101</td>
</tr>
<tr>
<td>#</td>
<td>554</td>
<td>24</td>
<td>101000</td>
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<td>D</td>
<td>587</td>
<td>25</td>
<td>101011</td>
</tr>
<tr>
<td>#</td>
<td>622</td>
<td>26</td>
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</tr>
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<td>F</td>
<td>659</td>
<td>27</td>
<td>101111</td>
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<td>#</td>
<td>698</td>
<td>30</td>
<td>110000</td>
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<tr>
<td>G</td>
<td>740</td>
<td>31</td>
<td>110001</td>
</tr>
<tr>
<td>#</td>
<td>764</td>
<td>32</td>
<td>110100</td>
</tr>
<tr>
<td>A</td>
<td>831</td>
<td>33</td>
<td>110101</td>
</tr>
<tr>
<td>#</td>
<td>880</td>
<td>34</td>
<td>111000</td>
</tr>
<tr>
<td>B</td>
<td>932</td>
<td>35</td>
<td>111001</td>
</tr>
<tr>
<td>A</td>
<td>988</td>
<td>36</td>
<td>111110</td>
</tr>
</tbody>
</table>

Rset | Silent 37 | 111111 |
of the note (0 through 7), the shortest, 0, being a sixteenth note and the longest, 7, being a whole note. In Chart B, the upper five bits define the actual musical pitch. Octal 077, for example, would be a middle C of whole-note duration. Depending on the system being used, the code may have to be converted to hexadecimal or binary format.

Required with each tune is an end-of-tune marker of octal 377 or binary 11111111. Also required in the PROM is octal 377 at location 0 and octal 376 at the end of the last tune. The end of each page must be marked with octal 125. In a 2708, octal 125 (55 hex) is required at octal locations 377 (FF hex), 1377 (1FF hex), 2377 (2FF hex), and 3377 (3FF hex). Figure 4 gives a simple programming example.

If you don't have an EPROM programmer or prefer not to blow your own PROMs, you can buy preprogrammed PROMs at reasonable cost (see Note 2 in Parts List).

Construction. Since only low-frequency digital signals are present in the Super Music Maker, the component layout is not critical. The use of a printed circuit board and sockets for the ICs are highly recommended. An actual-size etching-and-drilling guide for the board and a component-placement diagram are shown in Fig. 5.

When assembling the project, be
careful to observe the polarities of diodes and electrolytic capacitors and lead locations on the transistors. Do not install the ICs in their sockets until told to do so in the following procedure.

If you decide to use a 2716 EPROM for IC3, some minor changes must be made in the circuit. Pin 19 of IC3, the +12-volt supply-line connection for the 2708, becomes the eleventh address bit (A10) for the 2716. An auxiliary switch with pull-up resistor (R5 and R24 in Fig. 1) are used at point M to allow this additional address to be switched. Then, remove R19 and D8 and jumper from point M to the R19 pad whose trace goes to pin 19 of IC3 and remove D9 and R17 and jumper from pin 21 to pin 24 on IC3. With these modifications, there will be +5 volts on pins 21 and 24, and pin 19 becomes address bit A10 on IC3 for the 2716 EPROM.

After assembling the circuit, and before the ICs are installed in their sockets, apply power and check the power supply section to make sure the proper voltages are present. If all voltages are present at the right places, turn off the power and install the ICs in their respective sockets, making certain that they are properly oriented.

Exercise the usual safe-handling procedures to prevent damaging the CMOS ICs with static electricity. That is, ground yourself and tools before handling the ICs to drain off any charge. Once you pick up an IC, holding it by its narrow edges only, don’t put it down until it is installed in its socket.

**Checkout and Use.** Set ROM-select switch EXT in the S1 assembly to off, and check that all address switches are also off. Pressing the reset switch S3 should then cause the Westminster chime to play. Adjust tempo and pitch controls R26 and R15 for the most pleasing sound.

---

**USING THE SUPER MUSIC MAKER IN A CAR, VAN OR RV**

The project can be operated on a vehicle’s 12-volt dc electrical system if a negative bias is provided for the 2708 EPROM. A separate 9-volt battery will do fine and will last a long time, since the current drawn is only 20mA. (CAUTION: Never operate the project without negative bias or the 2708 will be damaged.) No negative bias is required when a 2716 EPROM (not a Texas Instruments TMS2716) is used, because only a single 5-volt is required. Circuit changes for using the 2716 are detailed in the text.

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- **AC Current:** 0.1µA to 2A, 5 ranges;
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- **Lo-Ohms:** 0.1Ω to 20Mohm, 6 ranges;
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The Great Software Ripoff

It is really amazing how many good, honest citizens who are kind to children and pets, help senior citizens across streets, and wouldn't think of keeping the extra nickel in change that the newsdealer gave by mistake are perfectly willing to steal software. After all, that's what it is when you make up ten cassettes of that new computer game for the guys in your club or when you and your brother-in-law chip in on a new album, one taking the disc and the other making a cassette copy. Not only are these practices fundamentally unethical, but they amount to taking potshots at the goose that lays the golden egg.

Naturally enough, anyone who invests capital in producing software of any description does so with the expectation of making a profit, and if the opportunity for that is taken away so is the motivation for creating the software in the first place. It was not too long ago that owners of the rights to high-level languages were almost willing to bypass the hobby market completely, fearing that they could not adequately fend off unauthorized distribution of their products. A repeat of that situation does not seem likely, but many of the small independent suppliers may well bail out if they find themselves working as a public service.

Though sanctions against unauthorized copying by individuals exist, even the RIAA (Recording Industries Association of America), the watchdog for the music recording industry, admits that enforcement is virtually impossible. And while sophisticated producers of computer software are often able to protect against piracy by hiding secret identifiers in their code (record companies cannot do the equivalent), they are equally powerless against individuals.

The only real solution to this is that people remember what is fair and act accordingly. Making a back-up copy (technically a violation of copyright) is one thing, but giving copies to all your friends is clearly another. If the problem remains serious, we may end up with a legislative solution (probably expensive) that no one will like. More important, the victims of software ripoffs are not faceless companies, but honest individuals who pay the price driven up by others who lack scruples. Another point to remember is that many software suppliers started as hobbyists, and you may someday be selling programs yourself.

Hal Rodgers

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The publisher has no knowledge of any proprietary rights which will be violated by the making or using of any items disclosed in this issue.
This advertisement is about a few wall timers I installed in my home. I expected them to automatically turn my lights on and off and make my home appear lived-in, even when I wasn't at home. But I was in for a surprise. The timers started to buzz. Not loudly, at first, but still very noticeably. Then, after a few months, they started buzzing more loudly. And finally a few of them pooped out completely.

**ABSOLUTELY SILENT**

No wonder. The timers I bought were mechanical devices with a motor and moving parts that switched on and off every 24 hours. In time, the parts aged and buzzed as they wore out. Eventually, they went out completely. I called my local timers, "Buzz Boxes" and knew the electronic revolution was not far behind and a silent and more dependable unit that would do a lot more.

Last month Dynascan Corporation contacted me with a new wall timer which they called the "Night Sentry." This one was totally solid state, no moving parts and above all, absolutely silent. But there were a few pleasant surprises.

**LIVING PATTERN PROGRAM**

The Night Sentry is very easy to program. Just turn a dial to the time (an AM or PM indicator appears) and press a button which turns on the light. Set the time you want the light to go off and press the same button to turn the light off. Keep repeating this process and the Night Sentry will remember the entire program and repeat it for you in silent accuracy year after year after year.

You can also program it in its 'living-pattern' mode. Simply turn your lights on and off throughout a typical day as you normally do. After 24 hours the Night Sentry will remember the exact pattern and your timer will operate your lights just as you yourself did—all automatically.

**LONGER BULB LIFE**

If by chance you have a power failure, the Night Sentry will keep its memory for at least 5 minutes. Since most power failures are momentary, you won't have to reprogram it. But if the power failure is longer than five minutes, when the power does come back on, your lights will remain in their off position.

The Night Sentry has a unique feature that in time could actually pay for the unit. Most bulbs burn out because the power surges each time a bulb is turned on. These power surges weaken a bulb. The Night Sentry has a built-in 'soft start' system that eliminates the surge and thus your bulb will last up to three times longer than its normal life. This is a very important feature for outdoor lighting where bulbs are often more difficult to change and seem to always go out in the dead of winter.

**BATTLESHIP CONSTRUCTION**

When Dynascan Corporation developed the Night Sentry, they decided to go overboard and produce a product that far exceeded standard specifications. For example, the Raytheon Triac used in the system was designed for 220-volt products—not just your fuse box, connect two wires by twisting them together and screw the Night Sentry into your old electrical box. Installation takes less than five minutes and you use the same wall plate you had on your switch before.

I have recently replaced all of the timers in my home. I even added a few in places like my bedroom so that all my lights turn on when it's time to get up. I don't need an alarm clock now. My outdoor and indoor lights are now silently and efficiently controlled, and my house looks lived in even when I'm away.

**TRY ONE OUT**

We urge you to order a Night Sentry for only $24.95 plus $2.50 for postage and handling (Illinois residents add 6% sales tax) or order two for $47 plus $3.00 postage and handling. Credit card buyers may call our toll-free number below. We'll send you a Night Sentry solid-state timer complete with easy-to-install instructions and a one-year limited warranty. There is also a three-way switch timer for $5 extra per unit.

Then use the Night Sentry for a month. Program it. See how silently it operates and then order more for the other rooms in your house. If, however, you're not completely satisfied, return your unit within 30 days for a prompt and courteous refund, including your postage and handling.

I can personally recommend the Dynascan Night Sentry timers. I have them throughout my home and my friends have them too. They really add to our security and peace of mind and I urge you to at least order one at no obligation, today.
In 1978 Ohio Scientific introduced a revolutionary new low cost computer — the Superboard II. This computer provides all important personal computer features on a single board at a cost of under $300. The Superboard II received rave reviews by microcomputer experts such as:

"We can heartily recommend the Superboard II computer system for the beginner who wants to get into microcomputers with a minimum of cost. Moreover, this is a 'real' computer with full expandability."

POPULAR ELECTRONICS MARCH, 1979

"The Superboard II weighs in at $279 and provides a remarkable amount of computing for this incredible price."

KILOBAUD MICROCOMPUTING FEBRUARY, 1979

"The Superboard II and its fully dressed companion the Challenger 1P series incorporate all the fundamental necessities of a personal computer at a very attractive price. With the expansion capabilities provided, this series becomes a very formidable competitor in the home computer area."

INTERFACE AGE APRIL, 1979

"The graphics available permit some really dramatic effects and are relatively simple to program... The fact that the system can be easily expanded to include a floppy means that while you are starting out with a low-cost minimal system, you don’t have to throw it away when you are ready to go on to more complex computer functions. At $279, Superboard II is a tough act to follow."

RADIO ELECTRONICS JUNE, 1979

"The Superboard is an excellent choice for the personal computer enthusiast on a budget."

BYTE MAY, 1979

Since the introduction of Superboard II, the cost of personal computers has actually gone up with new models by major manufacturers ranging from $1000 to well over $4000 due to the general cost of inflation and the increasing functionality included in these computers. Today Cleveland Consumer Computers is offering you the original Superboard II at its original price of just $279. In today’s economy this is by far the best buy in personal computing ever!

The Superboard II can entertain your whole family with spectacular video games and cartoons, made possible by its ultra high resolution graphics and super fast BASIC. It can help you with your personal finances and budget planning, made possible by its decimal arithmetic ability and cassette data storage capabilities. It can assist you in school or industry as an ultra powerful scientific calculator, made possible by its advanced scientific math functions and built-in "immediate" mode which allows complex problem solving without programming! This computer can actually entertain your children while it educates them in topics ranging from naming the Presidents of the United States to tutoring trigonometry — all possible by its fast extended BASIC, graphics and data storage ability.

The machine can be economically expanded to assist in your business, remotely control your home, communicate with other computers and perform many other tasks via the broadest line of expansion accessories in the microcomputer industry.

This machine is super easy to use because it communicates naturally in BASIC, an English-like programming language. So you can easily instruct it or program it to do whatever you want, but you don’t have to. You don’t because it comes with a complete software library on cassette including programs for each application stated above. Ohio Scientific also offers you hundreds of inexpensive programs on ready-to-run cassettes. Program it yourself or just enjoy it; the choice is yours.

The Superboard II comes fully assembled and tested. It requires +5V at 3 Amps and a video monitor or TV with RF converter to be up and running.

$279.00

Standard Features:

• Uses the ultra powerful 6502 Microprocessor.
• 8K Microsoft BASIC-in-ROM. Full feature BASIC runs faster than currently available personal computers and all 8080 based business computers.
• 4K static RAM on board expandable to 8K.
• Full 53-key keyboard with upper/lower case and user programmability.
• Kansas City standard audio cassette interface for high reliability.
• Full machine code monitor and I/O utilities in ROM.
## Software:

Ohio Scientific and independent suppliers offer hundreds of programs for the Superboard II, in cassette and mini-floppy form. Here is a sampling of popular Ohio Scientific programs for the Superboard II.

### EDUCATIONAL PROGRAMS

<table>
<thead>
<tr>
<th>Program</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIC Tutor Series</td>
<td>$35.00</td>
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<tr>
<td>Clock Tutor</td>
<td>$30.00</td>
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<tr>
<td>Computer Quiz</td>
<td>$30.00</td>
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<tr>
<td>Deluxe Integral</td>
<td>$30.00</td>
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<tr>
<td>French Drill &amp; Tutor</td>
<td>$30.00</td>
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<tr>
<td>German Tutor &amp; Drill</td>
<td>$30.00</td>
</tr>
<tr>
<td>Hangman (RK)</td>
<td>$30.00</td>
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<tr>
<td>Log Tutors I-3</td>
<td>$30.00</td>
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<tr>
<td>Math Blitz</td>
<td>$30.00</td>
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<tr>
<td>Math Intro</td>
<td>$30.00</td>
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<tr>
<td>Mathmind</td>
<td>$30.00</td>
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<tr>
<td>Matrix Tutor I-3</td>
<td>$30.00</td>
</tr>
<tr>
<td>Metric Tutor &amp; Quiz</td>
<td>$30.00</td>
</tr>
<tr>
<td>Spanish Drill &amp; Tutor</td>
<td>$30.00</td>
</tr>
<tr>
<td>Spellings Quiz</td>
<td>$30.00</td>
</tr>
<tr>
<td>Trip Tutor (RK) I-2 &amp; II</td>
<td>$30.00</td>
</tr>
</tbody>
</table>

### BUSINESS PROGRAMS

- Address Book
- Advertisement Demo
- Inventory Demo
- Mailing List (RK)
- Straight & Constant Decryption
- Time Calculator

### PERSONAL PROGRAMS

- Biohythum
- Calorie Counter
- Checking Account
- Loan Finance
- Personal Calendar
- Savings Account

### GAME PROGRAMS

- Baseball
- Black Jack
- Civil War
- Destroyer
- High Noon
- Hockey
- Leafer
- New York Taxi
- Poker
- Racer
- Space War
- Star Trek
- Star Wars
- Tic-Tac-Toe
- Tiger Tank

### HARDWARE:

- **Superboard II**: as specified in the advertisement. $279
- **610 Board**: For use with Superboard II and Challenger 1P, 8K static RAM expandable to 24K, or 32K system total. Accepts up to two mini-floppy disk drives. Requires 5V @ 4.5 amps. 298
- **Mini-Floppy Disk Drive**: Includes Ohio Scientific's PICO DOS software and connector cable. Compatible with 610 expander board. Requires +12V @ 1.5 amps and +5V @ 0.7 amps. 299
- **630 Board**: As specified in the advertisement. 4EP 79
- **AC-3P**: 12" combination black and white TV/video monitor. 159
- **PS-005**: 5V 4.5 amp power supply for Superboard II. 35
- **PS-003**: Mini-floppy power supply. 29
- **CIP Sams**: CIP/Superboard II Manual. 6
- **CS-600**: Metal case for Superboard II, 610 and 630 board and two power supply sections. 49
- **CS-610**: Metal case for single floppy disk drive and power supply. 49
- **AC-12P**: Wireless RC remote control system. Includes control console, two lamp modules and two appliance modules for use with 630 board. 175
- **AC-17P**: Home security system. Includes console, fire detector, window protection devices and door unit for use with 630 board. 248
- **C4P Sams**: C4P Manual. 16
- **CS Sams**: Challenger III Manual. 40

### ORDER FORM:

**To Order:**

Or to get our free catalog **CALL 1-800-321-5805 TOLL FREE.**
Charge your order to your VISA or MASTER CHARGE ACCOUNT.
Ohio Residents Call: (216) 464-8947. Or write, including your check or money order, to the address listed below.

**Cleveland Consumer Computers & Components**

P.O. Box 46627
Cleveland, Ohio 44146

**Order Form:**

- **Superboard II $279.**
- **610 Board $298.**
- **AC-3P 12" B-W Monitor $159.**
- **Mini-Floppy Disk Drive $299.**
- **CIP Sams Manual $8.**

(Attach separate sheet for other items.)

**NAME:**

**ADDRESS:**

**CITY:**

**STATE:**

**ZIP:**

**Payment by:**

VISA: __ MASTER CHARGE: __ MONEY ORDER: __

**Credit Card Account #**

**Expires:** [ ] Interbank # (Master Charge)

**TOTAL CHARGED OR ENCLOSED:**

All orders shipped insured UPS unless otherwise requested. FOB Cleveland, Ohio.

**CIRCLE NO. 55 ON FREE INFORMATION CARD**

**OCTOBER 1980**

**Freight Policies:** All orders of $100 or more are shipped freight prepaid. Orders of less than $100 please add $4.00 to cover shipping costs. Ohio Residents add 5.5% Sales Tax.

**Guaranteed Shipment:** Cleveland Consumer Computers & Components guarantees shipment of computer systems within 48 hours upon receipt of your order. Our failure to ship within 48 hours entitles you to $35 of software, FREE.

**Hours:** Call Monday thru Friday 8:00 AM to 5:00 PM E.D.T.
Video Review knows a bright idea when it sees one.

Video Review magazine tests a lot of sophisticated video products. They get to see virtually every make and type of color TV receiver. Which makes their selection of Magnavox as their standard TV receiver pretty impressive.

"We thought the Magnavox picture quality and resolution were superb."

"Ever since Video Review began testing products," says the magazine, "we've been looking for a top quality, 19-inch TV set that might serve as a standard of reference for all of the other products we test: video cameras, video cassette recorders, video cassettes. We thought the Magnavox picture quality and resolution were superb, and that off-the-air sensitivity was also extremely good.

"Major VHF channels were received with uniformly accurate color fidelity. This receiver produced superior color pictures even when using its own indoor VHF and UHF antennas:"

"The special tuning features and remote control capabilities of the Magnavox receiver are awesome."

"The tuning system is purely electronic and totally digital," they continue. "There is a fine tune switch and a memory lock button. If any channel is received mistuned, the user simply fine tunes up or down in frequency by holding the button, and when perfect tuning has been achieved, the button is released and the memory lock button is depressed once."

"Nearby is Magnavox's Video-matic feature. Depressing this button activates the electronic eye for automatic brightness adjustment, color adjustment circuits and automatic fine tune."

"...unusually good for any receiver."

Overall, Video Review rated the Magnavox 9.5 or better (out of a possible 10.0) on Video Quality, Reception Sensitivity, Color Fidelity, and Video Resolution and Fidelity. As they put it, "...unusually good for any receiver."

We can only add that once you see a Magnavox color TV at your Magnavox dealer, we think you'll agree.

For Magnavox color TV specifications, write Magnavox Consumer Electronics Company, Dept. 700, P.O. Box 6950, Knoxville, Tennessee 37914.

© 1980 MAGNAVOX CONSUMER ELECTRONICS CO.

The brightest ideas in the world are here to play.
Noise Generators and Tinnitus

I have had several letters with regard to uses for noise generators such as those described in my Experimenter’s Corner of March 1980. One of the more interesting came from a reader who suffers from tinnitus (the perception of sounds which are not actually present). He wondered if a noise generator would be effective in masking the tinnitus, which, in his case, is both a background noise and a pulsatile noise synchronized with his heartbeat. He noted that he gets some relief by listening to the “pepper and salt” noise produced by a nonbroadcast TV channel via an earphone. He also stated that his background tinnitus is almost eliminated by the high-pitched sounds produced by crickets and other insects on a summer evening.

It is indeed possible that a noise generator could be used to partially alleviate tinnitus by simulating and masking the noise. If any reader has suggestions or wishes to correspond with the original letter writer regarding tinnitus or pulse-triggered masking circuits, please send them to me in care of POPULAR ELECTRONICS and I will forward them.—Forrest M. Mims.

Switch Identification

In “Experimenting with a Sound-Effects Generator” (May 1980), one side of switches S14 through S18 is labeled 0. Does this mean “logic 0”? If so, where is it supposed to be connected? To ground?—Dale Hileman, Topanga, CA 90290.

As identified in Table II, one side of each of these switches is connected to logic 0, which in this case is ground, logic 1 being +5 volts. The switch points can all be connected together and then to ground.—Ed.

Out of Tune

In “Build a LED Pendulum for Digital Clocks” (July 1980, p. 30), the connections between the 7400 and the 7442 should be reversed. That is, pin 1 of the 7400 should go to pin 11 of the 7442, and pin 5 of the 7400 to pin 1 of the 7442.

In the Project of the Month in August 1980, the output terminal of the 741 op amp should be labelled 6 instead of 1.

NOVEMBER 1980
New Products

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

Micro-Acoustics
Phono Cartridge

Micro-Acoustics has announced a line of "System II" phono cartridges that it claims are the lightest weight, fastest-transient-response cartridges ever manufactured. The Model 3002 is the middle of the three-model line. It uses a direct-coupled microminiature transducer instead of magnet coils for improved transient response. Use of the electret transducer, a low-mass carbon-fiber housing, hair-thin beryllium cantilever, and an almost microscopic diamond stylus are responsible for the weight reduction. The ultralow mass of the cartridge is said to aid in accurate tracking and reduced record wear. Specifications: frequency response, 5 to 20,000 Hz ± 1.25 dB; tracking force, 0.7 to 1.4 g; transient ability (rise time), 5 µs; channel separation, 30 dB at 1 kHz, 20 dB at 10 kHz; cable capacitance/phono input load resistance (not critical), 25 to 100 pF/5 to 100 kΩ; cartridge weight, 2.5 to 4 g. $150.

CIRCLE NO. 87 ON FREE INFORMATION CARD

Technics "Class-A" Stereo Receiver

The Model SA-616 stereo receiver from Technics features a power amplifier, said to eliminate switching distortion, and rated to deliver 80 watts/channel into 8 ohms from 20 to 20,000 Hz with no more than 0.005% THD. It uses a quartz synthesizer tuner with digital display of station frequency. Manual tuning is accomplished by pressing the up/down scanning bar, providing 200-kHz steps on FM and 10-kHz steps on AM. Furthermore, 16 stations (8 each AM and FM) can be preset for instant recall at the touch of a button. Other features: two-way tape dubbing; 1/10-mV range boost/cut switches; LED power display; and protection/safety indicators.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Indoor Scanner Antenna

Antenna Incorporated's Persuader is designed for scanner monitoring of the public service bands between 25 and 900 MHz. It is meant to be hidden behind curtains or drapes and is said to outperform the short, stock telescopic antennas provided with most scanning monitors. It consists of a seven-foot wire antenna element that is to be attached vertically to an interior wall, a small adhesive-backed box to be mounted on the baseboard, a two-foot length of wire for attachment to a ground, and a ten-foot length of signal cable terminated with a pin plug for insertion into the scanning monitor's antenna receptacle. $11.95.

CIRCLE NO. 91 ON FREE INFORMATION CARD

FET Power Amplifier

Optonica's Model SX-9305 power amplifier is rated to deliver 100 watts minimum power per channel into 8 ohms from 20 to 20,000 Hz with no
UNDISCLOSED SOURCE

Now, the closely held secret behind many of today’s quartz timepieces is revealed.

Most major companies would rather have these facts remain secret, but one little-known company decided to show its genius to the world.

To effectively compete in world markets and when lacking in necessary technology, many major companies have turned to smaller more dynamic companies to build their products. Sometimes the product is built to the specs of the major company. But more often than not, the only unique parts are a label and different owner’s manual. This practice is quite prevalent in the digital watch industry.

One company that has been the real source behind products introduced in the U.S. by companies like Mattel, Timex and Texas Instruments, is Olympos Electronic Co., also known as Otron.

Olympos Electronic now wants the world to know its name and genius. We feel lucky to be selected to bring this story to you.

Olympos Electronic Co. is now introducing products into this country under its own trade name—Otron. We are introducing one of the first Otron products into the U.S.

12 or 24 HOUR DUAL TIME, DUAL ALARM CHRONOGRAPH

The first product we selected is the Alarm Chrono X watch. It may be the most advanced Quartz timepiece in the world today for under $200.

We know of no other watch that combines these unique features and design. It has both a 2nd time zone capability and a 2nd separate alarm. It comes in either 12 or 24 hour version. These features are just the beginning. Compare this watch feature-for-feature against any other in the world. We believe you will be convinced that there is not a better watch dollar-for-dollar anywhere. TESTED TO 100 FEET OF WATER

Three years ago, there were no digital water resistant alarm watches. Today they exist in some more advanced models, but cost $100, $200 or more. Our Alarm Chrono X is submersible to 100 feet of water. Its unique alarm emits sound right thru the stainless steel case. The O-ring construction and rock hard mineral glass lens provide a lock tight seal against water to 100 feet—it’s guaranteed.

THINNESS AND BOLD MASCULINE DESIGN

The Alarm Chrono X is a combination of bold masculine design and just the right degree of thinness. No sacrifice in function or masculinity, the Chrono X measures 8.9 mm from the top of its mineral glass lens to the back of its stainless steel case. That’s 1.6 mm thinner than the popular Seiko Alarm Chronograph, 2.1 mm thinner than the Citizen and 3.1 mm thinner than Texas Instruments. Yet Alarm Chrono X has the same bold design of each. The Seiko sells for $250; the Citizen for $200; and the T.I. for $125. What does Otron know that these other companies don’t?

CIRCLE NO. 46 ON FREE INFORMATION CARD

UNSURPASSED QUALITY AND ACCURACY FOR UNDER $70

Stainless steel case, and finely woven mesh bracelet, mineral glass lens, water resistant to 100 feet and quartz accuracy to ± 5 seconds per month. That’s quality and accuracy found only in watches costing $200 or more. The Alarm Chrono X sells for $69.95 in stainless steel case and $79.95 in gold with 3 microns of real gold over stainless. Compare features and price for yourself before you call to order.

ORDER TOLL FREE AT NO-RISK

The Alarm Chrono X is offered with a 15 day no-risk trial period. If during 15 days, you find the Alarm Chrono X not to your liking return it for a prompt refund of your purchase price.

In the unlikely event that anything should go wrong after the trial period, your Alarm Chrono X is backed by a full year warranty thru Otron’s Service by mail repair facility in this country.

To order your Alarm Chrono X fill out the order form below and send it with check or money order to us. For faster service, credit card customers call Toll Free 1-800-527-7066. Don’t wait—order today to insure getting a watch of this quality, with these functions, at this price.
more than 0.01% THD. It uses FET circuitry and direct coupling throughout. The power supply employs a toroidal transformer, and a gas/liquid heat-radiation system cools the output stage. The package includes a 10-band audio spectrum analyzer (switchable to display left or right channel) and LED power indicators, as well as a detented volume control and speaker selector switch (A, B, or A + B). $850.
CIRCLE NO. 92 ON FREE INFORMATION CARD

**EPROM Eraser**

Operating at 2537 Angstroms with a power of 1.5 watts, the QUV-T8 UV EPROM Eraser can be used with 2704, 2708, 2716, 2532, 2564, and similar ultraviolet erasable EPROMs. Claimed erase time is 25 minutes at a distance 1 inch from the ultraviolet source. The ultraviolet lamp requires 8 watts and has a rated 7700-hour operating life. $34.95. Address: Logical Devices, Inc. 1325 N. E. 26th St., Ft. Lauderdale, FL 33305.

**ID System for Wrapped-Wire Sockets**

OK Machine and Tool Corp. is now offering the "Socket-Wrap I.D.," an identification system designed for use with wrapped-wire IC sockets. This system comprises a number of socket-size plastic panels with numbered holes punched at the appropriate hole locations. A panel is simply slipped onto the protruding pins of the socket to be identified, after the socket has been mounted on the perforated circuit board but before any wrapped-wire connections have been made. The user can write the socket location, its IC type number, function, or similar data on the plastic panel with a felt-tipped marking pen. Benefits of the Socket-Wrap I.D. system include simplified assembly of a wrapped-wire project and easier troubleshooting and repair should they be required.
CIRCLE NO. 93 ON FREE INFORMATION CARD

**JBL Compact Speaker System**

A new three-way ported speaker system from James B. Lansing, Model L112, is designed in mirror-image pairs for more accurate stereo. The system features a new 1" dome-radiating tweeter, 5" midrange driver, and 12" woofer, plus a "High Resolution" dividing network. Tweeter and midrange level controls are located on the front panel, behind the grille cloth. The enclosure is constructed of dense compressed-wood panels faced with American black walnut veneer. The L112 can be driven by as little as 10 watts of power, and handles up to 300 watts continuous power. Size is 241/2" H X 141/4" W X 13" D.

CIRCLE NO. 94 ON FREE INFORMATION CARD

**Kenwood 2-Meter FM Transceiver**

Trio-Kenwood Communications' new Model TR-7800 FM transceiver covers the 2-meter amateur band as well as adjacent CAP and MARS frequencies (143.900-148.995 MHz). The microprocessor-controlled transceiver can be tuned to a desired frequency by means of either a keypad or a rotary tuning control. Fifteen programmable memory locations accept frequency and offset instructions. One of them accepts transmit and receive frequencies independently for access to repeaters on nonstandard splits, while another is for a "priority" channel. (An audible alert is generated upon receipt of a signal on the priority channel if this function is activated, and the push of a switch tunes the rig to that channel.) Information is retained in the memories after removal of power if four AA NiCd batteries are installed. The front-panel keypad also controls an internal tone encoder for autotach use, and is used to select transmit offsets, to program the memories, and to control the rig's scanning function. The latter can scan all 15 memory channels and the entire band in 5- or 10-kHz steps. Two buttons (UP and DOWN on the microphone's case) permit manual scanning of the band. Two seven-segment LED readouts display the memory channel selected and the receive frequency. A LED bargraph displays received signal strength and transmitter r-f output. Rated sensitivity is 0.5 µV for 30 dB (S+N)/N; selectivity -60 dB at ±12 kHz; and r-f output power into 50 ohms is 25 watts or 5 watts (switchable). Current demand is 6 amperes max. at 13.8 volts. The rig weighs 4.6 lb and measures 81/16" D X 61/8" W X 21/2" H. $399.95.

CIRCLE NO. 95 ON FREE INFORMATION CARD

**TRS-80 Cassettes Load at Disk Speed**

Personal Micro Computers Inc., announces a Fastload Cassette Interface said to input data to a TRS-80 Model 1, Level II computer at 8000 baud (16 times normal speed) using a modified CTR-4I recorder. Any cassette saved at normal (500 baud) speed can now be loaded at high speed. Fastload is also capable of high-speed search for BASIC programs by a single character designation, or system programs having a name up to six characters in length. High-speed recording is not provided. The system contains a keyboard debounce program having automatic repeat and provides a sound output for each keystroke. Instructions for the CTR-4I modification are provided. $188. Modified CTR-4I recorder is $95.

CIRCLE NO. 96 ON FREE INFORMATION CARD

(Continued on page 15)
The first personal computer for under $200.

The Sinclair ZX80.
A complete computer—only $199.95 plus $5.00 shipping.

Now, for just $199.95, you can get a complete, powerful, full-function computer, matching or surpassing other personal computers costing several times more.

It's the Sinclair ZX80, the computer that independent tests prove is faster than all previous personal computers. The computer that "Personal Computer World" gave 5 stars for 'excellent value.'

The ZX80 cuts away computer jargon and mystique. It takes you straight into BASIC, the most common, easy-to-use computer language.

You simply take it out of the box, connect it to your TV, and turn it on. And if you want, you can use an ordinary cassette recorder to store programs. With the manual in your hand, you'll be running programs in an hour. Within a week, you'll be writing complex programs with confidence.

All for under $200.

Sophisticated design makes the ZX80 easy to learn, easy to use.

We've packed the conventional computer onto fewer, more powerful LSI chips—including the Z80A microprocessor, the faster version of the famous Z80. This makes the ZX80 the world's first truly portable computer (6¼" x 8¼" x 1¼" and a mere 12 oz.). The ZX80 also features a touch sensitive, wipe-clean keyboard and a 32-character by 24-line display.

Yet, with all this power, the ZX80 is easy to use, even for beginners.

Your course in computing.

The ZX80 comes complete with its own 128-page guide to computing. The manual is perfect for both novice and expert. For every chapter of theory, there's a chapter of practice. So you learn by doing—not just by reading. It makes learning easy, exciting and enjoyable.

The ZX80's advanced design features.

Sinclair's 4K integer BASIC has performance features you'd expect only on much larger and more expensive computers. These include:
- Unique 'one touch' entry. Key words (RUN, PRINT, LIST, etc.) have their own single-key entry and are stored as a single character to reduce typing and save memory space.
- Automatic error detection. A cursor identifies errors immediately to prevent entering programs with faults.
- Powerful text editing facilities.
- Also programmable in machine code.
- Excellent string handling capability—up to 26 string variables of any length.
- Graphics, with 22 standard symbols.
- Built-in random number generator for games and simulations.

Sinclair's BASIC places no arbitrary restrictions on you—with many other flexible features, such as variable names of any length.

And the computer that can do so much for you now will do even more in the future. Options will include expansion of 1K user memory to 16K, a plug-in 8K floating-point BASIC chip, applications software, and other peripherals.

Order your ZX80 now!

The ZX80 is available only by mail from Sinclair, a leading manufacturer of consumer electronics worldwide. We've already sold tens of thousands of units in Europe, so demand will be great.

To order by mail, use the coupon below. But for fastest delivery, order by phone and charge to your Master Charge or VISA. The ZX80 is backed by a 30-day money-back guarantee, a 90-day limited warranty with a national service-by-mail facility, and extended service contracts are available for a minimal charge.

Price includes TV and cassette connectors, AC adaptor, and 128-page manual.

All you need to use your ZX80 is a standard TV (color or black and white). The ZX80 comes complete with connectors that easily hook up to the antenna terminals of your TV. Also included is a connector for a portable cassette recorder, if you choose to store programs. (You use an ordinary blank cassette.)

The ZX80 is a family learning aid. Children 10 and above will quickly understand the principles of computing—and have fun learning.

Phone orders only: (203) 265-9171. We'll refund the cost of your call.


Phones open Monday-Friday from 8 AM to 8 PM EST.

Sinclair Research Ltd. 475 Main St., P.O. Box 3027, Wallingford, CT 06492.

To: Sinclair Research Ltd., 475 Main St., P.O. Box 3027, Wallingford, CT 06492.

Please send me __ ZX80 personal computer(s) at $199.95 each (US dollars) plus $5 shipping. (Your ZX80 may be tax deductible.)

I enclose a check/money order payable to Sinclair Research Ltd. for $__________.

Name

Address

City __________ State ______ Zip __________

Occupation: __________________________ Age: __________________________

Intended use of ZX80:

Have you ever used a computer? □ Yes □ No.

Do you own another personal computer? □ Yes □ No. *For Conn. delivery, add sales tax.

PE-11-0

NOVEMBER 1980
HEAR WHAT YOU'VE BEEN MISSING!

Listen with an 801 Omnisonic Imager,™ a quantum leap forward in sound reproduction!

OMNISONIC IMAGERY™ IS HERE!
Our innovative state-of-the-art electronics restore the acoustical time-field characteristics and angular sonic positioning of the original recorded signal. The 801 analyzes the input signal and determines relative positions of instruments and vocals on the original source. They are then placed about the listening space creating the physiological sensation of three-dimensional sound — what we call omnisonic imagery™ — using only two speakers! Sound appears to come from many sources within the listening space. A common reaction is to look about for other speakers. And you don't have to sit rigidly fixed at a focal point between the speakers to enjoy the 801!

NEW DIMENSIONS IN STEREO AND MONO!
Stereo with an 801 Omnisonic Imager™ creates a vivid feeling of "being there". Depending upon the source, the system, and the listener, sound appears to surround you, emanating from well beyond the speakers, above and below, near and far. The music is so alive it envelopes you. It is the sound of the future!

From mono, the 801 creates omnisonic dimensional sound. You can input an AM or TV source from the earphone jack on your set and into the 801 and into your stereo system. The result is a "live" sound with depth and clarity, as well as separation. Television sound is vastly improved with the 801!

RETROFITS TO MOST STEREO SYSTEMS!
Any system with an internal tape loop can connect to the 801. Component systems can insert the 801 between pre-amp, other accessories, and the amplifier. There's a built-in tape monitor button on the 801, so you don't lose your existing tape monitor facility. The 801 works on any stereo or mono source — FM, tapes, records, AM, TV. You can record selections via the 801 and replay them on conventional home-use stereo equipment.

LIFETIME WARRANTY!
You get a lifetime warranty on the active circuitry and one year on all other components (case and line cord excluded) provided your 801 is used as specified.

SUGGESTED LIST: ONLY $179.95

Now that you've read all about our 801 Omnisonic Imager™, don't you think it's time to hear one? If we have stimulated your interest in seeking the finest sound reproduction in the purest sense, please ask your dealer for a live demonstration. If you have any questions, or need to know the name of the dealer nearest you, call or write to:

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P.O. Box 430
Northford CT U.S.A. 06472
(203) 239-6213

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DON'T MISS: Highway HiFi Imagery With The 801-A Auto Unit Coming Soon!
**new products**

**Low-Cost AM/FM-Stereo PLL Tuner**

JVC’s newly announced Model T-X3 is a low-cost stereo FM/AM tuner that features a phase-locked-loop (PLL) tuner, a phase tracking loop (PTL) FM-detector circuitry, and quieting slope control. The PTL system increases selectivity with wide bandpass response, while the quieting slope control automatically corrects weak FM signals by compensating the amount of left-with-right high-frequency mixing. The tuner’s 50-dB quieting sensitivity on FM stereo is 31 dB (quieting on auto), 36.8 dB (quieting off). Other specifications: stereo separation, 50 dB at 1 kHz, 0.13% stereo distortion at 100 Hz and 1 kHz, S/N, 78 dB stereo; frequency response, 30 to 15,000 Hz ± 0.3/± 2 dB; capture ratio, 1.0 dB. Size is 3 1/2” H × 18 1/4” W × 14 3/4” D. $219.95.

*CIRCLE NO. 97 ON FREE INFORMATION CARD*

**Rotatable Antenna Digital Readout**

The DX-3 kit takes ham or CB antenna rotor control position and converts it to a digital signal for display on a 3-digit, 7-segment LED readout. Claimed antenna azimuth aiming accuracy is one degree. The kit uses a three-wire interconnect and is adaptable to most rotor systems. $39.95. Address: Monitor, Box 55, Agincourt, Ont., Canada M1S 3B4.

**Logic Timing Recorder**

The Logic Timing Recorder from AP Products Inc., is a timesaving device for charting logic timing. The Recorder is fabricated from ABS plastic and measures 11 3/4” by 8 1/4” and is 1/4” thick. It consists of 320 slides arranged in eight horizontal rows. Moving vertically between two click-stop positions, the slides represent the two logic levels in a circuit. After the slides have been placed in the position that represents the logic state of the circuit, the board is placed in a conventional copying machine to make a record for filing. After copying, the Recorder can be reused for other digital circuits whose waveforms must be retained for future reference. Blank spaces are provided for notes, dates, model and drawing numbers, customer and product names, and space for designers initials. $44.95.

*CIRCLE NO. 99 ON FREE INFORMATION CARD*

**Logic Timing Recorder**

The Logic Timing Recorder from AP Products Inc., is a timesaving device for charting logic timing. The Recorder is fabricated from ABS plastic and measures 11 3/4” by 8 1/4” and is 1/4” thick. It consists of 320 slides arranged in eight horizontal rows. Moving vertically between two click-stop positions, the slides represent the two logic levels in a circuit. After the slides have been placed in the position that represents the logic state of the circuit, the board is placed in a conventional copying machine to make a record for filing. After copying, the Recorder can be reused for other digital circuits whose waveforms must be retained for future reference. Blank spaces are provided for notes, dates, model and drawing numbers, customer and product names, and space for designers initials. $44.95.

*CIRCLE NO. 99 ON FREE INFORMATION CARD*

**Low-Range Ohmmeter**

The Model RX-2 LOHMETER (low-ohmmeter) from Alpha Components Corp., is designed to work in conjunction with a conventional analog or digital voltmeter to make resistance measurements from 0.001 ohm to 100 ohms, in three ranges. The device uses the four-terminal principle to compensate for test-lead resistance. It is powered from the 117-volt ac line but is available in a 240-volt version. A pair of LEDs, coordinated with the range selector switch indicates the range. $39.95. Address: Alpha Components Corp., 115 Eucalyptus Dr., Box 306, El Segundo, CA 90245.

*CIRCLE NO. 98 ON FREE INFORMATION CARD*

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**...THEY HEARD WHAT THEY’VE BEEN MISSING! AND HERE’S WHAT THEY SAID:**

"...there isn’t anything I’ve heard that improves the sound quality as much as the 801 does. Especially for such an economical cost."

J. Hagen, Milwaukee, WI

"The 801 makes you feel like you are right in the studio or concert hall. The music totally surrounds you... An audiophile’s dream come true, SUPER FANTASTIC!!!"

J. Capsalis, Newport News, VA

"I have almost $6,000 in my stereo. I have time delay, reverb amp, equalizer, dynamic range expander, etc. I have never been more surprised or impressed by any piece of equipment than I was with your 801 Omnisonic Imager! Rig on!"

B. Nolan, Massillon, Ohio

"When I first turned on the switch I felt a resurgence of spirit—lifting. The quality of sound—especially in separation and clarity—was greatly improved. When I had my eyes shut I felt surrounded by music in space—very enjoyable feeling."

L. Jensen, Tampa, FL

"I must say before anything else that it’s the greatest piece of equipment I own! Every advertising claim made was true, which is quite unbelievable, until you hear the Imager in operation. I will never turn it off.

C. Zilavy, Vineland, NJ

"On the basis of subjective experience I can attest that the Omnisonic product works quite well. It seems to remove virtual sound sources from the plane of the loudspeakers and distribute them at various positions in the listening space, adding a sense of front-to-back dimension at the same time. At times, some sounds appear to come from in back of the listener, which is a startling effect, given that sound is being radiated only from the front. Another effect the device produces is a greatly increased sense of ambience or spaciousness."

Harold A. Rodgers
Executive Editor
POPULAR ELECTRONICS
July 1980

What better Holiday gift for yourself or your friend(s) than the 801 OMNISONIX IMAGER! Call or write today! (See opposite page.)

* 1980 OMNISONIX LTD.
Now NRI takes you inside the world's most popular microcomputer to train you at home as the new breed of computer specialist!

NRI teams up with Radio Shack to teach you how to use, program and service microcomputers... make you the complete technician.
It's no longer enough to be just a programmer or a technician. With microcomputers moving into the fabric of our lives (over 200,000 of the TRS-80™ alone have been sold), interdisciplinary skills are demanded. And NRI can prepare you with the first course of its kind, covering the complete world of the microcomputer.

**Learn At Home in Your Spare Time**

With NRI training, the programmer gains practical knowledge of hardware, enabling him to design simpler, more effective programs. And, with advanced programming skills, the technician can test and debug systems quickly and easily. Only NRI gives you both kinds of training with the convenience of home study. No classroom pressures, no night school, no gasoline wasted. You learn at your convenience, at your own pace. Yet you're always backed by the NRI staff and

your instructor, answering questions, giving you guidance, and helping you over the tough spots.

**Explore the TRS-80 Inside and Out**

NRI training is hands-on training, with practical experiments and demonstrations as the very foundation of your knowledge. You don't just program your computer, you go inside it...introduce and correct faults...watch how circuits interact...interface with other systems...gain a real insight into its nature.

You also build essential test instruments like a transistorized voltmeter and CMOS digital frequency counter. You work with the exclusive NRI Discovery Lab, performing over 60 separate experiments in all. You learn how your trouble-shooting tools work, and gain greater understanding of the information they give you. Both microcomputer and equipment come as part of your training for you to use and keep.

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Get all the details on this exciting course in NRI's free, 100-page catalog. It shows all equipment, lesson outlines, and facts on other electronics courses such as Complete Communications with CB, TV and Audio Servicing, Digital Electronics, eleven different interest areas in all.

Send today, no salesman will ever bother you. Keep up with the latest technology as you learn on the world's most popular computer. If postcard has been used, write to NRI Schools, 3939 Wisconsin Ave., Washington, D.C. 20016.

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(TRS-80 is a trademark of the Radio Shack division of Tandy Corp.)
As your computer skills grow, so does your Heath H8 System. New accessories and software are coming along all the time to make your system do more.

Special bus design gives you seven plug-in board positions so you can configure any combination of memory, I/O's and accessories. You can interchange boards. Add accessories. Build exactly the system you want.

A wide selection of software makes your life more fun and more efficient. Hundreds of programs for business, home and family are available from Heath User's Group. Also two BASIC languages, Microsoft" and Fortran. And more programs are being developed all the time.

If you haven't seen the latest Heathkit catalog, you haven't seen the latest in computer fun. There's a new Music Synthesizer Board, new Speech Lab, new Color Graphics Board and new Color Monitor. And coming soon, a new three-drive disk system. For an exciting computer hobby, there's no more exciting computer than the Heath H8 — available fully assembled or in money-saving kit.

For complete details and prices on the H8 and the complete line of Heath printers, terminals and accessories, write today for the new, free Heathkit Catalog, or pick one up at your nearby Heathkit Electronics Center.

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Complete support, so you're never left out in the cold.
SAE TWO Model R9
AM/FM Stereo Receiver

Features quartz-lock digitally synthesized tuning and 90 watts/channel into 8-ohm loads

THE SAE Model R9 is a deluxe AM/FM stereo receiver featuring digitally synthesized tuning and an exceptionally competent power amplifier section rated at 90 watts per channel into 8-ohm loads with no more than 0.05% total harmonic distortion. Like the other SAE TWO components, the R9 is finished in black, accented by walnut-grain wooden side panels. Accessory handles and mounting adapters are available for mounting the receiver in a standard 19-inch EIA rack. SAE TWO audio components are manufactured in Japan to SAE's design specifications. Suggested retail price is $800.

General Description. The “dial window” of the front panel is quite different from the usual receiver tuning display. Frequency is shown by four large (½") blue digits, flanked by the indicators “FM” and “MHz,” or “AM” and “kHz,” according to the selected band. Only the “odd” FM channels (88.1, 88.3, etc. MHz) can be tuned, AM tuning increments in 1 kHz steps.

Power to the speakers or voltage to the TAPE RECORDER jacks can be read from a dual horizontal LED display. The function chosen is shown by adjacent LEDs. The scale is calibrated in watts and decibels relative to 90 watts into 8-ohm loads. When showing output to the recorder jacks, the display is calibrated so that 0 dB corresponds to “0 VU” (0.77 volts). The DISPLAY selector also has an FM/AM position that converts the upper (LEFT) bar to a relative signal strength indicator for FM and AM, and the lower (RIGHT) bar to a multipath distortion indicator for FM. The LEDs that identify function change accordingly.

A large VOLUME knob is found on the panel, but there is no conventional tuning knob. Instead, a pair of flat pushbuttons to the right of the digital display tune the receiver UP and DOWN in frequency. There are two tuning modes, neither of which is clearly identified in any of SAE's accompanying literature. The choice between the two is implemented via the SCAN button. With SCAN disengaged, a momentary touch of either tuning button will step the tuned frequency in the corresponding direction until a signal is acquired. In the other mode, frequency changes as long as the button is held in, stopping at the first FCC-assigned channel reached after the button is released. A momentary touch of the button shifts the tuning by one channel.

After a signal has been acquired, a quartz-lock feature comes into action automatically. According to the manufacturer's description, quartz-lock fine tunes the receiver to the exact station frequency, instead of to the local oscillator frequency reference. (The need for this is not evident, nor is it explained further.) When the station is locked in, a green Q-LOCK indicator comes on below the level display. Below the frequency readout is a red STEREO indicator for FM.

A series of pushbuttons below the display area select the program source (PHONO 1, PHONO 2, AUX, FM, and AM), and engage HI BERN (for reducing noise on weak FM stereo signals), FM MUTE, and SCAN. FM MUTE is nor-
mally on and cuts out when SCAN is depressed.

Under the tuning buttons is a simi-
lar set of buttons for L FILTER, LOUD-
NESS, and audio MUTING (a –20-dB gain reduction). A similar button below the VOLUME knob is the POWER swit-
ch.

Three knobs act as separate BASS, MID, and TREBLE tone controls, and there is a switch that bypasses them all. Other switches provide tape MONI-
TOR functions for two tape decks and cross-connect the decks for dubbing with either as source. Another switch, marked EXT PROS, can connect an ac-
cessory such as an equalizer or noise re-
ducer into the signal path, either be-
fore or after the tape monitoring and recording circuits.

Normal or reversed stereo or mono operation can be chosen via the MODE switch. Either, both, or neither of two sets of speaker connections can be switched in, and there is a headphone jack that is always active. The bal-
ance control has a center detent.

Several internal protective circuits safeguard both the R9 and the speak-
ers connected to it from damage due to failure or careless operation. On ini-
tial power-up, there is a delay of 3 to 5 seconds before a relay connects the speaker outputs, to allow internal voltages to stabilize. If a significant dc offset voltage appears at the out-
put, the speakers are also discon-
ected. Service is restored auto-
matically when the fault is corrected. This system also protects against large in-
frasonic transients. Tripping the pro-
tection, say the instructions, does not silence the receiver, but reduces out-
put to a low level.

Other protective devices include a thermal cut-out, fuses, and a circuit that limits output current into resistive loads under 2 Ω without restricting the drive into 4-Ω or higher impedances, even with reactive loads such as electrostatic speakers.

On the rear of the SAE R9 are the various signal input and output jacks, insulated spring connectors for the speaker outputs, and small binding post terminals for the antenna connections. There is a hinged AM ferrite rod antenna. Three of the four ac out-
lets are switched.

The SAE R9 is 18¾” W, 17½” D, and 5¼” H. It weighs 35 pounds.

Laboratory Measurements. The one-hour preconditioning period at one-third rated power left the top of the SAE R9 only moderately warm. Power output at clipping, with both channels driven at 1 kHz, was 110 watts into 8-Ω loads, 123 watts into 4 Ω, and 166 watts into 2 Ω. The receiver is rated only for 8-Ω opera-
tion, so its IHF clipping headroom comes out to 0.85 dB. Short-term power output at clipping, using the tone-burst signal of the IHF dynamic headroom test, was respectively 156 and 168 watts for 4 Ω and 8 Ω. At 2 Ω, dynamic power output measured 0.3 dB less than the continuous clipping output. This seems unlikely in fact, and probably results from a less accu-
rate power measurement in the dy-
namic test (voltage at clipping must be read from an oscilloscope). The IHF dynamic headroom rating (at 8 Ω) is 2.4 dB.

Distortion performance easily met and surpassed its ratings (at least 90 watts per channel to 8-Ω loads from 20 to 20,000 Hz with no more than 0.05% total harmonic distortion). Measurements with 2-Ω loads were made with somewhat by interrup-
tions due to the thermal circuit break-
er, dc fuses, and overcurrent protec-
tive systems, but these, along with the data for 4-Ω loads, fell within the pri-
mary ratings.

At maximum gain (46 dB), the am-
plifiers required a high-level (AUX) in-
put of 14.5 mV for a reference output of 1 watt; A-weighted signal-to-noise ratio was 74.7 dB. Through the phono input, sensitivity was 0.21 mV (83 dB overall gain), with a 73.5-dB signal-
to-noise ratio. The lowest phono over-
load level in the 20 to 20,000 Hz range (referred to the equivalent 1,000 Hz levels) was 207 mV. Phono input impedance was 52 kΩ in parallel with 70 pF.

We measured IHF IM distortion using two equal-amplitude input sig-
als at 19 and 20 kHz. Their equiva-
 lent peak value corresponded to that of a sine wave output of 90 watts into 8 Ω. The lower-third-order distortion product at 18 kHz was at a −70-dB level (0.03%) and the second-order difference tone product at 1 kHz was at a negligible −90 dB (0.003%).

IHF transient overload recovery time was about 20 μs. This was mea-
sured with an input signal that gave continuous output of 9 watts at 1 kHz and was increased by 20 dB for 20 ms out of each half second.

Square-wave rise time was 6 μs through the AUX inputs, and the slew rate was 19 volts per μs. IHF slew fac-
tor was 5.5, with slew limiting becom-
ing apparent on a "full signal" drive wave form at 110 kHz.

When we drove a rather severe load of 4 Ω in parallel with 3 μF, using a 10-kHz square wave, we observed a couple of cycles of ringing at about 40 kHz, but no sign of instability or pro-
tective shutdown, even at full power.

The tone controls had the familiar Baxandall shape, with the bass turn-
ocver frequency shifting between 100 and 300 Hz, and the family of treble curves hinged at about 3 kHz. The midrange control effect was greatest.
Travellin’ Fridges
Save $30 if you act now!

These versatile recreational fridges also double as environmental test chambers. Some will heat as well as cool.

BEAT INFLATION: ELECTRONIC FRIDGES FROM $99.

You’re nicely away on your long-awaited vacation, camping trip or long weekend with the family. You’re comfortably cruising in your car, van or rec. vehicle along a busy interstate with few rest stops or restaurants. You guessed it... the kids want to stop for a snack. But your Koolatron P34 or P34A is full of sandwiches, cold pop, fried chicken...home made, fresh and cold. The family helps themselves and you’ve saved valuable vaca tion time and another expensive restaurant bill.

Or you’re a commuter, salesman or trucker and you spend many thirsty hours in your vehicle daily. But with your amazing Koolatron P10 plugged in beside you, you open the lid and instantly fresh food and drinks are at your fingertips. Now for the price of a good cooler and one or two seasons of buying ice, (or about 10 family restaurant meals), all the merits of home refrigeration are available electronically. An amazing space-save miracle...the thermo-electric solid state module...makes this revolution in refrigeration possible.

THOUSANDS IN USE

These amazing heat pumps have not only gone to the moon, but have provided the breakthrough for Koolatron’s new portable refrigerators and food warmers.

Koolatron now has tens of thousands of electronic fridges in use worldwide using these powerful solid state modules. Built to take it, these electronic modules are encased in tough, plastic insulated chests that are designed to be rugged and trouble-free. Non-rusting hinges and latches prevent corrosion in salt water environments. And with only one moving part (a small 12 volt fan) Koolatron’s portables seldom see a service depot. Now you can enjoy Koolatron’s whole family of electronic portable refrigerators and food warmers that eliminate costly ice and provide “home refrigeration” convenience at sane and sensible prices.

MODEL P34 STANDARD

$139.00 (In Canada $149.00)

FRIDGE (see photo above)

Holds over 40 lbs. of food and beverages or 48 pop cans. Refrigerates in air temperature up to 95°F. Rugged ABS case in sand beige colour with dark brown non-corroding latches and handle. Large 34 litre capacity (1.2 cu. ft.) weighs 17 lbs. empty. Ext. 21" L x 16" H x 16" W Int. 15.5" L x 11" H x 11" W. Operates on 12 volts DC with supplied power cord or with optional 120V DC/110 VAC power adaptor.

The P34 is our standard portable refrigerator. This new, improved model has a non-adjustable solid state thermostat which keeps your food at normal refrigeration temperature even in 95° weather. It holds more than three times as much as the P10. Fits into any boat, van, camper or car back seat. Plugs into car lighter receptacle, refrigerates over 40 lbs. of food (no space wasted by ice) yet it draws no more power than the P10.

MODEL P34A DELUXE

RECREATIONAL FRIDGE AND FOOD WARMER

$199.00 (In Canada $219.00)

This unique, improved model has all the features of the P34 and includes food warmer features (up to 125°F), highly adjustable temperature control (you can even dial with cooling temps.) and low battery warning indicator tells you when to recharge. Refrigerates in air temperatures up to 95°F (or keeps hot foods hot). Packed into the lid of a switch...great for fall hunting, camping, boating and winter ice fishing, skiing and snowmobiling.

The P34A is our top of the line portable. It heats, it refrigerates and with specially designed electronic control (patent pending) it allows you to dial a complete range of temperatures from very cold to very warm. Refrigerates weekend supplies for boating, camping, hunting and fishing. Then bring your fish or game home refrigerated. Low battery indicator warns you when you need a recharge. Powerful solid state electronic circuitry efficiently control your power consumption to save on battery drain. This is our best-of-the line, recreational fridge and food warmer with all the bells and whistles for the discriminating amateur who demands quality, size and complete versatility. Use from a cigarette lighter receptacle or plugged into house current with our optional 110 volt adaptor.

SAVE $30 IF YOU ACT NOW!

By ordering off-season you can save a full $30 off our regular price! We keep our plant operating at an efficient level.

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between 1 and 2 kHz, with a range of about ±10 dB. Loudness compensation boosted both low and high frequencies, and the low-cut filter had its -3-dB response at 30 Hz.

RIAA phono equalization was within ±0.5 dB of the ideal curve from 20 to 20,000 Hz. The phono preamplifier of the R9 uses a low-noise IC, apparently an "op amp," that completely isolates the equalization components from the cartridge input. As a result, phono response was identical whether measured through the inductance of a cartridge or from a resistive source.

The FM tuner had a mono IHF usable sensitivity of 11 dBf (1.9 µV) and a stereo sensitivity of 17 dBf (4 µV). There was no stereo switching threshold, so that weak signal stereo reception was limited only by noise and distortion. Mono and stereo 50 dB quieting sensitivities were respectively 13.8 dBf (2.7 µV) and 36.6 dBf (37 µV).

The FM distortion at 65 dBf (1.000 µV) input was 0.17% in mono and 0.2% in stereo. The respective noise levels were -74 dB and -68.5 dB.

An IHF-1M distortion measurement of the tuner, using 14 and 15 kHz tones of equal amplitude and a peak deviation of 75 kHz, revealed equal third-order distortion products at 13 and 16 kHz at -53 dB (0.2%) and a 1-kHz second-order component at -46 dB (0.5%), 100% modulation.

FM stereo frequency response was flat within ±0.5 dB from 30 to 5,000 Hz, and rose to +3.7 dB at 15 kHz. Lacking a schematic, we could not judge whether this was the result of an incorrect multiplex filter response, or an error in the FM de-emphasis time constant (both channels measured alike). Any "brightness" resulting from this response would probably not be audible except in direct comparison to another tuner. (We did not hear it in regular listening.) Stereo channel separation was 40 dB in the midrange, 26.5 dB at 30 Hz, and 31 dB at 15 kHz.

FM capture ratio was 1.25 dB at 45 dBf (100 µV) input. AM rejection was 61 dB at 65 dBf. Image rejection of the varactor-tuned front end was an exceptional 97 dB. Alternate channel selectivity—about 64 dB—was adequate though not especially large, and was associated with a highly asymmetrical i-f response. The asymmetry was also observed in the adjacent-channel selectivity data, which averaged 9.1 dB.

Muting threshold was 10.3 dBf (1.8 µV). In the signal-seeking mode, it was 15.5 dBf or 3.2 µV. Leakage of the 19-kHz pilot was at a -59-dB level, and the tuner hum was a very low -75 dB. AM tuner frequency response was very restricted, about ±3 dB from 45 to 1,500 Hz and down 6 dB at about 2.5 kHz.

User Comment. We were favorably impressed by the fact that the SAE R9, whose performance is specified with exceptional thoroughness, met most of the ratings we checked. The only notable exception was FM tuner response. Overall, this is not only a very fine receiver "on paper," but it lives up to its promise in use.

Unfortunately, the instruction manual falls short of the standard set by the receiver. Descriptions of the digital tuning modes were particularly inadequate.

In SCAN, it was very difficult to cover a large part of the FM band and stop on or next to the desired frequency. The tuning always seemed to over-shoot the mark by a couple of channels. In this receiver, we find synthesized tuning less convenient than the old-fashioned analog variety.

The power and tuning indicators worked very well, and the multipath display was one of the best of its type we have used. Antenna orientation for minimum length of the bar display always gave good FM reception. Location of the POWER button (hidden by the VOLUME knob) and the fact that it looks like all the other buttons on the panel, can result in some confusion.

We discovered one bothersome aspect of the R9's behavior when we switched between the AM and FM modes. There was a loud transient noise burst that could be, at best, startling, and at worst dangerous to one's speakers. Of course, if you, like many people, rarely listen to AM, the problem is not all that serious. More to the point, SAE indicates that this difficulty arises when, after the switch is made, the tuner section comes out of muting while still seeking a station. SAE advises that future production will have a slower unmuting action.

Happily, the actual operation of the SAE R9 left little to be desired. It is certainly one of the most complete receivers we have seen, able to interface with almost any other components an advanced audiophile might wish to use. FM tuner and audio performance are absolutely first rate, and the power amplifiers are impressively stable with loads that often elicit misbehavior from other units. — Julian Hirsch
In Concert/Montreux '79. Joe Beck, Bob Brookmeyer, Jon Faddis, Richard Davis with Bing Miki and The Inner Galaxy Orchestra of Japan. Gryphon G-913. In a note from its producer on the jacket of this album, it is billed as a collector's item, a claim that is pretty well justified if you're a lover of jazz. Considering the restrictions on microphone placement and mixing inherent in a live recording situation, the engineers have done a phenomenal job. The pressing, unfortunately, does not seem to be up to the same standard, as the sample we received was marred by an unseemly number of minor ticks.

Musically, the album is first-rate. The Inner Galaxy Orchestra is a very pleasant exception to the tendency that many Japanese orchestras have of playing jazz just a little too neatly. The soloists do a fine job, with Jon Faddis—whose tone might be the envy of any Bach clarino player—a special standout.
If you have put off learning more electronics for any of these reasons, act now!

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MAIL TODAY!
Panasonic's PV-1400 Video Cassette Recorder

The Panasonic PV-1400 video cassette recorder (of which our sample is the first to enter the U.S.) brings with it an interesting array of features. It incorporates a 14-day programmable timer that can be set for seven programs daily. In addition, an eighth program can operate once a week at any time and will not erase itself. The clock has a 60-minute backup battery (for power outages) that is kept on trickle charge.

Other niceties include soft-touch controls (now standard in the Panasonic line) and automatic rewind at the end of record or play. There is also "cue and review," a neat little picture search system that runs at $9 \times$ normal speed. In addition, there is an automatic back-up of a few frames in the pause mode to eliminate gaps in the program. The price for the whole package is $1,295.

The heart of all this control flexibility is a powerful little microprocessor. Each switch, when closed, signals the processor to initiate one of various actions, which are executed by integrated circuits, discrete devices, motors, servo systems, modulators, and demodulators under its control. The vocabulary of commands consists of eject, rewind, stop, fast forward, play, record, audio dub, pause, forward and reverse search, VCR/TV viewing selection, timer operations, channel selection, and power on/off; not to mention external memory on/off, counter, SP (standard play), LP (long play), and SLP (super long play) selections.

A push-to-open flap on the front conceals switches for selecting clock, normal, program, and check; day, hour, and minute; and dim/bright for the green clock readout. Beneath the flap and front apron is the remote-control plug by which forward and reverse search, pause, and channel change can be executed. On the lower left side are video, audio, and microphone inputs, as well as a camera/tuner switch, and the usual thumb-wheel for fine adjustment of tape speed. Tiny rectangular red lamps identify all important functions on the front panel, including the dew sensor lamp and camera connection. Channel tuning and aft are under a plastic flap in the right top, and cassette load is at the left. Although this equipment doesn't have viewable fast scan or pause modes, it really does just about everything else you could want.

On the rear panel are uhf/vhf inputs and outputs, as well as video and audio out jacks, plus the usual Channel 3/4 selective switching. There is an unswitched ac-line outlet that can provide up to 300 watts.

(Continued on page 32)
Save on Scanners! NEW Rebates!

Communications Electronics™, the world’s largest distributor of radio scanners, celebrates Christmas early with big savings on Bearcat synthesized scanners. Bearcat Company, the manufacturers of Bearcat brand scanners is offering consumer rebates on their fantastic line of crystalless scanners purchased between September 15 and November, 1980.

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The Bearcat 250 is a scanner which can monitor all public service bands plus the exciting AM aircraft band channels. Up to twenty frequencies may be scanned at the same time. Overseas customers should order the Bearcat 250F at $295.00

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The Bearcat 210XL scanning radio is the second generation Bearcat, it is almost twice the scanning capacity of the Bearcat 210 with 18 channels plus dual scanning speeds and a bright green fluorescent display.

**NEW! Bearcat® 160**

List price $279.95/CE price $189.00/10% rebate Your final cost is $169.00

- 16 Channels
- 3 Bands
- AC only
- Dual Scan
- Priority Scan

The Bearcat 160 performs a new dimension in scanning form and function. The keyboard is smooth, super buttons, push to talk, a high gain antenna, and an infrared remote control. It has the now famous Bearcat touch screen. The Bearcat 160 is a new model designed for international operation. The Frequency range: 23-50, 118-136, 144-174, 242-412 MHz. The Bearcat 160 offers a new scanning feature. It auto-Scan (AC only). It will scan any band or the entire bandwidth at your fingertips. You will also get the new Bearcat -on-Scan and Fanon.
This unit has highly worthwhile, although not obvious, internal advantages over its predecessors. For instance, both head and tape cylinders now use direct-drive motors— for better stability and more compactness—and there are three solenoids, one for play, one for pressure roller, and another for fast forward. In the transport, a separate motor whose speed is directly changed for the LP and SLP speeds powers tape takeup. There is also a loading motor for the tape.

If a tape isn’t loaded into the recorder, or if the stop tape tab is missing and there is an unattended recording program under way, the timer/record LED will flash to indicate an error. If no program is entered, the timer/record LED will not light.

According to Panasonic, there are 10 protective sensors throughout the machine, with two of special importance—a Hall-effect integrated circuit that senses the absence of rotation of the supply reel and an LED indicator and cadmium disulfide (CDS) cell that sense takeup problems and cause the transport to halt. Also, synchrollock is maintained during que and reverse, even with noise bars in the 9X forward and 9X reverse speeds. Furthermore, the LP speed now has a channel through a half-line horizontal delay system that keeps the machine synchrolocked and picture stable during forward and reverse search. Normal servolock takes over in the SLP mode.

**Lab Tests.** Initially revealing tests were made on this equipment in the two modes of operation with outputs deliberately taken from two separate sources to see what, if any, differences were apparent. As usual, multiburst from a specially modified Sencore VA48 generator was used as a signal source.

In the record mode via Ch. 4 (Fig. 1), the top trace shows VCR response through a 10:1 low-capacitance probe connected to the synchronous video detector of a full 4-MHz broadband TV receiver. The bottom waveform is that of the video output of the player/recorder itself. Signals enter from the source through Ch. 4 and are passed to the recorder.

The top trace shows both the 3.02- and 3.56-MHz third and fourth multiburst bars at about half amplitude or 6 dB down (voltage). In the lower trace, directly out of the VCR’s video output without modulator or tuner and TV demodulating stages, 4 MHz shows at less than 6 dB down, and the multiburst between 0.75 and 3.56 MHz maintains virtually the full amplitude.

In the playback mode via Ch. 4 (Fig. 2), signal amplitudes drop rapidly as this VCR processes luminance and chroma signals, and the end result—both through the TV and pure video output—are rather less than sensational, delivering hardly more

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Fig. 1. Video output (lower trace) shows full 4-MHz record bandwidth.

Fig. 2. In playback mode, signal amplitudes drop rapidly as VCR processes luminance and chroma.

Fig. 3. There are substantial differences in recording and some subtle differences during playback.

Fig. 4. Overall response may be usable to as much as 3.5 MHz.

Fig. 5. Grayscale tracking reveals that eight steps are somewhat erratic though horizontal portions are fairly even.

Fig. 6. Chroma tracking between TV receiver and recorder’s video output are very similar.
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than 3 MHz. Overshoots prominently identify the nonexistent 3.56-MHz multiburst bar.

To further test this new VHS recorder we put the same signals at baseband into the video input of the PV-1400, bypassing tuners and de-modulators. As you will see in the waveform photograph (Fig. 3), there are substantial differences in recording, and some subtle ones during playback. This would also hold true in record if you were using a TV monitor (without r-f and i-f) as your display device instead of a television receiver. In other words, full bandpass!

When recording through the video input jack, the response in the lower trace at the video output is a maximum 4.08 MHz with no loss of amplitude and excellent staircase linearity. This amounts to little more than straight channel passage through the PV-1400. (In the upper trace, you'll see some droopoff in the amplitudes of this multiburst information through the TV, but most of it's there, and the receiver has proven its 4-MHz capability at the video detector.)

In playback through the video jack (Fig. 4), overall response does extend beyond 3.02 MHz and may be usable to as much as 3.5 MHz. This suggests that video inputs and outputs offer considerably greater bandwidth if the various tuners, i-f strips, and modulator/demodulators. This lesson should not be lost on those who want best resolution and definition in the picture, although the operator would have to use a good camera or some other straight video wideband device to take advantage of it. The upper trace shows a signal that has passed through the TV receiver.

As for grayscale tracking (Fig. 5), the eight steps of the B&K-Precision NTSC generator, which are supposed to be identical in amplitude, are actually somewhat erratic. All horizontal step portions are pretty much the same, however, even in the video output (lower trace). The receiver waveform at the top dutifully follows all

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**WHAT A VHS RECORDER LOOKS LIKE INSIDE**

The tuner section supplies i-f amplifiers and video detector with broadcast information. Sync is taken off after the video input for any camera-pure composite video (baseband) that might be used for servo-system countdown. Video and chroma are converted to frequency modulation for the video output, the Ch. 3/4 i-f converter, and/or the recording amplifier and heads. Heads A and B are rotated at 1800 rpm by the direct-drive cylinder motor, while the tape is moved at standard or long-play speed by the capstan motor.

Playback uses the same heads as does record. Head outputs are amplified and switched alternately depending on which is in contact with the tape. Video is reconverted from FM to AM, with chroma heterodyned from 629 kHz to 3.58 MHz once again. Taped results can be viewed through any slave television receiver on Ch. 3 or 4, or through the VCR's video output at baseband. If this is a re-recording, the 65- (or 67-) kHz erase head aligns the tape's magnetic field before the new recording and electronically wipes it clean.

The various capstan control count-downs for standard and long play, with servo control feedback and frequency comparison. During operation, 80-Hz vertical sync pulses are divided in half so that 30-Hz control pulses reach the control head and are recorded on the tape's lateral control track. The stop solenoid actually re-moves some dc power from the machine and stops it completely when ac power is interrupted or when the interaction of two or more events could cause damage.

When this occurs, all front-panel controls are reset to off. The PV-1400, has four heads instead of two. The larger pair gives better performance at the slower speeds, adequately covering the two diagonal tape tracks that represent 262.5-line fields of information and constitute a single frame. There are 30 frames recorded or played each second.

Audio is processed in standard TV FM, with the same 65-67-kHz frequency that erases previous magnetic video and audio recordings, providing recording bias.
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the video-signal discrepancies of the lower trace.

In analyzing such distortion, remember that the grayscale here begins at blanking, next to the horizontal sync pulse, and extends upward to peak white until it reaches full-range modulation, or 100 IRE (Institute of Radio Engineers) units. Nonlinear staircases originate from quadrature distortion, itself caused by nonlinear diode-type envelope video detectors. These often generate color-subcarrier second harmonics, as well as errors in differential gain. The latter will produce, in aggravated instances, cross-modulation between chroma and luminance, usually seen as a modulated staircase. Normally, it is a product of apl, or average picture level, that relates principally to the brightness of each scene, and often results in actual image displacement. Here, the problems are not severe, but they do have a modest effect on the video output and overall chroma information.

Chroma tracking (Fig. 6) at the receiver (top trace) and from the player/recorder’s video output (bottom trace) are very similar in most respects with a fairly squared-off horizontal sync pulse (denoting no low-frequency rolloff) and a sort of egg-shaped burst riding on the back porch of the adjoining horizontal blanking pulse. Note, however, that all six color bars from both sources appear somewhat indistinct, without well-defined edges and normal impulse separation. This is due to traditional noise found in many VCRs and contributes to picture degradation. The cause could be poor tape, but more likely it arises in the electronics of the playback mechanism that restore chroma from its “beatdown” narrowband 629-kHz condition to the usual 3.58-MHz center frequency for video and receiver outputs.

Comments. Is this a good machine? Considering the constant evolution in video cassette recorders, of course it is! You don’t have a somewhat imperfect stop frame for individual picture viewing and some other fancy gee-gaws, but there is relief from mechanical switches, a clock that keeps time during power outages, lights to tell what’s going on and why, and, overall, a convenient and deluxe piece of equipment, responsive to your slightest command.

Furthermore, its appearance is more than attractive, and the silver-walnut coloring will match many of the television receivers on the market this Fall. Do you actually need 14 days of recording time? Perhaps not now, but in the future when you’re taping instructions or shopping information from the cable or late-night broadcasts, this large time span might become quite handy. —Stan Prentiss

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MODEL PV-1400 VITAL STATISTICS

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tape speeds and recording times:</td>
<td>2 hr at 1.33 in./s</td>
</tr>
<tr>
<td>Ac power requirements:</td>
<td>42 W (record)</td>
</tr>
<tr>
<td>Video bandpass (-3 dB):</td>
<td>3 MHz (average)</td>
</tr>
<tr>
<td>Audio bandpass (-3 dB):</td>
<td>100 to 7000 Hz</td>
</tr>
<tr>
<td>Weight</td>
<td>27 lb</td>
</tr>
<tr>
<td>Dimensions:</td>
<td>19&quot; X 14&quot; X 5.34&quot;</td>
</tr>
</tbody>
</table>

Notes: Plays and records at power inputs between 105 and 130 volts ac.

Some descriptions are not to scale.

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Radio Shack Shows Surprises

FOR more than a year now, a number of industry pundits have conjectured about what the Fort Worth, TX-based Radio Shack would introduce as its next generation microcomputer system. Everything from the mythical TRS-90, which was to be a machine based on 16-bit technology, to a machine costing less than $500 was conjectured. The less-than-$500 machine was introduced (PE Oct 1980) in the form of a timesharing terminal. It has, however, been reintroduced as a color system called the TRS-80 Color computer.

This unit is the basic Videotex* machine I discussed last month, and has application cartridges that add value in the form of games or useful household programs. Yes, the unit is programmable, too, and has a version of Microsoft BASIC written specifically for the MC-6809 microprocessor. The TRS-80 Color computer, is aimed at the low-end user market.

The color unit isn't all that Radio Shack is offering for the early 80s though. Supporting the idea of computers for the consumer, the Fort Worth marketers have introduced the TRS-80 Pocket Computer. This $249 hand-held unit, uses a liquid-crystal 24-character display, incorporates a Level I-type BASIC, and is program- and expansion facilities. This design upgrades from the add-on bailing wire structure of the Model I. The Model III is base-priced at $699 for a 4K RAM, Level I BASIC system. A full-blown, 32K RAM, double-density (175K bytes per disk) dual integrated disks, and Model III BASIC goes for $2495. The Model III has the same display format (64 x 16) as the Model I, and is designed for any Model I software (using a conversion program). Radio Shack officials see Model III as the ideal machine for the small office that needs strong computing capability for less than $5000.

Even though Radio Shack has broadened its computer market with these introductions, it is also strongly supporting the Model II introduced last year. To enhance the Model II and the other units, they have developed, in conjunction with other unnamed companies, printers that support everything from general data processing to plotting.

The plotting printer is possibly the most exciting entrant. The printer/plotter is priced at $1460 and is designed to interface directly to either the Models I, II, or III computer systems. The printer/plotter uses a pen system, and prints caps and lower case.

North Below the Border. Recently, I had the good fortune to visit the magic makers at Microsoft in Bellevue, Washington. Vern Raburn squired me around the growing, yet crowded headquarters of the dynamic software house. He let me view some new developments they are working on, specifically on the system side of the house. That's where they build BASIC, FORTRAN, and other high-level languages. One product, UNIX, a very high-level operating system from Bell Labs, is being revised for microcomputers by Microsoft and adapted to their product structure. This is an extremely powerful O/S and might change the whole picture of microcomputer data processing in the near future.

Vern is president of the Consumer Products Division of Microsoft, and as such is responsible for the development and marketing of application software and products such as the Z80 card I talked about in the August issue. The application software products sold by the division include items like a typing tutor, an adventure game, and an editor. Vern explained that most of the products are being developed for the Apple and TRS-80, with some plans to support units like the Heath H8 and H89.

Color Next Important Step. While I was visiting Microsoft, I attended the SIGGRAPH conference held in Seattle. This is where manufacturers of graphics machines show their wares. This year color was the name of the game, with companies demonstrating terminals with as many as 4000 displayable hues.

Now these aren't the machines you buy for the home; but they are used by companies like Boeing for computer-aided design, and range in price from $20,000 on up. Apple was there in full force, dem-

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onstrating that they have color and graphics capability in the same plane as many of the "high-end" manufacturers. Reinforcing the strength of Apple was ABW Corp. of Ann Arbor, MI. This company demonstrated a device called Teksim®, which is a read-only-memory (ROM) that plugs into the Apple computer. The $475 device makes use of the Apple's high-resolution plotting capabilities to emulate a Tektronix 4010-type graphics terminal, but with color.

To place this in perspective for you, the Tektronix line of graphics terminals are those that virtually every company tries to equal. The Tek terminals are of the monochrome type, but exhibit various degrees of gray scale and high resolutions. Consequently, a device that permits emulation of a Tek terminal, on a raster scan system such as an Apple, is definitely an achievement.

There is a caveat, though. The device is only valuable if you can use it. I don't recommend buying the Teksim just to buy it, but if you are doing computer graphics on the Apple, and need the enhanced functions that Teksim provides, then by all means add it to your system.

Following this philosophy of purposeful products is Godbout electronics. Bill's latest entry into the S-100 world is called Spectrum®. It is a board designed to give you color graphics capability for less than $400. It can fit into any memory location you have available and delivers composite NTSC video. Although Godbout doesn't tout it, the board is capable of 2D transforms and simulated motion. Bill sees the Spectrum as an ideal board for use in process-control systems—specifically those controlled by an S-100 bus computer system.

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Record Care, Part 1:
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Electron microscopy (Figure 1) shows the principal cause of record wear: small particles of microdust, deposited from the air by gravity, are ground along the record groove by the stylus. Surface noise goes up. Sound quality goes down.

In some record care products, organic solvents are used rather than water. Organic solvents such as ozone-gobbling chlorofluorocarbons, petroleum distillates (hexane, heptane) and alcohol concentrates are indeed speedy extractors and delivery solvents. They evaporate fast. Some organic solvents can dissolve vinyl stabilizers. Organic solvents may leave a “slick” looking record by treating the disc with other compounds carried in the solvent mix. In doing so, record contamination may also be dried back onto the disc in a nice even layer. Dust is often “held” to the record surface by “treatment.”

Figure 1 shows a drop of the aqueous Discwasher D4 Fluid, literally lifting dust and contamination out of record grooves. The extraordinarily complex D4 Fluid uses water pure enough for kidney dialysis, along with eleven chemically engineered additives that still results in lower dry-weight residue than most tap water. This formula is amazingly high in cleaning activity, uniquely safe for vinyl and vinyl additives, and preferentially “carries” contamination into the new Discwasher D4 pad.

Electron micrograph (Figure 3) shows a record cleaned with the Discwasher D4 System. High technology record care leaves only a clean surface.

Discwasher, Inc., 1407 N. Providence Rd., Columbia, MO 65201

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Computer Sources

By Leslie Solomon
Senior Technical Editor

Hardware

Apple Music. The MusicSystem is designed for Apple II computers and produces 16 voices including the generation of sounds with the sounds of real musical instruments. The accompanying Editor program permits graphical input of sheet music using standard music notation. The Player utility permits polyphonic performance of musical compositions. Stereo output is provided. Address: Mountain Computer Inc., 300 Harvey West Blvd., Santa Cruz, CA 95060 (Tel: 408-429-8660).

S-100 APU. The MemTech Arithmetic Processing Unit interface features floating-point multiply performed in 56 microseconds, 11 trig and exponential functions, and automatic floating point normalization and error codes. It is jumperable as any pair of I/O ports on an S-100 bus. It provides a considerable speedup for both FORTRAN and BASIC. $390 (multiply in 84 μs), $460 (multiply in 56 μs). Address: MemTech Co., 4891 Clairemont Mesa Blvd., San Diego, CA 92117 (Tel: 714-292-1219).

Cryptograph. The Cryptographic Primer Kit includes an RS-232 Interface Cryptographic Board that attaches to the RS-232 port of a computer and accepts 300 baud data. The user inputs the 64-bit cryptographic key from the terminal. The board contains the WD20001F implementation of the NBS Data Encryption Standard. A Cryptographic Primer that describes the software implementation, an assembly manual, and the book “Codebreakers” by David Kahn are included with the kit. $395. Address: Western Digital, 3128 Redhill Ave., Newport Beach, CA 92663 (Tel: 714-557-3550).

AIM-65 Enclosure. Made from high-strength ABS plastic, this enclosure for the AIM-65 computer comes with mounting hardware, wire, and switches, and is ready for assembly. All parts are precut and drilled. Room is left for two additional boards. $49.95 plus $2.50 shipping/handling. Address: Don-El Enterprises, 3261 Michigan Ave., Costa Mesa, CA 92626 (Tel: 714-546-7481).

SS-50 Double Density. The DCB-4 Disk Master is an SS-50 bus double-density controller board that allows 336K bytes of storage on a single minifloppy, and is capable of handling up to four 51/4" or 8" drives simultaneously. It includes DOS-68B or 69B, is fully compatible with hard disk systems, and allows users to select either single- or double-sided operation, single or double density data, stepping rate, 35- or 40-track operation, etc. It occupies only 16 bytes of memory space and can read/write a single sector by itself. An on-board buffer allows full interrupt capability and once data has been initiated, no further processor time is required. $49. Address: Smoke Signal Broadcasting, 31336 Via Colinas, Westlake Village, CA 91361 (Tel: 213-889-9340).

TRS-80 to 488 Bus. The Model 488-80B Interface Adapter allows any TRS-80 Model I having 16K of RAM and level 2 BASIC to be used as a GPIB-488 controller. The machine-language program provided with the device interacts with level 2, level 3, or disk BASIC. $225. Address: Scientific Engineering Labs., 11 Neil Drive, Old Bethpage, NY 11804 (Tel: 516-694-3205).

S-100 I/O Ports. The Model 4P4S Parallel-Serial I/O board combines four parallel bi-directional data ports with full handshaking and interrupt capability. In addition, there are four serial RS-232 I/O ports and room for prototyping. The board is mapped as 16 consecutive I/O ports and will work with any 280, 8080, 8080, 8082, 8089, 6502, or 8085 IEEE standard S-100 products. $199. Address: MicroDataSys, Box 36215, Los Angeles, CA 90036 (Tel: 213-731-0876).

WH89 CP/M. This plug-in modification for the Heath Z89/WH89 makes it possible to use CP/M as well as HDOS. Up to two additional disk drives can be added to this modified computer allowing a total capacity of 306K of storage. The modification kit with CP/M 1.4 Operating System and documentation is $249. Address: Magnolia Microsystems, 2812 Thorn- dyke Ave., West Seattle, WA 98199 (Tel: 206-285-7266).

Apple Light Pen. The Lipson Light Pen connects to an Apple II game paddle connector and uses a cadmium-selenium cell for light detection. This allows the measurement of varying intensities of light. Besides a 48-page manual, a number of integer and Applesoft BASIC programs are included to make use of the high-resolution graphics, sound, and color. $24.95. Progressive Software, POB 273, Plymouth Mfg., PA 19462.

Atari Printer Interface. This Parallel Printer Interface can be used with the Atari 400 or 800 computers and connects via the front-panel controller jacks. The board is small enough so that it does not interfere with normal keyboard operations and a three-foot ribbon cable connects to the printer. A short machine language program directs all LPRINT outputs to the printer interface. The interface works with BASIC, DOS, and Assembler/Debug. $69.95. Address: Macrorotronics Inc., 1125 Golden State Blvd., Suite G, Turlock, CA 95380 (Tel: 209-667-2888).

SS50 I/O Ports. The GIMIX 2 Port Serial ISO board has two independent RS-232 compatible I/O ports with handshaking on a single 30-pin board. It features independent baud rate and interrupt for each port and uses the 6850 ACIA. The board is compatible with both the SS50 (4 addresses per slot) and SS550C (16 addresses per slot). $128.43 less cables. The GIMIX 8 Port Serial I/O board has eight independent RS-232 ports with handshaking on a single 50-pin board. It features selectable baud rate for each port, extended address decoding for SS550C, selectable interrupts, and also uses the 6850 ACIA. $318.46. Address: GIMIX Inc., 1337 W. 37th Pl., Chicago, IL 60609 (Tel: 312-927-5510).

PROM Programmer. The PP-2532 TMS2532 EPROM programmer is a complete programming package that connects, via a 4-foot ribbon cable, to
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A financial VP in Massachusetts is cutting the time it takes to prepare month-end reports from three days to three hours. 
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Thousands of other personal computer users are also sold on how VisiCalc is increasing their productivity. Besides saving time and money, they're simplifying their work and getting more information that helps them make better decisions. A typical user reaction comes from a New York dentist:

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VisiCalc displays an "electronic worksheet" that automatically calculates nearly any number problem in finance, business management, marketing, sales, engineering and other areas. The huge worksheet is like a blank ledger sheet or matrix. You input problems by typing in titles, headings and your numbers. Where you need calculations, type in simple formulas (+, -, X, +) or insert built-in functions such as net present value and averaging. As quickly as you type it in, VisiCalc calculates and displays the results.

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When you finish, you can print a copy of the worksheet just as it appears on the screen and/or save it on diskette.

"I like VisiCalc's ease of use."

That response comes from a Utah businessman using VisiCalc for production forecasts, financial report ratio analysis and job cost estimating. Ease of use is VisiCalc's best-liked feature. It's designed for a non-programmer, and has an extensive, easy-to-understand instruction manual.

Users also like solving a wide variety of problems with VisiCalc. . . and solving them their way. VisiCalc can even justify the cost of a personal computer, according to a New Hampshire financial analyst:

"VisiCalc is paying for itself over and over."

VisiCalc is available for 32k Commodore PET/CBM, Atari 800 and Apple disk systems. VisiCalc is written by Software Arts, Inc.

See VisiCalc at your Personal Software dealer. For your data es's name, call Personal Software Inc. at 408-745-7841, or write 1330 Bordeaux Drive, Sunnyvale, CA 94086.

While there, see our other Productivity Series software: Desktop Plan and CCA Data Management System. They're like time on your hands and money in the bank.
any read-only PROM socket. Data is sent via the eight lower address lines to the programmer. No additional power supplies are required, and all timing and control sequences are handled by the programmer. Each programmer comes with an internal de-to-dc switching regulator and a zero-insertion-force socket. $295. Address: Oliver Advanced Engineering, Inc., 676 West Wilson Ave., Glendale, CA 91203 (Tel: 213-240-0080).

Software

Statistical Analysis for TRS-80. For Level II or disk BASIC, this package consists of 13 programs. Ten describe data sets and conduct statistical data analysis, two are utility programs for preparing, updating, and listing data files, and one aids in the selection of data samples. Program names include Tape Data Files, Disk Data Files, Random Sample, Descriptive Statistics, Histogram, Frequency Distribution, Analysis of Variance, T-Test for Matched Pairs, Correlation and Linear Regression, Multiple Linear Regression, Time Series Analysis (two), and Chi Squared Analysis. Available at Radio Shack Computer Stores for $39.95.

BASIC Precompiler. EZ-CODER is a BASIC precompiler that can be used with a North Star system. It features a self-documenting BASIC, allows mnemonic variables of arbitrary length, and table for line references. Complete cross-referencing of all variables, labels, and user-defined functions are permitted. Source files are created using a built-in text editor. The precompiler produces North Star compatible code for use with North Star BASIC. $79. Address: Demerco Industries, Box 2396, Van Nuys, CA 91404.

Altair CP/M. Used by the Altair 8800 and MITS 3202 disk systems, this approach takes full advantage of the 300K plus capacity per diskette with no changes to the hardware. The use of CP/M allows languages such as C, COBOL, FORTRAN, PASCAL, etc., to be run immediately. Address: Lifeboat Associates, 2248 Broadway, New York, NY 10024 (Tel: 212-580-0082).

Extended Z80 Operations. The PDS Z80/8080 assembly language development system has been extended to include an additional 96 Z80 operations heretofore undiscovered. These implement four additional byte registers by allowing access to the two halves of the index registers. The PDS includes a relocating macro assembler, interactive editor/asmber, trace debug/monitor, text editor, linkage editor, and relocating loader. $99 for North Star, or CP/M on 8-inch soft sector or 5-inch 10- or 16-hard-sector diskette. Address: Allen Ashley, 395 Sierra Madre Villa, Pasadena, CA 91107 (Tel: 213-793-5748).

Language Teacher. Featuring French, Spanish, German and Italian, the Language Teacher operates from a TRS-80 Model I disk system. The drill-learning format features language-to-English and vice versa and offers hundreds of word combinations, phrases and verb conjugation forms to challenge the student. It also allows print-out of multiple-choice tests and has a full quiz diagnostic routine. $19.95. Address: Acorn Software Products Inc., 634 North Carolina Ave., S.E., Washington, DC 20003 (Tel: 202-544-4259).

Flight Simulation. The A2-FS1 (Apple II) and T80-FS1 (TRS-80) are visual flight simulators that offer a real-time, 3D, "out of the window" view of the flight. The view is updated three times per second. The viewed panel contains all the instruments required under Part 91 of the FAA Regulations for visual flight. It also includes a stall warning, turn indicator, radar screen, ammo indicator, and control position indicators. Other (keyboard) controls include throttle, brakes, bomb drop, machine guns, high-low world, and declare war. An airborne battle game is included. Requires 16K of RAM. Cassette is $25, diskette is $33.50. Address: Sub Logic, Box V, Savoy, IL 61874 (Tel: 217-359-8482).

6800/6809 DOS. The FLEX Disk Operating System for 6800 and 6809 systems supports such features as dynamic filesystem allocation, random and sequential file accessing, user startup facility, user environment control, English error messages, and over 20 disk operation commands. It requires a 256-byte soft-sectored diskette, and includes an editor and assembler. $30. Address: Technical Systems Consultants, Inc., Box 2570, West Lafayette, IN 47906 (Tel: 317-463-2502).

Accounts Receivable. ACCT-M2 for the TRS-80 consists of five programs for almost any small business. The user can specify parameters such as company name and address, late charge policy, etc. It can sort customers by name, and you can add, inquiry, delete, and adjust transactions and customer information. Transaction can be paid or unpaid invoice, credit, debit or payment. Sub commands allow search, display, print, and updating of records. Order entry allows multiple items to be entered and an invoice can be printed if desired. Many other customer related functions are also included. Special features include form input, live keyboard, double-precision arithmetic, fast SHELL sort, audit log, error trapping formatted date and numeric output, I/O buffering and blocking and a number of management options. $149. Address: Micro Architect, 96 Dothan St., Arlington, MA 02174.

British PASCAL. Available on IBM 3740 format 5" or 8" diskettes to run under CP/M, this is a full standard PASCAL, and uses as little as 32K to run. With linker and relocatable files, the package can handle complex problems. This PASCAL was developed in Great Britain. Address: Transam Components Ltd., 12 Chapel St., London, NW1 5DH, Eng.

Utilities. DISK FIX is a general-purpose disk utility for MITS/Pertec disks that allows any sector of an unmounted diskette to be examined, edited or rewritten. It will copy an entire diskette in less than two minutes. Check sectoring, verify sectoring, and improve sectoring. Sub commands allow add, delete, and move sectors. A separate $10 diskette is required. Requires 8080, 32K of memory, floppy-disk drive (two drives for DISKCOPY). $95. SELECT/MWP provides for copying selected records from a miniword processing name-address file to a new file as determined by the operator. Requires an 8080/Z80 with 48K and disk. Uses CP/M. $95. TX/RX (transmit-receive) provides computer-to-computer communication for 8080/Z80 machines at up to 19,200 baud. The receiver is capable of continuous unattended operation and the transmitter operates in the batch mode. Uses CP/M. $195. Address: The Software Store, 706 Chippewa Square, Marquette, MI 49855 (Tel: 906-228-7622).

OS1 Sort. BPSort is a high-speed disk file sort utility for Ohio Scientific OS-65U operating system. It is written in assembly language and uses a Shell-Metzner sorting algorithm. $124. Address: BPS, 320 W. 57th St., New York, NY 10019 (Tel: 212-765-0815).
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PHONOGRAPH PLAYBACK

It's better than you think!

The vinyl disc, being seriously challenged by new technologies, is still a strong competitor

BY THE DISCWASHER RESEARCH STAFF*

The vinyl-disc playback system (VPS)—the phonograph record and the components used to manufacture and play it—stands challenged by newer technologies. Therefore, understanding its strengths and weaknesses looms great in importance. How good is the system? How long can the disc be expected to last? How can its original quality be preserved? Can the overall system be significantly improved?

On the basis of research findings so far, the VPS can be said to have the ability to store and redeliver on home high-fidelity equipment with a quality surpassing that of all other systems extant or projected at this time—including digital. For example, certain well-pressed audiophile discs have noise floors of about −76 dB re RIAA zero VU. Adding to this the +12 dB or so headroom that most high-quality phono cartridges can successfully track gives a peak S/N ratio of 88 dB. Not only does this exceed the 84-85 dB claimed by a projected 14-bit digital disc playback system, it rivals the 90 dB claimed for digital tape systems.

A normal European pressing was found to contain recoverable modulations on the order of 0.434 nanometer, about $\frac{1}{450}$ the wavelength of violet light. The recorded signal, in this case, was the 19th harmonic of a 900-Hz violin tone (17.1 kHz), at about −70 dB. A normally produced disc of U.S. manufacture was found to have a residual noise level of −68 to 70 dB, for a total dynamic range of about 80 dB.

It may seem surprising that a stylus can sense such fine low-amplitude modulation when its very passage through the groove deforms the vinyl by a much greater amount, typically 250 nanometers. Perhaps even more surprisingly, the modulation is durable and withstands many passes of the stylus. But vinyl is, in fact, quite elastic and readily returns to its original shape, provided that the contact pressure is not too great. The stylus is in much the same situation as the legendary princess who could feel a pea through a thick layer of mattresses.

Interestingly, a digital recorder does not do a very precise job of capturing low-level signals either. A 16-bit system with a 50-kHz sampling rate would catch slightly less than 3 samples per cycle of the 17.1-kHz violin harmonic mentioned earlier. Because of its low level, the tone would be encoded to only a 3-bit accuracy, placing it perilously close to the level of quantizing noise, which has a far more annoying spectrum than ordinary white noise.

Bandwidth is another area in which

**fact:**

five new Shure Cartridges feature the technological breakthroughs of the V15 Type IV

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**Plus**

Unprecedented stylus protection

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the M97 Era IV Series phono cartridges

<table>
<thead>
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<th>Stylus Configuration</th>
<th>Tip Tracking Force</th>
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<td>M97HE</td>
<td>Nude Hyperelliptical</td>
<td>¾ to 1½ grams</td>
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<tr>
<td>M97ED</td>
<td>Nude Biradial (Elliptical)</td>
<td>¾ to 1½ grams</td>
<td></td>
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<tr>
<td>M97B</td>
<td>Spherical</td>
<td>1½ to 3 grams</td>
<td>For 78 rpm records.</td>
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<td>78 rpm Stylus for all M97’s</td>
<td>Biradial (Elliptical)</td>
<td>1½ to 3 grams</td>
<td></td>
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Shure has written a new chapter in the history of affordable hi-fi by making the space-age technological breakthroughs of the incomparable V15 Type IV available in a complete line of high-performance, moderately-priced cartridges: the M97 Era IV Series Phono Cartridges, available with five different interchangeable stylus configurations to fit every system and every budget.

The critically acclaimed V15 Type IV is the cartridge that astonished audiophiles with such vanguard features as the Dynamic Stabilizer—which simultaneously overcomes record-warp caused problems, provides electrostatic neutralization of the record surface, and effectively removes dust and lint from the record—and, the unique telescop ed stylus assembly which results in lower effective stylus mass and dramatically improved trackability.

Each of these features...and more...has been incorporated in the five cartridges in the M97 Series—there is even an M97 cartridge that offers the low distortion Hyperelliptical stylus! What’s more, every M97 cartridge features a unique lateral deflection assembly, called the SIDE-GUARD, which responds to side thrusts on the stylus by withdrawing the entire stylus shank and tip safely into the stylus housing before it can bend.

NEW! M97 Series Era IV Phono Cartridges...

Five new invitations to the new era in hi-fi.
the VPS excels. Digital systems are rigidly limited to signals whose frequencies are less that one-half the sampling rate. At present, the maximum sampling rate that can be provided at reasonable cost appears to be 50 kHz. This limits practical signal bandwidth to about 22 kHz or less, depending on how complicated a low-pass filter is used. The VPS, on the other hand, is known to possess a bandwidth on the order of 45 kHz. While few human beings can hear anything above 15 to 25 kHz, depending on the individual, there is some evidence that trained listeners sense the absence of such frequencies if the audition period is sufficiently long. Studies showing that listeners do not miss anything above 15 kHz have used relatively short auditions.

**Weakness of the VPS.** Like any information-storage system, the VPS can allow errors to occur. First, it is not certain the groove cut into the master disc will correspond exactly to the information to be preserved. Second, the modulation cut into the master may not be accurately duplicated through all the manufacturing stages leading to the final pressing. Third, the playback equipment may misbehave and not trace the modulation accurately, or, if it accomplishes that successfully, fail to translate it into a correct electric signal. In general, there are more of the errors of the third category.

Playback discrepancies can be perceived as changes in distortion and also as losses of low-level signals. According to previous literature, playback problems can be attributed to tracing distortion, poor stylus scanning radius, incorrect stylus rake angle (SRA) or vertical tracking angle (VTA), poor stylus/groove interface, and characteristic electromechanical properties of a particular cartridge, such as resonances.

Problems of the playback equipment are usually evaluated by means of test records containing known signals that can be examined via distortion analysis or an oscilloscope after they have been played by the cartridge. It is extremely important to know whether any given cartridge output corresponds to the recorded modulation or is an artifact of the playback process. Research has shown that test records often suffer from inaccuracies in frequency response. (See Stereo Scene, December, 1979.) It was decided, therefore, to "fingerprint" the various test records by analyzing the high-frequency spectra of recorded sine and square waves.

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Fig. 1. Oscilloscope trace (above) of cartridge output from a 1-kHz square-wave band of a CBS STR-1 test record. "Ringing" at 41 kHz is evident. Fig. 2. (right) shows an electron micrograph of the test record groove. Note how the ripples in the groove correspond to the "ringing" signal observed in Fig. 1.

Fig. 1 shows an oscilloscope trace of a cartridge playing a 1-kHz square wave from a CBS STR-112 test record. The trace shows a disruption at 41 kHz, consisting of a characteristic "ringing" that many magazine reviewers have attributed to resonances in cartridges they have tested over the past 10 years. To examine this hypothesis, the disc was played at a speed different from the standard 33 1/3 rpm. If the ringing were an artifact of the cartridge, its frequency would remain fixed; if recorded onto the disc, its frequency would change in proportion to the difference in speed.

As the frequency did change, it was concluded that the "ringing" was cut into the disc and the cartridge that reproduced it was actually outperforming one that did not. Subsequent examination of the groove walls by electron microscopy showed the ringing signal clearly. Note how the ripples at the beginning and end of the flat portion of the square wave shown in Fig. 2 correspond to the large displacements in the oscilloscope trace. This ringing is a characteristic of the Westerle阐释 cutting system used in the production of the CBS STR-112 test record! Test records of other manufacture with square waves show no such ringing.

Another classic misrepresentation of the actual VPS occurs in state-of-the-art playback testing procedures. Most audiophiles know that mistracking should be avoided like the plague. Mistracking, however, is not always a brittle, total disruption of playback events, but may be a gradual nonlinear occurrence. Such "soft mistracking" (Fig. 3) can occur on many passages of a record. Spectrum analysis of soft mistracking shows a low-level series of harmonics generated at multiples of the fundamental frequency. These are a result of reduction rather than total loss of stylus groove contact. The most frequent cause of soft mistracking is incorrect compensation for
Experiments using a spectrum analyzer on a test record with an IM distortion band (a 4-kHz test tone modulated by a 400-Hz tone) provided some interesting results. Sideband frequencies spaced 400 Hz apart on either side of the 4-kHz peak are true IM distortion. Heavily mistracked IM signals produce additional peaks at 400-Hz intervals which appear under spectrum analysis as a “picket fence” of spikes. These spikes (Fig. 4) have been incorrectly termed IM distortion. Actually, it can be shown that these picket-fence side bands are not IM at all, but mistracking of the 400-Hz test tone. These spikes precisely mask and accentuate the true IM sideband products and explain how mistracking has been previously confused with IM distortion. Theoretical models of the oscillographic data of this mistracking event can be developed. A mathematical model based on the velocity-related output of a Denon DL-303 moving-coil cartridge with verification using a Stax CP-X condenser cartridge that directly interprets stylus displacement led to the conclusion that the picket fence of Fig. 4 may occur as a stylus encounters a highly modulated groove.

Figure 5 is a drawing of a monophonic sine-wave groove. The mechanical impedance of the cartridge (stiffness) causes the stylus to ride up the groove wall (A) as the stylus tries to make a “tight turn.” Progressively, the stylus loses pressure with the opposite groove wall (B) until a total loss of contact occurs. The stylus tip rides up on the wall until the vertical tracking force (VTF) catches up with the eccentric inertial condition, and the stylus literally slams back down into the groove, recontacting both walls (C).

A European test record with high-velocity 300-Hz bands was played 850 times under the conditions of mistracking. The scanning electron microscope clearly shows the path where the stylus rides up one channel and scores it (Fig. 6). Research has shown that the best way to reduce this type of mistracking is to play a given cartridge at the high end of the manufacturer's recommended VTF. This does not increase record wear within the measurement capability of our systems. Correctly setting the anti-skate of a turntable/tonearm system for VTF and groove modulation is very important. A system to accurately make this type of adjustment in the home environment is under development.

The Myth of the Vertical Tracking Angle (VTA). Commonly accepted knowledge about the VPS holds the vertical tracking angle (VTA) between the cartridge/cantilever pivot point and the record (with stylus contact as the angle apex) to be extremely critical in accurate and low distortion playback. (See...
changes. This is because of their contact geometries.

As the table in Fig. 8 shows, a spherical stylus has relatively stable distortion levels as VTA changes in the range of two to four degrees. A similar change in VTA for a shibata-type stylus, however, changes SRA as well, and the data show a larger increase of distortion products. There are indications that some cartridges, because of the distance between system pivot and stylus tip (armature length), cannot maintain correct VTA under any circumstances. Even these cartridges can be shown to have minimum distortion (null) points with proper setup.

These data suggest that SRA may in fact be the important setup dimension. This contention has been supported by taking a shibata type of stylus and physically bending the cantilever such that the cartridge VTA is grossly (±5 degrees) out of alignment, while the SRA remains correct. This odd condition produced data not significantly different from that obtained for a correctly aligned shibata.

The conclusions support the idea that VTA may be customarily overemphasized as a parameter of audio quality in the VPS. SRA alone, on the other hand, is extremely critical by both listening tests and distortion measurements.

Communications with the manufacturers and engineers of cutting lathe systems indicate that the cutting stylus carves the record with a vertical contact profile "tipped" slightly forward (away from the tonearm) pivot by one or two degrees. Thus the SRA of the cutting system is 92 degrees, with a VTA of 16 to 20 degrees. Critical matching alignment of playback-stylus SRA results in audible improvement in the VPS. A procedure to allow SRA alignment to be performed easily in the home is under development. Such alignment is possible now, but it is difficult.

Prospects for the VPS. It is a matter of historical record that the VPS has fulfilled virtually all of the demands made on it, in particular, those for extended playing time and stereo capability. In addition, it has withstood the challenges posed first by open-reel tape and later by the cassette medium. Research into the nature of the VPS leads to the surprising conclusion that, with carefully manufactured software and critical alignment of playback equipment, it can compete successfully even with digital recording systems. In such a contest, the cost-effectiveness of the VPS is undoubtedly one of its strong advantages.

Fig. 7. Though in a fixed relation for any one cartridge, stylus rake and vertical tracking angles are independent.

Fig. 8. Distortion levels for spherical and shibata stylus as the vertical tracking angle is varied.
An introductory look at this ubiquitous mass-storage technique

BY LESLIE SOLOMON
Senior Technical Editor

FOR large-capacity data storage with fast program access and retrieval, no present computer peripheral can beat the magnetic disk medium. A typical, moderately priced, floppy-disk system can randomly access stored data in no more than a few seconds and can load it into a computer at an extremely high rate. (Hard-disk systems are even faster.) In both these respects it outperforms cassette tape systems handily. For example, a typical 51/4" disk system operates at 15.6K bytes/second, an 8" drive works at 31K bytes/second, while a typical cassette system uses a leisurely 150 bytes/second. Also, in a disk system, most operations are automatic, while with a cassette system, the operator has to manually perform all operations. The cassette medium's sole advantage is very low cost.

The Floppy-Disk System. Three elements make up the floppy-disk system: the flexible diskette on which data is stored; the mechanical disk-drive element; and the electronic controller that interfaces the disk drive to the computer. Let's take a close look at each:

Floppy Diskette. This is the "medium" onto which data is recorded (written) and from which data is played back (read). It consists of a durable, thin, flexible ("flexible," translated into computer jargon, becomes "floppy") plastic disk coated on both sides with a layer of magnetic oxide similar to that used on audio recording tapes. The magnetic medium (the actual "diskette") is sealed into a durable and somewhat less flexible plastic jacket that protects and lubricates it as it rotates.

A large hole in the center of the jacket exposes a smaller circular hole in the magnetic medium, which allows the motor-driven spindle in the drive mecha...
disk systems

nism to mechanically hold and rotate the diskette against the read/write head. Rotational speed is usually 360 rpm for both 5¼" and 8" (the two sizes available) systems.

Data is stored as magnetic flux changes in circular "tracks" that are concentric with the center of the diskette. In all, there are from 35 to 77 tracks on a 5¼" diskette and up to 154 tracks on an 8" diskette. Tracks are subdivided into "sectors," each of which can contain 256 to 1024 bytes of data. In a hard-sectored diskette, there are typically 10 to 16 sectors on a 5¼" diskette and 15 to 30 sectors on an 8" diskette.

Access of the read/write head medium is through a slot in the jacket. (See Fig. 1). A small circular hole through the jacket is used by the index/sector detector. When a diskette is installed in the drive, a photoelectric detector "looks" through this hole and detects the start of a sector on the diskette when a corresponding hole (or holes, in the case of a hard-sectored disk) is aligned with the index hole in the jacket. Having detected the hole in the diskette, the computer can locate all sectors.

The write-protect notch, always located along an edge of the protective jacket, is sensed by either a photoelectric device or a mechanical switch. Covering this notch on a 5½" diskette suppresses write operations and protects the recorded data against overwriting. When the notch is open, write operations to the diskette are allowed. The reverse is true of 8" diskettes: writing is suppressed when the notch is open, and permitted when it is covered. However, some manufacturers use nonstandard write-protect systems. Consult the instruction manual if in doubt. Some diskettes have very small notches on one edge; these are for jacket strain relief and should not be confused with the actual write-protect notch.

**Disk Drive.** A basic approach to the mechanics of disk-system operation is illustrated in Fig. 2. When the front door of the disk drive is closed, the drive spindle is forced through the hole in the diskette against a stop located above the diskette. A belt connects the spindle to its drive motor. When the diskette is firmly seated on the spindle, a signal from the computer to the disk system's control logic starts the drive motor, which then rotates the diskette. Meanwhile, the write-protect detector will have determined whether or not the diskette can be written to and so inform the read/write logic. Additionally, the index/sector sensor will have detected the correct starting location for the upcoming write or read.

When the start signal is received by the control logic, the head is mechan-ically stepped to the correct track, where it makes direct contact with the magnetic oxide on the diskette. A pressure pad on the opposite side of the diskette, in line with the head, maintains intimate contact between head and diskette. Most manufacturers include a front-panel LED that glows to indicate when the disk drive is operating. Also, in most cases, you will hear a click or grinding sound as the positioning mechanism moves the head to the correct track.

Once the disk drive goes into operation and the sensors have done their job, the head "seeks" the correct track and sector and reads the requested data. This data is passed to the read/write logic, where it is processed for use by the computer.

When all operations are completed, the head automatically lifts from the surface of the diskette and the front-panel LED extinguishes. Then, opening the front door of the drive allows the diskette to be removed from the drive spindle. A darkened LED is a reliable indicator that all operations have been completed. The drive may simply be pausing between steps and may re-start at any time. Only when the "prompt" symbol appears on-screen is it safe to open the drive door and remove the diskette.

**Disk Controller.** Each manufacturer supplies a DOS (disk operating system) that is unique to each single- and multiple-drive system. In most cases, a disk controller takes the form of a plug-in card that interfaces with a computer. A typical DOS, usually in ROM, will contain enough commands to allow flexible use of a diskette. Though basically similar, DOSes vary in the additional convenience functions that they provide.

Some DOS operations are also used in disk BASICs, which are specialized versions of this popular high-level language specifically written with disk manipulations in mind. A disk BASIC is usually written for a particular DOS or disk system and may or may not work with other disk systems. There may also be a slight difference in syntax used for the same command in DOS or BASIC. In multiple-drive systems, each drive is assigned an identifying code so that it can be "called" to provide data from its diskette.

A well-written DOS with a large number of commands is a programmer's best friend. It enables access to hundreds of thousands of data bytes that need not occupy the relatively sparse amount of RAM usually found in a small computer. Bear in mind that an eight-bit microcomputer can conventionally address 65,536 bytes of memory, and not all of this can be RAM, since operating utilities such as ROM, video plug-ins, and other elements take up

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Fig. 1. Configurations of a 5¼" (above) and 8" (opposite) diskettes as used in small computers, with makeup of a diskette at far right.
space in the address field. A well-written DOS can function efficiently with as little as 16K bytes of RAM.

**Soft and Hard Sectoring.** In general, there are two mutually incompatible types of track sectoring used in modern diskettes. Physical differences make it easy to determine whether a given diskette is hard- or soft-sectored. Soft-sectored diskettes have only one index hole. Hard-sectored diskettes, on the other hand, nominally have 10 or 16 holes. In reality, they have 11 or 17 holes; the extra hole, centered between two of the "official" holes, tells the computer that the next hole identifies the start of sector 0. Each hole thereafter identifies the start of a sector. Circuits in the disk controller detect the shorter space between the index hole and the hole following it and reset the counter to 0.

On a soft-sectored diskette, the DOS creates sectors on an ad hoc basis. Conceivably, the entire disk could be a single sector.

To determine the type of sectoring used in a given computer, check either the instruction manual or the diskette itself. If you wish to examine the diskette, hold it by its protective jacket. Being careful to avoid touching the magnetic medium through the head-access slot or bending the diskette, use a slender nonmagnetic tool to lift the jacket away from the diskette through the large center hole. Look into the opening, and count the number of indexing holes. If there is only one hole, the diskette is soft-sectored. If there are 11 or 17 holes, it is hard-sectored. Make a note of the number of holes used in your diskettes.

In most cases, the manufacturer's label on the diskette's jacket will inform you of the diskette's formatting. For example, Verbatim uses the following three-digit code prefix: 525 for a 5 1/4" single-sided diskette; 550 for a 5 1/4" double-sided, double-density diskette; and 577 for a 5 1/4" single-sided, double-density diskette. These are followed by a two-digit suffix: -01, -10, or -16, which identify soft-sectoring and 10- and 16-hole hard-sectoring, respectively. Hence a diskette with a 525-10 code is a 5 1/4" single-sided, 10-hole hard-sectored diskette.

To increase the amount of data that can be stored on a diskette, manufacturers have gone to "double-density" (twice the number of bits per track), "double-sided" (recording the disk on both sides), and "quad-density" (a combination of the above) schemes. All have their advantages, but they can present some problems. For example, because there is no standard for double-density systems, such diskettes often cannot be interchanged. In double-sided systems, there is a read/write head on both sides of the diskette, each acting as a "pressure pad" for the other. This can exert too much pressure, damage the medium, and cause rapid head wear. New drives do not have this problem.

Generally speaking, a disk controller designed for a double-density system can read either single- or double-density diskettes with appropriate hardware or software changes. However, a single-density controller cannot read double-density diskettes.

Since a diskette is coated on both sides with magnetic oxide, there is yet another approach to increasing storage capacity. You can punch an index hole and write-protect notch through the diskette's protective jacket and make the "other" side of the diskette available for data storage. Bear in mind, though, that in a single-headed drive, the head is backed up by a pressure pad. If this pad becomes contaminated with oxide or particulate matter, it can destroy the soft oxide on both sides of the diskette.

**More Details.** Data in a disk system is written onto the diskette using a form of frequency modulation (FM), wherein a single data pulse (0 or 1) is written so that it is centered between clock pulses. The presence of a flux transition indicates a binary 1, its absence a binary 0. Double density is achieved by using a modulation technique called modified
disk systems

FM (MFM) or modified-modified FM (M2FM). Here, a double-frequency write oscillator is used to maintain the same flux changes per inch. Thus, a bit cell in MFM/M2FM is only half that used in FM. The data-transfer rate is doubled, since a 1:1 relationship exists between the flux changes and bits per inch (2:1 in FM).

In M2FM, clock bits are written at the beginning of each cell if there is no data bit written into the previous cell and if there will be no data bit written into the present cell. Since a double-density bit cell may not have a clock pulse at its beginning, data separation is more complex and prone to errors.

Transfer rate is the speed at which requested data can be moved from the diskette to the computer. Look out here for the "numbers game," though, since a system that can transfer at 250,000 bits per second is not the same as one that can transfer 250,000 bytes per second.

Error rates in the typical diskette system have been estimated to be one per $10^8$ bits during read operations for soft-sectored diskettes; one per $10^4$ bits during read for hard-sectored diskettes; and one per $10^6$ bits during seek.

Life of a diskette is estimated to be about two years under "normal-use" conditions. One manufacturer (Shugart) claims a life of 2 million passes on any one track. A track is considered to be worn when its output signal voltage falls by 20% from its original level.

Estimated MTBF (mean time before failure) in the typical diskette system is approximately 8000 hours. Component design life is usually estimated conservatively at five years.

Selecting a Disk System. Before you buy a diskette system, determine what you want to do with your computer. If your diskette system will be used as a game "player" or for experimenting, learning computer techniques, or anything else that does not require extensive number/

data "crunching," a single 5¼" drive will probably suffice. But if you want a really large-capacity mass storage, you may need a multiple-drive system.

Mass storage requirements will also dictate the choice between 5¼" and 8" drives. (An 8" diskette can hold twice as much data as a 5¼" diskette at less than twice the cost.) Note that you never really have all the available disk space for program-data storage. Some is reserved for formatting (file names, headers, etc.).

If your data demands range into millions of bytes (megabytes), a "hard-disk" system may be your best economical alternative. Bear in mind, however, that you will have to back up the data on the hard disk with one or more floppy-disk drives, just in case the hard disk suddenly "loses" a megabyte of data.

In most cases, a single disk controller board and DOS can handle up to three drives. This allows you to add drives to a minimal system as you need and want them.

There is no hard and fast rule that can guide you in selecting the "best" diskette system for a particular computer but there are some basics to be observed. Most important is that the electronics and DOS or high-level language provided with the diskette system must be compatible with your computer. The DOS, BASIC, assembler, and any other software features supplied on the diskette system's diskette must be able to call your particular computer's keyboard, video display, printer, etc. Unless you are very experienced in using software, you will find it extremely difficult to integrate a "strange" DOS or language into your computer's routines.

Make sure that any software you require is available for the diskette system you select. While on the subject of software, it is important to note that not all CP/Ms (a popular, "universal" DOS) are as insensitive to hardware as claimed. If you should have single-density drives and obtain double-density-formatted CP/M, the disk cannot be read, and CP/M will not run. So, before you buy a given CP/M, make certain it will run in your system.

Access time (the time taken to move the head to a desired track) can sometimes be important. Long waiting times,
even though measured in milliseconds, can interfere with some sophisticated software or may nullify its advantages. It is also crucial that the disk system be compatible on the hardware level. The North Star hard-sector system, for example, achieves high transfer by outputting data on the address bus. Naturally, it requires a special interface.

The Future. There is little doubt that the hard-disk ("Winchester-drive") system is the wave of the future for low-cost multimegabyte mass storage. What makes the hard-disk different from the floppy-disk medium is that the former offers no physical access to the disk and read/write head(s), which are hermetically sealed in a protective enclosure. Hermetic sealing is necessary because the read/write head literally "flies" a minute distance above the rapidly rotating (3600 rpm) surface of the magnetic disk. If any particulate matter, even microdust, were to get between disk and head, catastrophic disk damage would almost certainly result.

The hard-disk drive employs a very precise mechanism in which tolerances are extremely tight. Track density, therefore, has vastly increased, making it possible for the disk to store considerably more information than is possible with floppy disks.

Although hard-disk systems appear to be very expensive, they are actually much less expensive than floppy disks and RAMs on a cost-per-byte basis. In a typical 5 1/4" floppy-disk system, average per-byte cost is 0.002¢, while an "inexpensive" 64K byte RAM system's typical per-byte cost is 0.006¢. Now contrast these figures with the 0.0002¢ per byte cost for a 26-megabyte hard-disk system that sells for $5000.

Hard disks come in a variety of sizes, ranging from 5 1/4" to 14". The latest on the market is Shugart's Model ST506, which offers 6.3 megabytes unformatted (5 megabytes formatted) storage capacity on 612 tracks and four read/write heads at a suggested retail price of $1000. With a per-byte cost of only 0.0002¢, the ST506 may well signify the start of a trend in low-end hard-disk systems for the small-computer system owner.

At present, no industry standard exists for the computer/disk interface. However, because of the large market share controlled by Shugart Associates, this company's Model SA1000 hard-disk system has become the de facto standard used by low-cost hard-disk system manufacturers. (This trend is similar to the "standard" set by the MITS S-100 bus for eight-bit microcomputers.) It is more than likely that the SA1000 interface will soon be modified to handle any floppy-disk drives that may be used to back up the data on the hard disk.

Whether or not prices for hard-disk systems will drop as dramatically as the prices for computer systems in general is difficult to foretell. But even if prices remain the same as they are now and more hard-disk systems come on the low-end market, many computer owners are likely to move up to the hard disk, especially if they already have miniflop-py systems that can plug directly into the hard-disk system for backup.

FRAGILE—HANDLE WITH CARE

Because the magnetic oxide on floppy diskettes is relatively soft and very thin, it can easily be damaged unless special care is exercised during handling, use, and storage. For this reason, we have drawn up a list of 10 things to avoid. Here they are:

• Don’t touch the magnetic-oxide surface on the diskette, especially around the head-access slot in the jacket. Body oils in fingerprints can permanently destroy data.
• Don’t leave a diskette lying around where it can collect dust, dirt, and other contamination. Even a tiny dust particle passing between head and diskette will scratch the oxide medium. Always return each diskette to its storage envelope.
• Don’t smoke when you are handling diskettes (or when you are operating your computer, for that matter). Airborne smoke and ash particles have a habit of collecting on diskettes and ruining them.
• Don’t write on a label that is already on a diskette with a ballpoint pen. Transmitted pressure from the pen’s point can easily damage the oxide surface on the diskette. If you cannot write out your labels off the diskette, use only a soft felt-tipped pen and very little pressure.
• Don’t erase a label while it is on a diskette. No matter how careful you are, eraser and paper particles are almost certain to contaminate the diskette.
• Don’t force a diskette into a disk drive or its storage envelope. If you encounter resistance, back out and try again.
• Don’t bend or fold a diskette. If you do, tiny pieces of oxide will flake away and render the diskette useless.
• Don’t store diskettes in locations where temperatures are likely to rise beyond 110°F or where there is danger of stray magnetic fields.
• Don’t store diskettes lying flat and on top of each other. Like phonograph records, store them vertically, in dust-tight containers.
• Don’t power up or power down a disk system with a diskette in the drive. If you do, stray magnetic fields generated by the drive’s motors may alter the data on the diskette making it incorrect.
If you follow these rules religiously and keep everything scrupulously clean, you should obtain the maximum operating life from every diskette you own.
9K RAM (8K user available), 14K BASIC interpreter operating system ROM.

User-programmable, in both BASIC and MC6800 machine language.

Built-in RF modulator.
Built-in sound synthesizer.

Two built-in game controllers, with joysticks and numeric keypads.

Built-in cassette deck, with both digital and audio tracks.

Load in excess of 1500 baud rate. Saves and loads programs in 45 seconds or less.

Built-in speaker.

Keyword shift plate.

Full, standard, 53-key typewriter keyboard.

High resolution picture on your TV screen, in 8 colors.

256 x 192 graphics mode.

Microphone jack enables you to add audio to program tapes.
All that computer for $599.

The Imagination Machine, the personal computer from APF Electronics.

The Imagination Machine is more personal computer than you'd expect at $599. The Imagination Machine is a superbly designed, expandable, user-programmable computer system...at $599.

No other personal computer on the market can touch it, at that price.

Read what it brings you:
First of all, The Imagination Machine has 9K RAM and 14K BASIC-IN-ROM. A full 53-key professional, typewriter keyboard. A high-resolution picture on your TV set, in eight colors. Fast loading (1500+ baud rate), built-in dual-track cassette deck, for APF's digitally recorded tape programs. Built-in sound synthesizer. And, even a built-in RF modulator, which is a $40 option on other computer systems.

All that, plus user-programmability.
We know sophisticated users aren't going to be satisfied forever using preprogrammed software. (Even though we offer a large library of educational, entertainment, home and business management programs.) So, we made The Imagination Machine user programmable, in both BASIC and MC6800 machine language. To simplify matters, we've just developed the first and only BASIC TUTOR course on cassette. With it, you can learn to program The Imagination Machine in BASIC, with hands-on training, right at the computer.

Some exceptional features.
The Imagination Machine has several unique features that can help you use your time at the computer more effectively.

For example, it stores programs and data on the same cassette tape. (With other computers, you have to read programs from one tape into the computer, remove the tape, put in another tape and store your data on the new tape.)

Another special feature is The Imagination Machine's unique keyboard system, which simplifies BASIC programming. The machine has 24 different programs statements and commands printed at the top of the keyboard. You can enter these 24 into your program without retying them every time you use them. Instead of typing out "PRINT," for instance, you just press two keys and the word appears on the screen. The system prevents typing errors and can speed up entering programs.

The third feature is Timed Response Monitoring, which automatically adjusts the computer's pace and level to your own. It makes "tutoring programs," for instance, easier and more interesting to follow.

And then there are The Imagination Machine's three graphic display modes: 1. Alpha numerics, mixed with low-resolution graphics in as many as eight colors. 2. High resolution — up to eight colors — 128 x 192 display. 3. High resolution graphics — up to four colors — 256 x 192 display.

And expandability.
A personal computer that can't grow along with your requirements soon becomes obsolete. So, we designed The Imagination Machine to be expandable. By adding APF's optional "Expansion Box" and interface cartridges, you can hook up any compatible floppy disk or printer, or an additional 8K RAM memory cartridge.

Full mini-floppy system $995.

For small business and professional use, you may require a full mini-floppy

Price list:
BB-1. Expansion Box with RS232 cartridge. $199.95
BB-2. Expansion Box with floppy disk interface cartridge. $199.95
8K RAM memory cartridge. $99.95
RS232 cartridge. $99.95
Floppy-disk interface cartridge. $149.95
Mini-floppy Disk Drive. $399.95

$599. Manufacturer's suggested retail price.

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Prepare yourself for future! You can learn to operate and program a computer for job opportunities in the computer revolution. Our Level II Basic is a version of Microsoft and is equivalent to all Level II Programs currently available. This basic includes a super set of operations in floating point with integer and string arrays, direct memory access, PEEK and POKE, direct statement execution, two character variable names, user definition functions, multi-statement lines, editing, scrolling, file management, and 8080A MACHINE LANGUAGE AND EDITOR PROGRAMS ARE AVAILABLE.

Since the computer can talk, play music and perform in color IT IS A PHENOMENAL TEACHER. You can now use the TV to EDUCATE not frustrate your family. You will eliminate TV boredom with programs that challenge, stimulate and entertain you. Create your own programs or select from over 30 programs offered. IT IS A BRILLIANT MUSIC TEACHER. You can practice on the piano keyboard overlay, select key and tempo, write a tune and record. It has a great color art program, you can improve your memory, math, spelling, vocabulary and sharpen your strategy skills. IT IS A GREAT TUTOR FOR YOUR KIDS.

A MOST EFFICIENT BUSINESS TOOL
It comes ready to handle a wide range of business applications. The Level II Basic and 16K Byte system capacity give you the instruction set and the room to write your own programs for payroll, inventory, client records, etc. For accountants, attorneys, doctors, salespeople and small businesses; Calculator, Financial Library and 1 and 2. Check Book Balancer and Message Center programs are offered.

IT ALSO PLAYS GAMES
A total entertainment center with color, sound, and music. There are Chess, Backgammon, Star Track, Black Jack, Volleyball, Touchdown, Hangman, Showdown, Computer Maze, Breakthrough and more! Challenge the computer or another opponent. Each game brings the family and friends together for hours of quality fun.

SERVICE AND WARRANTY
If the unit fails because of factory defect within 90 days of purchase, it will be repaired at no charge for labor and parts - you just send the unit United Parcel prepaid to the Service Center designated and it will be sent back to you promptly. United Parcel prepaid! A complete Diagnostic program tape and instructions are available. You can get a Service manual, Cassette alignment tape, Schematics, and parts list plus a Money Saver Service and Warranty Card. Everything you need to check and service your computer.

IT CAN BE EXPANDED AT LOW COST
It is a single board computer. RS232 interface is available at $99.50 for adding printers and telephone modems. A telephone modem allows you to access "MICRONET", "SOURCE" and other data banks. You can also communicate with other computers. It is possible to increase the RAM to 32K and the ROM to 16K. We plan to offer a low priced expander January '81 for basic in ROM and 16K Additional RAM. Our Factory sponsored National Computer Club membership is available to learn from other Owners the Fantastic things you can do with this computer.

PRICE COMPARISON
Competitive 16K RAM Personal Computer Suggested List prices are: Radio Shack $549, T. L. $950, Atari $1,125, Apple $1,195, Ohio Scientific $850. Radio Shack's TRS-80 that has only 4K RAM, no color, or sound, sells for $499.

WHY SUCH A LOW PRICE
Selling on a factory direct to customer basis, we save you the profit normally made by computer stores and distributors. You also save the cost of a computer monitor as this computer is FCC approved and designed to hook up to any TV antenna terminal. We are willing to take a small margin at the factory to develop volume that allows lowest cost operation.

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- For the Professional
- For Small Business
- For the Home Owner

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NOW YOU CAN BUILD MICROPROCESSOR PROJECTS USING AN INEXPENSIVE PRODUCT DEVELOPMENT SYSTEM!

BY GEORGE MEYERLE

In May 1980, our first article on designing with microprocessors, "It's a Whole New Ballgame," showed how, with an understanding of just a few instructions and very modest hardware, one could build a microprocessor-based combination lock. However, to implement more generalized microprocessor product design with confidence, additional skills in programming and hardware are required. Development of these skills will be the theme of this and future articles.

This article describes the use of input and output ports and how the microprocessor interfaces with peripheral hardware such as random access memory (RAM) and read-only memory (ROM). We will go on to the construction of an 802 microprocessor product development system. This is an inexpensive system (professional models cost thousands of dollars) that allows the processor to be programmed, tested, and debugged for a particular application. The unique property of this system is that it is contained on two separable circuit boards: the product board and the programming board. The former becomes part of the finished project—whatever that may be; the latter is used to program other product boards.

The product or application board we will describe includes a CPU (central processing unit), a crystal-controlled system clock, 1024 bytes of RAM, 2048 bytes of ROM, one 8-bit input port, one 8-bit output port, address latches and decoding, buffered CPU flag inputs, Q output, INTERRUPT/DMA (direct memory access) request input, a POWER ON CLEAR circuit, and battery backup. The product board is shown at top, and the programming board below.

The board uses bus connectors to plug in the programming board as well as additional product expansion cards or boards such as additional I/O, memory, A/D, graphics keyboard, cassette I/O, etc. The programming board that we will describe includes a hex keyboard to input programs, six 7-segment displays that show the status of the address and data busses, a variable-speed single-step system used to step through the program, LEDs on the MODE and STATE CODE lines of the CPU to indicate what the processor is doing, and a series of switches to completely control the action of the CPU. Functions include RESET, RUN/EXECUTE, WAIT, LOAD, INPUT and MEMORY PROTECT. (This programming card is not necessary if you already own an Elf II; the product board plugs into an Elf II and can be programmed directly.)

Product Board Operation. The central component of the product board is the microprocessor (CPU), which controls the activities of all the peripherals. For the time being, we will not be concerned with what happens inside the CPU, only with external effects and signals. The following is a description of events and signals present at the CPU during various operations. (See Fig. 1.)

Clock. The clock signal required by the processor is generated by an external oscillator. It is used by the CPU to produce internal and external timing signals needed to control the peripherals as well as to transfer signals and data internally between parts of the CPU.

CPU Mode Control. Two processor mode-control pins completely control the CPU action. They are labelled WAIT and CLEAR. The line (vinculum) over the name indicates that a low-logic level (0 volts) at that point will cause the stated effect. To change the CPU mode, we simply have to present the CLEAR and WAIT lines with the logic levels shown in Fig. 2. When we want to put the processor in the RESET mode (CLEAR low, WAIT high) certain internal registers are set to predictable states. It will suffice for the moment to realize that the program counter is set to 0. This insures that when the mode is changed from RESET to RUN or LOAD, the first address issued by the CPU will be 0000. When the CPU is put into the LOAD mode (must be preceded by RESET), it is possible to load a program into memory via the direct-memory access line of the CPU. The
program is loaded directly into memory from the hex keypad during this mode. When the CPU is in the WAIT or PAUSE mode, the internal timing generator does not function. The clock continues to run but it is ignored. Note that the data, address, and other control lines may not have valid data or status in the WAIT mode.

The RUN mode (both CLEAR and WAIT high) may be entered from a PAUSE or RESET mode. Remember that the first machine cycle following a reset to RUN is followed by a memory fetch at address 0000. This is extremely important and simplifies the hardware interfaces.

State Code Lines. When in RUN, the CPU can perform only one of four types of operations. They are: INSTRUCTION FETCH, also called S0 (S an abbreviation for "state"), EXECUTE, S1, a DIRECT MEMORY ACCESS, S2 or INTERRUPT, S3. Ignoring DMA and interrupt for the moment, we can say that the CPU is simply either fetching instructions or executing them. A FETCH requires one machine cycle (each machine cycle is made up of eight clock pulses). EXECUTE requires one or two machine cycles, two required only during long-branch operations.

The State-Code lines labelled SCI and SCO are used to tell the peripherals which type of operation is being performed by the processor. (See Fig. 3.) Note that during FETCH, both SCI and SCO are low; during EXECUTE, SCI is low and SCO is high.

Timing Pulses. (In addition to the state code lines, there are TIMING PULSE A and B (TPA, TPB). These signals the peripherals when the address, data and I/O COMMAND lines are valid and other internal operations are completed.

MEMORY READ and MEMORY WRITE LINES. These, designated MRD and MWR, are both active with logic low. MRD is present when the processor wants data from the memory. MRD must occur during a FETCH when the processor is reading memory for its next instruction. It must also occur during an OUTPUT exec-

Fig. 2. Logic needed to change CPU Mode.

<table>
<thead>
<tr>
<th>CLEAR</th>
<th>WAIT</th>
<th>MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>L</td>
<td>Load</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>Reset</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>Pause</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>Run</td>
</tr>
</tbody>
</table>

Fig. 3. State code lines define operation

Fig. 4. The timing diagram is used to show signal relationships. Shaded areas indicate undefined state when multiple transition may occur.
If you own a car stereo, you’ve probably already discovered that many cassette tapes don’t last as long in your car as they do in your living room. Conditions like heat, cold, humidity, and even potholes can contribute to a cassette’s premature demise.

At Maxell, our cassette shells are built to standards that are as much as 60% higher than the industry calls for. Which is why we can offer you the best guarantee in the industry. An unconditional lifetime warranty.

So if you’d like better mileage out of your cassette tape, try Maxell. Even after 100,000 miles on the road, it’ll run like new.

If only they made cars this well.
The TPB indicates to the external devices that the data bus is prepared for the transfer.

**I/O Command Lines.** The input/output command lines, referred to as the N lines, are activated by a program instruction to signal input and output devices, either requesting data from them during an input instruction or sending data to them during an output instruction. The three lines can be decoded into seven separate output signals so that all 14 input/output instructions can be used.

A general timing diagram is shown in Fig. 4. It is not complete, but should give an idea of when transfers occur between the CPU and peripherals. Understanding this timing will enable us to use the

---

**Fig. 5.** The various parts of the circuit on the Product Board are shown schematically above and on the opposite page. Numbers in circles indicate jumper pads.
correct hardware I/O signalling devices. Note the eight clock pulses, 0–7, and the synchronization between them and the signals on the CPU lines. STATE CODES become valid just before the leading edge of TPA and continue valid until the trailing edge of TPA. External hardware is responsible for reading CPU signals during valid periods only. Each machine cycle outputs a 16-bit address of which the high-order eight bits are valid at the trailing edge of TPA and are followed by the low-order eight bits which are valid.

PARTS LIST—PRODUCT BOARD

C1—2.2-µF, 16-V electrolytic
C2,C3,C4—0.01-µF, 50-V disc ceramic capacitor
C5,C6—10-µF, 16-V electrolytic
D1 through D6—1N4148 switching diode
D7—1N4001 rectifier
IC1,IC2—2114 random-access memory
IC3—2716 ROM
IC4,IC5—18521/0
IC6—1852 1/0 port
IC8—CD4050 hex noninverting buffer
IC9,IC10,IC11—74LS00 quad 2-input NAND gate
IC12,IC13—74LS174 hex D flip-flop
IC14,IC15—74LS30 eight-input NAND gate
IC16—7805 5-volt regulator
Q1—2N3484 transistor
The following, unless otherwise specified, are 1/4-watt, 10% tolerance, fixed carbon-composition resistors.
R1,R2,R3,R11—100 kΩ
R4,R5—4.7 kΩ
R6—700 kΩ
R7—47 Ω, 1/2 W
XTAL1—3.579-MHz quartz crystal
Misc.—Suitably etched and drilled, double-sided printed circuit board with plated-through holes and gold-plated edge-con- nector contacts; one normally open, momentary-contact pushbutton switch; IC sockets (one 40-pin, three 24-pin, two 18-pin, ten 14-pin) or Molex solder-cons; three 14-pin DIP headers; heat sink for IC18 measuring 1" × 1/2" × 1/4" or simi- lar; hookup wire; solder; etc.
through the trailing edge of TPB. When the CPU reads from the data bus, data is latched into the CPU during TPB. I/O command lines N0, N1, and N2 are valid from the beginning of TPA to the end of TPB. The CPU tests the flag lines during an SI cycle; the CPU responds to control signals WAIT and CLEAR during TPA, and samples DMA and INTERRUPT during TPA. Some conditions are valid only during certain types of machine cycles. For example, DMA is sampled only during machine cycles SI, S2, or S3.

Interfacing Memory. Having studied the signals present at the CPU, let’s look at the schematic of the product board shown as Figs SA through SG. Data, in this case the high-order address bits, are latched into the Q outputs of the flip-flop during a low-to-high transition on the clock input. This low-to-high signal is produced through inversion of TPA.

![Fig. 6. How to determine load resistances on output ports. In circuit above, minimum relay coil resistance is 2.1 kΩ. The relay is active when the output is high. In the lower circuit, minimum relay coil resistance is 0.2Ω. The relay is active when the output is low.](image)

![Fig. 7. Programming board circuits (A through F) are shown here and opposite](image)

### PARTS LIST—PROGRAMMING BOARD

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C5</td>
<td>1 µF, 16-V electrolytic</td>
</tr>
<tr>
<td>C2, C3</td>
<td>0.15 µF Mylar capacitor</td>
</tr>
<tr>
<td>C4</td>
<td>2.2 µF, 16-V electrolytic</td>
</tr>
<tr>
<td>C6, C7</td>
<td>22 µF, 16-V electrolytic</td>
</tr>
<tr>
<td>C8</td>
<td>0.1 µF disc ceramic capacitor</td>
</tr>
<tr>
<td>D1 through D13, D15</td>
<td>1N4148 switching diode</td>
</tr>
<tr>
<td>D14</td>
<td>1N4001 rectifier</td>
</tr>
<tr>
<td>DIS1 through DIS6</td>
<td>Common-cathode, seven-segment LED display</td>
</tr>
<tr>
<td>IC1</td>
<td>74C923 CMOS 20-key encoder</td>
</tr>
<tr>
<td>IC2</td>
<td>74C173 CMOS TRI-STATE quad D flip-flop</td>
</tr>
<tr>
<td>IC3, IC4</td>
<td>CD4016 quad bilateral switch</td>
</tr>
<tr>
<td>IC5, IC14</td>
<td>CD4013 dual D flip-flop</td>
</tr>
<tr>
<td>IC6, IC15</td>
<td>74LS08 quadruple 2-input AND gate</td>
</tr>
<tr>
<td>IC7, IC18</td>
<td>4066 hex inverter</td>
</tr>
<tr>
<td>IC19</td>
<td>74LS90 six-bit increment counter</td>
</tr>
<tr>
<td>IC20</td>
<td>74LS110 eight-bit decrement counter</td>
</tr>
<tr>
<td>IC21, IC22</td>
<td>74LS123 quad 2-input NOR gate</td>
</tr>
<tr>
<td>LED1 through LED5</td>
<td>Red light-emitting diode (HP5082 or equivalent)</td>
</tr>
<tr>
<td>R1</td>
<td>15 Ω, 1/2 W</td>
</tr>
<tr>
<td>R2, R6, R7</td>
<td>Through R10, R18, R19—4.7 kΩ</td>
</tr>
<tr>
<td>R3</td>
<td>1 MΩ, linear-taper trimmer potentiometer</td>
</tr>
<tr>
<td>R4</td>
<td>22 kΩ</td>
</tr>
<tr>
<td>R5</td>
<td>1 MΩ</td>
</tr>
<tr>
<td>R11, R14</td>
<td>Through R17—470 kΩ</td>
</tr>
<tr>
<td>R12</td>
<td>200 Ω</td>
</tr>
<tr>
<td>R13</td>
<td>47 kΩ</td>
</tr>
<tr>
<td>Misc.</td>
<td>Suitably etched and drilled, double-sided printed circuit board with plated-through holes and gold-plated edge-connector contacts; 86-contact edge connector with gold-plated contacts; 22 normally open, momentary-contact push-button switches (this includes those comprising the hexadecimal keypad); two spdt toggle switches; IC sockets (seven 16-pin, eleven 14-pin) or Molex Solder-conns; suitable hardware; hookup wire; solder; etc.</td>
</tr>
</tbody>
</table>
by IC9. The high-order address lines A8 to A15 are therefore present at the Q outputs of IC12 and IC13. Now, with the full 16-bit address present on the memory address bus, we can look at how the RAM IC1 and IC2 and ROM IC3 are actually addressed. RAM IC1 and IC2 contain 1,024 different memory cells or addresses; while ROM IC3 contains 2,048 different cells. The CPU is capable of addressing 65,536 different cells or addresses. To uniquely position our blocks of memory in the 65,536 address field, we must decode the upper address lines. If we want to address a RAM (IC1 or IC2 for example), we need 10 address lines, A0 through A9 (\(2^{10} = 1024\)). Note that on the 2114s, pin 8 is a chip-select line, active when low. The pin, when active, connects the memory cells to the data bus.

The 1,024 block could be addressed in any of 64 different blocks in the 65,536...
address field. Address lines A10 through A15 are decoded to select a specific field. If all the inputs to eight-input NAND gate IC17 are high, the output on pin 8 will be low and the RAM memory will be selected. The six address lines can be connected to the inputs of the NAND gate either directly or through hex inverter IC16. The use of inverters at selected address lines allows 64 (2^6) different possible locations for the block of memory.

To determine which address lines require an inverter, write the binary equivalent of the first address in the block of memory. Label the high-order six digits A15 through A10. An inverter must be used at all locations with a 0 binary digit. To locate the memory block at F000 (hex), we would use an inverter on address 11 and connect A12 through A15 directly to the NAND gate. If only one memory block is used and it is to be located at 0000, the chip-select CS line can be grounded and IC's 14, 15, 16, and 17 can be removed.

The same principle is used in the 2K bank-select, using IC14 and IC15 to locate the position in the memory field for IC3.

To finish our discussion on the memory, let's look at the MEMORY READ and MEMORY WRITE lines. IC1 and IC2 deposit their data on the bus whenever the CS line is low so there is no need to have the CPU READ signal connected. The MWR (P) is connected to pin 10. When the CHIP SELECT and MWR lines are low, the information on the data bus is copied into the memory cell address. Data flows from IC3 to the data bus only when both the CS and MWR lines are low. Although the position of IC3 is principally intended to be filled by a 2716 EPROM (which requires that pin 21 be tied high), a 2K RAM can be used instead by connecting its pin 21 to MWR. If you plan to use a 2K RAM at IC3, check the specs carefully for signal requirements. Finally the MEMORY WRITE line, pin 10 (IC1 and IC2), is labelled MWR (P). This means that the memory can be protected against accidental written data by grounding pin 9 of IC8, which prevents MWR from reaching the memory. This line, MP, is also connected to pin 43 on the 86-pin bus.

Interfacing I/O Ports. Integrated circuit IC5 has pin 1 tied low and acts as an input port. It has eight input lines that can be connected to external equipment via plug P2. These inputs, typically, would be connected to the status switches on a robot, alarm system, etc. When the data is valid and to be read, IC5's CLOCK line (pin 11) is externally made high. This latches the data into the input side of the port. A high-to-low transition of the CLOCK line causes the input data to be latched into the input port's output register and simultaneously sets the SERVICE REQUEST line, pin 23, low. At this point, the output drivers of IC5 are disabled and the data is not yet on the bus. The SERVICE REQUEST line of IC5, pin 23 can be connected to the CPU flag EF3, INTERRUPT, or DMA. If you use EF3, your program must intergate EF3 and issue an instruction that results in the transfer of data from the port to a memory location designated by the program, as well as to the D register in the CPU. Actual data transfer takes place when IC5's CS1 and CS2 both go high. This enables the output drivers and puts the data on the bus. At the same time, SERVICE REQUEST is reset. Voltage at the inputs must be in the range of -0.5 to 5.5 volts dc. This is true of all the gates and inputs that we will discuss.

Output port IC4 is identical to input port IC5. Tying pin 2 high converts the chip to its output mode. Data is latched into the port when CS1 is low during a MEMORY READ and CS2 is high during an output instruction, and when TPB is high. Data is immediately transferred to the output lines and is available at plug P3.

A SERVICE REQUEST pulse is generated by the port after WR0 line goes high. This pulse can signal the receiving device that new data is available.

The output lines can be connected to low-current relays or other digital devices. The 1852 will deliver up to 2.3 mA when the output is high or will sink up to 6 mA when the output is low. See Fig. 6 to determine the maximum and minimum resistances that may appear as loads on this port. Input and output commands can be changed by connecting pin 13 to a decoded n line (decoder must be on an expansion board). The output instruction for this board is 61 and the input is 6B. A detail regarding the I/O ports is pin 14 CLEAR. A low on this line resets the port's registers and the SERVICE REQUEST output.

INTERRUPT/DMA Interface. As shown in the CPU timing diagram, DMA and INTERRUPT lines are only sampled for a short interval by the CPU. Therefore we must hold the request low until the CPU acknowledges that it has been received. This is done by flip-flop IC10B. A negative-to-positive pulse on pin 11 (clock) sets pin 8 low. Pin 8 can be connected to either the INT or DMA OUT line on the CPU. If an interrupt is chosen, pin 8 of IC7 will go low because the STATE CODE lines SCO and SCI will both be high. (See Fig. 4.) This will reset IC10B and signal the device requesting the interrupt that the CPU has responded. Juniper 7, A to C, must be connected. If IC10B pin 8 is connected to DMA OUT, IC7 pin 11 will go low when the STATE CODE lines indicate that DMA is in progress, again resetting the flip-flop and acknowledging the DMA request via jumper 7, A to B. These examples illustrate the importance of understanding timing diagrams.

To Output Port

| 0000 | OUT 1 | 61   | Output next byte |
| 0002 | FF    | All 1's |
| 0003 | IDL   | 00    | Idle            |

To Input Port

| 0000 | LD1   | F8 00 B1 | Load 00 in high order Reg. 1 |
| 0003 | LD1   | F8 10 A1 | Load 10 in low order Reg. 1  |
| 0004 | Set X | E1     | Set X to         |
| 0005 | IN3   | 6B     | Input data       |
| 0006 | Out 4 | 64     | Display it on program board |
| 0007 | IDL   | 00     | Idle             |
POWER ON/CLEAR Circuit. This automatically resets the CPU in the event of a power failure. Its usefulness depends on the retention of data in memory despite power loss, which means that the memory or program memory must be in ROM. When the CLEAR line on the CPU is held low with the WAIT line high, the CPU is reset. This condition is met on a power up because the CLEAR line is held low by IC9 until C1 charges. This delay lets the onboard crystal oscillator stabilize before program execution begins.

The crystal clock generator (2 gates of IC9) generates a 3.578-MHz square wave. The D-type flip-flop IC10A is used to divide the frequency by two. The 1802 clock input is connected to pin 5 of IC10A. A CLOCK signal is provided to drive a color video system in an expanded setup.

Buffers and Power Supply. Input and output buffers in IC6 isolate the external flags and Q lines from the CPU. Buffers are far less costly than CPUs and can serve as protection against voltage transients and short circuits that may occur in the outside world. Additionally, they are capable of sourcing and sinking larger currents than can CPU lines.

The power-supply regulator Q2 will deliver up to 500 mA dc. The programming board also gets its power from this source. The power requirement of the product board, fully loaded, is 110 mA. An optional NiCd battery pack can be added (four 1.5-volt cells) to power the product board for about 2 hours in the event of a power failure.

Programming Board. The purpose of the programming board is to load a program into the memory on the product board and to test the program and hardware. It can be disconnected from the product board when the programming and testing are complete. The programming board (Figs. 7A through 7F) is connected (via the 86 pin bus) to the CLEAR and WAIT lines on the CPU; therefore it can place the CPU in any of its four modes, displaying the mode selected on LED1 and LED2. Two LEDs (LED3 and LED4) on the STATE CODE lines identify the type of CPU machine cycle in progress.

The hex value of the entire 16-bit address line is displayed on 7-segment display DIS1 through DIS4. Two 7-segment displays (DIS5 and DIS6) perform the same function for the data bus. Data bus displays are also configured as an output port responding to a 64-output instruction. A hex keyboard is connected to the data bus via two 4116 gates. IC1 converts the hex value of the key press to its 4-bit binary equivalent. When a second key is pressed, the value

(Continued on page 74)
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Part 2: Comparing what's available today.

There are so many hundreds of electronic games on the market today that buying decisions are generally made rather quickly on the spot. In most instances, the buyer has never seen the game before and has no idea if a particular desirable feature might be available in a competing brand. So here's a guide to electronic games to help you prepare yourself before you visit a dealer.

A 10-factor weighted rating system can be employed in evaluating electronic games available in today's marketplace. This system assigns a different number of points from 10 to 25 to each factor, depending on the importance to the user. The highest weight, 25 points, is given to "interest retention" (long-term popularity).

The rating system or "Electronic Game Evaluation Guide" does not include price. Therefore, a game with a high rating is not necessarily a good value. For this reason, ratings we compiled were used mainly to determine the games to be reviewed in this article and actual ratings are mentioned sparingly.

The same system should be helpful to you in evaluating games prior to purchase (if you get an opportunity to try the games). It is described in Table 1.

Board Games (Table 11) include electronic versions of old, familiar games (chess and backgammon), modified versions of conventional board games (such as "The Generals," a computerized game based on "Stratego") and new games specifically designed to take advantage of electronic technology ("Electronic Detective").

Fidelity emerged as a leader in electronic game technology in 1978 when it captured first place in a San Diego microcomputer chess tournament. Its "Chess Challenger" went undefeated in 12 games (winning 10 and drawing 2) against "Micro-Chess 1.0" (Heath H8), "Micro-Chess 1.5" (Radio Shack TRS-80), "Micro-chess 2.0" (Commodore PET), "BORIS" and "SARGON 1" (Radio Shack TRS-80).

The newest chess product in Fidelity's line is "Voice Sensory Chess Challenger." Its artificial voice lacks the natural qualities of "Speak & Spell," but that's about its only flaw. With a suggested retail price of $360, "Voice Sensory

Fidelity's Voice Sensory Chess Challenger

### Table I—Electronic Game Evaluation Guide

<table>
<thead>
<tr>
<th>No.</th>
<th>Consideration</th>
<th>Comments</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interest retention</td>
<td>What is the probability that the game will still be popular months after its initial use?</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Player skill required</td>
<td>How much skill and judgment is needed to play? Is it too easy or too difficult?</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Design creativity</td>
<td>How unusual is the game? In the case of sports-based games, does it simulate on-the-field action in an enjoyable manner?</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Competitiveness</td>
<td>Can two or more players feel active competitive involvement?</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Display realism/ packaging/controls</td>
<td>How clever are the graphics? How lively is the action on the screen? Are the controls easily manipulated?</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>Time needed to learn the game</td>
<td>Is the game tricky to learn? If it is, an experienced player has an advantage not provided by skill but by familiarity with the system.</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Computer as opponent</td>
<td>Is the computer smart enough to perform as a worthy adversary or to challenge the ingenuity of the player?</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>Sound effects</td>
<td>Has voice or sound been used effectively to enhance game play?</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>Game variation/ random generation</td>
<td>Are a number of interesting variations of the basic game offered? Is random generation used, and if so, is it used effectively?</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>Overall execution</td>
<td>All factors considered, how well have the previous nine factors been combined to form an appealing game?</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td>150</td>
</tr>
</tbody>
</table>
Challenger” makes good use of its 50-
word vocabulary and its 224,000 bits of
ROM. For the inexperienced player, it
can tell how to set the board and illumi-
nate paths to illustrate how each piece is
moved. If the player needs help, the
computer will recommend a move. Should the player violate the rules of
chess it announces “illegal move.”

The new Fidelity game can duplicate
64 of the world’s greatest chess games
including matches played by Morphy,
Capablanca, Spassky and Fischer. The
player can assume the role of either of
the original participants; the computer
will award points for correct moves and
reveal how the game was played by the
original opponents. It can, of course,
also play a mean game of chess when
operated at its highest skill level (ten
levels are provided).

To move a piece, the player first
touches its present position and then
touches the new position. This is a great
improvement over using the usual sepa-
rate built-in keypad. A light at each po-
sition indicates that the move has been
registered with the computer. The com-
puter announces both its own moves and
the player’s moves. According to the
manufacturer’s promotional literature,
the “Voice Sensory Challenger” calls
out every capture; actually, it only an-
nounces the computer’s captures.

Blending the Old and New. Some-
where in the city, a thief is about to com-
mitt a crime. You’re a private detective
armed with the latest development in so-
phisticated crime detection equipment,
an electronic “Crime Scanner.”

You press the “Clue” button on your
crime scanner and the display reveals
the street on which (or the building in
which) the crime is taking place. But
that’s not all you scanner does; it also
monitors the scene of the crime for
sound. You hear the thief as he breaks
a glass window.

The chase is on. You head for the
jewelry store across the street from Ma’s
Ice Cream Shop. And you’re not alone.
Other private detectives, who are also
after the reward money, are joining in
the pursuit.

Now you hear the thief running along
the street but you’re still too far away to
apprehend him. You and the other de-
tectives continue to close in as he heads
for a nearby subway station.

You’re playing “Stop Thief,” an elec-
tronic cops-and-robbers game, con-
trolled by a four-bit microcomputer.
Eventually, you or one of the other
players will track the thief down suc-
scessfully and move in for the arrest.
You’ll collect at least $800 in reward
money as the police arrive with sirens
wailing and guns firing, unless the thief
slips away. In that case, all you’ll get is a
parting, “Na-na-na-an-na-na,” from the
thief as he escapes.

“Stop Thief” is a modern-day board
game; it has buildings and streets, and
it’s played with dice and paper money. If
this description is reminiscent of “Mo-
nopoly” it should be pointed out that
Parker Brothers, the creators of “Stop
Thief,” also developed “Monopoly” 45
years earlier.

Are they trying to rework the same
formula? Both games have decks of
chance cards and both involve moving
player pieces along streets (although
the streets in “Monopoly” have famous
names such as Boardwalk and Park
Place; whereas the streets in “Stop
Thief” merely have numbers).

No, “Stop Thief” is not “Monopoly,”
updated. It is uniquely a product of the
microcomputer era. It uses a complex
software program, imbedded in a Texas
Instruments TMS1000 microcomputer
IC by a single-level mask technique.
Three parts of the microcomputer con-
figuration are programmed simulta-
neously: read-only (instructions) memo-
ry, instruction decoder, and output en-
coder. These three sections control
information storage and processing.

“Stop Thief” can be thought of as a
blend of the old and the new. It retains
the competitive nature of the basic
board game, while introducing comput-
er-controlled challenge (finding the
thief), computer-assisted play (for ex-
ample, if a player forgets some clues, he
can recall the last 10 clues from the
microcomputer’s memory), and comput-
er-generated sound.

A recently published review compar-
ing Ideal’s “Electronic Detective” with
Parker Brothers’ “Stop Thief” came to
four conclusions: (1) the two games are
similar, (2) “Electronic Detective” is
much more complicated, (3) “Electronic
Detective” is a greater challenge, and
(4) “Stop Thief” is more appropriate for

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**TABLE II—ELECTRONIC BOARD GAMES**

<table>
<thead>
<tr>
<th>Game</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRYOM</strong></td>
<td>Computer employs all backgammon strategies</td>
</tr>
<tr>
<td>Omar V</td>
<td>against player.</td>
</tr>
<tr>
<td><strong>SUPER SYSTEM III</strong></td>
<td>Moves shown on LCD display window.</td>
</tr>
<tr>
<td><strong>FIDELITY</strong></td>
<td>Moves automatically entered/indicated on board.</td>
</tr>
<tr>
<td>Sensory Chess Challenger</td>
<td>Moves shown on LED window and announced.</td>
</tr>
<tr>
<td>Voice Chess Challenger</td>
<td>Indicates and announces moves automatically.</td>
</tr>
<tr>
<td>Sensory Chess Challenger</td>
<td>Moves shown on LED window.</td>
</tr>
<tr>
<td>Checker Challenger</td>
<td>Moves shown on LED window; conventional dice.</td>
</tr>
<tr>
<td>Backgammon Challenger</td>
<td></td>
</tr>
<tr>
<td><strong>IDEAL</strong></td>
<td>Electronic equivalent of Stratego.</td>
</tr>
<tr>
<td>The Generals</td>
<td>Killer’s identity is deduced through clues.</td>
</tr>
<tr>
<td>Electronic Detective</td>
<td></td>
</tr>
<tr>
<td><strong>PARKER BROTHERS</strong></td>
<td></td>
</tr>
<tr>
<td>Stop Thief</td>
<td>Part “Monopoly,” part “Clue,” but mostly new.</td>
</tr>
<tr>
<td>Code Name Sector</td>
<td>“Aging” search-and-destroy submarine hunt.</td>
</tr>
<tr>
<td><strong>EPOCH</strong></td>
<td>Sound clues, search-and-arrest buttons.</td>
</tr>
<tr>
<td>Detective Game</td>
<td></td>
</tr>
<tr>
<td><strong>MILTON BRADLEY</strong></td>
<td>Electronic version of grid-position, sea battle.</td>
</tr>
<tr>
<td>Electronic Battleship</td>
<td></td>
</tr>
<tr>
<td><strong>LAKESIDE</strong></td>
<td>Attack pilot tries to slip through missile defense system.</td>
</tr>
<tr>
<td>Intercept</td>
<td></td>
</tr>
<tr>
<td><strong>CARDINAL</strong></td>
<td>Conventional backgammon set with randomly</td>
</tr>
<tr>
<td>Brian</td>
<td>generated electronic dice.</td>
</tr>
<tr>
<td><strong>ELECTRONIC CHESS</strong></td>
<td>Seven-level and 12-level versions (beginner to</td>
</tr>
<tr>
<td></td>
<td>expert).</td>
</tr>
</tbody>
</table>

* Considered as a board game though a board is not actually used in playing the game.
The games are not similar even though they both employ versions of the TMS1000 microcomputer. “Stop Thief,” like “Monopoly,” is a board game; that is, apprehending the criminal depends upon being in the right place at the right time. Getting there is a combination of luck (resulting from the roll of the dice) and skill (knowing where to move and when). “Electronic Detective” is not a board game; it is a game of deduction, careful scrutinization of alibis and weighing of evidence.

“Electronic Detective” is no more complicated than “Stop Thief” and every bit as easy to learn. “Stop Thief,” because the criminal is constantly on the move, presents a different kind of challenge. In one case, the players are trying to overtake a fleeing criminal; in the other, they are trying to determine his or her identity.

As “Electronic Detective” begins, a murder takes place. Now it’s up to each player to determine who the killer is through questions keyed into the computer. Alibis of suspects must be carefully checked because even innocent suspects may sometimes lie.

As suspects are interrogated, evidence is uncovered. The player wins if he correctly identifies the killer. But, be careful, a false accusation removes the player from the game. The computer plays the funeral dirge for each detective who is eliminated.

More than 130,000 different crime situations are possible. Players can choose from three levels of skill: gumshoe, sleuth or master detective.

Anyone who likes to solve a mystery, should enjoy playing either “Electronic Detective” or “Stop Thief.” The two games differ not only in the type of criminal being tracked down (in “Electronic Detective,” he’s a murderer; in “Stop Thief,” he’s just a crook) but in basic concept and method of play. Both games are appropriate for younger players once an experienced player has explained the rules and briefly discussed strategy considerations.

Generals Battle It Out. Ideal’s “The Generals” is a computerized version of Milton Bradley’s board game “Stratego,” which, in turn, was an American version of a game developed in Holland. The marshall in “Stratego” is now a five-star general and the nearly powerless spy has been replaced by an extremely dangerous agent, but the cast of players is generally the same. So is the object, which is to capture the opponent’s flag.

In both games, the players are supplied with armies and move their troops across a battlefield. But the addition of an electronic judge in “The Generals” does have its benefits. In an encounter between two battle pieces, the computer identifies the winning piece without revealing its rank. This is a major improvement over “Stratego,” where opponents must reveal the ranks of their pieces in each confrontation. Not knowing the ranks of an opponent’s remaining pieces forces a player to make more assumptions and use more risky strategic planning.

The role of the electronic arbiter is limited to revealing which of two pieces, engaged in battle, has the higher rank. “The Generals” is strictly a two-player game; one player cannot oppose the computer.

When scored by using the rating system described earlier, “Electronic Detective,” “Stop Thief,” and “The Generals,” each tallied over 80%, as shown in Table III. A score of 65% or better is considered acceptable.

Road Racing (Table IV). You might call Kenner’s “Redline” a dashboard game. It is designed as a replica of a dragster steering wheel and has a digital console with gear and gas controls, gear and rpm readouts and a string of engine status lights.

The idea of the game is to control the engine so as to win the race without jumping the start signal or exceeding the safe limit (redline) for engine speed.

### TABLE III—APPLICATION OF RATING SYSTEM

<table>
<thead>
<tr>
<th>No.</th>
<th>Consideration</th>
<th>Electronic Detective</th>
<th>Stop Thief</th>
<th>The Generals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interest retention</td>
<td>23</td>
<td>24</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>Player skill required</td>
<td>17</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Design creativity</td>
<td>18</td>
<td>19</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>Competitiveness</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Display realism/packaging/controls</td>
<td>15</td>
<td>13</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>Time needed to learn the game</td>
<td>6</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Computer as opponent</td>
<td>10</td>
<td>10</td>
<td>N/A</td>
</tr>
<tr>
<td>8</td>
<td>Sound effects</td>
<td>9</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>Game variations/random generation</td>
<td>10</td>
<td>10</td>
<td>N/A</td>
</tr>
<tr>
<td>10</td>
<td>Overall execution</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Total Points: 138 141 93
Max. Possible Points: 150 150 115
Score (%): 92 94 81

**N/A** = Not Applicable

### TABLE IV—ELECTRONIC ROAD GAMES

<table>
<thead>
<tr>
<th>Game</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BANDAI</strong></td>
<td></td>
</tr>
<tr>
<td>Champion Racer</td>
<td>5-gear racing game with separate starting line. Two-button steering control.</td>
</tr>
<tr>
<td><strong>KENNER</strong></td>
<td></td>
</tr>
<tr>
<td>Redline</td>
<td>4 gears. No lanes to drive. Player controls engine speed.</td>
</tr>
<tr>
<td><strong>MATTEL</strong></td>
<td></td>
</tr>
<tr>
<td><strong>TIGER</strong></td>
<td></td>
</tr>
<tr>
<td>Raceway</td>
<td>4-gear racing game. Counts number of collisions. Trumpeting sound for victory; buzzer sound for defeat.</td>
</tr>
</tbody>
</table>
both games is to cover four laps in as short a time period as possible. If the four laps haven't been driven after 99 seconds have elapsed, play ends.

"Raceway" has several nice touches. Its miniature steering wheel and throttle are more realistic than would ordinarily be expected from a car-racing game. Both provide the equivalent feel of full-scale arcade games as the player shifts gears and changes lanes. If the driver successfully completes the required four laps, "Raceway" displays both elapsed time and the number of collisions with oncoming vehicles along the way. Mattel's game only displays elapsed time (or the 99-second time limit).

(another way in which "Champion Racer" differs from "Raceway"). Points are scored by avoiding collisions on the track; the faster the driving speed, the more points that can be accumulated. Each time a collision occurs, the player must start again from the pit.

If a player covers more than 99 miles, the two-digit light-emitting-diode display switches from digital to alpha/numerical readout (A1=101 miles, C1=121 miles, etc.). The display flashes with 10 seconds left to play alerting the player that the game is ending.

Electronic Games of Chance (Table V). Picture yourself playing Gin. Your opponent says "no thanks," as you discard the ten of clubs. It's his last decision. On your next move, you draw the card you need for Gin. You've just beaten Mattel Electronics' "Computer Gin" at the low-skill setting. Now you're ready to play it at the high-skill level.

Besides two skill levels, Computer Gin also can oppose you in Go Draw or 33. In Gin, you receive 11 cards, face up, on the display. Your hand is unknown to the computer; its hand is unknown to you. You dispose of the least desirable card by pushing the discard button. The discarded card then disappears from the screen; the computer either accepts it with "thanks" or picks a fresh card from the deck. It's your turn again and, automatically, a new card from the deck flashes on the screen. If you want it, you push the select button and again dispose of the least desirable card. If you don't want it, you hit the draw button and receive a different card. And so on, until either you or the computer gets Gin.

Don't get too excited if you draw a great poker hand against the dealer (the

In both games, the computer sends vehicles into the same driving lane being used by the player; constant reaction by the player, therefore, is needed. Each collision knocks the player's car back one space. If the player doesn't move his car from its lane immediately after a collision, the other car will continue to push him backwards. The cars are displayed as lines, not graphic images. The line representing the player's car is a brighter red than the other lines, which is sufficient for distinguishing between the player's car and other vehicles. However, the pictorial representation of moving cars, such as used by Bandai Electronics in "Champion Racer," is visually superior.

In "Champion Racer," the player has 90 seconds to cover as many miles as possible. He can shift through five speeds (as compared to four with Tiger's "Raceway") and he can move into reverse (not possible with "Raceway").

To start "Champion Racer," the player moves his car from the pit onto the racetrack. He must be careful as he works his way up the field because cars can come at him from either direction.

<table>
<thead>
<tr>
<th>Game</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAMBINO Blackjack</td>
<td>Has bet, hit, stay buttons and keyboard. Includes sound effects. Also plays poker and bridge.</td>
</tr>
<tr>
<td>Jackpot Gin Rummy</td>
<td></td>
</tr>
<tr>
<td>FIDELITY Voice Bridge Challenger Bridge Bidder</td>
<td>Announces bids in accepted bridge terminology. Can be partner or opponents. Learning aid. Player enters hand. Bid is suggested by computer.</td>
</tr>
<tr>
<td>MATTEL Computer Gin</td>
<td>Computer can oppose you in three different card games: Gin, Go Draw, and 33.</td>
</tr>
<tr>
<td>UNION MAJOR Yacht Four</td>
<td>Rolls dice numbers electronically. Provides musical cheer for winner.</td>
</tr>
<tr>
<td>UNISONIC &quot;21&quot;</td>
<td>Has insurance, splitting, doubling down, hit, stand, bet and play buttons; 12-digit display.</td>
</tr>
</tbody>
</table>

TABLE V—CARD AND CHANCE GAMES
When playing the online version of Classic Poker, the player can discard existing cards and draw new cards. He can then bet or fold. After the first bet, two dealer cards are revealed. The player can call or bet again, and another dealer card is revealed. The player can bet again, or call and the computer will reveal the winning hand, display the winnings or losses and the accumulated totals.

Union Major’s “Yacht Four” is an electronic 5-dice game similar to “Kismet,” “Yahtzee,” “Poker Dice,” and “Casino Games” (trademarks of Spare-Time Products, Inc.; E.S. Lowe Co., a Milton Bradley Company; Aurora Products Corp.; and Invicta Games, respectively). The readout displays the most strategic move to make after each roll.

Land, Sea, Air, and Space Warfare Games (Table VI). Most of the handheld space-warfare electronic games are similar in concept to the popular arcade game, “Space Invaders.” Exceptions are Kenner’s “Star Wars,” which puts the player in command of the “X-Wing Fighter” in combat with a “Tie-Fighter,” and Bambino’s “Space Laser Fight,” a space version of a shootout in the Old West.

In “Space Invaders,” an alien squadron is heading toward the earth. The player defends his planet by destroying the attackers as they attempt to land.

The Entex version is remarkable in its duplication of most of the features of the arcade and video cassette games. The pace of the attack, the rapid fire by the enemy ships, the destruction of the defense shields, the cruising mother ship and the landing on earth are expertly programmed. The visual display provides spaceship replicas not lines as several other games offer.

---

**TABLE VI—WARFARE GAMES**

<table>
<thead>
<tr>
<th>Game</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ATARI</strong></td>
<td></td>
</tr>
<tr>
<td>Space Invaders</td>
<td>Hand-held version of popular arcade game.</td>
</tr>
<tr>
<td><strong>BAMBINO</strong></td>
<td></td>
</tr>
<tr>
<td>Space Laser Fight</td>
<td>Robots shoot it out on outstanding visual display.</td>
</tr>
<tr>
<td>UFO Master Blaster</td>
<td>Simplified version of Space Invaders.</td>
</tr>
<tr>
<td><strong>BANDAI</strong></td>
<td></td>
</tr>
<tr>
<td>Missile Invader</td>
<td>The enemy doesn’t try to land in this version of Space Invaders.</td>
</tr>
<tr>
<td>Super Galaxy Invader</td>
<td>Deluxe version of Missile Invader.</td>
</tr>
<tr>
<td><strong>ENTEX</strong></td>
<td></td>
</tr>
<tr>
<td>Space Invader</td>
<td>Well-executed version of the arcade game.</td>
</tr>
<tr>
<td><strong>EPOCH</strong></td>
<td></td>
</tr>
<tr>
<td>Invader From Space</td>
<td>Three skill-level version of Space Invader.</td>
</tr>
<tr>
<td><strong>KENNER</strong></td>
<td></td>
</tr>
<tr>
<td>Star Wars</td>
<td>Object is to determine grid position of enemy and destroy.</td>
</tr>
<tr>
<td><strong>MATTEL</strong></td>
<td></td>
</tr>
<tr>
<td>Space Alert</td>
<td>Mini Space Invaders. Also called Battlestar Galactica and Flash Gordon.</td>
</tr>
<tr>
<td>Sub Chase</td>
<td>Drop depth charges while dodging torpedos.</td>
</tr>
<tr>
<td>Armor Battle</td>
<td>Duel enemy tank while avoiding mine mines.</td>
</tr>
<tr>
<td><strong>TIGER</strong></td>
<td></td>
</tr>
<tr>
<td>Sub Wars</td>
<td>Torpedos are fired against fleet.</td>
</tr>
<tr>
<td><strong>TOMY</strong></td>
<td></td>
</tr>
<tr>
<td>Cosmic Combat</td>
<td>Avoid enemy missiles when shooting at overhead ships.</td>
</tr>
<tr>
<td><strong>VANITY FAIR</strong></td>
<td></td>
</tr>
<tr>
<td>Electron Blaster</td>
<td>Still another version of Space Invaders.</td>
</tr>
</tbody>
</table>

**TABLE VII—FOLLOW THE LEADER GAMES**

<table>
<thead>
<tr>
<th>Game</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ATARI</strong></td>
<td></td>
</tr>
<tr>
<td>Touch Me</td>
<td>Offers three games requiring repeating of lights, sounds, and colors.</td>
</tr>
<tr>
<td><strong>CASTLE</strong></td>
<td></td>
</tr>
<tr>
<td>Einstein</td>
<td>Player repeats colors and sounds.</td>
</tr>
<tr>
<td><strong>MILTON BRADLEY</strong></td>
<td></td>
</tr>
<tr>
<td>Pocket Simon</td>
<td>Miniature version of Simon.</td>
</tr>
<tr>
<td>Super Simon</td>
<td>Player duplicates colors and sounds.</td>
</tr>
<tr>
<td><strong>TIGER</strong></td>
<td></td>
</tr>
<tr>
<td>Copy Cat</td>
<td>Sequences of lights and sounds. Speed up as game progresses.</td>
</tr>
</tbody>
</table>

**TABLE VIII—CODE-BREAKER GAMES**

<table>
<thead>
<tr>
<th>Game</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INVICTA</strong></td>
<td></td>
</tr>
<tr>
<td>Electronic Mastermind</td>
<td>Break the secret code set by the computer. Deluxe Electronic Mastermind with sound.</td>
</tr>
<tr>
<td>Supersonic Mastermind</td>
<td></td>
</tr>
<tr>
<td><strong>LAKESIDE</strong></td>
<td></td>
</tr>
<tr>
<td>Computer Perfection</td>
<td>Four games based on turning lights on in sequence. Search for clues to defuse the bomb.</td>
</tr>
<tr>
<td>Le Boom</td>
<td></td>
</tr>
<tr>
<td><strong>MILTON BRADLEY</strong></td>
<td></td>
</tr>
<tr>
<td>Comp IV</td>
<td>A correctly guessed number is indicated by flashing lights.</td>
</tr>
</tbody>
</table>

Follow-the-Leader Games (Table VII) are simply games that test the memory of the player in some way. He might be asked to duplicate a string of numbers or a series of musical notes. Some of the products listed in the multifunction category include follow-the-leader games among other types.

**Code-Breaker Games** (Table VIII) require the player to identify unknown information generated by the computer. Trial-and-error or deduction techniques are employed.

To be continued next month.
Pulse Amplitude Reference

Easy-to-build circuit amplifies input pulses when calibrating an oscilloscope.

BY IMRE GORGENYI

WHEN working with very narrow, low-amplitude, low-energy pulses, it is advantageous to calibrate the oscilloscope you are using at actual working conditions with probes and attenuators in place. This is not always easy since pulse amplitude calibrators usually have low-level outputs—often under one volt.

The simple, all-FET circuit shown here provides pulse amplitudes to 25 volts, if desired, from pulse inputs of 5 to 20 volts. Since the two FET pairs are driven to their open-saturated condition, output pulses have the same amplitude as the power supply voltage. Absolute amplitude of the output can be monitored by a DVM at all times.

The circuit can handle narrow pulses and slow repetition rates. It can be assembled on a small piece of perforated board using BNC connectors for the input and output and can be connected directly in the 50-ohm line between the pulse generator and scope. The circuit, including power supply and digital voltmeter connectors, is “floating.” Circuit protection is formed by the fuse and zener diode.

The printer you always wanted but could never afford,

now you can afford.

The most revolutionary thing about the Epson MX-80 isn’t the bidirectional printing or the logical seeking function. It isn’t even the disposable print head — although that’s pretty revolutionary. The most revolutionary thing about the MX-80 is the price. How, you may ask, could a printer that does as much as the MX-80 cost less than $650?

Frankly, it wasn’t easy. But the MX-80 could only have come from the world’s largest manufacturer of print mechanisms, Epson.

The world’s first disposable print head: when it wears out, just snap it out and throw it away. A new one costs less than $30, and you can install it yourself with one hand.

We spent three long years designing the MX-80 from the ground up to have all the functions people wanted, to be reliable like all Epson Printers, and to be produced on a scale that would allow us to charge less for each one. The MX-80 is our proof that it can be done.

Among its features, the MX-80 prints 96 ASCII, 64 graphic and eight international characters in a tack-sharp 9x9 matrix. It prints bidirectionally at 80 CPS with a logical seeking function to maximize throughput. And it has the world’s first disposable print head.

If you’ve ever wanted a printer that could do it all at a price you could afford, you’ve got to see the Epson MX-80.

Because seeing is believing.
A Microcomputer for everyone at a Micro Price

The [MicroAce] - a new generation of miniature computers

A COMPLETE COMPUTER for $149.00 for 1K Kit
Post and Packing FREE
(Add 6% Tax for Shipments inside California)

The MicroAce is not just another personal computer. Quite apart from its exceptionally low price, the MicroAce has two uniquely advanced components: the powerful BASIC interpreter, and the simple teach yourself BASIC manual. The unique versatile BASIC interpreter offers remarkable programming advantages:

- **Unique 'one-touch' key word entry**: the MicroAce eliminates a great deal of tiresome typing. Key words (RUN, PRINT, LIST, etc.) have their own single-key entry.
- **Unique syntax check**: Only lines with correct syntax are accepted into programs. A cursor identifies errors immediately. This prevents entry of long and complicated programs with faults only discovered when you try to run them.
- **Excellent string-handling capability**: takes up to 26 string variables of any length. All strings can undergo all relational tests (e.g. comparison). The MicroAce also has string input - to request a line of text when necessary. Strings do not need to be dimensioned.
- **Up to 26 single dimension arrays.**
- **FOR/NEXT loops nested up 26**
- **Variable names of any length.**
- **BASIC language also handles full Boolean arithmetic, conditional expressions, etc.**
- **Exceptionally powerful edit facilities, allows modification of existing program lines.**
- **Randomisation function, useful for games and secret codes, as well as more serious applications**
- **Timer under program control.**

- **PEEK and POKE enable entry of machine code instructions, USR causes jump to a user's machine language sub-routine.**
- **High-resolution graphics with 22 standard graphic symbols.**
- **All characters printable in reverse under program control.**
- **Lines of unlimited length.**

'Excellent value' indeed!

For just $149.00 (excluding handling charge) you get everything you need to build a personal computer at home... PCB, with IC sockets for all ICs; case, leads for direct connection to a cassette recorder and television (black and white or color), everything!

Yet the MicroAce really is a complete, powerful, full-facility computer, matching or surpassing other personal computers at several times the price.

The MicroAce is programmed in BASIC, and you can use it to do quite literally anything, from playing chess to managing a business.

The MicroAce is pleasingly straightforward to assemble, using a fine-tipped soldering iron. It immediately proves what a good job you've done: connect it to your TV ... link it to the mains adaptor ... and you're ready to go.

Fewer chips, compact design, volume production-more power per Dollar!

The MicroAce owes its economical low price to its remarkable design: the whole system is packed on to fewer, newer, more powerful and advanced LSI chips. A single SUPER ROM, for instance, contains the BASIC interpreter, the character set, operating system, and monitor. And the MicroAce 1K byte RAM (expandable to 2K on board) is roughly equivalent to 4K bytes in a conventional computer — typically storing 100 lines of BASIC. (Key words occupy only a single byte.)

The display shows 32 characters by 24 lines. And Benchmark tests show that the MicroAce is faster than all other personal computers.

No other personal computer offers this unique combination of high capability and low price.

The MicroAce teach-yourself BASIC manual.

If the features of the BASIC interpreter mean little to you—don't worry. They're all explained in the specially-written book free with every kit! The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming—using standard principles to complex programs. (Available separately—purchase price refunded if you buy a MicroAce later.)

A hardware manual is also included with every kit.

The MicroAce Kit: $149.00 with 1K COMPLETE $169.00 with 2K

Demand for the MicroAce is very high: use the coupon to order today for the earliest possible delivery. All orders will be despatched in strict rotation. If you are unsuccessful in constructing your kit, we will repair it for a fee of $20.00, post and packing FREE. Of course, you may return your MicroAce as received within 14 days for a full refund. We want you to be satisfied beyond all doubt — and we have no doubt that you will be.

JOIN THE REVOLUTION - DON'T GET LEFT BEHIND - ORDER YOUR MICRO ACE NOW!!

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Unit Price</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MicroAce Kit 1K</td>
<td>$149.00</td>
<td>$149.00</td>
<td></td>
</tr>
<tr>
<td>MicroAce Kit 2K</td>
<td>$169.00</td>
<td>$169.00</td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td>$10.00</td>
<td>$10.00</td>
<td></td>
</tr>
<tr>
<td>1K Upgrade Kit</td>
<td>$29.00</td>
<td>$29.00</td>
<td></td>
</tr>
</tbody>
</table>

Shipment inside California add 6% TAX

Quantity Description Unit Price TOTAL

Amex Diners
Check Money Order Master Charge
Visa

Card No.________ Exp. Date________

Send Check, Money Order or quote your Credit Card No. to: MicroAce 1348 East Edinger, Santa Ana, California Zip Code 92705, or phone (714) 943 2750 quoting your Credit Card Number.
Solid-State Developments

By Forrest M. Mims

For Sale: Free Energy from the Sun

SOLAR energy proponents sometimes become so enthusiastic over the free availability of sunlight that they overlook the cost of purchasing and maintaining the equipment necessary to tap and store it. Recently, for example, a specialist in the solar heating of homes appeared as a guest on a popular radio talk show. In response to a listener's question, the guest ventured into an aspect of solar energy conversion about which he knew very little: photovoltaics. He made some elaborate claims about how roof-top panels of solar cells could supply all the electrical needs of a home but failed to mention the enormous expense at today's prices of the panels, storage batteries, voltage regulators and inverters.

If you've ever looked into the subject, you know that the current price of solar cells is a long way from the goal of $0.10 or less per watt set by the U.S. Department of Energy. Unless you can afford to buy in large quantities, the average experimenter will have to pay at least $15 for enough solar cells to generate one watt of electricity!

Many companies that sell parts to experimenters also sell solar cells, and the price per watt for these cells varies widely. To illustrate some typical variations, here's a table comparing the current output ($I_{out}$) and cost for a 3" circular silicon solar cell having an open-circuit voltage of 0.45 V.

<table>
<thead>
<tr>
<th>Company</th>
<th>Stock No.</th>
<th>$I_{out}$ (A)</th>
<th>Cell Cost ($)</th>
<th>$/Watt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheney Electronics</td>
<td>C24159</td>
<td>0.75</td>
<td>8.50</td>
<td>25.19</td>
</tr>
<tr>
<td>EDI</td>
<td>E-43</td>
<td>1.0</td>
<td>6.88</td>
<td>15.29</td>
</tr>
<tr>
<td>Edmund Scientific</td>
<td>42.270</td>
<td>1.2</td>
<td>19.95</td>
<td>36.94</td>
</tr>
<tr>
<td>Ferranti</td>
<td>ESC-3</td>
<td>0.6</td>
<td>23.50</td>
<td>56.75</td>
</tr>
<tr>
<td>Newark</td>
<td>69F121</td>
<td>1.2</td>
<td>17.00</td>
<td>31.48</td>
</tr>
<tr>
<td>Poly Peks</td>
<td>92cU3862</td>
<td>1.0</td>
<td>7.95</td>
<td>17.67</td>
</tr>
<tr>
<td>Radio Shack</td>
<td>276-123</td>
<td>1.0</td>
<td>9.99</td>
<td>22.20</td>
</tr>
</tbody>
</table>

The cells in this table are made by several manufacturers. The more expensive ones have no defects, while some of the cheaper ones may include culls or seconds. For example, some may have cosmetic blemishes which might reduce slightly the cell's power conversion efficiency (the ratio of solar power striking the cell to electrical power produced by the cell). Others may be inherently less efficient ("below spec") than standard cells due to manufacturing defects.

The extraordinary price of the Ferranti cell, which is shown in Fig. 1, is due to its unique protective housing and electrical connection pins. All the others are bare cells without connection leads.

The parts dealers who sometimes sell manufacturers' culls may buy their solar cells from more than one source. I learned this the hard way a few years ago upon receiving an order of 3" cells. They appeared to have come from two different sources. Most of them had cosmetic blemishes, and only some were 3" cells. The others were slightly smaller. You can avoid this problem, if top efficiency is your quest and money is no problem, by purchasing the more costly first-run cells or buying them from a retail electronics parts store so you can inspect them before buying.

Another tip: Since dealers may buy cells from different sources, always compare prices on any size cell you plan to buy. A dealer whose 3" cells are very economical may sell very expensive 2 cm × 2 cm cells.

Practical Solar Cell Applications. By now you probably have the impression that I'm not a solar-energy enthusiast, but quite the contrary is true. Even at today's ridiculously high prices, solar cells can be used in cost-effective power supplies.

For example, you're probably familiar with several different widely adver-
World's First and Only Solar-Powered Watch*
Guaranteed to outperform any watch sold today... or costs you nothing!

The Sunwatch; acclaimed as the most accurate, most versatile, most rugged watch ever made.

These features make all other watches obsolete:

- Clearly visible by day or night
- Natural side-view window simplifies reading
- 100% solar-powered, you never replace batteries
- No resetting of calendar, even in leap years

Space age accuracy
Now you'll never worry about accuracy again. Because the Sunwatch will keep you on time for the rest of your life. (Accurate within 1 sec. per month.)

Solar age efficiency
Miniature solar cells automatically convert sunlight, daylight or ordinary light bulb light into usable energy for storage. The solar cells last virtually forever. So you'll never replace a watch battery again.

Programmed for ever a century
The built-in computer on a chip will always display the correct time date and month. Also, it automatically adjusts the watch calendar for long and short months, leap years and is programmed until the year 2100.

Easy to read
The natural side-view display lets you tell the time, day and date without twisting your arm into an uncomfortable position.

Numbers always visible
Four varying light intensities are built into the viewing display, allowing the Sunwatch to adjust automatically to any light. This means you can always read it, even in the brightest sunlight.

10 Display functions
The Sunwatch is capable of displaying the following information: hour, minutes, seconds, date, month, time, day, leap year, speed calibration and AM/FM indicator.

Extreme accuracy
Unlike other electronic watches using tuned crystals to control timing accuracy, the Sunwatch incorporates unique, programmable, microcircuit synthesizer to make it the first watch in history that is accurate to less than 1 second per month. That's 5 times more accurate than the latest quartz Accutrons.

The Power Source
Tiny silicon power cells, which are constantly being energized by natural sunlight, daylight or an ordinary light bulb keep the Sunwatch energy storage system charged. Should the watch not be exposed to light it will continue to operate for months on stored power.

The most indestructible watch in the world
The workings of the watch: solar panel, energy cells, quartz crystal, computer on a chip, etc. are all permanently sealed in a Lexan module. This module is so unique it's protected by U.S. and foreign patents.

Completely waterproof
Leave the Sunwatch in salt water for months. Dive with it 150 feet down. Put it in a bag of ice for 24 hours. There are no openings - magnetic slide bars activate all functions. With Sunwatch's exclusive, permanently sealed Lexan module, there are no "O" rings or seals to leak.

Shock resistant to 20,000 G's
You can crash it into a rug-surfaced brick wall at 90 mph with no noticeable effect. Wear it while doing heavy work, exercising or any strenuous activity.

Temperature resistant
Put the Sunwatch in boiling water for 30 minutes, freeze it in a block of ice for a year. Extreme temperatures will not damage your Sunwatch.

Pressure resistant
There are no air spaces inside the Sunwatch. Therefore, it is not susceptible to high pressures such as might be encountered diving to great depths.

The perfect watch for a lifetime
Imagine split-second accuracy for the rest of your life. Sunwatch is a virtually indestructible, beautifully styled, space-age timepiece and it's available in three exciting finishes: Brushed stainless steel, Gold tone stainless steel, or a Durable black finish on stainless steel. All Sunwatches come with a matching stainless steel band with removable links and adjustable clasp.

Made in the United States
The Sunwatch, designed by Roger Riehl, was being worn by its inventor nearly a year before the first electronic digital watch was even available to the general public. Since that time constant engineering evaluations and design improvements have been made on the Sunwatch to incorporate the latest in digital microcircuit and solar power technology. Thus the Sunwatch today represents state-of-the-art electronics technology. It is built to the same rigid standards practiced by the manufacturer in creating sophisticated computer microcircuits for the U.S. Government and other major users of these components.

Unique and memorable gift
Available in a special gift box (see order form) the Sunwatch makes an ideal gift for special birthdays, graduation, Fathers Day etc. Perfect for business people, commuters, teachers, athletes and sportsman, who require split second accuracy.

Free custom engraving
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[ ] Master Charge [ ] VISA (BankAmericard)

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Bank ________________________
Account Number ________________________
Expires Date ________________________

Signature ________________________

Name to be engraved ________________________
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State ________________________
Zip ________________________

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CIRCLE NO. 66 ON FREE INFORMATION CARD
solid-state

tis r-powered watches and calculators. These devices aren't gimmicks. The solar cells provide a trickle charge to one or more nickel-cadmium storage cells, even in subdued light. The solar cells used in these products are so small that their cost is perfectly reasonable for the purpose they serve.

A typical reader cannot begin to afford to purchase enough solar cells to power his home. (Nor can the typical columnist.) Nevertheless, there are some very practical household and recreational applications for solar-cell power supplies, the most obvious being battery charging.

Some boat owners use small solar-cell panels to maintain a charge on their rig's storage battery. The battery can then be used to start an engine, operate a bilge pump or power the running lights.

Hikers and campers can also benefit from small solar-cell battery chargers. Several companies sell small solar-cell panels specifically designed to charge small batteries that can then be used to power flashlights and radios.

If you're a do-it-yourself enthusiast, you may be able to save some money by building your own solar panels. The November 1981 issue of "Experimenter's Corner" (POPULAR ELECTRONICS, p. 110) described a couple of homemade solar cell battery chargers I once assembled for use on a bicycle tour in the mountains of New Mexico. Those two panels are now four years old and are still working well. They've certainly paid for themselves several times over, and, hopefully, will see many more years of service.

Their latest assignment was to recharge the lighting system on my bicycle during a recent bike tour to the Texas Gulf Coast. One panel charged the NiCd cells in a homemade miniature xenon strobe light that clips onto my cycling shorts while night riding. The other panel charged a 6-volt light mounted on a headstrap.

Figure 2 is a photograph showing both these solar chargers hard at work atop a volcanic rock in New Mexico's Jemez Mountains. The small panel at left recharges two NiCd AA cells installed in a holder mounted on the panel's back. A small blocking diode prevents the batteries from discharging through the solar cells during periods of darkness.

The larger panel at right is charging a series-connected module of four AA batteries attached to the headband of a 6-volt headlight. When fully charged the batteries will power the light for about 55 minutes continuous operation.

The small meter in the photo monitors the charging current of the larger panel. Thanks to the very clear New Mexico sky, the panel was generating more than 90 milliamperes when the photo was snapped. Here at my home in south central Texas, almost exactly four years later, this same panel is charging a NiCd pack with a current of slightly more than 85 milliamperes as this is being written.

How to Build One. If you want to try building your own solar panel, your best plan of action is to collect as much manufacturer's literature as possible before selecting and buying the cells and storage cells. The latest edition of McGraw-Hill's Electronics Buyers' Guide lists 39 companies that sell or make photovoltaic cells. Here are some companies that have recently supplied this column with good data sheets and applications information:

* Edmund Scientific Co. (150 Edscrop Building, Barrington, NJ 08007)
* Motorola Semiconductor Products (Box 20912, Phoenix, AZ 85036)
* Sensor Technology, Inc. (21012 Lassen St., Chatsworth, CA 91311)
* Solarx Corporation (1335 Piccard Drive, Rockville, MD 20850)

The applications literature from Solarx is particularly good, although I've yet to see an applications note that covers thoroughly all the considerations involved in the design of even a simple solar-cell battery charger. You can com-

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**Fig. 2. Solar-cell arrays shown here are being used to recharge batteries on long bicycle trips.**

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solid-state

bine applications guidelines from Solar-,
ex and other firms with the specifica-
tions for various solar panels sold by 
these same companies to design your
own custom panel. Here are a few im-
portant points to remember:
1. A typical solar cell has an open-
circuit voltage of 0.45 volt. Connect cells in series to boost the voltage.
2. Connect cells in parallel to boost the current output.
3. Make sure the finished panel does not deliver too much current to the bat-
teries it is intended to charge. Big 1-
apere cells may be fine for charging large storage batteries, but they are to-
tally unsuited for charging AA, C and
other small NiCd batteries.
4. Solar cells are very brittle. Use care when handling them. Protect them from damage with a clear protective housing.
5. Use care when soldering connection leads to solar cells. See the August 1980 issue of Popular Electronics (p. 90) for tips about soldering leads to so-
lar cells.
6. For best results, use four series-connected cells for each NiCd cell you plan to charge. One additional solar cell per array will be needed if you use a blocking diode (and you should). There-
fore you will need nine cells to charge two series-connected NiCd batteries (see Fig. 2).
7. Make sure all the cells in an array are equally illuminated. Blocking the light to most or all of but one cell in a series-connected array will reduce the output to almost nothing.

New Solar-Cells Developments.
In recent years several breakthroughs in photovoltaic technology have occurred.
One is the growth of continuous ribbon or film solar cells from silicon. Another is the development of potentially inex-
pensive solar cells made by coating thin films of polycrystalline silicon on a graphite substrate.

Many other kinds of silicon photovoltaic devices are also undergoing develop-
ment, but many solar cells of the future may be made from gallium arsenide or cadmium sulfide, not silicon. Gallium-
arsenide solar cells are more expensive to make than silicon cells, but they have demonstrated a much higher efficiency
(26% vs. 22%).

 Cadmium-sulfide photovoltaic genera-
tors have a maximum possible power conversion efficiency of only 16% So far
more than 9% has been achieved in the laboratory. While this isn't nearly as high as silicon or gallium arsenide, cad-
mium-sulfide cells are potentially very inexpensive. Some researchers predict a cost for such cells of only 10c to 30c per
watt by 1990! One scientist has predic-
ted a cost of 35c per watt as early as 1982. Should that happen, people can begin thinking seriously about deriving some of their household electrical power from sunlight.

Miniature Solar Cells. As noted ear-
lier, solar cells are being used to power
solid-state

electronic watches and calculators. Surprisingly small cells can be employed, thanks to the ultra-low power consumption of the CMOS circuits used in these products. Actually, small cells must be used since the tiny NiCd batteries that power these products must be charged at very low current levels.

I learned about the latter point firsthand a few months ago after building a miniature (1" x 3") radiation detector. The detector is powered by a single 1.2-volt NiCd button cell, and I wanted to design a NiCd solar charger for it. Unfortunately, none of the solar cells in my limited benchstock were small enough to deliver less than the maximum allowable current to the cell!

Several companies make miniature solar cells and panels. Three new entries from Japan's Sharp Corporation are series-connected arrays designed to power watches with a liquid-crystal display. These tiny arrays contain 5, 6 or 8 cells and produce 1.5, 1.8 and 2.4 volts, respectively. The cells, which measure 2 x 5 mm, are slightly smaller than a 3-digit number on the reader's service card in this magazine. The cells are mounted on a thin Kapton film.

HY50 30 watts RMS $28.95

HY30 15 watts RMS $25.95

HY6 Mono Preamp $25.95

HY66 Stereo Preamp $48.95

Fig. 3. Microniature IC package now available from Signetics for thirteenth of its analog chips.

HY120 60 watts RMS $59.95

HY200 120 watts RMS $79.95

HY400 240 watts RMS (4 ohm) $99.95

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CIRCLE NO. 30 ON FREE INFORMATION CARD

Popular Electronics

Probably the most interesting miniature solar-cell developed thus far was announced earlier this year by NASA. Conventional silicon solar cells must be soldered together in series to produce voltages higher than the 0.45 volt available from a single cell. NASA's new development, which is mounted solderable commercially, allows an array of series-connected cells to be formed on the surface of a monolithic silicon substrate.

In one version, the silicon substrate includes a sine-wave generator integrated adjacent to the solar-cell array to provide an ac output. Future uses for integrated circuits on thin-film solar-cell arrays include chips which are powered solely by light.

Super Capacitors. Two Japanese companies, NEC Electron and Panasonic, have announced a new kind of electrolytic capacitor with up to several thousand times the capacity per unit volume of conventional electrolytics. Panasonic will soon be selling a complete line of 1-to-100-farad (that's farad, not microfarad!) capacitors small enough to fit on a pc board. Panasonic will be selling a line of "Super Caps" ranging from 0.1 to 1 farad.

There are some exciting applications for small capacitors with such huge capacities. Super long timing and power backup for CMOS memory chips are two possibilities.

One of NEC's 0.47-F Supercaps comes in a squat cylinder about the diameter of a C cell and a fourth as long. I've not yet seen prices for these new capacitors, but they should be about the same as conventional electrolytics.

Midget ICs. Figure 3 shows a new IC package Signetics offers as an option for 13 of its standard analog chips. The new microniature package is one-fourth the size of a standard 8-pin mini-DIP.

The new package has exciting possibilities for circuit miniaturization. A bonus feature of its size is much better ac specifications than standard DIPs.

Are the new chips too small for experimenters to use? Based upon my experience with flat-pack ICs, I suspect a careful experimenter could solder these new chips to a pc board by using reflow soldering. This is a soldering method wherein solder is applied to both halves of a prospective connection. The two solder-coated terminals are then placed together (perhaps secured by a small clamp or with tape) and the connection is reheated. The solder on the two halves of the connection melts together to effect a sturdy bond. A magnifying lens and a soldering iron with a very small tip will be essential.
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LEVEL “B” SPECIFICATIONS

Explorer/85’s “Level B” System adds the Intel 8088 CPU, 802132 RAM and 64k PROM/EPROM to the “Level A” system. The 8088 CPU, used on many IBM compatible computers, is a 16-bit microprocessor with powerful instructions and a complete operating system. The 802132 RAM has 64k bytes of memory and is designed for use with the Intel 8088 CPU.

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**Hobby Scene**

By John McVeigh, Technical Editor

**Video Bandwidth Limitations**

Q. I recently modified a solid-state, black-and-white television receiver for use as a terminal in a TRS-80 computer system. My problem is that the dots which comprise the displayed characters are smeared horizontally to such an extent that neighboring dots overlap. This smudge overlap makes the horizontal portions of displayed characters too bright. Therefore, legibility is poor—even when the contrast controls have been adjusted for “optimal” performance. I applied the video signal from the computer interface to the base of the video amplifier. Removing the 4.5-MHz sound trap did not improve the situation. Any suggestions? — Dennis Keboe, Flint, MI.

A. It is obvious from a glance at one of the schematics you included with your letter that you consulted the TV TYPE-WRITER COOKBOOK by Don Lancaster. I really can’t offer you much advice that doesn’t appear in Don’s book. The major techniques for improving video bandwidth (which is to a large degree a function of video bandwidth) that Don suggests are careful adjustment of brightness and contrast controls (lowest possible brightness and contrast are best), removal of the sound trap, mini-

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**Add a Center Tap Revisited**

Q. In reference to the item that appeared in the July 1980 Hobby Scene column, a center tap may be successfully obtained by simulation (no “surgery” required). The procedure involves placing two resistive or reactive components in series in the winding in question. Examples are shown in the accompanying figure. The choice of component types and their values are subject to several variables. Unfortunately, there has been little written on this subject, but available material on voltage dividers and dual-polarity power supplies can serve as a starting point in arriving at a suitable configuration for a specific application.

Resistors are probably the most frequently used a brightness and contrast control and should be satisfactory in certain power and audio applications. Nonpolar, low series-inductance capacitors are acceptable for r-f work, as are high-Q inductors. If the impedances of the components employed are equal, the voltage drop across each of them will be half the total voltage induced across the secondary winding. This gives the simulated “center tap” the desired symmetry.

Some inefficiency is the price to be paid if this solution is adopted. Any center-tap current has to flow through (at any one time) one of the two devices forming the voltage divider. Also, the divider itself places a load on the transformer. In some applications, these effects are acceptable, and the cost of a center-tapped transformer can be avoided if necessary. — Norman M. Monroe, Gadsden, AL.

A. Thanks for your suggestions. (Thanks also to readers Harford R. Post, H. Johnson, Hal Knippenberg, and H.L. McFann for similar responses.) I was aware of this technique, and have employed it in op-amp and r-f applications. I did not mention it because I inferred that the intended use was in a relatively high-current, bipolar or full-wave d-c supply. In that case, the inefficiency introduced by the resistors would most probably be unacceptable. However, I stand by my original answer. I know of no way of adding a center tap to the secondary of an existing transformer without rewinding it. The technique described by Mr. Monroe and the other readers who were kind enough to write in effectively center-taps a transformer or simulates the addition of a center tap—but it doesn’t add a true center tap, and cannot be used in every application.
mizing stray capacitance, adding more peaking, and “running hot” by increasing the operating current of the video output stage.

Having already eliminated the sound trap and adjusted the brightness and contrast controls for best performance, you must look into the other approaches. Stray capacitances can be suppressed by keeping all video-signal-carrying leads as short as possible. If the video output stage is the bandwidth-limiting factor, it will sometimes respond to increasing its operating current. Before doing this, make sure that the stage can dissipate the additional amount of heat and handle the extra current, that the power supply can cope with the increased demand to be placed on it, and that the video-output stage is not already operating at its gain-bandwidth peak.

In all probability, adding additional peaking will make matters worse. As Don says... Generally, too little peaking will give you low-contrast dots; too much will give you sharp dots but will run dots together and shift the more continuous portions of the characters objectionably. Peaking is changed by increasing or decreasing the series inductor (peaking coil) from its design value. If the peaking is excessive, the circuit might “ring.” This can cause smearing of the trailing edges of the dots.

Solving the TV “Whistle” Problem

In our February, 1980 column, reader Jon Dattorro asked if we knew the possible source of a high-frequency “whistle” coming from his TV receiver. We replied that the noise was probably due to magneticstriction in the horizontal output transformer and that there was not a very satisfactory solution. However, we have received some letters since then with hints that may be helpful. Here are two suggestions.

Frank J. Burris, Fallbrook, CA, says that any open mounting supports on the flyback transformer should be examined, and frame holding screws tightly secured. A piece of electrical tape can be inserted between the doped lamination bundles (does not apply to molded powdered-iron cores) and the frame elements. Small wooden wedges (toothpicks?) can be slipped between the winding core and the laminations. This tightens up the laminations that usually produce the 15-kHz audio noise.

Jim Gieseke, Garden City Park, NY, suggests the use of liberal coats of “corona doke” to the laminations of the transformer to hold them together.

Thanks to those readers who took the time to send me their tips.
More On Shift Registers

In last month’s column, we introduced the shift register as one of the most versatile of all digital-logic circuits. Shift-register operation and several shift-register applications were then covered. This month, we’ll complete our discussion of shift registers by examining some specific chips and experimenting with some application circuits we think you’ll enjoy.

Integrated Shift Registers. As we mentioned last month, you can custom-design a shift register by using any number of cascaded flip-flops. Fortunately, this procedure is rarely necessary. Semiconductor companies have designed and manufactured in integrated form most of the popular shift-register configurations.

Many different TTL and MOS shift registers are available, often for very reasonable prices. Even if you don’t have immediate plans for incorporating one or more shift registers in a project of your own design, you’ll be far better prepared to tackle a future project if you’re aware of some of the chips that are now available.

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<th>TABLE I—TTL SHIFT REGISTERS</th>
<th>Type</th>
<th>Function</th>
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TABLE II—CMOS SHIFT REGISTERS

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Tables I and II list most of the TTL and CMOS shift registers available to experimenters. These tables, which were compiled from Motorola, National, RCA and Texas Instruments data books, list only some of the more important shift register parameters. Also, some specifications (such as maximum clock frequency) can vary somewhat within the same chip type if different manufacturers are involved. Therefore, you should check the specifications provided by the manufacturer of the chip you are thinking of using in a project for more specific information.

Here is a brief explanation of the table headings:

**Function.** The function of each shift register is identified by a four- or five-letter code. S means serial, P parallel, I in, O out, and B bidirectional. Therefore, a shift register listed as B/PIPO can provide bidirectional, parallel-in/parallel-out operation. Incidentally, many of the shift registers listed in the tables will provide more than one operating function. Most PIPO registers, for instance, also provide SISO operation.

**Bits.** This parameter specifies the number of register elements in the listed device.

**Frequency.** The maximum shift (clock) frequency is given. Frequency specifications for CMOS shift registers vary with both the $V_{DD}$ supply voltage and the manufacturer. Consult the manufacturer’s literature for the specific operating frequencies for a given chip.

**Modes.** Four operating modes are given. Those whose functions are obvious are shift left and shift right. Load is normally found on parallel-input shift registers. Depending upon the status of the load input, upon receipt of the next clock pulse, the register will either ignore or accept the data present at its input(s). Hold means that the clock input can be inhibited or disabled so that the shift register will store its contents like a memory register.

Several other operating modes not listed in the tables may also be available. Preset or clear enables all the register elements to be cleared to logic 0. Recirculate causes the data at the output of a shift register to be cycled back to the input.

Exotic Shift Registers. Several kinds of elaborate integrated shift registers are available for such serial-memory applications as refreshing cathode-ray tube traces and storing characters to be printed by high-speed printers. A typical example is Synertek’s SY1404A 1024-bit MOS dynamic shift register. This family also includes a dual 512-bit register (SY1403A) and quad 256-bit register (SY1402A). The maximum clock rate for these chips is a relatively slow 2.5 MHz, but by means of a multiplexing technique, data can be accepted at a 5-MHz rate. Even more capability is provided by 2048-bit shift registers such as the SY2401 and SY2827.

Bubble memories and charge-coupled devices (CCDs) are among the most exotic shift registers available. Bubble-memory capacity can exceed a million bits per chip, making this exotic register a strong contender in the search for a solid-state replacement for the disk memory.

Application Circuits. Now let’s try experimenting with some readily available shift registers to see how they work and what they can do. The circuits that follow use both CMOS and TTL shift registers. Once you see how easy it is to use...
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CIRCLE NO. 68 ON FREE INFORMATION CARD
Pseudorandom Sequencer. Figure 1 is the schematic of a pseudorandom generator whose operation is patterned after the S2688/MM5837 shift-register noise generator that was described in the March 1980 installment of this column. The circuit consists of two 8-bit 4021 CMOS shift registers (IC2 and IC4) cascaded to form a single 16-bit register.

The 4021 is a PISO register with the bonus feature that the outputs of the 6th, 7th and 8th stages are available. This means it can be used as a 6-, 7- or 8-bit shift register and makes possible the pseudorandom sequencer circuit. Such a circuit requires that the outputs of two stages in a shift register be coupled back to the input via an exclusive-OR gate.

By connecting the exclusive-OR gate's inputs to the final two outputs of the shift register, the sequencer will generate a pseudorandom sequence that recycles after 255 clock pulses. The bit pattern within a single 255-bit cycle is essentially random, but the periodic recycling of the pattern compromises its randomness over the long term.

V_{DD} or V_{SS} to set up any desired sequence of logic 0's and 1's. Then toggle S1 from RUN to INITIATE and then back to RUN to load the PARALLEL DATA inputs. Repeat this procedure as desired to create many different bit sequences.

Incidentally, if you intend to use this circuit for commercial purposes, you should first write the U.S. Patent and Trademark Office (2021 Jefferson Davis Highway, Arlington, VA 22202) and request a copy of U.S. Patent 4,191,175. The fee for a single copy of a patent is $50. I've not yet seen this patent myself. However, after the March 1980 "Experimenter's Corner" appeared, William L. Nagle, president of Paratronic Systems, Inc. (Honeybrook, PA 91344) wrote to this magazine that, "... Your readers should be cautioned that use of this for any other than private purposes would be an infringement of the patent our company holds for such devices and their applications." The complete letter was reproduced in the Letters column of the July 1980 issue.

I am interested in seeing this patent because its number indicates an issuance date late in 1979. Publications describing pseudorandom sequence generators date back to at least 1973 when Fairchild Semiconductor's The TTL Applica-

Pseudorandom Voltage Generator. Connect a suitable resistive ladder network to the outputs of a SIPO or PIPO shift register set up as a pseudorandom sequencer and you get a pseudorandom voltage generator. The resistor network serves as a digital-to-analog converter.

Figure 2 shows such a circuit designed around a 74164 or 74LS164 SIPO 8-bit shift register. The four NAND gates (IC2A through IC2D) form an exclusive-OR gate. You can substitute one-fourth of a 7486 quad exclusive-OR gate in the circuit if you prefer.

Use a 555 timer IC connected as an astable oscillator like the one shown in Fig. 3 to provide clock pulses for the circuit. The amplitude of the pseudorandom, stepped output voltage can be changed by connecting pin 2 of IC2A to any of the six other output pins of IC1.

An interesting application for this circuit is a pseudorandom tone sequencer that can be made by connecting its output to the control input of a voltage-controlled oscillator or voltage-to-frequency converter. One suitable vco is the 4046, a chip that was highlighted in "Experimenter's Corner" for July and August 1980. Suitable V/F converters include the

Pseudorandom Sequencer, The Complete Circuits Handbook (a truly outstanding book) described two such sequencers on pages 8 through 21.

Incidentally, one of the Fairchild circuits employed one 4-bit and seven 8-bit shift registers to generate a truly long, nonrepetitive output bit sequence. According to the descriptive text, "... even at a frequency of 20-million states per second the counter would not repeat until more than 18 centuries had elapsed." (!) For more information about pseudorandom sequencers, see Don Lancaster's indispensable CMOS Cookbook (Howard Sams & Co., 1977). Don discusses the topic and presents two circuits on pages 318 through 323.
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experiment with the circuit as I did when working with the prototype, connect the cathode of a LED to each output pin of IC2. Connect the anodes of the LEDs to 1000-ohm resistors which are in turn connected to +5 volts. You can use smaller resistance values (as small as 270 ohms) for the current-limiting resistors if you want the LEDs to glow brighter. I prefer 1000 ohms to keep current consumption down to 2 or 3 milliamperes per LED.

An additional LED and series resistor connected between pin 8 of IC1 and ground will allow you to monitor the status of the shift register. You can then manually test the circuit by slowing down the clock to about one pulse per second and applying input data bits to pin 1 of IC3.

This circuit can be used as the receiving portion of a digital data-transmission system. A good design exercise would be to devise a suitable transmitter for converting 8-bit bytes into a serial bit stream. Hint—use a PISO shift register and a divide-by-8 counter.

**Programmable Sequence Generator.** Figure 5 schematically shows an 8-bit programmable sequence generator made from two series-connected 74194 shift registers (IC1 and IC2). In operation, any desired bit pattern is first selected by means of switches S1 through S8. A normally closed pushbutton switch, S9, is momentarily opened to load the selected bit pattern into the two shift registers. When clock signals are applied simultaneously to pin 11 of both shift registers, the bit pattern will be shifted one position for each clock pulse. Because the serial output of the second shift register (pin 12 of IC2) is connected to the serial input of the first shift register (pin 2 of IC1), so long as the clock pulses are received the bit pattern will recirculate through the registers. It will remain unchanged until it is modified by means of the data-select and load switches.

Use the oscillator shown in Fig. 3 to generate clock pulses for this circuit. The output LEDs shown in Fig. 5 are optional, but including them allows the circuit to double as an attention-getting programmable light flasher. The LEDs can be arranged in various patterns to enhance the effect.
A more practical application can be accomplished by connecting a resistor ladder network (see Fig. 2) to the outputs of the shift registers. The circuit then will function as a programmable waveform generator. Without the ladder network, the circuit can be used to strobe various circuits in any programmed sequence. More shift registers can be added for even longer sequences.

If you build this circuit, be sure to include the 0.1-µF power-supply decoupling capacitors. Without these capacitors, the shift registers will be affected by power-supply transients that can arise during the switching sequence. A typical effect of such a transient is an unwanted change in the sequence.

Fig. 5. A shift-register 8-bit programmable sequence generator.

Fig. 6. A bargraph generator made from a pair of 74194 shift registers.

Bargraph Generator. Figure 6 is the schematic diagram of an unusual bargraph generator made from a pair of 74194 shift registers. In operation, the circuit’s ENABLE INPUT is brought momentarily to logic 0 to start the circuit. This causes seven of the eight bit positions to be loaded with logic 1’s, because their inputs are left unconnected and therefore assume a high state. The output of the first stage of IC1 goes to logic 0 because its input (pin 3) is grounded.

The bits in the first and last stages, logic 0 and logic 1, respectively, are combined in AND fashion by IC3A and IC3B. The result is presented to the serial input of the first shift register. On the first clock pulse, therefore, the outputs of the first two positions go to logic 0 while all of the other outputs stay at logic 1. This pattern continues as subsequent clock pulses are received until each of the shift-register outputs switches in turn from logic 1 to logic 0. When the final stage goes low, the bit resulting from the gating of the first and last bits is a logic 0.

Because this bit is fed back to the input of the first register (pin 2 of IC1), it might at first glance appear that all of the register outputs would remain at logic 0 after the first cycle of clock pulses. Note, however, that the output of gate IC3C is connected to pin 10 of both registers. When the output of this gate is logic 0, the shift registers ignore the data presented to their parallel inputs. When its output switches to logic 1, the shift registers load the data present at their inputs. This, of course, is what occurs when the ENABLE INPUT is brought to logic 0 to start the circuit.

This circuit has such practical applications as strobing various external circuits in a sequential fashion. It also makes a very interesting visual display.

Going Further. Shift registers are ideally suited for experimentation. The bargraph generator shown in Fig. 6 is a good example of this. I began with the remnants of the circuit in Fig. 5 (the input switches were removed) and tinkered with the basic circuit by adding a single 7400 quad NAND gate IC. Within a few minutes, the bargraph effect was achieved. You can do the same kind of experimentation on your own by selecting different register outputs to be connected to NAND gate IC3A in Fig. 6. You can also try adding additional stages for more complex effects. The cost of integrated shift registers is very reasonable, and you’ll learn a good deal about these very versatile logic circuits by experimenting with them.

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**DX LISTENERS** can keep up with worldwide economic developments through financial, economic and business programs on certain stations. Here is a selected listing of such programs. All times and days are GMT.

**AFRTS-Washington** conveniently groups six different U.S. network business reports into a 25-minute block, Tuesday-Saturday on 0035, repeated at 0435 (times one hour earlier until Oct. 27). Among the frequencies are 21570 and 6030 kHz.

**Radio Australia** has a “Business Report” Monday-Friday at 0820 on 15115, 11740, 9570, repeated at 1220 on 9580, and also every two hours through 2220 when R. Australia is more difficult to pick up here. There’s also “Week in Business,” Saturdays at 0212 on 21740 and 17795 and 0810 on the same frequencies as above.

**BBC World Service** excels in this programming area, as in so many others. “Stock Market Report” is Monday-Friday (except bank holidays, which also affect some of the programs below), at 1939-1943; try 15070 and 12095. “Financial News” is Monday-Friday 2230-2239 on 15260, 15070, and 9410; repeated at 0445 on 9510, 9410, and 6175.

**BBC** also has two weekly business programs: “Financial Review,” Sundays at 0445 to 0454 on 9510, 9410, and 6175, repeated at 1709 on 17830 and 15260. And the half hour show, “Business Matters”, Thursdays 1130 on 11775, 11750, 9740, 9510, and 6195; 2130 on 15420, 15260, and 15070; and Fridays 0330 on 9410, 6175, and 5975.

**Canada**’s “As It Happened” newsmagazine once included a Tuesday segment called “Easy Money,” and may still do so, sometime between 2330 and 0100 on 5960 (one hour earlier until Oct. 27).

**South Africa**: Radio RSA has business programs at these approximate times: “Business Front,” Mondays 1130 on 25790, 21535, and 15220; 2135 on 21535; Tuesdays 0235 on 11900 and 9585. “Economic News” is Monday-Friday at 1245 on 25790, 21535, and 15220. “Economic Review,” Saturdays 0410 on 1900; 9585, and 5980; 2110 on 21535 and Sundays 0210 on 11900 and 9585.

South Africa also has a Monday-Friday “Market and Meat Prices” on its domestic services at 1607, last reported on 4880, though not likely to be heard in North America. But keep it in mind if you’re further east.

**Austria.** Thursday broadcasts of ORF’s “Report from Austria” include a segment on the Austrian economy—0130 and 0330 on 9770 and 5945; 0430 on 12015; 1230 on 21655.

All the programs mentioned so far are in English, but for business programs from two other countries we of necessity go to their native languages. France has a “Bourse” spot Monday-Friday 1158-1200 and 1705 on 21645, 21595 and 17775 and at 1820 on 21620, 21580, 21515, 17720, as well as many other frequencies.

**West Germany**’s Deutsche Welle has a Monday-Friday stock market quotation report (“Börsenkurse”) at about 2255 on 15410, 9735, repeated at 0255 on 9735, 6145 and others.

**Country by Country**

**Anguilla.** This tiny Caribbean island may gain a shortwave voice if an American gospel broadcasting organization follows through on plans to establish “The Caribbean Beacon” here.

**Austria.** ORF is working to upgrade its signal into North America by 1982, with a new 250-300-kW transmitter and two new antennas (a fixed but swappable curtain, and a “turnable” antenna).

**Costa Rica.** Radio Noticias del Continente survived a challenge about irregularities in its licensing. The government of Argentina and other Latin American military-led administrations have brought pressure against Costa Rica for allowing this private left-wing voice to be heard (almost 24 hours a day on 9615). One solution proposed was to let it continue broadcasting, but cut its power from 50 kW to one kW so it could no longer be heard well in Argentina.

**Cuba.** Though a country which is (barely) in the tropics, post-revolutionary Cuba has never used the tropical bands deliberately (though its prolific mediumwave harmonics fall in this area). One pre-revolutionary station, COCW, had a frequency of 5045 kHz. More than twenty years later Radio Moscow World Service and The Voice of Cuba were heard testing on that frequency between 1000 and 1100 GMT—seemingly with a transmitter much more powerful.
powerful than the one kilowatt listed for COCW.

Meanwhile, the growing Cuban population in Florida has led to an increase in clandestine broadcasting, headed by La Voz de la Junta Patriótica Cubana, heard most evenings on 7400.

A Hiawatha man accused of broadcasting illegally as “Comandante David” was busted by the FCC in July.

Italy. HCB may be middle-of-the-road in its gospel outlook, but it’s extremist in broadcast power. A nominally 100-watt experiment on 26020 kHz may be dropped to only 10 watts; on the other hand, its homemade 500,000-watt transmitter, under construction for several years in Eikhart, Indiana, has been installed in Ecuador and should be testing on the air now. Meanwhile, another faith is on the air from Ecuador—Radio Bahá’í, on 2340 kHz during the daytime. We’ll have to wait for its projected morning and evening broadcasts on 60 meters in order to hear them.

France. Radio France Internationale continues to ignore its great potential audience in North America, as it announces plans to begin using new relay facilities in Gabon, French Guiana and Morocco to improve reception in Africa and Latin America.

Guatemala. The Voice of Guatemala, 6180 kHz, has begun a brief English feature, “Guate-Scope,” heard at varying times late at night.

Iran. Besides the Soviet-based National Voice of Iran, which has been on the air for many years from Baku, three other anti-Khomeini clandestine radio stations went on the air this year. A report in the Financial Times placed The Free Voice of Iran in Baghdad on behalf of Gen. Gholam Ali Ovissi; Radio Iran in Basra, Iraq on behalf of former prime minister Shapur Bakhtiar; and Radio Homeland in Cairo, connected with supporters of the late shah. The last station is also tied in with Radio of the Mujaheddin (Islamic guerrillas) of Afghanistan. Frequencies for these often change. Radio Homeland may still be on 15555 kHz at 1705 to 1800.

Ireland. R. Condor is testing for North America during October at 0600 to 0800 on 6243 kHz; in November, the time will change to 0700 to 0900 and 11463 kHz will be added.

Korea, North. Radio Pyongyang has a well-deserved reputation for far-out broadcasting, both in program content and frequency choice far outside the designated bands (such as 9977 kHz). But now, a great many frequencies inside the SW/BC bands have been registered by North Korea with the ITU. Few of them so far have actually been heard, so this may just be for the sake of appearances.

Mexico. Super-power border station XERF, 1570 kHz, is now carrying “The Mexican Hour” in English, GMT Mondays, at 0400. A new station, XEVJ, in Linares, N. L., 5980 kHz, has been ad-
versitying in a Monterey newspaper.

Nicaragua. Clandestine radio played a major role in the victory of the Sandinistas. Last May, the stations were turned with the appearance on 6015 kHz of "FESGA"—the Voice of the Special Forces of Anti-Communist Guerrillas, possibly a mythical organization. Emb- 

The independent authorities quickly located the station in San Pedro Sula and supposedly closed it down. Press reports said it was transmitted from Radio Swan, which in the past had operated as an anti-communist outlet.

Papua New Guinea. Night owls shivered as check 9520 kHz after 0600 GMT to sporadic broadcasts from NBC, and on special occasions, 9575 kHz.

Portugal has an external service of its own, and serves as a relay site for several other countries and religious broadcasters. Now, the Lisbon Catholic station, Radio Renascença, is adding shortwave, possibly by the end of the year, to reach expatriates.

Solomon Islands. Like Papua New Guinea, this country operates irregularly on the 31-meter band after 0600 GMT. Try 9545 kHz, and if you don't hear them there, 9520.

Sweden. Radio Sweden acquired some 500-kilowatt transmitters a few years ago, and has engineered to learn that its antennas would handle no more than 350 kW. Six new curtain antennas are under construction at Hörby now, so the station should soon be able to put a stronger signal into North America.

U.S.A. With unrest in the Philippines, the Voice of America has been investigating other countries for shortwave relay stations. Among the possibilities are Darwin and North West Cape, Australia; and U.S. territory in Guam, Hawaii, and the Aleutian Islands.

U.S.S.R. Radio Moscow uses a great many sites throughout the country, but either through incompetence or for security reasons, the sites it acknowledges seldom correspond to sites determined by other evidence. In his USSR High-Frequency Broadcast Newsletter, Roger Legge reports on a study by Douglas Johnson and Olle Alm of "Operational Navigation Charts" issued by the U.S. National Ocean Survey, which shows where broadcasting towers are located in the U.S.S.R. An 18-transmitter complex, previously believed to be near Zhigulevsk, was determined to be near Kuybyshev instead. Ten transmitters at "Ar ince" are actually near Krasnodar. Four transmitters designated as "Or-

shas" are actually at Moghilev. Frunze, listed as a site, does not have any suitable towers. Five 500-kW transmitters are at Nikolayev in the Ukraine, not at other sites in that S.S.R. However, sites in Alma Ata, Dushanbe and Tashkent were confirmed.

"Vanatu. The independence controversy here produced some interesting listening. Radio Vanuatu, on 7260 could be heard with English news at 0830 GMT, and live coverage of independence ceremonies at the end of July. The breakaway group at Espiritu Santo, led by Jimmy Stevens, revived its broadcasting station, but on a new name and new frequency: Radio Vemaran, on 3522 and 3576 kHz, broadcasting in the 0730-1130 GMT period for several weeks before and after independence.

Information Sheet. We'll be glad to send you a listing of many other sources of information about shortwave and DX listening if you send a self-addressed stamped envelope to: Glenn Hauser, University Radio WUOT, Knoxville, TN 37916.

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Tips & Techniques

Low-Cost Crystal Oven

When a stable frequency source is needed, an oscillator designed around a quartz crystal is the logical choice. There are some applications, however, in which a standard quartz crystal oscillator is simply not stable enough. The principal problem in such a situation—say, the timebase of an accurate frequency counter—is that changes in ambient temperature cause small variations in the dimensions of the crystal and hence frequency drift.

One way to reduce thermally caused drift is to keep the temperature in the vicinity of the crystal as constant as possible. This can be done by means of a crystal oven, a small, temperature-controlled environment in which a piezoelectric crystal can be kept for maximum stability. In this article, we shall describe a simple crystal oven that can be built from a handful of low-cost components. It's very possible that you have all of the components in your junk box, which will reduce the effective cost of the oven to zero. Because the oven's circuit is simple and uses readily available parts, it provides an especially attractive way to enhance the stability of a planned or existing crystal oscillator.

A schematic diagram of the crystal oven circuit appears in the figure. The heart of the circuit is TDR1, a negative-temperature-coefficient thermistor (temperature-dependent resistor) chosen so that its resistance is approximately 1000 ohms at room temperature. This thermistor, together with resistor R1, form a voltage divider which supplies base drive to Q1.

When power is first applied to the circuit, the resistance of TDR1 is approximately 1000 ohms. Transistor Q1 is approximately 1000 ohms. Transistor Q1 begins to conduct and sinks base current for Q2. As these transistors conduct, they dissipate heat which is coupled to the crystal and to TDR1. This warms up the thermistor, causing its resistance to decrease. The decrease in thermistor resistance results in the application of less base current to Q1 and hence to Q2. With less collector current flowing through the transistors, less heat is generated, causing increases in its resistance and base current through Q1.

The process continues in this manner, with TDR1 acting as a thermostat and the transistors as heating elements. Once equilibrium is established, temperatures of the crystal and the thermistor remain at fairly constant values. Heat is generated by the transistors and coupled to the crystal and thermistor as needed to make up for radiated energy.

The circuit of the Low-Cost Crystal Oven is very simple, so it can be easily assembled using point-to-point wiring techniques. The author's prototype was assembled by cutting a small strip of copper flashing so that its short dimension equaled the height of the crystal case. The transistors have TO-92 plastic packages with one flat side. The author affixed the flat side of each transistor case to the copper strip using epoxy cement. He also epoxided TDR1 to the strip.

Next, silicone thermal compound was applied to the crystal case and tightly wrapped the copper strip around it. He temporarily held the strip in place with a large alligator clip and soldered the point where one end of the strip overlapped the other, using a small soldering pencil, he made the necessary connections between the transistors, resistors, thermistor and power supply. Finally, he took a small block of styrofoam and cut out a slot in it so that the crystal/oven-circuit assembly could be slid into the slot. The styrofoam is a good insulator and helps stabilize the crystal temperature once power has been applied to the oven circuit.

Any one of several thermistors can be used for TDR1, as the choice of a specific component is not critical. In general, the device should be a small glass-bead or glass-probe type with a negative temperature coefficient and a resistance at room temperature approximately equal to 1000 ohms. The value of the other member of the voltage divider, R1, is not shown in the schematic. It is intentionally omitted because the exact value depends on both the thermistor employed and the temperature at which the crystal is to be kept. A good ballpark figure is 10,000 ohms. Substituting the series combination of a 1000-ohm fixed resistor and a 10,000-ohm 25,000-ohm potentiometer for R1 allows adjustment of the oven circuit for best performance.

An AT-cut crystal has, in its normal range of ambient temperature, a nega-
The wave rectified the oscillator crystal counter and the oven's as possible. The sample is then measured using a very accurate frequency counter and the oven's temperature control adjusted so that the oscillator is at its lowest operating frequency.

You can follow this approach to the adjustment of the potentiometer if that component is included in the oven circuit. However, if you don't want to bring the crystal up to its turning point, you'll find that the oven still enhances the stability of the oscillator over what it would be if the ambient temperature of the crystal was not controlled.

The most common application for the crystal oven is the stabilization of an oscillator in an existing piece of equipment. Thanks to its compact size, the finished oven will fit easily inside just about any existing equipment enclosure, such as one housing a frequency counter, receiver or transceiver. If the equipment employs more than one crystal whose oscillating frequency is critical, several ovens can be built. Each one could be fitted over a given crystal and then the crystal returned to its socket.

The operating voltage for the oven circuit should be regulated and could usually be furnished by the host components power supply. An operating voltage other than the 12 volts specified can be used, but some changes in component values might be necessary.

The low cost, simplicity, and compactness of this crystal oven make it ideal for installation in existing or planned equipment employing a quartz crystal oscillator, or for experimental work with very stable oscillators. If you intend to experiment, keep the following points in mind. All quartz crystals suffer to some extent from aging. In general, high-quality crystals are more expensive but are made from select material and are cut in such a way as to minimize aging. Finally, keep in mind that power input to the crystal should be kept as low as possible if a low aging rate is to be maintained. This means that oscillators teaming up quartz crystals to TTL gates are to be avoided in preference to those employing CMOS gates or very-low-power discrete devices.—Jack Rutherford, Burlington, N.C.

**Drill Speed Control**

If you don't have a variable-speed electric drill, you probably wish you did. There are a number of situations in which low-speed drilling yields the best results—drilling such brittle materials as Bakelite and Plexiglass, drilling in tight spaces, and where a slip of the drill would be disastrous, such as drilling holes in a finished front panel or project enclosure. Medium-speed drilling is often employed when working on nonferrous metals such as aluminum and brass. The circuit presented in the figure will allow you to vary the speed of a standard fixed-speed drill without performing any modifications to the tool.

Modular bridge rectifier **RECT1** converts the ac power waveform into full-wave rectified pulsating dc. A portion of the rectified current passes through the 10,000-ohm potentiometer to the **RC** network that delivers gate drive to the **SCR**. The drill is plugged into socket **SO1** and its speed controlled by the setting of the potentiometer. Diode **DJ** protects the circuit from reverse voltage spikes.

The **SCR** and the modular bridge rectifier should have current ratings of 25 amperes and PIV ratings of 600 volts. Diode **DJ** should have a current rating of 2 amperes or more and a PIV rating of 600 volts. A small aluminum utility box can function as the circuit's enclosure. A power tool or other appliance (soldering iron, lamp, etc.) drawing up to 10 amperes or so can be controlled by the circuit. If the tool or appliance plugged into **SO1** draws four to eight amperes on a continuous basis for more than 10 minutes, the **SCR** must be heat sunk.

**Harry J. Miller, Sarasota, FL.**
This is a helpful publication for those who need to cross-reference an OEM semiconductor type number to a component that is available at the retail level. According to the publisher, the book contains cross-reference/substitution listings for more than 100,000 semiconductor devices. These listings are said to have been generated by computer and to be the result of an analysis of the key parameters of each device. In addition, information is included on the care and handling of semiconductors, on case styles and dimensions, and on testing transistors and diodes. There is also a glossary of terms, symbols, and abbreviations. Pertinent electronic and physical characteristics of each member of Radio Shack's line of semiconductors are presented in data-sheet form. Published by the Radio Shack Div. of Tandy Corp., 1300 One Tandy Center, Fort Worth, TX 76102. 224 pages. $1.99 soft cover.

Programming the Z80 by Rodnay Zakos
This book is a wealth of information that can help you get started programming a Z80 computer at the machine/library language level. Each chapter proceeds from the simple to the complex, and overall treatment covers elementary through intermediate programming techniques to get you started programming on your own. Flow charting and other data presentation methods and Z80 hardware organization are introduced in the early chapters. Then almost 50% of the book is devoted to fully detailed description of the Z80's powerful instruction set. The final chapters cover addressing techniques, I/O techniques, I/O devices, application examples, data structures, and program development. Published by Sybex, Inc., 2020 Milvia St., Berkeley, CA 94704. Soft cover. 624 pages. $14.95.

Radio Enters the Home by Harry F. Bart
This book was originally published in 1922 by the Sales Department of the Radio Corporation of America. It was intended, "For those who desire to be entertained with concerts, lectures, dance music—as well as for the radio amateur," and cost 35 cents. The book will be of interest to old-time radio buffs as well as those who would like to learn about the early days of wireless commu

The Radio Amateur's License Manual edited by Wyland Dale Claft, WA3NLO
This latest edition of The Radio Amateur's License Manual (77th Edition) is a radical departure from those of the past 50 years. Gone are the question-and-answer format and coverage of theory for the Novice Class license exam. Theory for the Technician, General, Advanced and Extra Class license exams is now presented in easy-to-read essay form. There is a short chapter dealing with the Novice Class license exam, and a note directs readers interested in becoming Novices to employ the ARRL's code-and-theory package for the Novice test entitled Tune In The World With Ham Radio. There are separate chapters for amateur licensing procedures, the station license, Technician/General Class theory, Advanced Class theory, Extra Class theory, International Regulations, and where and how to take an amateur examination. At the end of each theory section are sample questions, answers to which are presented in the back of the book. The text in the theory sections is illustrated with many schemes and drawings. Published by the American Radio Relay League, 225 Main Street, Newington, CT 06111. Soft cover. 168 pages. $4 in the U.S.

How to Make Printed Circuit Boards by Joel Goldberg
How to Build Electronic Projects by Douglas R. Malcolm, Jr.
These two books make an excellent training course in project building for newcomers to the electronics hobby. Printed Circuit Boards details every aspect of single- and double-sided pcb-board fabrication, from initial design through final assembly. Photos and drawings help describe how to make pcb boards from scratch using direct, photographic, and silk-screen techniques. Electronic Projects details with numerous photos and drawings procedures for converting schematic diagrams and components into finished projects. Leading off with component descriptions, it proceeds to soldering techniques and
project layout and circuit board construction and closes with a selection of circuits to build, using the information contained in previous chapters.


Antenna Data Reference Manual
by Joseph Carr, K4IPV

Contained in this book is design information for those who want to construct antennas for amateur, shortwave listening, CB and FM broadcast applications. Each chapter deals with a different type of antenna (Horizontal Dipoles, Inverted Vees, Verticals, Quads, Yagis, etc.) and has computer program printouts giving the physical dimensions for a sequence of frequencies within each amateur and broadcast band. Also provided are line drawings showing the physical configurations of the antennas described, summaries of their electrical and radiating characteristics, and suggestions for their physical construction. Other topics discussed are transmission lines, tuning procedures, impedance-matching systems, and antenna measurements and instrumentation.

Published by Tab Books, Blue Ridge Summit, PA 17214. 266 pages. $12.95 hard cover, $7.95 soft cover.

Introduction to T-BUG
by Don & Kurt Inman

Written to acquaint the reader with the use of Radio Shack's T-BUG Monitoring and Debugging Aid, this book describes in detail the machine-language operations of the TRS-80 microcomputer. (It is not intended to serve as a complete machine-language textbook.) Each T-BUG command is thoroughly explained and examples are given to demonstrate how each can be used. Every step is discussed for each of the many sample programs contained in the book, and each program is accompanied by a sketch of the video display.

Published by Dilithium Press, 30 NW 23 Pl., Portland, OR 97210. Soft cover. 120 pages. $6.95.

DC Power Supplies
by Robert J. Traister

Detailed information on dc power-supply theory and applications is contained in this book. Where it departs from most similar books is in its stress on experimentation with existing circuitry so the reader can develop new designs for particular needs. Divided into two parts, the first deals with theory, covering power-supply circuitry, components and ratings, dynamic and electronic regulation, protective circuits, voltage multiplication, metering, and safety circuits. Part II focuses on actual circuits: ac and dc supplies and low-, medium-, and high-voltage circuits.

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Atwater Kent model 427 AM receiver. Need original speaker with output transformer. Ron McCoy, Box T-42, APO, NY 09164.

Philco model 39-36 radio. Need schematic. Wiring diagram push buttons and glass plate dial. Max Cooper, Route 1, Box 68 Peabody, MA 01960.


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Philco model P1052 video board and Synphonotone model TPS5050. Need parts list. N. Carter, 1276 3 West Street, Room 319, Cleveland, OH 44113.


Knight-Kit model R-100 amateur communications receiver. Need schematic and operating manual. W.T. Kramer, 3633 Scranton Rd, Cleveland, OH 44109.

Webcor model 2500 stereo tape deck. Need schematic and parts list. J. Walton, Box 518, Merrittville, NY 22116.


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Concord model 884 tape recorder. Need operations manual, service manual and parts list. Also need rubber idler wheel. Ted Budnik, 81 Chestnut, Chicopee, MA 01013.

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Pintech Electro RC test oscillator. Need schematic. Werner Sier, 5249 Hoevels, Germany.


Dressens-Barnes model 1X500b power supply. Need schematic and operating manual. J. Allan Celf, 1876 E. 2990 S. Salt Lake City, UT 84106.


Panasonic 8 track player and recorder, model #RS-903US, serial #R9030550 and Sony TV model 500S. Need schematics, parts lists and service manuals. Herman Rummelt, 9356 Wabas- sie Ave., Greenville, NY 10839.


Tektronix model 511-A oscilloscope. Need power transformer. Erik J. Vallow, WB3ITY, Beach Road, Ambler, PA 19002.

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Ross Electronics model 5011 AM/FM TV. Need schematic and parts list. Wayne R. Larson, 210 S. 37th, Artesia, NM 88210.


DuMont cathode ray oscillograph model 206-B. Need schematic and service manual. Greg Morgan, 11 Jerome Ct., West- nut Creek, CA 94598.


Dietzen model ESR-1 slide rule calculator and Olivettl Underwood programma 101. Need service manuals and schematics. Jim Morgan, 916 So. 27th Ave., Yakima, WA 98902.

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PROJECT OF THE MONTH

BY FORREST M. MIMS

THIS month's project is a programmable digital timing circuit that has countless applications around the shop and home. You can learn how the circuit works by referring to the schematic diagram in Fig. 1. A 10-bit multivibrator IC1 provides clock pulses for IC3, a 74192/74LS192 decade counter. The clock frequency can be altered by changing the value of either R1 or C1.

The circuit can be programmed to generate any one of ten timing intervals. Any desired starting point from 0000 (0) to 1001 (9) is selected by means of switches S1 through S4. When pushbutton S5 is closed momentarily, the BCD number present at the parallel data inputs of the counter's input. The clock pulses cannot reach the counter when the BORROW output is at logic 1.

As IC3 begins its downward count, the current BCD number present at its outputs is decoded by IC4 and is displayed on a common-anode, seven-segment LED readout. Once the count has reached 0000, the BORROW output goes to logic 0 upon receipt of the next clock pulse. Clock pulses are thereupon blocked and the counter outputs idle at 0000. The counting cycle can be initiated again by momentarily depressing S5. Of course, a new starting point can first be loaded into the counter by means of switches S1 through S5.

The circuit shown in Fig. 1 includes
Programmable Countdown Timer

Model-Rocket Countdown Launcher. Having long been a model-rocket enthusiast, my favorite application for countdown timers is in automatic rocket-launching systems. Such systems are ideal for rocketeers who like to photograph their birds lifting off their launch pads. An audible beeper circuit triggered by the clock pulses applied to the counter input would be a helpful addition. It would allow the photographer to keep track of the countdown sequence while he aims his camera at the rocket as it sits on its launcher.

Figure 2 schematically shows how to add a rocket-motor ignition circuit to the basic countdown timer. A relay is used as the power-switching component because the resistance of its closed contacts is much less than the “on” resistance of an SCR or other solid-state switching device. This ensures that the highest possible current will flow through the nichrome-wire rocket-motor igniter. The diode connected across the relay coil absorbs the high-voltage spikes which can be generated by the collapsing magnetic field when the relay coil is de-energized.

If you use this circuit to launch model rockets, be sure to follow all of the standard safety precautions. Avoid the temptation to place the ignition-control system adjacent to the model-rocket launcher. Instead, connect the countdown circuit to the launcher with a 20’ length of lamp cord. Be sure to include a disarming switch so that you can safely and quickly deactivate the launch sequence should an unforeseen problem occur. You can use the ignition circuit’s 6-volt battery to power the countdown circuit as well, if you so desire. This will simplify the overall launch system by eliminating the need for two separate power supplies. To do this, connect the +5-volt bus of Fig. 1 to the cathode of a 1N4001 diode. Connect the anode of the diode to the positive terminal of the battery, and the ground bus of Fig. 1 to the negative battery terminal, using a suitable length of lamp cord.

Other Applications. Of course, lauching model rockets is only one application for this versatile circuit. Many others are possible. For example, you can alter the timer’s clock circuit to produce pulses at the rate of, say, 5 Hz. It can then be used as a darkroom timer. Slowing down the clock rate to one pulse per minute makes it possible to time a boiled egg, a phone call, or any other event lasting 10 minutes or less.

You can even extend the timing capacity of this circuit by cascading one or more additional counting stages. And you can reverse its operating mode by applying the gated clock pulse to the count-up input (pin 5) and connecting pin 2 of IC2A to the carry output of the counter (pin 12) instead of to pin 13, the borrow output. Because the programmable countdown timer circuit is reasonably foolproof, it’s an excellent first project for the novice experimenter.

Fig. 2. How to add a relay to the timer for igniting model rockets.
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November 1980

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VCR OR VIDEODISC? According to a recent survey conducted by Venture Development Corp., more than two-thirds of consumers queried prefer one or the other system. Consumers who don't own video-playback equipment prefer VCRs to videodiscs by more than three to one, while about one-fifth of potential buyers want both systems. Another 23% express no preference but are certain that they would purchase only one of the two. The study also reveals that VCR owners have a greater interest in having both systems (almost 59%) than people who don't own a VCR. On the other hand, three out of five VCR owners express no interest in videodiscs.

A "TALKING" AUTOMOTIVE DIAGNOSTICS WARNING SYSTEM, employing speech synthesis technology, has been demonstrated in prototype form by National Semiconductor Corp. It takes inputs from a microcontroller and gives audible warning messages, such as "low fuel," "low brake fluid," etc. The system employs National's speech processor and memory device containing the words and phrases to be spoken. An actual recorded voice is A/D converted and its code is compressed by a factor of 100 and stored in a ROM for individual word or phrase playback through the speech processor chip. Speech quality is claimed to be comparable to that of a high-fidelity magnetic tape recording and is related to the number of bits of memory used to store the speech.

DISK INSURANCE is now being offered by Micro Lab, Highland Park, IL, to microcomputer users who buy its Data Factory product lines. The insurance-policy package is sold with two locked versions of the master diskette. Should a master become damaged or blown during the policy period, the policy holder can simply return the inoperative disk for immediate free replacement. In addition, if an update in the program occurs, policy owners will be notified and older versions will be revised free of charge. Cost of the insurance policy (not disks) is $17.50 per year.

PAY-BY-PHONE IS A REALITY with Chase Manhattan Bank's "Bank-by-Phone" computer and a "Touch-Tone" telephone with * and # keys. Checking-account customers access the computer with a keyed-in-personal account number and security code. Then, using the phone's "dial" buttons, the computer is instructed to pay the specific merchant you have in mind and how much. You can even check your account balance, cancel a call in midstream, and send an SOS to get help. No Touch-Tone phone? ... simply call, toll-free, and a Chase representative will relay bill-payment information to the computer.

UNCHECKED COMPUTER CRIMES may mean the loss of a billion dollars annually if The Federal Computer Systems Protection Act (S-240) is not passed says Philip R. Manuel, who drafted the legislation and is an investigative consultant in the area of white-collar crime. Computer crimes are now covered by "existing, but inadequate, laws dealing with crimes ranging from mail and wire fraud to obscene phone calls," observes Manuel. The new bill was drafted to put a clearer definition on computer crime and provide protection for computer systems of all types. It would also protect from fraud sophisticated electronic fund transfer systems. The bill was first introduced by Sen. Abraham Ribicoff (D-Conn.) in 1977, and was reintroduced in January 1979. It has prompted several states to pass similar legislation, but it is feared that the bill will die at the Federal level unless acted upon before Congress adjourns this Fall.

NATIONWIDE ELECTRONIC SERVICE FRANCHISING is the goal of a new company called "Tronics 2000" in Bloomington, IN. Sensing that the independent serviceman will be faced with increasing complexity and diversity in the future, the company intends to sell franchises to provide technical assistance through training courses, updated business techniques, national and local advertising, and volume buying. The headquarters will contain graphic arts and training departments, and a supervisor for every five franchises.
For less than $25, hire a full time Night Sentry to protect your home.

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Most home security experts agree that one of the most effective deterrents to intruders and burglars is lighting that creates the "lived-in" look while you're away. Now the new Dynascan Night Sentry enables you to easily achieve that lived-in look. Using a micro-computer that does the work of more than 10,000 transistors, it provides automatic control of indoor or outdoor light fixtures, including porch, post, kitchen, bathroom, and bedroom lights.

The amazing micro-computer's "memory" permits automatic self-programming (just use the Night Sentry as a conventional light-switch—after 24 hours, your pattern of light use will be repeated daily thereafter.) You also can program it manually in a matter of seconds! Up to 48 ON-OFF settings per 24-hour period are possible. Installs in minutes with only a screwdriver.

Check these "never-before-available" features: No clock motor or gears to become noisy; easy override of program to use as conventional ON-OFF switch (no fumbling behind or under furniture to locate an override button); built-in variability of ON-OFF times to confuse intruders or burglars "casing" your home; usable in single or gang switch boxes; uses existing standard or decorator switch plates; available in 3-way versions. Also available: table top model for controlling lamps plugged into wall outlets.

Visit your local hardware, home center, or department store and see the new Night Sentry. Suggested retail price under $25.

**Comparison Chart**

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>NIGHT SENTRY</th>
<th>OTHER TIMERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Automatic programming</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>2. Manual programming</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>3. Built-in microprocessor/memory</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>4. Solid-state reliability</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>5. Silent operation (no motor)</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>6. 48 ON-OFF selections</td>
<td>YES</td>
<td>SOME MODELS</td>
</tr>
<tr>
<td>7. Variable ON-OFF times</td>
<td>YES</td>
<td>SOME MODELS</td>
</tr>
<tr>
<td>8. Easy pushbutton override</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>9. Easy 2-way installation</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>10. Fits any single or multiple switch box</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>11. Usable with most standard or decorator switch plates</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>12. Attractive &quot;low-profile&quot; decorator styling</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>13. &quot;Soft-start&quot; triples bulb life</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>14. Available in 3-way model</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>15. Available in table model with dimmer</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>

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While most lightweight, hear-thru stereophones have earcushions that fit against the ear, the new Koss HV/X features a unique, contoured, variable-density cushion that fits around the ear. Not only does this unique earcushion design create a far more comfortable stereophone but it has also allowed Koss engineers to create a dramatically better element design as well. These new variable-density earcushions are made up of a very porous material that is acoustically transparent at the perimeter of the earcushion yet compressed toward the center region. This varies the pattern of acoustic resistance over portions of the earcushions creating the proper seal for specific bass frequencies while allowing the flow of middle and high frequencies at the perimeter of the earcushions.

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The uniqueness of the new variable-density earcushions made it possible for Koss engineers to design a lightweight element that reproduces a Sound of Koss you have to hear to believe. Incredibly, even though the overall weight of the element was reduced, Koss engineers were able to develop a magnet with enough magnetic density to drive an extra large diaphragm. With a response range of 15 to 35,000 Hz, the new Koss HV/X will drive you into ecstacy and our competitors nuts.

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