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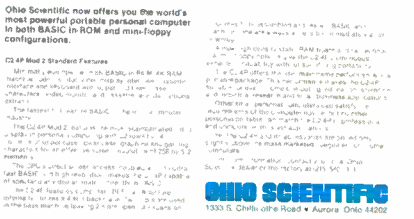

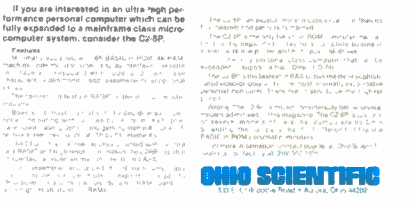

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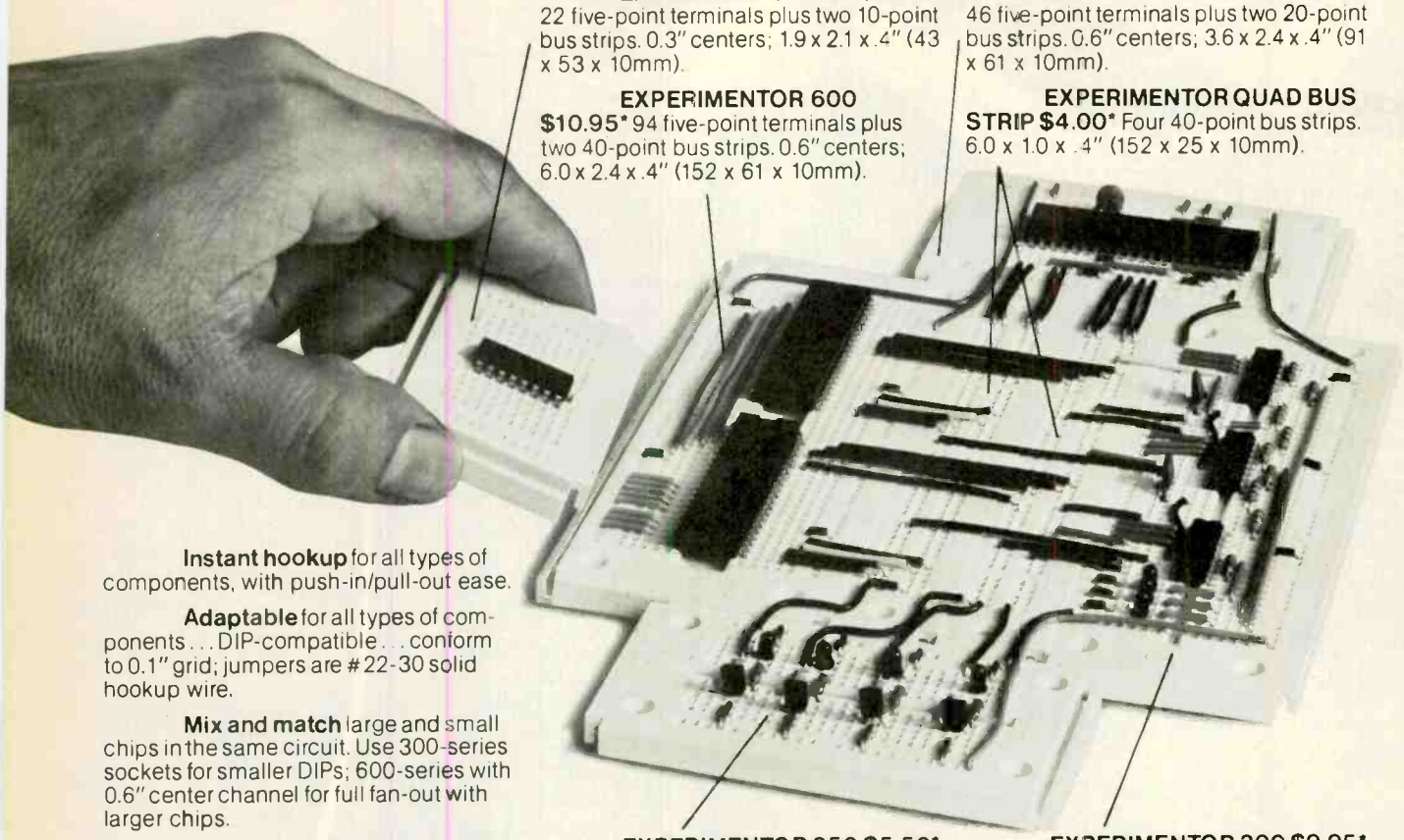

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COMPONENTS CHART

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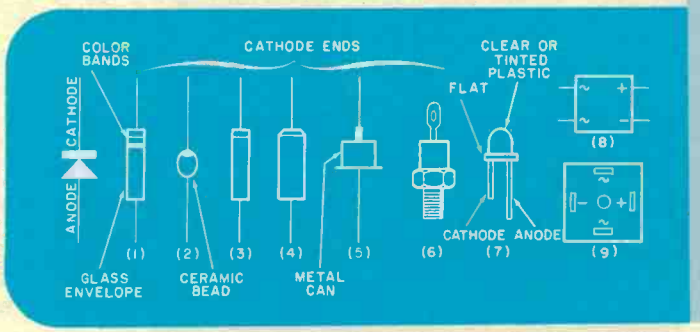
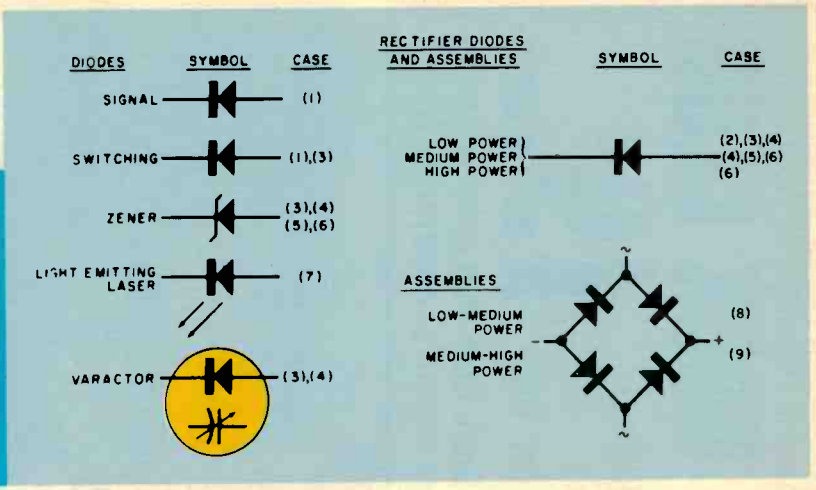
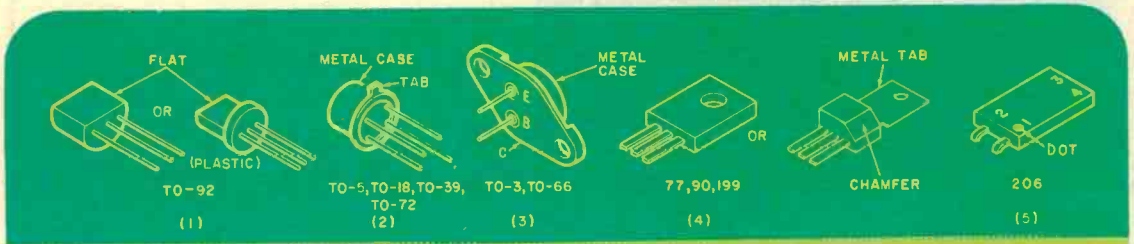
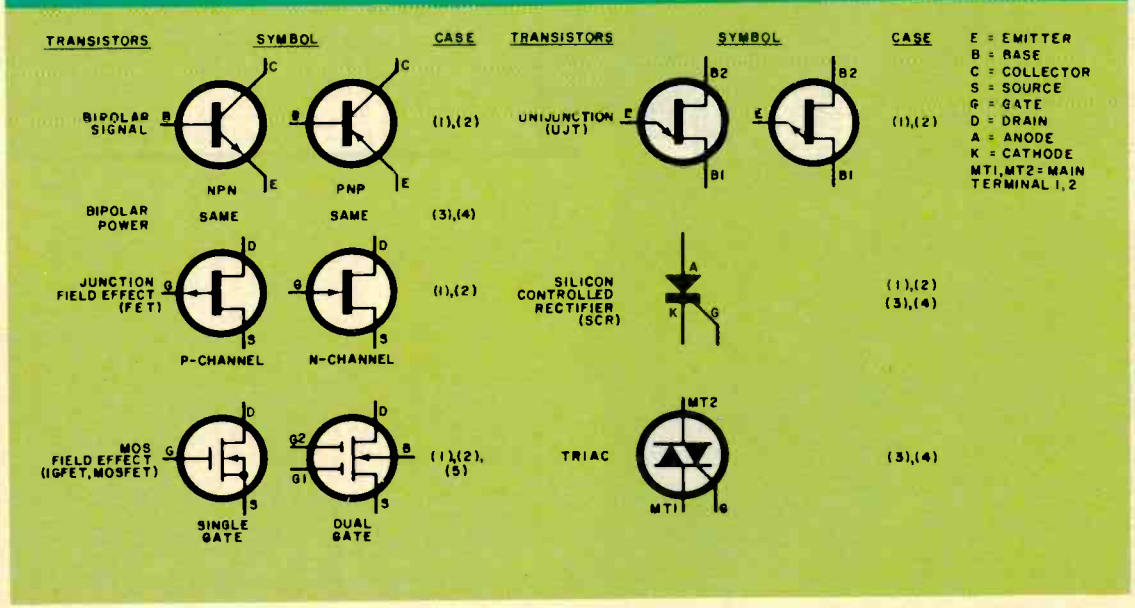
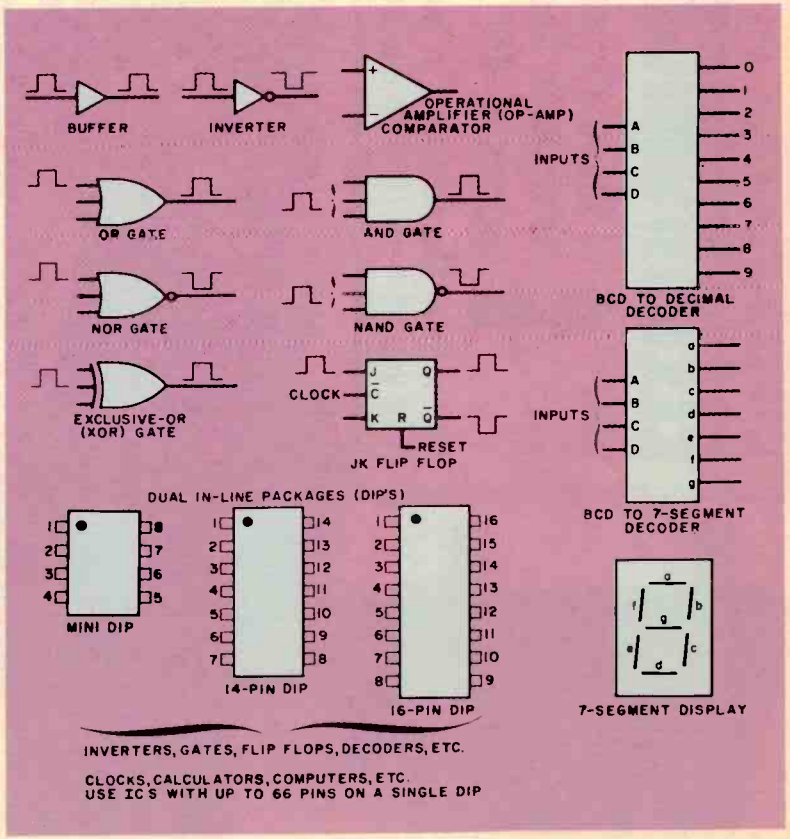








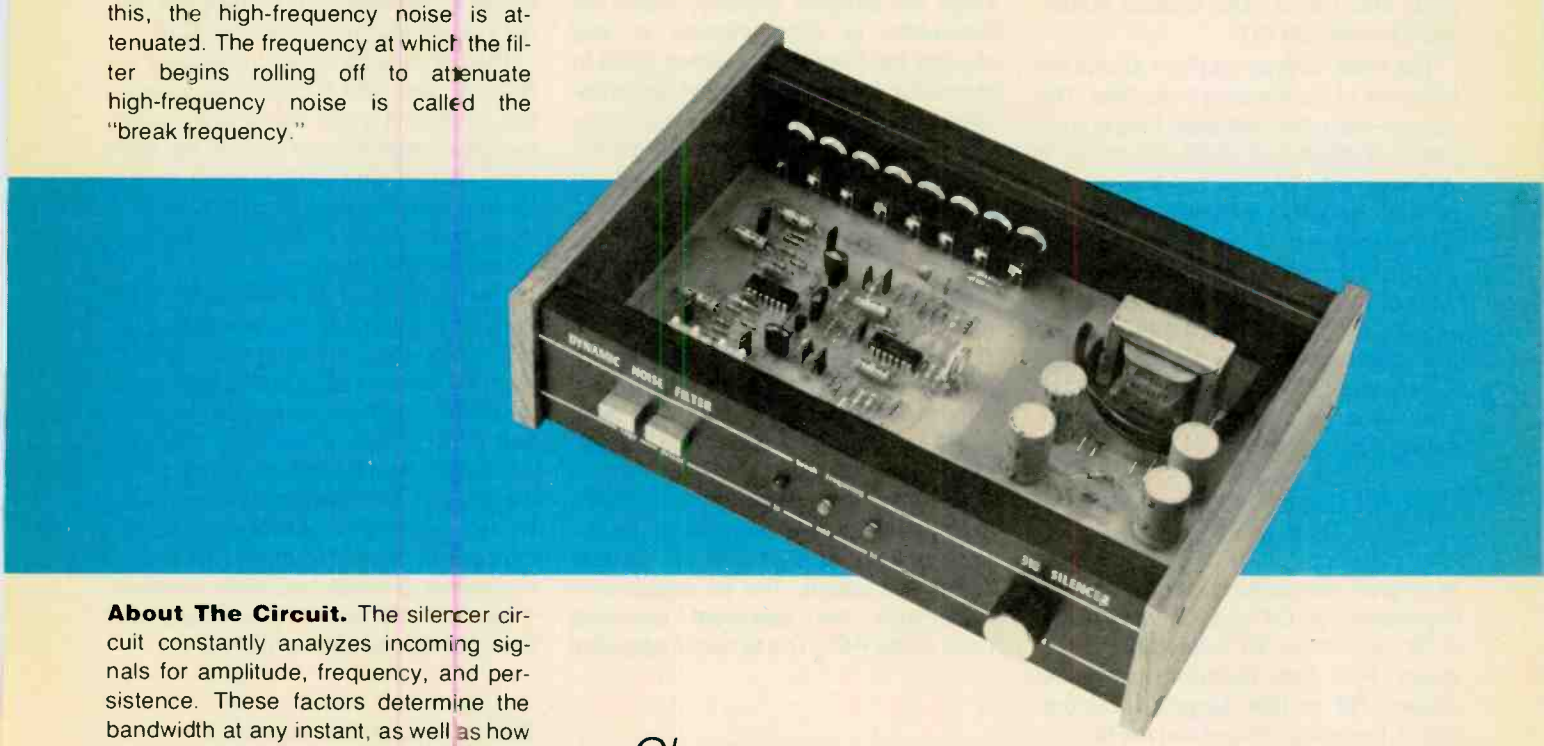


BY COLLEEN McNEICE AND ROGER COTA

Build a DYNAMIC AUDIO NOISE FILTER

THE "SILENCER" dynamic noise filter described here can eliminate tape hiss, record-surface noise, and atmospheric radio noise. Consequently, it is an ideal add-on device for stereo hi-fi systems. Moreover, it does not require encoding and decoding.

The device is essentially a voltage-controlled low-pass filter whose cutoff or break frequency is continually changing to accommodate program material and shut out any detracting noise. It only filters when noise and hiss are audible, when program material is at a low level or absent. The phenomenon of masking is utilized. That is, high-level signals mask noise that would be objectionable if program material level were low. When such masking occurs, the whole signal is passed. When there is no masking by program material, however, the filter extends the bandwidth only as far as required by the music. Beyond this, the high-frequency noise is attenuated. The frequency at which the filter begins rolling off to attenuate high-frequency noise is called the "break frequency."



Cleans up radio, tape and record signals from any stereo system

About The Circuit. The silencer circuit constantly analyzes incoming signals for amplitude, frequency, and persistence. These factors determine the bandwidth at any instant, as well as how quickly the variable low-pass filter changes. Attack and release times vary with the music, thus eliminating a "pump and wheeze" effect of noise modulation.

The device has a continuously variable threshold control, with front-panel LEDs calibrated to indicate "Low," "Mid," and "High" break frequencies. The filter's break frequencies vary between 1.5 and 20 kHz with a roll-off slope of 9 dB/octave (maximum). The Silencer is a single-ended stereo device, making it ideal for use with tapes, records, and tuners for playback and record purposes.

The unit connects either in the auxili-

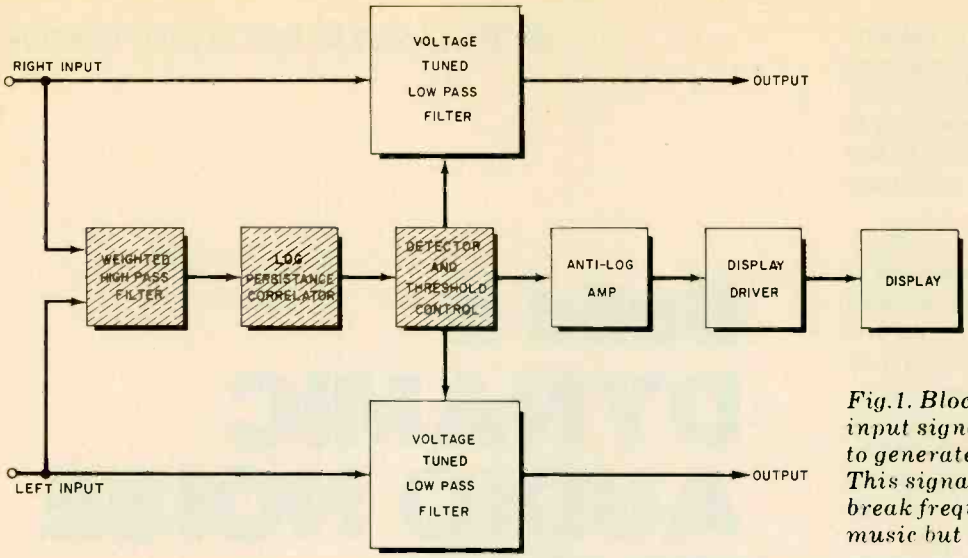


Fig. 1. Block diagram shows how input signals are processed to generate a control signal. This signal governs filter's break frequencies to pass music but attenuate noise.

ary mode or in the tape loop of your audio amplifier. On the back panel are IN and OUT jacks for the tape loop; the front panel also has a TAPE monitor button, and a system DEFEAT.

The block diagram of Fig. 1 shows the functions of the dynamic noise filter. The voltage-controlled low-pass filter is composed of *IC1A* and *IC1B*, as shown in the schematic of Fig. 2. (The components to the left of the dashed line make up one stereo channel; only one is shown in the schematic for clarity.) The gain of op amp *IC1A* is approximately *R3/R5*. At low frequencies, the capacitive reactance of capacitors *C4* and *C5* is very high, making the output of *IC1B* look like a low impedance source. The gain of *IC1A* is then:

$$A = R3/R5 = 10{,}000 \text{ ohms}/1000 \text{ ohms} = 10$$

At higher frequencies, however, the impedance of *C4* and *C5* decreases; *IC1B* generates an output and bootstraps *R5*. This bootstrapping effect causes *R5* to look larger. Therefore, gain A becomes smaller and the filter attenuates the high-frequency energy.

To vary the breakpoint of the filter, FET *Q1* has the ability to shunt the signal at the non-inverting input of *IC1B* to ground. Figure 3A shows the filter with the FET open and the high frequencies attenuated, while 3B illustrates the filter's action with the FET shorting the signal to ground. The control signal applied at the gate of the FET allows the bandwidth of the low-pass filter to be self-adjusting for any frequency. This allows high-frequency signals and subtle harmonics of fundamental bass frequencies to be passed, while unmasked noise is attenuated.

The circuits represented by the shaded blocks of Fig. 1 are the dynamic analytical controls. They automatically judge the program material, adjust the bandwidth to accommodate it, and change the attack and release times to maximize the masking effect and minimize noise modulation. The control signal is applied to the gate of *Q1*. It's determined by the (1) spectral content, (2) amplitude, and (3) persistence of the incoming signal.

The spectral content is sensed by the high pass weighting filter, a network made up by *R8, R29, R30, R31, C6, C17,* and *IC2A*. This network is driven by the output of *IC1B*, which actually determines the quiescent operating point of the low-pass filter. Amplitude is determined by threshold control, *R27*, a 100K-ohm front-panel potentiometer. This pot sets the voltage divider for the positive input to *IC2A*, and the dc level for *IC2A*'s output. The dc output level determines the quiescent operating point of the FET. The dynamic operation of the FET is adjusted by the ac control signal, allowing it to follow the program material. The ac component of *IC2A*'s output is determined by sensing the signal's amplitude on the output of *IC1B*.

The persistence log amp is formed by *R33, D2,* and *C20*. It checks the correlation coefficient of the signal, and adjusts the attack and release time of the low-pass filter to minimize any noise modulation problems. Variable attack and release times allow for the most effective masking of the noise.

The anti-log amplifier *IC2B* also senses the control voltage output of *IC2A*. This signal is then rectified and filtered by *D4* and *C21*, and is then used to drive threshold comparators *IC2C* and *IC2D*. These amps drive the logic network of *D5, D6,* and *D7*, which drives the display. The 10K-ohm trimpot, *R37*, is used to calibrate the LEDs. The red LED indicates a break frequency of 1.5 kHz, the yellow, a break frequency between 1.5 and 20 kHz, and the green that the filter is opening up above 10 kHz.

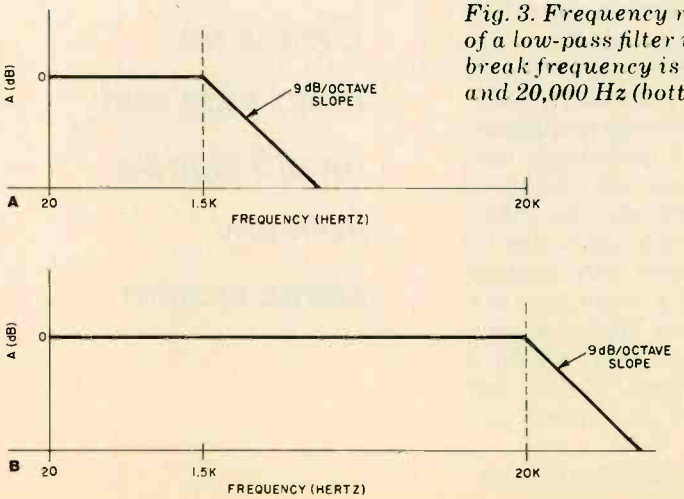


Fig. 3. Frequency response of a low-pass filter when its break frequency is 1500 Hz (top) and 20,000 Hz (bottom).

PARTS LIST

C1, C3, C9, C11, C21—1-μF 50-volt axial-lead electrolytic capacitors
C2, C10—680-pF disk ceramic capacitors
The following are 100-volt Mylar capacitors:
C4, C5, C12, C13—.022-μF
C6, C14, C17—.001-μF
C7, C15, C20—.1-μF
C8, C16—.01-μF
C18, C22, C23, C24—1000-μF 35-volt radial-lead electrolytic
D1—33-volt Zener diode
D2 through D7—IN914 signal diode
D8 through D11—IN4002 rectifier
F1—½-ampere fuse
IC1, IC2—μA4136 quad op amp (Fairchild)
J1-J8—RCA phono jacks
LED1—Red (Fairchild FLV 110 or equivalent)
LED2—Yellow (Fairchild FLV 410 or equivalent)
LED3—Green (Fairchild FLV 310 or equiv.)
Q1, Q2—Matched pair of 2N5458 JFETs.
The following are ¼-watt, 5% tolerance resistors:
R1, R13, R26—47,000 ohms
R2, R14, R35, R43, R44—4700 ohms
R3, R15, R33, R38—10,000 ohms
R4, R16—100 ohms
R5, R17—1000 ohms
R6, R18—39,000 ohms
R7, R19, R45, R46—2200 ohms
R8, R20, R29—15,000 ohms
R9, R21—11,000 ohms
R10, R22, R36, R39, R41—100,000 ohms
R11, R12, R23, R24, R34—1 megohm
R25—22,000 ohms
R28, R32—470,000 ohms
R30—680,000 ohms
R31—130,000 ohms
R40, R42—27,000 ohms
Other resistors and controls:
R27—100,000-ohm potentiometer with switch (CTS FR-GC-XM 450 or similar)
R37—100,000 ohm thumbwheel trimpot
R47, R48—10 ohms, ½ watt, 5% tolerance resistor
S1, S2—DPDT switches
S3—110-V,2-A switch (part of R27)
T1—22-volt center-tapped, 50-mA transformer
Misc—Ac line cord, knob for threshold pot, buttons for switches, suitable enclosure, hardware, hookup wire, solder, etc.
Note—The following items are available from Logical Systems, 3314 "H" St., Vancouver, WA 98663 (Tel. 206-694-7905): Complete 318 Silencer kit, including 6063 extruded aluminum chassis and hand-finished black walnut end pieces, $129.00. Also available separately: Etched and drilled circuit board, $15.00; individually tested and matched 2N5458 FETs, $3.50. Washington state residents please add 5% sales tax.

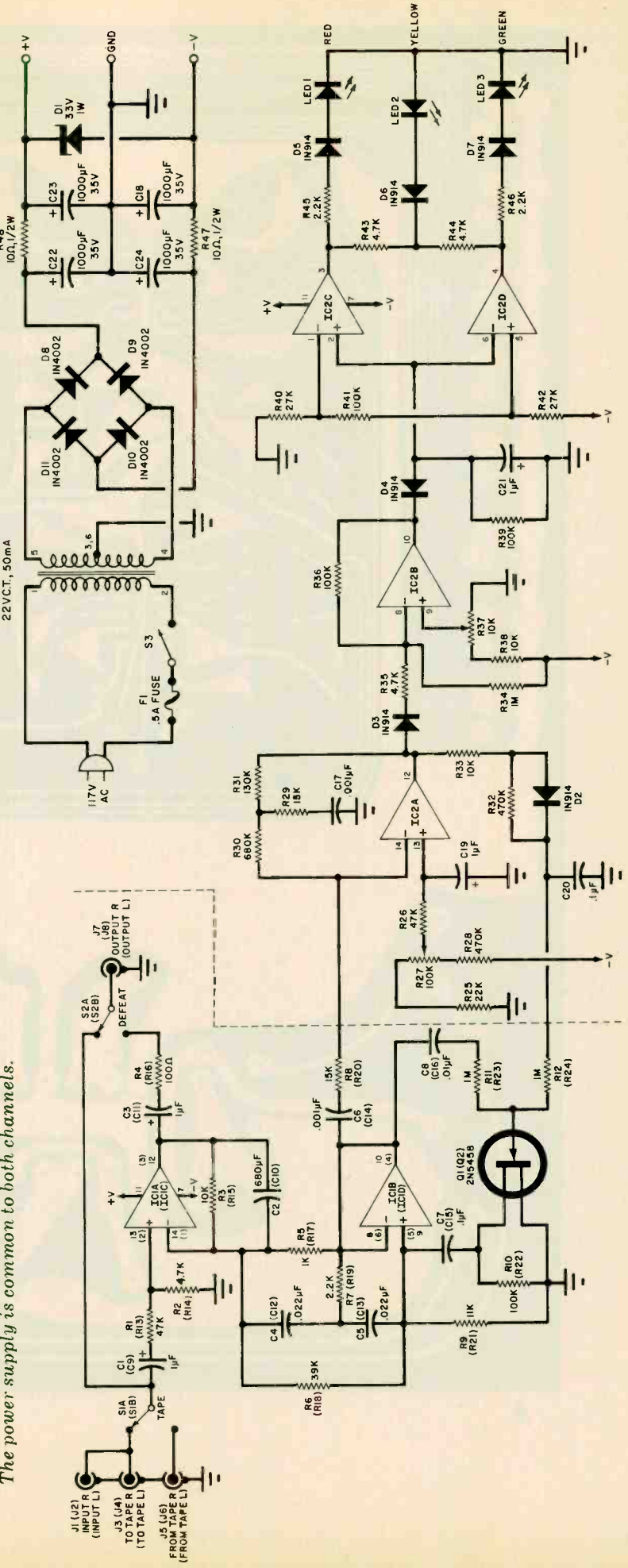
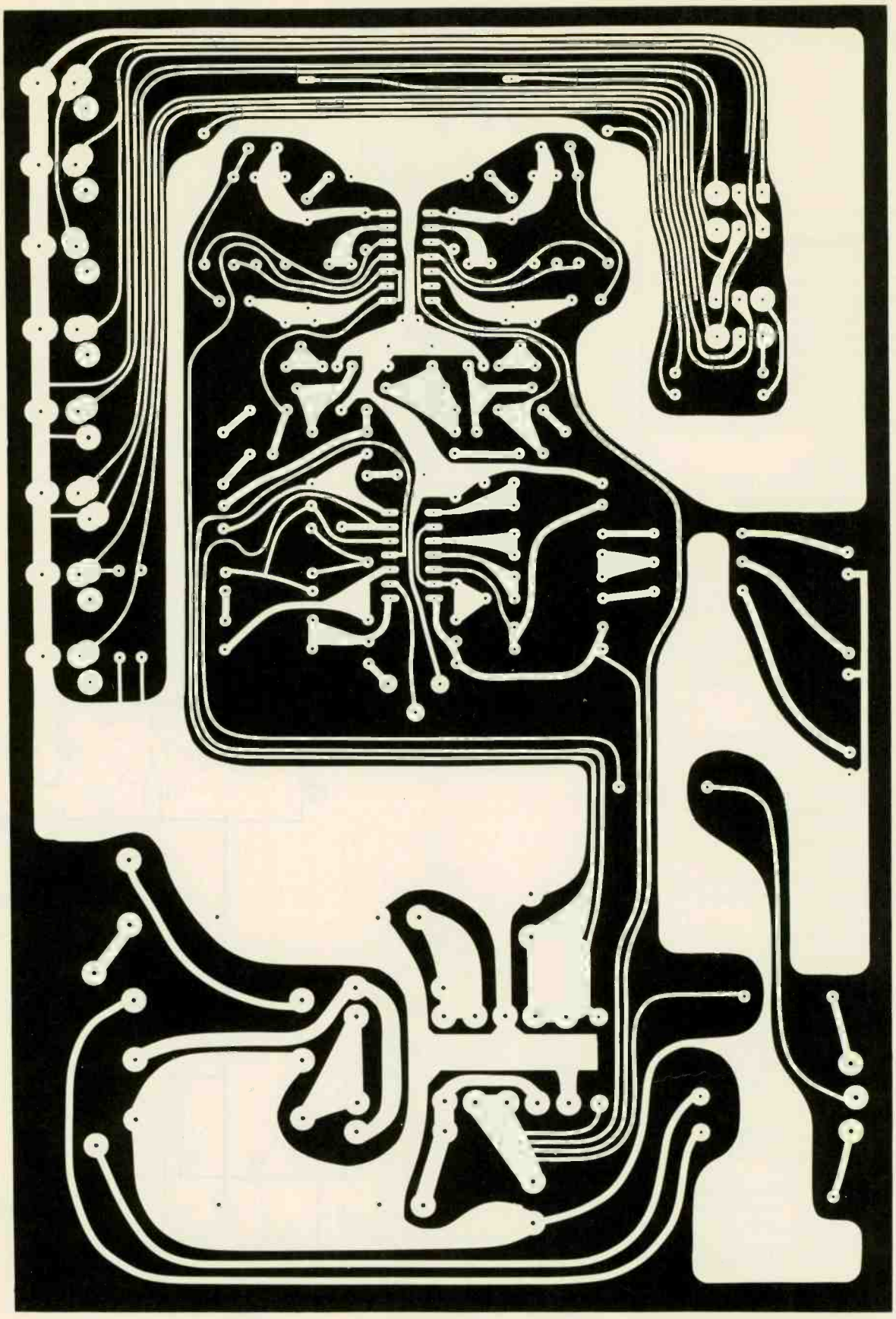


Fig. 2. Schematic diagram. Components of the left-channel filter are numbered in parentheses. The power supply is common to both channels.



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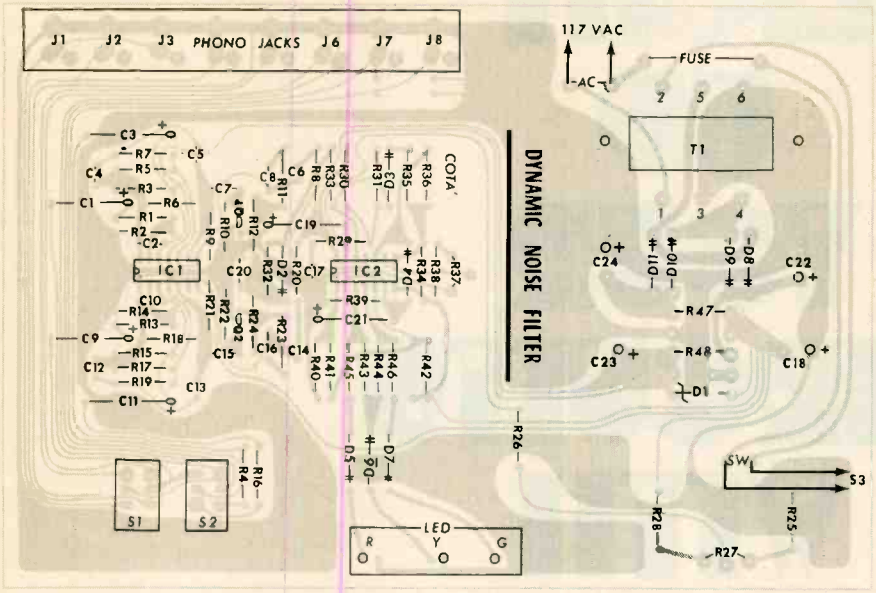

B

Fig. 4. Actual-size etching and drilling guide for the "Silencer." Board is shown at (A); parts placement at (B).

OPERATING SPECIFICATIONS—"SILENCER"

Hiss Reduction:	15 dB at 10,000 Hz
Max. Filter Slope:	9 dB/octave
Frequency Response:	20 to 20,000 Hz ±0.5 dB
Minimum Bandwidth (Filter Closed)	1500 Hz
Dynamic Range:	Output noise greater than 100 dB below max. output, 20 to 20,000 Hz
S/N Ratio:	Better than 85 dB below 2 V ac output 20 to 20,000 Hz
THD:	Less than 0.1%, at rated output, 20 to 20,000 Hz.
IM Distortion:	Less than 0.01% at rated output 60/7000 Hz mixed 4:1; typically less than 0.005%
Rated Output:	2 V ac into 10,000 ohms
Max. Output:	10 V ac into 10,000 ohms
Input Impedance:	47,000 ohms, single ended
Output Impedance:	100 ohms
Power requirements:	110/120 V, ac 50/60 Hz, 8 W

Note: All measurements made with filter bandwidth open maximum except where specified. (This is the worst-case condition.)

Construction. This unit is most easily constructed using a printed-circuit board. Complete etching and drilling guides are shown in Fig.4A, with the component guide shown in Fig. 4B. Proper orientation of parts is very important. Take careful note of how FETs *Q1* and *Q2* are mounted as well as op amps, diodes, and electrolytic capacitors. Also observe that the dynamic characteristics of the FETs must be matched. Moreover, when choosing op amps, it is important to make sure that the one chosen for the detection circuit, *IC2*, has an open-loop gain of at least 50 dB at 10 kHz. Op amps in the parts section were chosen for their excellent noise figures.

The unit is designed to fit into a custom aluminum extrusion, held by the eight screws in the wood ends. Any suitable enclosure will work, however. The circuit board itself measures 6" × 9". The RCA phone jacks, front-panel switches, and threshold pot are circuit-board mounted for ease of construction and minimum noise. LEDs may be circuit-board mounted or attached to your front panel and then wired. If you choose not to use the furnished printed-circuit guides, make sure that the power supply is as far away as possible from the rest of the circuit to eliminate stray hum.

Calibration. Calibration should be done before you fully enclose the unit. To calibrate, connect the noise filter into your amplifier's or receiver's auxiliary or tape input. Find a low-level noise source—an erased magnetic tape would be ideal. If you don't have tape facilities you may use the inside groove of an LP record. Increase the amplifier's gain so you can hear the noise very well.

Start with the Silencer's threshold pot turned fully counter-clockwise and slowly turn the control knob clockwise. You will hear the noise change character and become more objectionable. Return to the position where the noise-content change just begins (listen several times so you will be able to identify this point). With the threshold knob in this position, adjust *R37*, the thumbwheel trimpot, so that the red LED lights. You should adjust the pot so that it is at the point where only a slight adjustment will cause the yellow LED to light.

In conclusion, this easy-to-build noise-reduction system will be a helpful and versatile addition to any stereo hi-fi system, cleaning up signals from any source. ◇

LIGHT UP YOUR CIRCUITS WITH LED'S

How light-emitting diodes work and some tips on where to use them

BY WALTER G. JUNG

IN JUST a few short years, the light-emitting diode (LED) has found its way into innumerable circuits and devices as a "state" indicator. Not too long ago, there was only one type of LED (red); but today there is such a wide variety from which to choose that selection can become confusing.

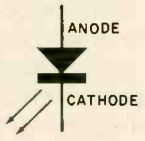

Fig. 1. Schematic symbol for LED is standard diode with arrows for light output.

To correct this, let's take a look at what a LED is, how it works, what electrical and optical characteristics are available, and how to make the best use of them.

What Is a LED? A LED is a pn-junction semiconductor device specifically designed to emit light when forward biased. This light can be one of several colors—red, amber yellow, or green—or it may be infrared and thus invisible. The schematic symbol for a LED is shown in Fig. 1. It is similar to the symbol for a conventional diode except that the arrows are added to indicate light emission.

Electrically, a LED is similar to a conventional diode in that it has a relatively low forward voltage threshold. Once this threshold is exceeded, the junction has a low impedance and conducts current readily. This current must be limited by an external circuit, usually a resistor.

The amount of light emitted by the LED is proportional to the forward current over a broad range, thus it is easily controlled, either linearly or by pulsing. The LED is extremely fast in its light output response after the application of forward current. Typically, the rise and fall times are measured in nanoseconds. Because of this fast response, LED's make excellent high-speed switched sources of light for

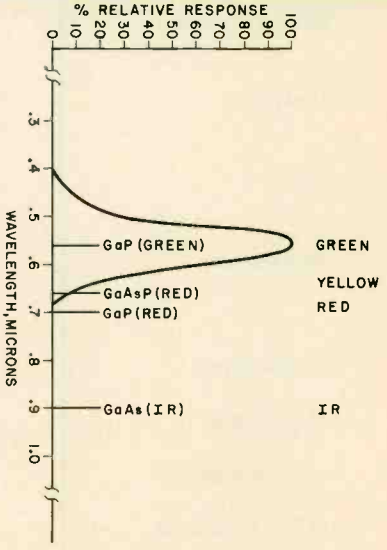

Fig. 2. Response of the human eye to various types of LED light emissions.

use in multiplexing, strobing, and optical communications systems.

LED's are small in size compared to conventional incandescent lamps; and, in fact, a LED actually consists of a tiny "chip" a few thousandths of an inch across mounted in a relatively large plastic package. As you might expect, a LED is also very light in weight.

Because of their low operating voltage and low current drive requirements, LED's consume very little power—about 30 mW (20 mA at 1.6 V being typical). Consequently, LED's generate little heat. A side benefit of the low power requirement permits interfacing LED's with most digital and linear IC's or low-power transistor stages.

A LED does not "use itself up," and has little wearout mechanism, so very long life can be expected. Some manufacturers predict 100,000 hours or more, which amounts to over 11 years of continuous use. On a practical basis, once wired in and operated within specified ratings, a LED should last forever.

Characteristics. It was once said that LED's came in three colors—red, redder, and reddest; but recent advances in semiconductor technology have changed the picture greatly. The early red LED's were made of gallium-arsenide phosphide (GaAsP) compounds. These are still the most inexpensive types available. Gallium phosphide (GaP) is now used to produce green, yellow, and red LED's.

The relative sensitivity of the human eye to the standard LED emission wavelengths is shown in Fig. 2. Note that the eye is most sensitive in the green area with the peak at 0.56 microns. The GaP red emission is at 0.69 microns, while GaAsP red is at 0.66 microns.

The light output of a LED tends to be monochromatic—of a single color (wavelength). The light output of LED's is usually specified in candelas, a measure of intensity; though sometimes it is specified in foot-lamberts, a measure of intensity per unit area.

Interpreting Data Sheets. To use a LED properly, you must have some understanding of the data sheets. A few illustrations from typical data sheets are shown in Fig. 3.

The simple curve in Fig. 3A shows that LED light output increases linearly with forward current up to 50 mA, which, incidentally, is a typical continuous maximum current for plastic-packaged devices. Figure 3B is a current/voltage characteristic, showing the "knee" where conduction starts (in this case, at about 1.65 V, which is typical for a GaAsP diode). A GaP diode has a higher knee voltage (2 to 3V), but the curve's general shape is similar. Note that the diode current increases rapidly above the knee, which is why current limiting must be used to prevent damage to the diode.

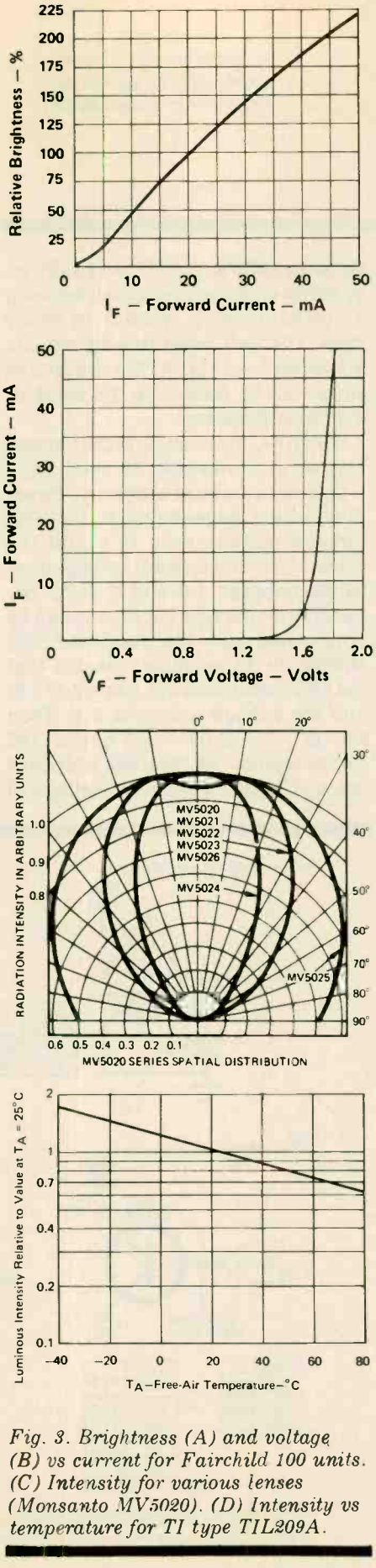

Fig. 3. Brightness (A) and voltage (B) vs current for Fairchild 100 units. (C) Intensity for various lenses (Monsanto MV5020). (D) Intensity vs temperature for TI type TIL209A.

The lensing arrangement of the diode package makes a big difference in how bright the LED appears off axis. As shown in Fig. 3C, the light can be formed into a narrow beam (as for the MV5024) or it can be wider (as for the MV5025). The beam-width used depends on the application. For example, a narrow-beam LED is correct for an optical communicator, but it is not good for a panel lamp since it will not catch the eye off to one side.

Even with a constant-current drive, temperature plays a role in the light output of a LED, as shown in Fig. 3D. However, for most hobby applications, this is not an important consideration unless a high-temperature environment is contemplated.

As a general rule, the LED should always be operated within recommended values. Maximum current can be exceeded on a *peak* basis as long as the *average* current is within specifications. The reverse voltage applied should be watched—3 volts is the usual maximum. A clamping diode can be used to prevent voltages that are too high.

Package Styles. Although LED's are manufactured in a wide variety of packages, only a few of the configurations have become favorites.

One of the most popular packages is the T-1 ¾, a ¼"-diameter, high-dome, epoxy-encapsulated style. The Monsanto MV5020 series is typical of this type. It is intended for front panel or pc board mounting, and is available with a clear lens (MV5020), a diffused lens (MV5021), a plain red lens (MV5022), or a diffused red lens (MV5023). An uncolored, clear lens produces a point source of light, while a clear diffused lens softens the effect. A red lens aids contrast if the ambient light is high. A diffused red lens spreads the beam and widens the angle of visibility, often desirable features.

These LED's are shipped in a plastic clip for insertion in a panel. The leads

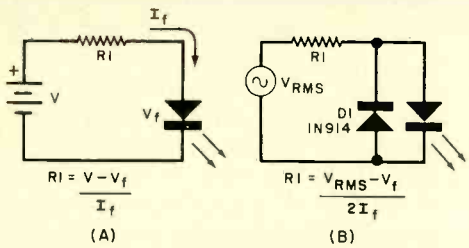

Fig. 4. Calculation of series current-limiting resistor for dc shown at (A); for ac, shown at (B).

are square and can either be soldered or wire-wrapped. The cathode lead is identified by the flat side on the plastic base, though in some cases the cathode is identified by a shorter lead. Green and yellow LED's that complement the MV5020 red series and have the same packaging are the MV5222 and MV5322, respectively.

The Fairchild FLV 100/101/102/108 series of "button" LED's are in small plastic packages similar to the TO-106 outline, but with only two leads. The respective part numbers correspond to a point source (FLV 100), diffused wide angle (FLV 101), red diffused area source (FLV 102), and an uncolored version (FLV 108) of the FLV 102. All of these packages benefit from the contrast enhancement provided by a black case. Although these units are best suited to pc board mounting, a plastic panel-mounting clip is available.

Another useful type of LED is the Texas Instruments TIL209/TIL209A, a red LED is a miniature ⅛"-diameter T-1 lamp size. It has a diffused red lens and is visible over a wide angle. The TIL209 has round leads, while the 209A has square leads. A companion green LED (TIL211) is also a diffused source. TI is currently working on yellow LED's, which should be available soon.

Hewlett-Packard has a series of red LED's which have a built-in current-limiting resistor. This eliminates the need for an external limiting circuit. Two models that operate from a 5-volt supply (can be driven by TTL) are the 5082-4860, a red diffused unit in T-1 ¾ size, and the 5982-4468, a clear diffused unit in T-1 size. The 5087-4860 can be panel-mounted and has wrap leads.

Litronix has also incorporated a current limiter in a LED package to operate over a wide variety of supply voltages. These devices come in T-1 ¾ and T-1 sizes. They have red diffused lenses. The RLC-200 is usable at voltages up to 12.5 V maximum, while the RLC-210 works up to 16 volts.

Driving LED's. A LED can be driven by either an ac or dc source, requiring a current-limiting resistor in either case. The two basic driving circuits are shown in Fig. 4 The equations show how to determine the value of the limiting resistor.

In Fig. 4A, the positive of the voltage source is connected to the LED's anode, so a forward current, I_f, flows. The current depends on V, the LED forward voltage drop (V_f), and the value of *RI*. The forward voltage drop varies between 1.6 and 3 volts, depending on the type of LED and can be determined from the published data sheets. As an example, assume that the LED requires 20 mA, has a V_f of 1.6, and the voltage source is 5 V. Then $RI = (5 - 1.6)/0.02 = 170$ ohms. (180 ohms would the nearest standard value.) Check the required wattage of

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"Application Notes," Monsanto
"Optoelectronics at Work," Motorola
"The Optoelectronics Data Book," Texas Instruments
"Application Notes," Hewlett-Packard

Manufacturers' Addresses

Chicago Miniature Lamps, 4433 N. Ravenswood, Chicago, IL 60607
Dialight, 60 Stewart Ave., Brooklyn, NY 11201
Fairchild Microwave & Optoelectronic Div., 464 Ellis St., Mountain View, CA 94040
General Electric Co., E. Nela Park, Cleveland, OH 44101
Hewlett-Packard Co., 620 Page Mill Rd., Palo Alto, CA 94304
Litronix, 19000 Homestead Rd., Cupertino, CA 95014
Monsanto, 10131 Bubb Rd., Cupertino, CA 95014
Motorola Semiconductor Products, 5005 E. McDowell Rd., Phoenix, AZ 85036
National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051
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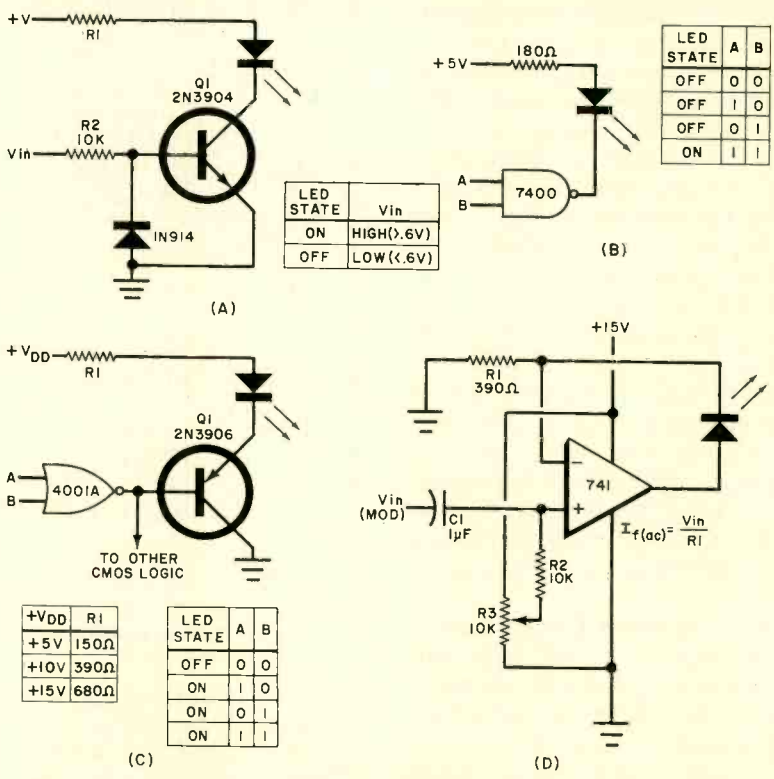

Fig. 5. (A) Saturated transistor drive and truth table. (B) and (C) are TTL and CMOS drives. (D) uses linear modulator.

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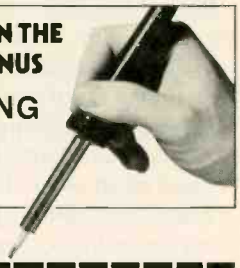

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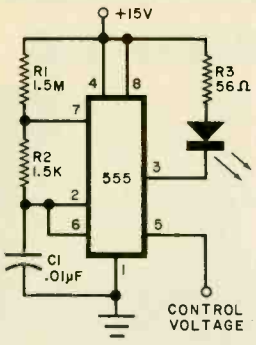


Fig. 6. Using a 555 IC to pulse-modulate LED.

the resistor since it will dissipate most of the source voltage.

In the ac circuit in Fig. 4B, the voltage source is V_{rms}, a sine wave. If the peak reverse voltage applied to the LED is over 3 V, the protective clamping diode, *D1*, is used. Any small-signal or rectifier diode can be used for *D1*. Since the LED rectifies the ac, only half of the total current contributes to useful light output. To maintain a brightness equal to that obtainable with dc, the value of the limiting resistor is cut in half—thus the 2 in the denominator of the equation.

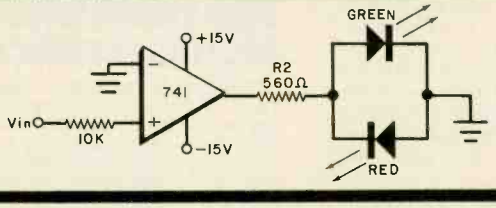
Some practical drive circuits are shown in Fig. 5. An npn switching transistor is used in Fig. 5A. A high level on the input line switches *Q1* into saturation, supplying current to the LED. Current-limiting resistor *R1* is chosen as shown in Fig. 4A. The value of the supply voltage (+V) can be anything up to the V_{ceo} rating of *Q1*.

One of the most important uses for the LED is as a logic status indicator in digital circuits. Since TTL logic can sink up to at least 16 mA, it mates easily with a LED as shown the example in Fig. 5B. This is an AND gate so that the LED is on only when both A and B are high. Keep in mind that the current flows through the LED when the gate output is low. This, in effect, subtracts from the fanout of the stage if it is coupled to another logic stage. If the fanout is required, use a TTL buffer to drive the LED alone.

Low-power logic such as CMOS cannot drive LED's directly so a buffer such as a CD4049 or CD4050 must be used, but current is limited. A solution is to use an emitter-follower buffer as shown in Fig. 5C. A beta of 100 for *Q1* will reduce the drive current required to 200 μA, which is compatible with the 4000A series of CMOS. The circuit in Fig. 5C is an example of OR logic since the LED is lit for a logic one on either A or B. Limiting resistor *R1* should be selected to match the supply voltage. An npn transistor could also be used for *Q1* by connecting the collector to the supply with the LED and *R1* in the emitter circuit. A basic asset of CMOS is its very high noise immunity, so a slightly reduced output swing from the gate in Fig. 5C is not a real detriment as far as driving other CMOS inputs is concerned. There are no fanout restrictions.

So far, we have discussed only on-off types of LED drives. A linear driver is shown in Fig. 5D. An op amp is used to make the LED current precisely proportional to the input modulation signal. Potentiometer *R3* determines the dc bias current in the LED since the voltage at the rotor of *R3* also appears across *R1*. If *R3* is centered, *R1* "sees" 7.5 volts and the current through the LED is 20 mA. The audio signal, through *C1*, modulates the dc bias signal to control the LED current proportionally. This circuit could be used as the transmitter end of light-beam communicator. It is simple, inexpensive and easy to set up; and none of the components is critical.

Fig. 7. Sensitive polarity indicator using op amp and two LED's of different colors.



Some Applications. A pulser that is useful for on-off modulation of visible or IR LED's is shown in Fig. 6. A 555 timer IC is used as an astable oscillator which provides a 10-μs pulsed output every 10 ms (a 100-Hz rate). The circuit can be frequency modulated by applying an audio signal to pin 5. Resistor *R3* sets the peak LED current to about 200 mA; and, since the duty cycle is only 0.001, the LED is not overloaded.

Using a narrow-beam IR LED (such as the Motorola MLE60) in this circuit and a silicon detector at the receiver, an invisible light-beam communication link can be constructed.

A sensitive polarity (or null) indicator is shown in Fig. 7. The circuit uses an op amp to achieve a very low input-voltage threshold. Since the input signal is applied to the op amp noninverting input (+), the op amp output is positive when the input is positive and negative when the input is negative. A positive input lights the green LED, and a negative signal lights the red LED. The LED's can be separate devices, or a dual unit such as the Monsanto MV5491 (red/green) LED can be used.

The input threshold is the offset of the op amp used. For a 741, it is ±6 mV or less. There are no loading effects since the input draws very little current. If the added sensitivity is not needed, the op amp can be omitted and the LED's driven directly through *R2*. This is a useful option if the source impedance is low.

The circuit shown in Fig. 8 uses two high-gain comparators to determine whether a critical voltage is between two limits. In the circuit shown, the limits are +4 and +6 volts. The two comparators are wired as OR gates, so that the LED is energized if either comparator output is low. This would occur if V_{in} were less than +4 V or more than +6 V. Using this general idea, different reference voltages can be used to monitor almost any voltage level.

Conclusion. Of course, we have not covered all of the possible uses for the various types of LED's. Hopefully, some ideas have been generated. Others can be obtained from the references given in the accompanying box. ◈

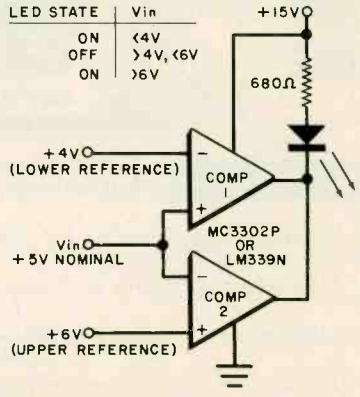


Fig. 8. Window comparator turns LED on when input exceeds predetermined limits.

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A DIGITAL STOPCLOCK FOR SHORT AND LONG EVENT TIMING

Times events to 10 hours in 0.1-second intervals.

BY MICHAEL S. ROBBINS

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

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

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

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

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

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

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

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

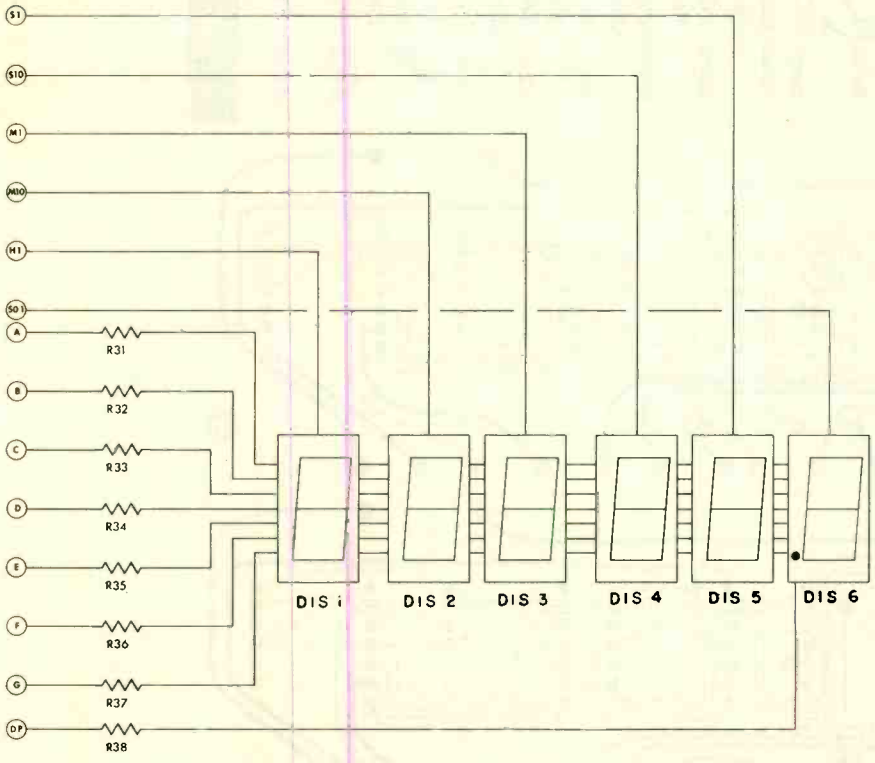

Fig. 1. Complete schematic of stopclock is shown above and on opposite page.

C1—1000-μF, 16-volt electrolytic capacitor
C2,C5—0.1-μF, 20-volt disc capacitor
C3,C4,C7—0.01-μF disc capacitor
C6—0.005-μF disc capacitor
D1 through D4—1N4001 rectifier diode
D5 through D16—1N914 switching diode
IC1—CD4023AE (RCA) or MC14023CP (Motorola) integrated circuit
IC2—MC14566CP (Motorola) integrated circuit
IC3—MC14511CP (Motorola) integrated circuit
IC4—MM5309 (National) integrated circuit
DIS1 through DIS6—Seven-segment LED display (Litronix DL747 or similar)
Q1,Q2,Q9 through Q15—2N5172, MPS5172, or MPSA20 transistor
Q3 through Q8—2N4403 transistor
The following resistors ½ watt, 10%:
R1,R2,R3,R30—1000 ohms
R4,R7—100,000 ohms
R5,R17 through R23—10,000 ohms
R6—330,000 ohms
R8,R9—470,000 ohms
R10 through R16—2000 ohms
R24 through R29—470 ohms
R31 through R37—120 ohms
R38—270 ohms
S1,S2,S3—Normally-open spst pushbutton switch
TS1—Two-lug screw-type terminal strip
TS2—Four-lug screw-type terminal strip
Misc.—Chassis box; printed circuit boards (2); 74 Molex Soldercons or one 28-pin, two 16-pin, and one 14-pin IC sockets; 2 small L brackets (optional); four spacers; four rubber feet; red acrylic display filter; machine hardware; hookup wire, solder; etc.

Note: the following are available from Caringella Electronics, Inc., P.O. Box 727, Upland, CA 91786: etched and drilled main pc board No. DSC-1PC for $7.95; etched and drilled display board No. DSC-1APC for $6.95; complete kit of parts, including cabinet, hardware, etc., No. DCS-1K for $79.95 plus $2 shipping. California residents, please add 6% sales tax on all items. There are no kits available for the circuits shown in Fig. 4.

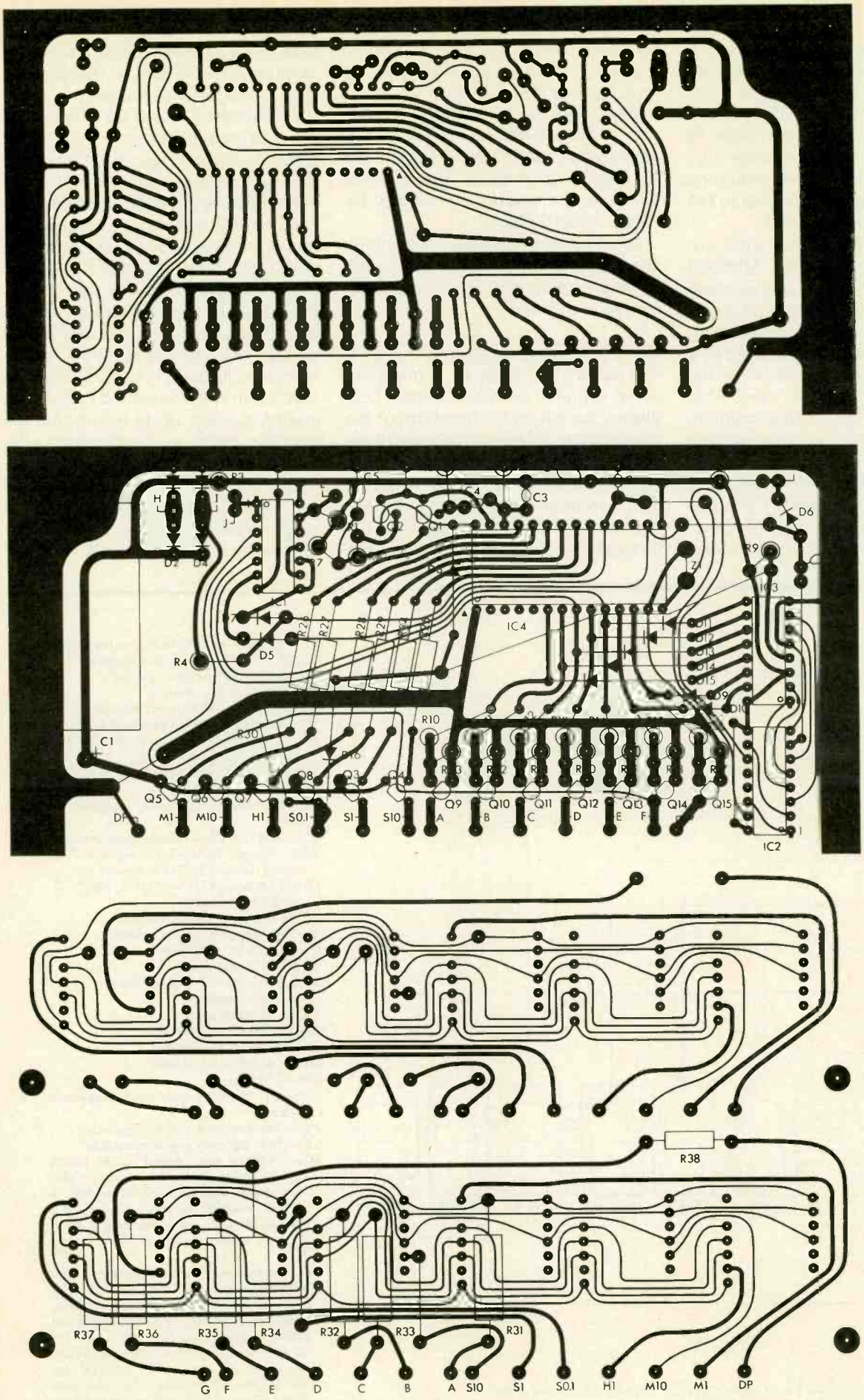

Fig. 2. Etching and drilling guides with component layout diagrams for the two pc boards.

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

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

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

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

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

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

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

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

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

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

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

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

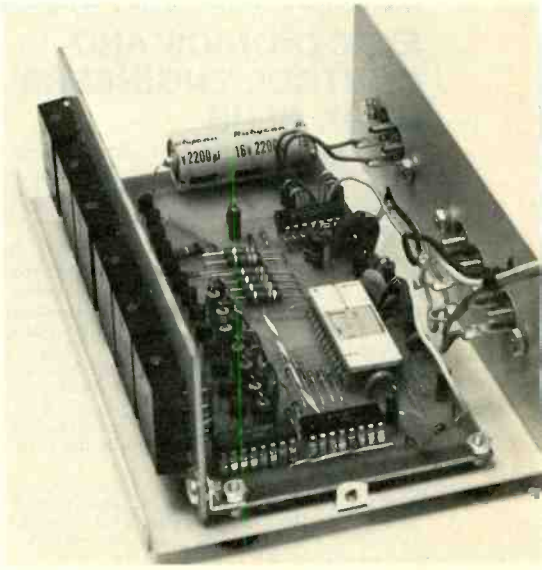
Bear in mind that each of the three circuits operated by the pushbutton switches in Fig. 1 is held at +12 volts by *R1*, *R2*, and *R3*. To enable an input, the bottom ends of these resistors must be connected to ground. Therefore, any external switching device connected to *TS2* must have an on resistance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

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

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

The circuit in Fig. 4C can be used to

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



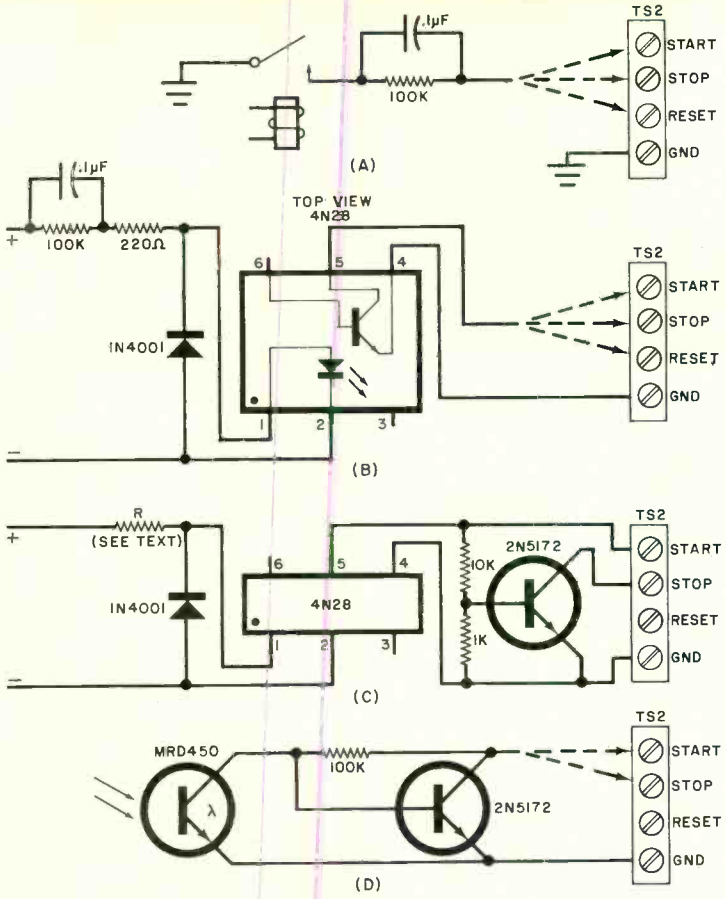
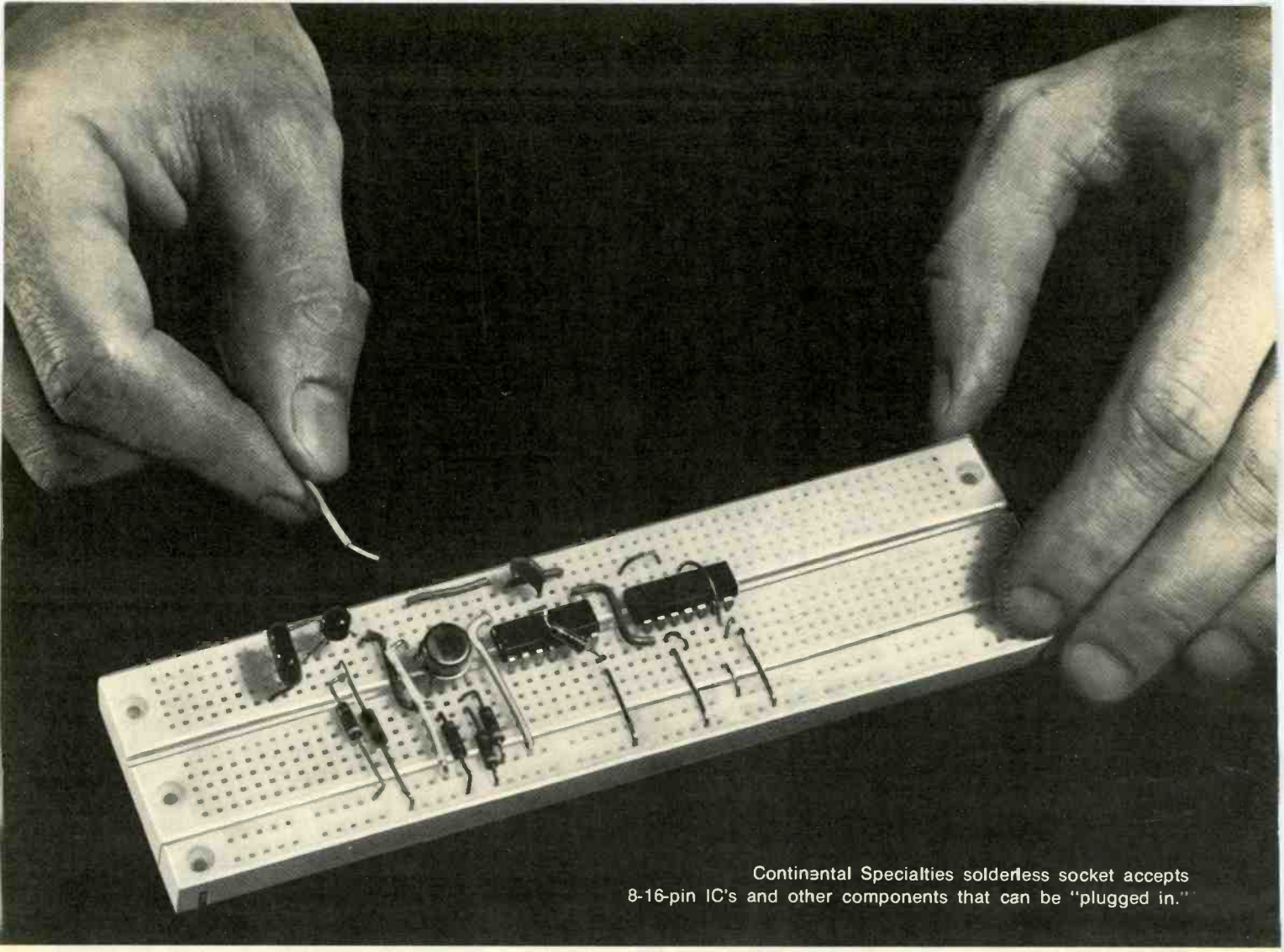


Fig. 4. Stopclock can be operated by a relay (A), an optoisolator (B and C), or a phototransistor (C).

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

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



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

Getting Started with Op Amps

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

BY SOL D. PRENSKY

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

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

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

One or more of the solderless sock-

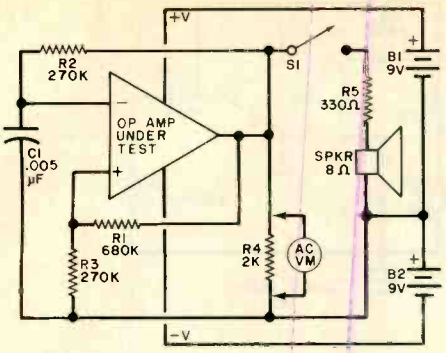


Fig. 1. Simple op amp tester has meter and audio outputs.

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

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

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

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

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

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

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

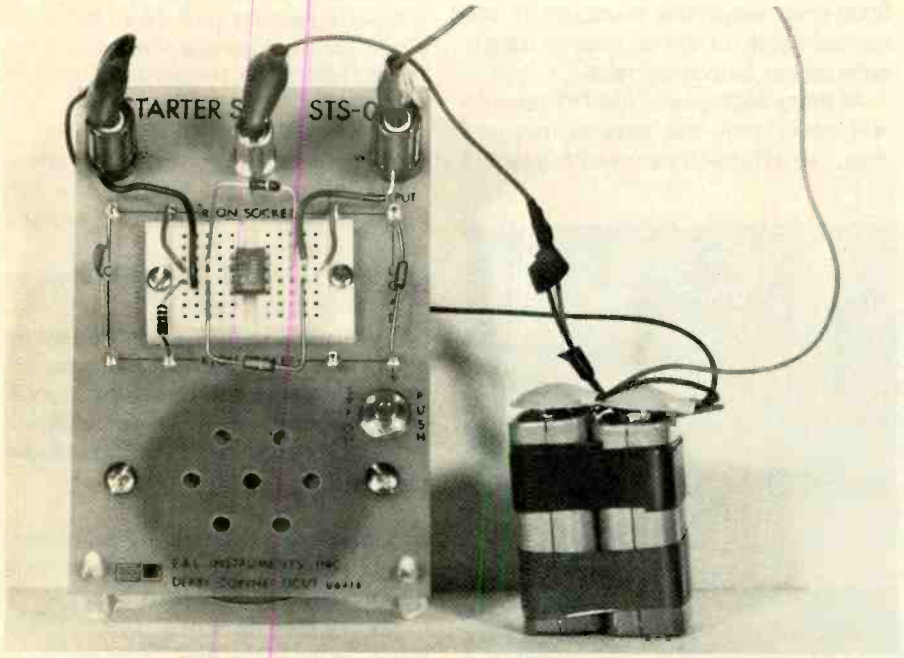


Fig. 2. Commercially available "starter kit" from E&L Instruments illustrates breadboarding of the test circuit in Fig. 1. Can be purchased from E&L Instruments, 61 First St., Derby, CT 06418 for $14.00 plus 50¢ postage and handling; order no. 355-7100.

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

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

The basic circuit in Fig. 3 is similar

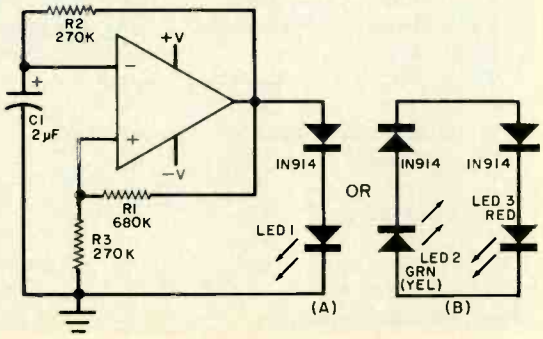


Fig. 3. A 1-Hz op amp oscillator can drive either a single LED on the positive-going cycles, or a pair of LED's alternately.

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

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

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

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

At these high gains, the 741 op amp will cover only the speech frequencies. For extended bandwidth, you will have to use an externally compensated 748 op amp in place of the 741. For loudspeaker operation, replace the earphone with an equivalent value fixed resistor and use this signal to drive an audio amplifier.

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

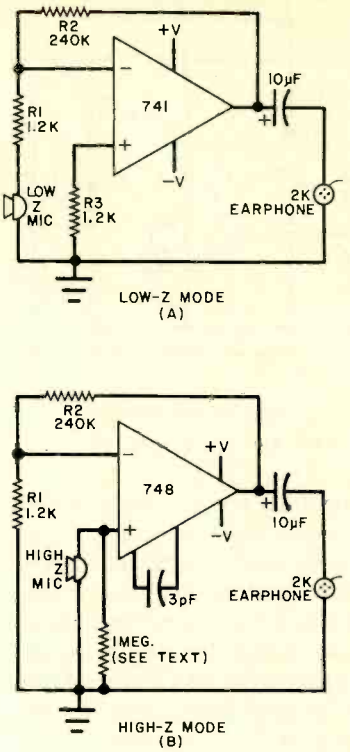
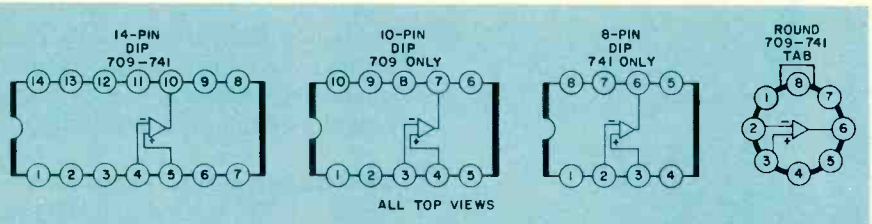


Fig. 4. Low-impedance microphone can be used with circuit (A) and a high-impedance unit with (B). Since 741 is frequency-limited, a 748 (externally compensated) can be used to extend the range.

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

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



PIN ARRANGEMENTS

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

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

Note: NC = No Connection

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

BUILD A DIRECT-DRIVE TURNTABLE

BY GEORGE MEYERLE

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

FEATURES AUTOMATIC PITCH CONTROL AND METER-READOUT "STROBE"

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

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

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

PARTS LIST

C1—4.7-μF, 10%, 10-volt electrolytic capacitor
C2—0.015-μF, 10%, 50-volt polyester film capacitor
C3—47-μF, 10%, 10-volt tantalum capacitor
C4—1-μF, 10%, 10-volt tantalum capacitor
C5,C6—330-μF, 10-volt electrolytic capacitor
C7,C9—220-μF, 35-volt electrolytic capacitor
C8—1000-μF, 35-volt electrolytic capacitor
C10—100-pF, 50-volt disc capacitor
C11—0.047-μF, 10%, 50-volt polyester film capacitor
C12—0.22-μF, 10%, 50-volt polyester film capacitor
D1 through D5,D8—1N4148 diode
D6,D7—100-volt, 1-ampere rectifier diode (1N4002 or similar)
IC1—MC1732CL integrated circuit (Motorola)
IC2,IC3—747 operational amplifier integrated circuit.
J1,J2—Dual phono jack assembly
M1—Zero-center, ±75-μA meter movement
The following resistors are ¼-watt unless otherwise noted:
R1,R2,R3,R31—100,000 ohms, 10%, carbon film
R4—220,000 ohms, 10%, carbon film
R5,R6,R35—12,000 ohms, 10%, carbon film
R7—10,000 ohms, 2%, metal film
R8,R12,R16—300,000 ohms, 2%, metal film
R9,R11,R32,R33—330,000 ohms, 10%, carbon film
R10,R13—1200 ohms, 10%, carbon film
R14—1000 ohms, 2%, metal film
R15—22,000 ohms, 2%, metal film
R17—22,000 ohms, 10%, carbon film
R18,R22,R27—560 ohms, 10%, carbon film
R19—2400 ohms, 2%, metal film
R20—390 ohms, 2%, metal film
R28—10 ohms, 10%, carbon film
R29—200 ohms, 2%, metal film
R30—2700 ohms, 2%, metal film
R34—6800 ohms, 2%, metal film
R21,R26—10,000-ohm trimmer potentiometer
R23,R24—2500-ohm trimmer potentiometer
R25—39-ohm, 10%, 5-watt resistor
R36—2500-ohm potentiometer
S1—3-pole, 3-position rotary switch (or toggle equivalents)
S2—Spst switch
T1—16-volt, 100-mA wall-plug transformer with line cord
Misc.—Direct-drive, brushless dc motor with integral circuit board assembly; printed circuit board for control circuit; motorboard; turntable base; control panel; acoustic-isolator springs (8); wire nuts (6); control knobs (3); 6-32 × 1" machine screws and nuts (3); No. 6 × ¼" woodscrews (2); double-sided tape; hookup wire; solder; etc.

Note: The following items are available from Netronics Research & Development Ltd., 333 Litchfield Rd., New Milford, CT 06776: Complete turntable kit, including all parts and Audio-Technica Model AT-1005II universal tonearm No. 450D for $159.95; complete kit less tonearm (motorboard minus tonearm holes) No. 350D for $130.00 plus $3.00 postage and handling; dust cover for above No. 40-004 for $12.00 plus $1.50 postage and handling; motor with cast platter and rubber mat No. 99-001 for $65.00; control circuit pc board No. 99-007 for $5.90; meter movement No. 99-004 for $6.50. auto pitch control switch (S2) No. 99-004 for 90¢. When ordering complete kit, add $2.50 for postage. Connecticut state residents, please add sales tax.

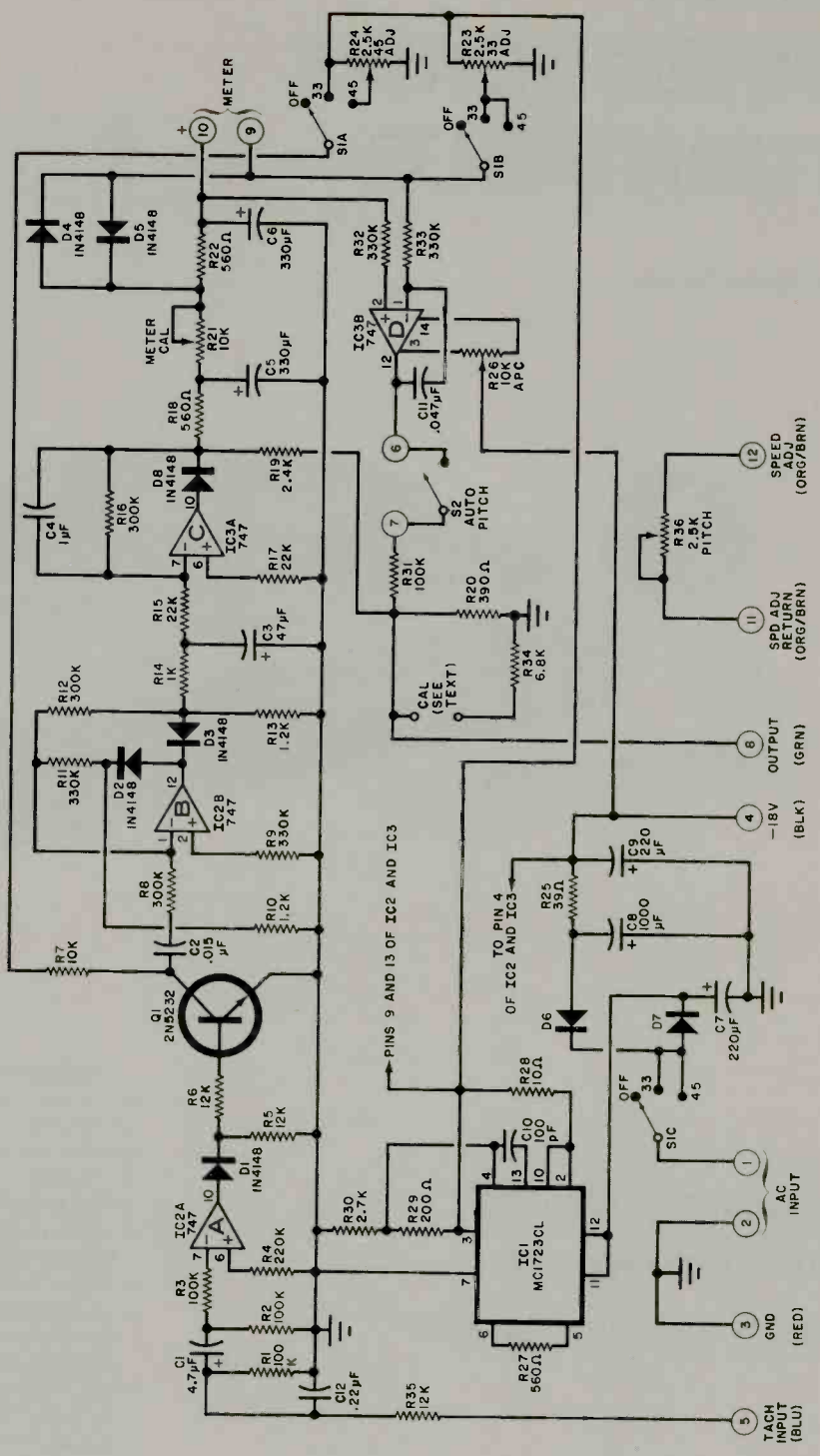


Fig. 1. The control circuit for the turntable motor. The tachometer signal is converted to square waves, differentiated and fed back to the motor. The oscillator and filter for the power supply are also located on the control board assembly.

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

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

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

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

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

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

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

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

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

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

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

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

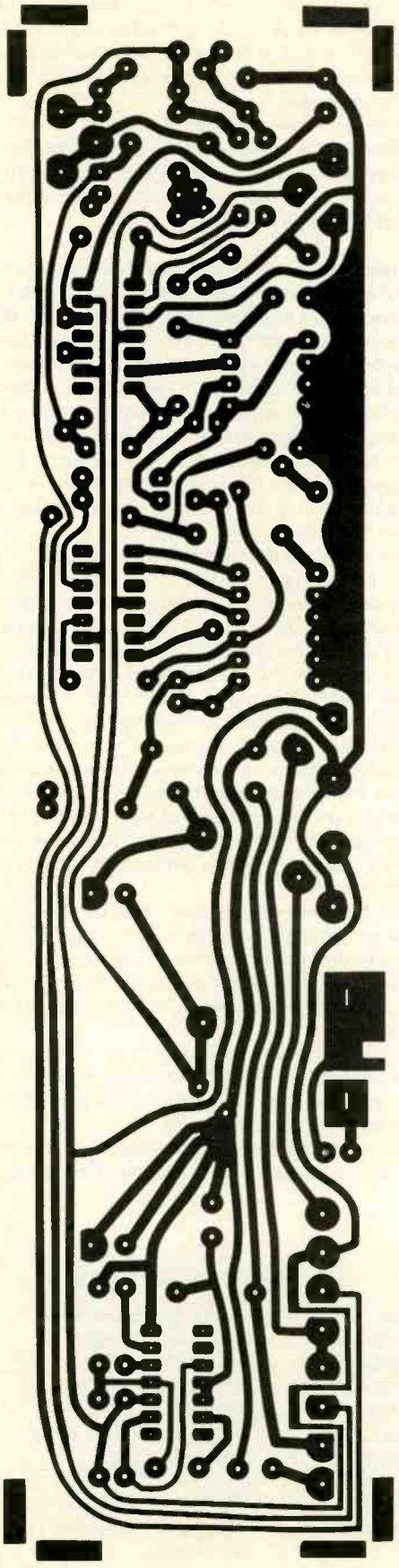
The base of the turntable must be large enough to accommodate the motorboard and leave enough room to house the control electronics package in front. It must also be deep enough to clear the motor or permit the rear end of the motor's housing to sit in a cutout in the bottom panel.

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

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

SPECIFICATIONS

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



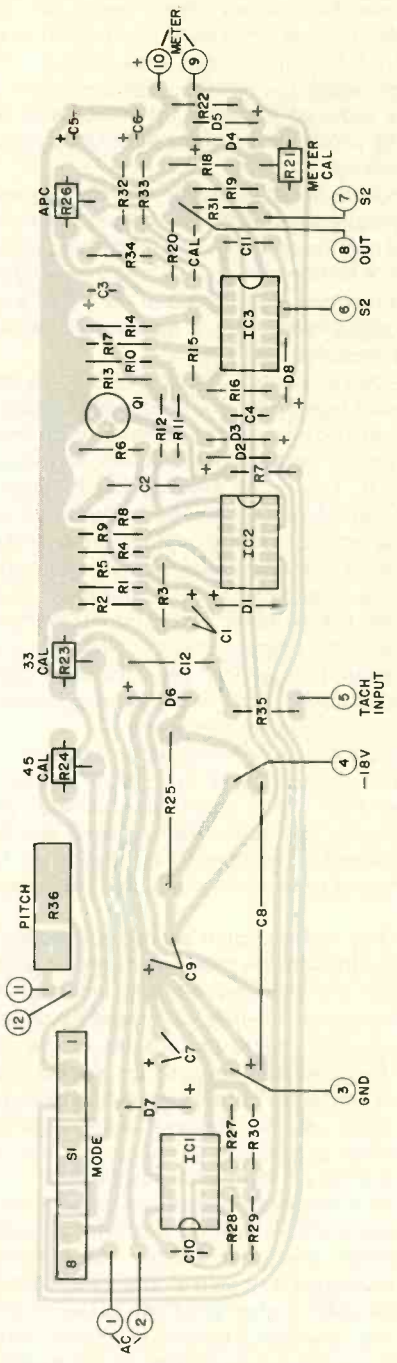


Fig. 2. Etching and drilling guide for the turntable is shown above. Component layout is above right.

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

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

Next, connect and solder the cartridge leads coming

TEST RESULTS
A Hirsch-Houck Labs Report

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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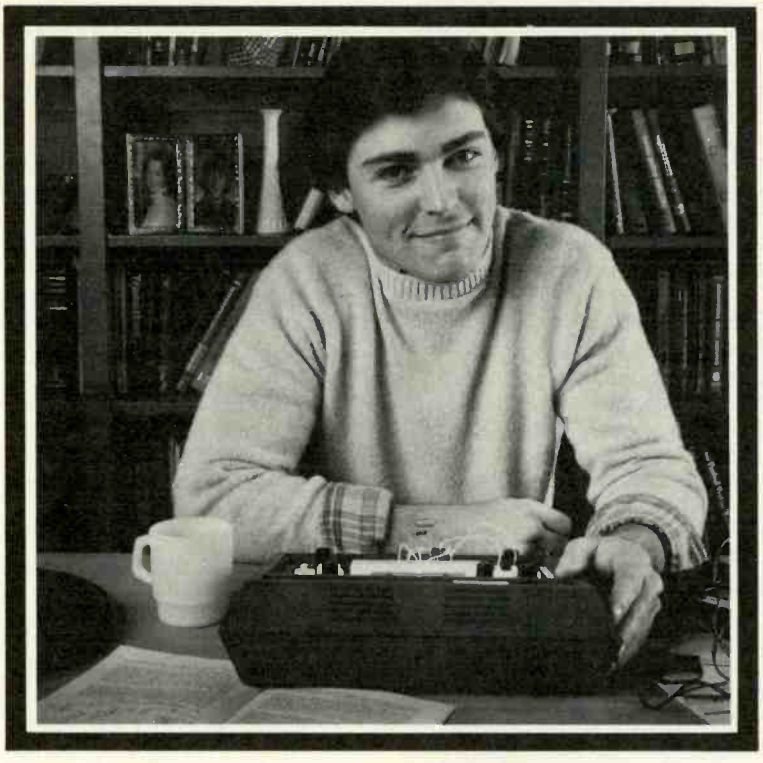

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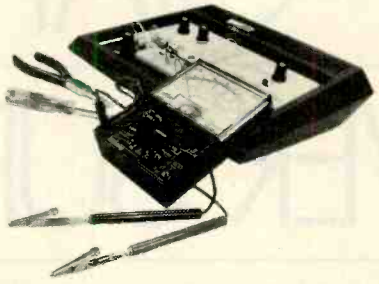

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BUILD THE LITTLE GIANT POWER SUPPLY

One IC makes blow-out-proof selectable voltage supply.

BY J.B. WICKLUND

INTEGRATED circuits available to the electronics experimenter usually require ±15 volts (for op amps) or +5 volts (for TTL digital logic). Anyone who has done much experimenting with these devices knows the necessity for a good regulated power supply.

While it is not difficult to design and build a power supply for either of these voltages, the easiest and cheapest way to get a good supply is to use a voltage regulator chip, the 78XX series made by Fairchild. This IC looks like a conventional three-lead plastic power transistor; and, when coupled with a bridge rectifier and filter capacitors, it can deliver 5, 6, 8, 12 or 15 volts at currents ranging up to 1 ampere.

Besides providing excellent regulation, the IC is internally protected from excessive load current or heat dissipation. Even if a heat sink is not used, it will not burn out since the power supply shuts off when it gets too hot and turns on again when it cools down.

Circuit Design. The basic circuit is shown in Fig. 1. Note that transformer *T1* has two independent 7½-volt secondaries which can be connected either in series for the 15-volt supply or parallel for 7½ volts (at more current) for the 5-volt supply. Diodes *D1* through *D4* form a conventional bridge rectifier, with *C1* as a filter.

In the 15-volt version, the voltage at the input to the the regulator is about

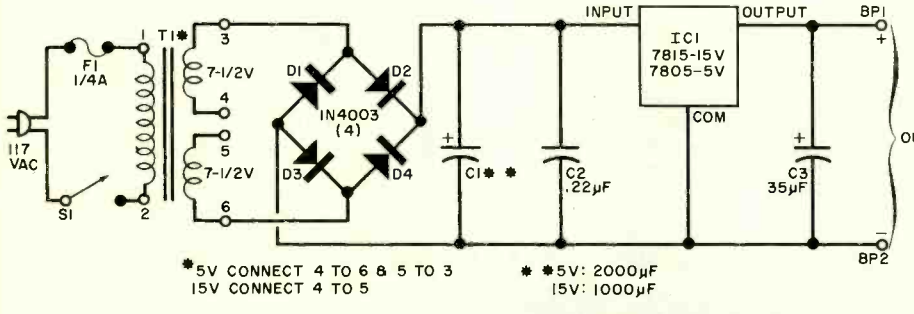


Fig. 1. Same circuit is used for either supply. Components and jumpers must be changed.

PARTS LIST

BP1,BP2—Five-way binding post (red and black)
C1—2000-µF, 15-volt electrolytic capacitor (for 5-volt supply)
1000-µF, 25-volt electrolytic capacitor (for 15-volt supply)
C2—0.22-µF Mylar capacitor
C3—35-µF, 25-volt electrolytic capacitor
D1-D4—Silicon rectifier diode (1N4003 or similar)
F1—¼-ampere fuse and holder
IC1—5-volts—7805 12 volts—7812
6 volts—7806 15 volts—7815
8 volts—7808
S1—Spst switch
T1—Dual 7½-volt ac secondary, 500-mA transformer (Triad F-152XP or similar)
Misc.—Suitable chassis, optional neon indicator lamp, line cord, mounting hardware.

Note: The following are available from Northwest Engineering, 801 Duchess Rd., Bothell, Wash. 98011: printed circuit board (N004A-PCB) at $5.00; IC1 (N004A-REG) at $3.10; kit of board and board-mounted components. (N004A-FK) at $17.50 (specify voltage output). Kits are sent postpaid in continental USA.

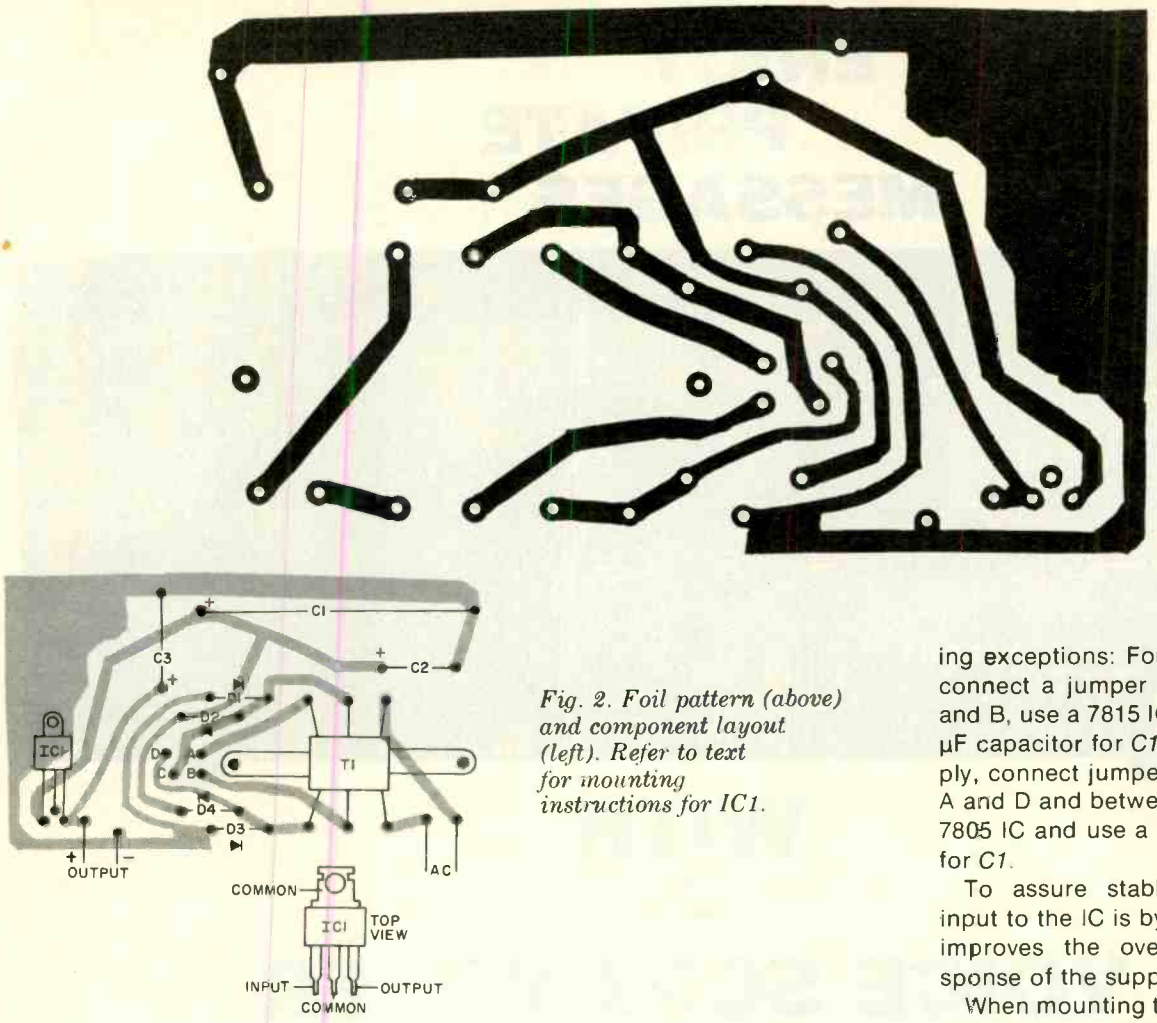


Fig. 2. Foil pattern (above) and component layout (left). Refer to text for mounting instructions for IC1.

21 volts dc; in the 5-volt version, the dc input is about 10 volts. The output for the former is between 14.4 and 15.6 volts with variations of less than 0.15 volt for load changes of 5 to 500 mA. For a 5-volt output, the load can be 1 ampere, which can drive up to 50 TTL devices.

Construction. The printed circuit board shown in Fig. 2 is the same for either type of supply, with the following exceptions: For a 15-volt supply, connect a jumper between points A and B, use a 7815 IC, and use a 1000-µF capacitor for *C1*. For a 5-volt supply, connect jumpers between points A and D and between B and C, use a 7805 IC and use a 2000-µF capacitor for *C1*.

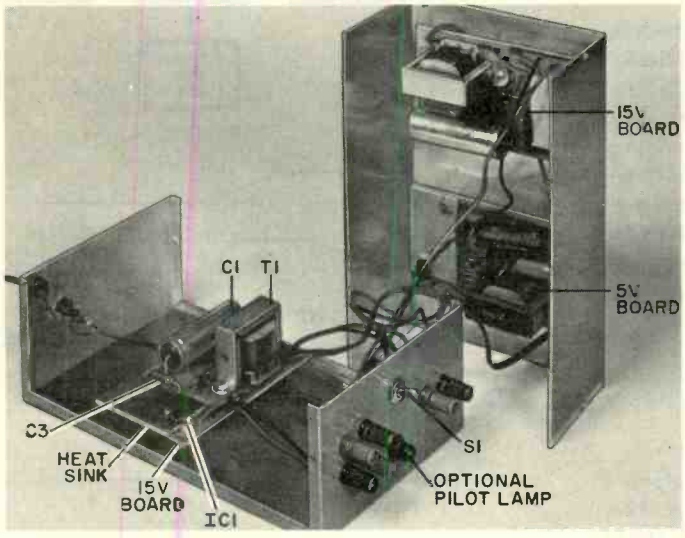
To assure stable operation, the input to the IC is bypassed by *C2; C3* improves the overall transient response of the supply.

When mounting the IC, bend it over so that the mounting lug (in electrical parallel with the common pin) can be attached to the negative portion of the foil pattern (the large area). This is where a heat sink should be used to provide the best current rating. Use a 1½" by 3" piece of aluminum for the heat sink and attach it and the IC mounting lug to the PC board with a bolt going through a properly sized hole drilled in the board.

The prototype power supply used two 15-volt sections, and one 5-volt version with each terminated at its own 5-way binding posts on the front panel. Use a red binding post for the positive side and a black post for the negative. Do not use the chassis at any point as a common.

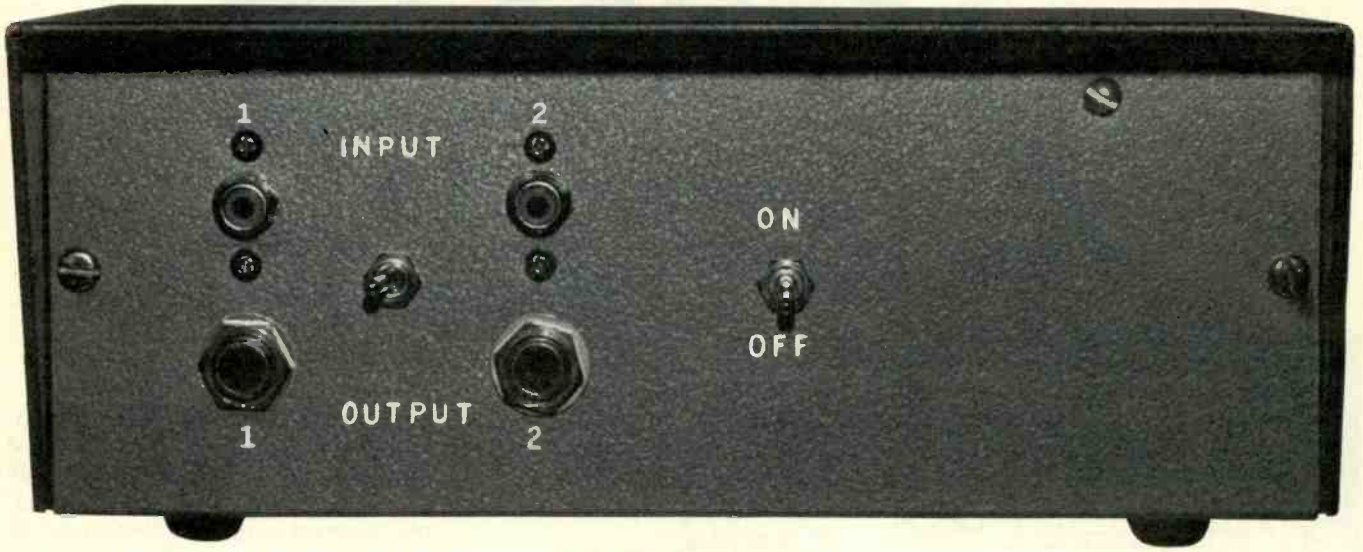
Fuse *F1* is mounted on the rear panel, with the power on-off switch on the front. If desired, a conventional 117-volt neon power indicating lamp can be connected across the primary of *T1*.

Any type of chassis can be used to support the three supplies. If you need 6-, 8-, or 12-volt supplies, use the 15-volt circuit and select the desired 78XX regulator integrated circuit. ◈



Prototype supply had a 5-V board and two 15-V boards. Binding posts and pilot lamp are on front.

ENJOY PRIVATE MESSAGES



WITH A VOICE SCRAMBLER

Low-cost IC circuit makes message unintelligible without a similar unit

BY JOSEPH B. WICKLUND JR.

WOULD you like to be able to keep unauthorized people from listening to your private communications? Thanks to recent advances in integrated circuit technology, it is possible to build a low-cost voice scrambler that will make your message unintelligible to anyone who doesn't have a compatible unscrambler. Of course, voice scramblers have been around for many years, but most of them are too expensive or too difficult to use (or both). This circuit is easy to build, is reliable, and can be used as either the scrambler or unscrambler.

(Continued on page 42)

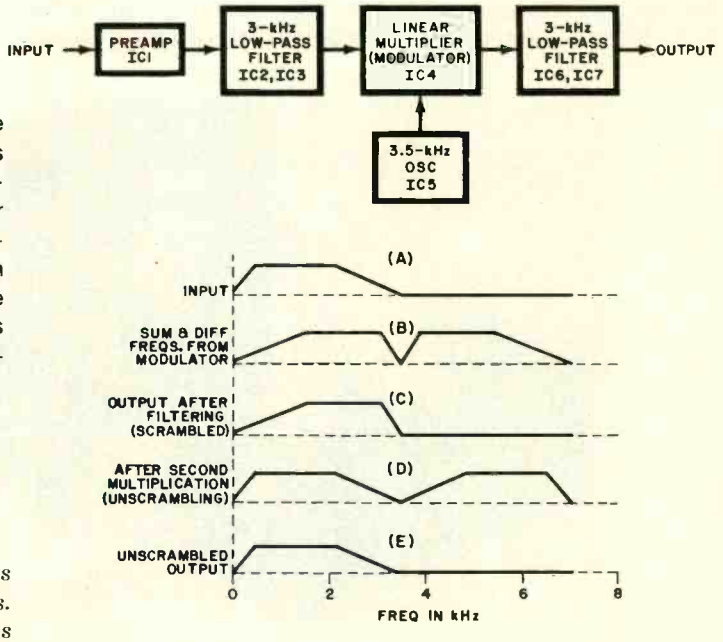


Fig. 1. Block diagram and waveforms show how the scrambler works. (A) is incoming signal; (B) is sum and difference; and (C) is output after filtering. Unscrambling is shown in (D) and (E).

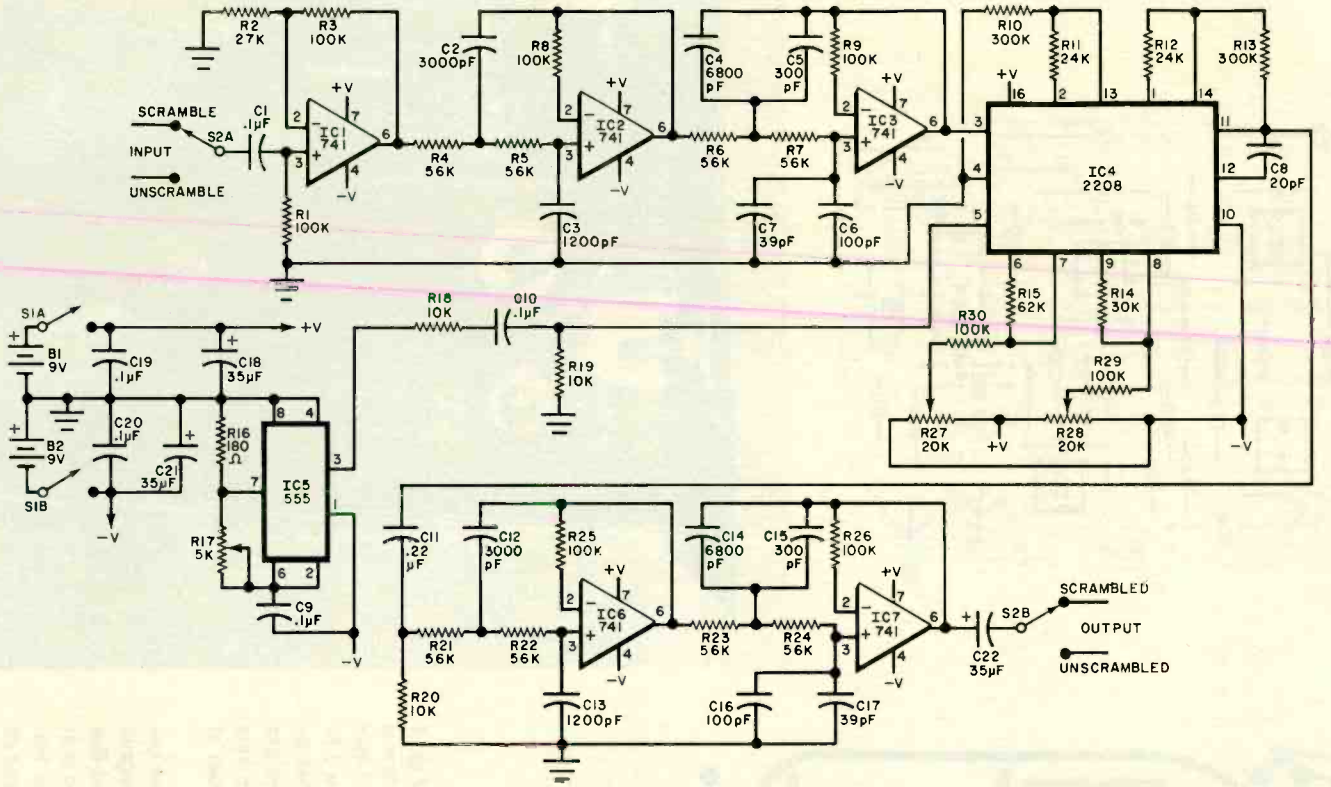


Fig. 2. Complete schematic of Scrambler.

PARTS LIST

B1, B2—9-volt battery (see text)
C1, C9, C10, C19, C20—0.1 μF Mylar capacitor
C2, C12—3000-pF, 5% capacitor
C3, C13—1200-pF, 5% capacitor
C4, C14—6800-pF, 5% capacitor
C5, C15—300-pF, 5% capacitor
C6, C16—100-pF, 5% capacitor
C7, C17—39-pF, 5% capacitor
C8—20-pF, 5% capacitor
C11—0.22-μF, Mylar capacitor
C18, C21, C22—35-μF, 25-volt electrolytic capacitor
IC1, IC2, IC3, IC6, IC7—741 op amp
IC4—2208 multiplier (Exar)
IC5—555 timer
R1, R3, R8, R9, R25, R26, R29, R30—100,000 ohm, ¼-watt, 10% resistor
R2—27,000-ohm, ¼-watt, 10% resistor
R4-R7, R21-R24—56,000-ohm, ¼-watt, 5% resistor
R10, R13—300,000-ohm, ¼-watt, 5% resistor
R14—30,000-ohm, ¼-watt, 5% resistor
R15—62,000-ohm, ¼-watt, 5% resistor
R16—180-ohm, ¼-watt, 10% resistor
R17—5000-ohm trimmer potentiometer
R18-R20—10,000-ohm, ¼-watt, 10% resistor
R27, R28—20,000-ohm trimmer potentiometer
S1, S2—Dpdt switch
Misc.—Suitable chassis (Bud SC2132), battery holders and connectors, mounting hardware, suitable input/output jacks, etc.

Note—The following are available from Northwest Engineering Co., 801 Duchess Rd., Bothell, WA 98011: Pc board (N007-PCB) at $8; IC4 (N007-MULT) at $9.25; Kit of pc board and board mounted parts (N007-PK) at $34.50. All postage paid in U.S. via parcel post or UPS.

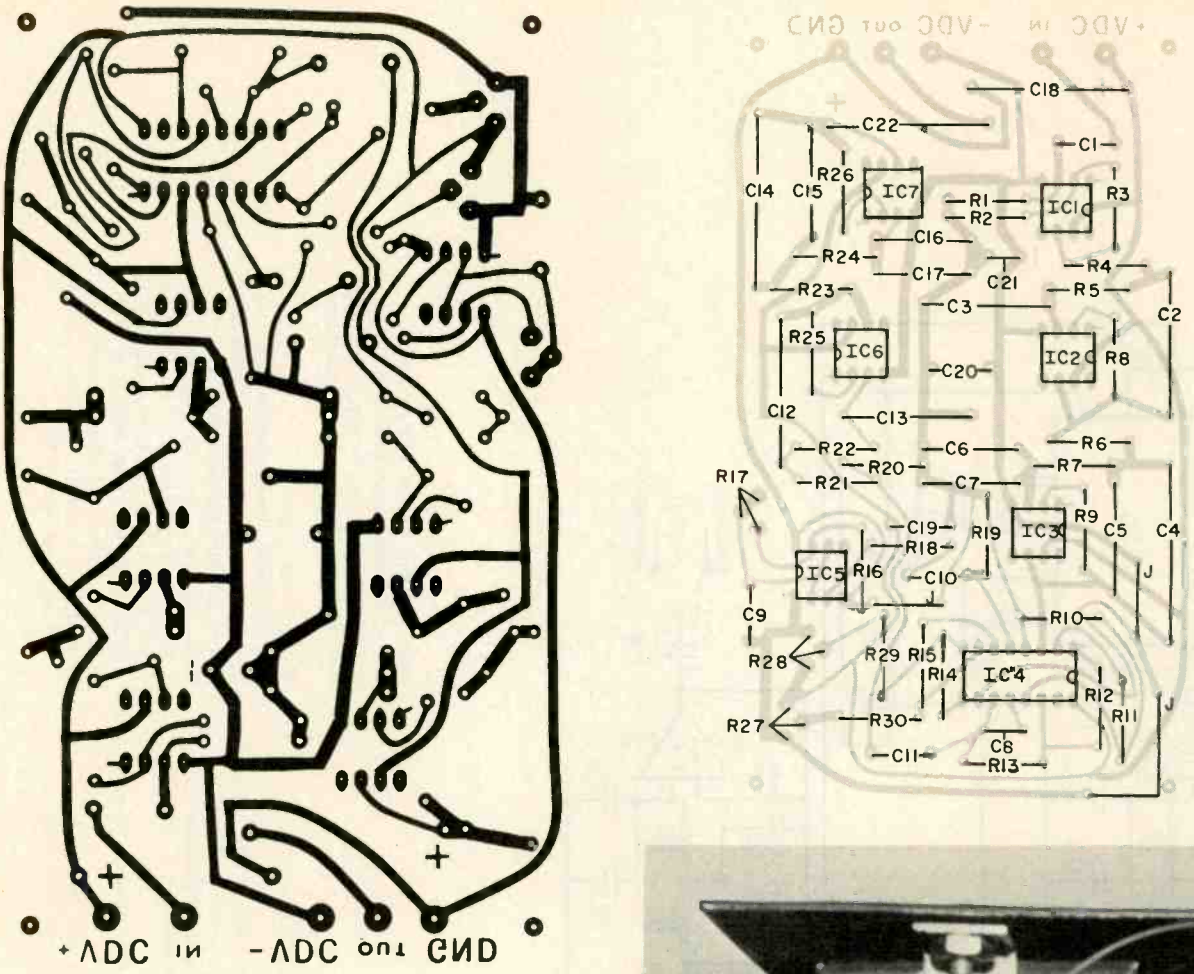
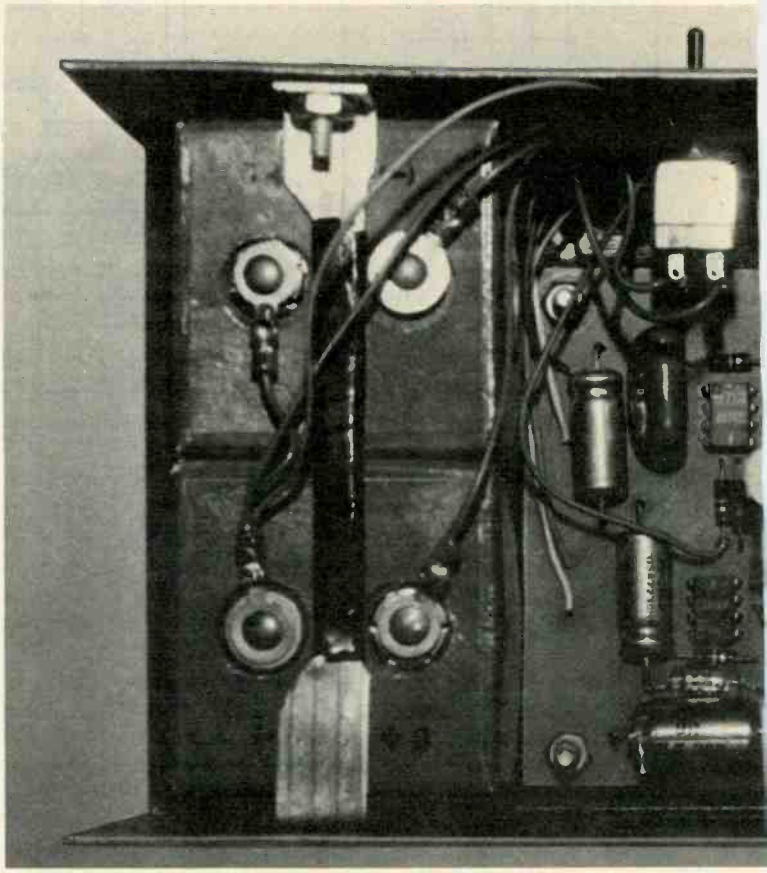


Fig. 3. Actual-size foil pattern for scrambler is shown at left; component layout at right.



How Scrambling Works. The block diagram in Fig. 1 shows how the scrambler works. The incoming audio signal is filtered to remove all frequency components above 3 kHz as shown at (A). The signal is then used to modulate a 3.5-kHz oscillator signal, with a linear four-quadrant multiplier as the modulator. The output (B) of the multiplier includes the sum and difference frequencies and any remaining 3.5-kHz carrier, leaving only the difference frequencies as shown at (C).

It is interesting to note that, in the output, the voice channel from 300 to 3000 Hz is contained in a single-sideband signal from 3200 to 500 Hz. It can be recorded or transmitted like any other voice signal, but the frequency spectrum of the output is an inversion of the input. (For example, an input frequency of 300 Hz is 3200 Hz in the output and an input of 2500 Hz is 1000 Hz in the output.) The inversion thus makes the voice message unintelligible.

When the scrambled signal is coupled to the input of a similar unit, the signal is re-inverted and the original audio comes out in unscrambled form as shown at (D) and (E) in Fig. 1.

Circuit Operation. The complete schematic of the voice scrambler is shown in Fig. 2. Integrated *IC1* is used as a high-input-impedance buffer amplifier to prevent loading on

the signal source. Resistors *R2* and *R3* control the gain of the buffer. An active low-pass filter with a cutoff frequency of 3000 Hz is provided by *IC2* and *IC3*. The shape of the filter is controlled by the feedback components (*R4-R7* and *C2-C7*) and the circuit is designed to provide a four-pole Chebyshev filter characteristic with 1 dB of ripple in the passband and a sharp roll-off. Integrated circuit *IC5* is a stable square-wave oscillator operating at a frequency determined by *R16, R17,* and *C9*. Potentiometer *R17* is used to adjust the oscillator frequency so that two or more units can be matched. The oscillator output is attenuated by resistors *R18* and *R19* and modulated by the output of *IC3*, the filtered input signal. The balanced modulator is *IC4*. Trimpots *R27* and *R28* provide balancing adjustments for the modulator. When they are properly adjusted, only the sum and difference frequencies of the two inputs will appear at the output. Integrated circuits *IC6* and *C7* form a low-pass filter to pass only the desired output signal.

The output of *IC7* can be used to drive load impedances as low as 2000 ohms. It can be used with most amplifiers, for speaker applications, or a set of 2000-ohm headphones.

Construction. To ensure that the active filters are properly tuned, it is recommended that 5% resistors and capacitors be used for the critical components (*R4-R7, R21-R24, C2-C7, and C12-C17*). The gain-controlling resistors for the multiplier (*R10-R13*) should also have 5% tolerances.

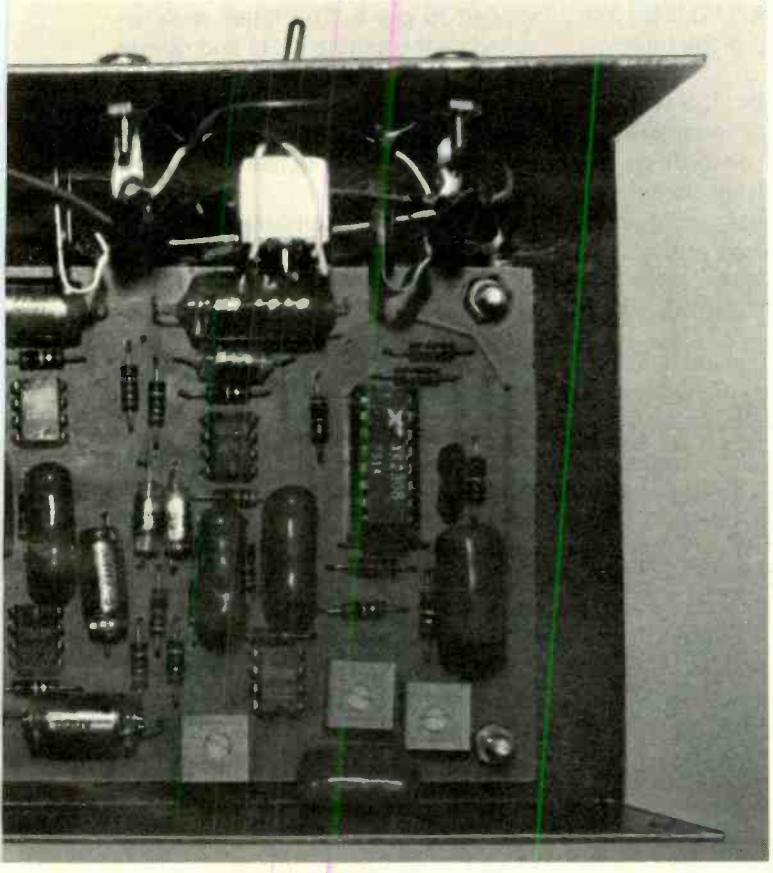


Photo shows how the prototype was assembled. Batteries are at left, but an extended supply can be used if desired.

Although the circuit can be wired point-to-point on perforated board, it is preferable to use a pc board such as that shown in Fig. 3. Be sure to observe the notch codes on the IC's and the polarities of the electrolytic capacitors so that they are properly installed.

In using a pc board, note that 8-pin DIP 741 op amps are required. If point-to-point wiring is used, other versions of the 741 (round, 14-pin DIP or dual) can be substituted.

Mount the batteries in holders in any convenient location in the chassis. If desired, the power can be obtained from an external supply between ±6 and ±15 volts. The supply voltage is not critical as far as circuit operation is concerned, but the maximum input signal level and the overall gain will vary for different supply voltages. The gain can be adjusted by changing the values of *R3* (raising it to increase the gain) and *R18* (lowering it to increase oscillator signal level).

The input and output connectors on the front panel must be chosen to suit the application.

Adjustment. For the proper operation, the oscillator should be adjusted to 3500 Hz. If an accurate counter or oscilloscope is available, *R17* can be adjusted while monitoring the output of *IC5* (pin 3). An alternate method of adjustment based on the accuracy of the lowpass filter can be used if necessary. With the input shorted to ground and *R17* turned fully counterclockwise, adjust *R28* to get an output of 0.15 volt on an ac voltmeter. Now adjust *R17* until the output voltage falls to 0.026 volt. The oscillator is now adjusted to approximately 3500 Hz.

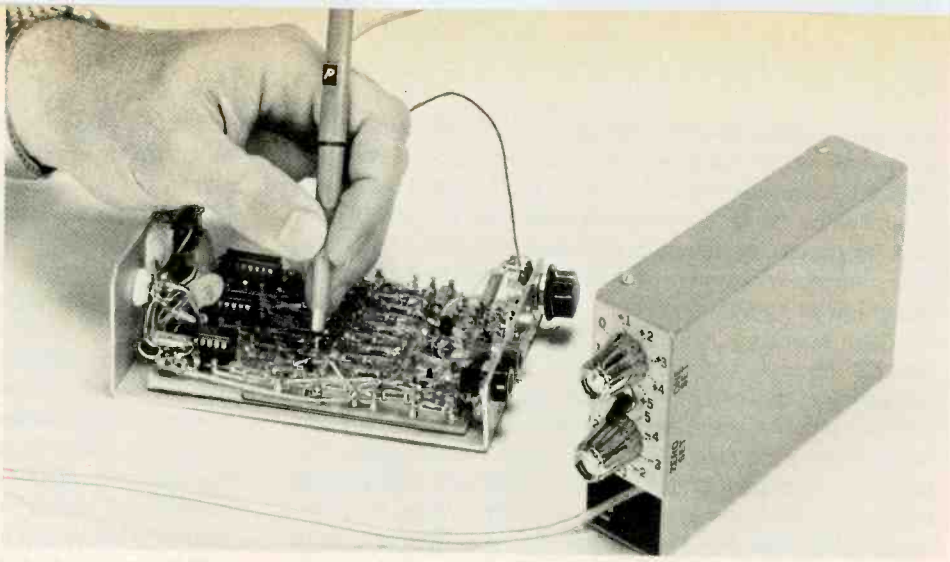
To balance the multiplier, it will be necessary to adjust *R27* and *R28* while monitoring the scrambler output with an ac voltmeter or a set of headphones. With no signal input, adjust *R28* for minimum output (near the middle of its range). To adjust *R27*, it is necessary to disable the oscillator by shorting across capacitor *C9*. With an input signal of about ½ volt (1000 to 3000 Hz), adjust *R27* for minimum output signal. The scrambler is now ready for use.

Use. A crystal microphone can be connected to the input of the scrambler with the output (with unity gain) connected to the MIC input of a tape recorder or transmitter. If headphones are used, the scrambled signal is connected between the recorder preamplifier and speaker amplifier (or receiver detector and audio amplifier).

The multiplier portion of the circuit can be used as a single-sideband modulator. The multiplier can be modified to operate with carrier frequencies as high as 5 MHz. Pins 13 and 14 of *IC4* should be shorted to pin 4, with *R10* through *R13* removed, a 5100-ohm resistor connected between pins 4 and 15, and pin 2 connected to pin 16. With *IC5* removed, the desired carrier signal can be coupled into pin 4 (using about 1 volt). The output of *IC4*, from pin 15, can be coupled into a SSB filter to remove the unwanted sideband.

The multiplier can also be used as a variable-gain amplifier, or remote volume control. If the oscillator is removed, the gain of the multiplier can be controlled by varying the dc level on pin 5 of *IC4* from 0 to 5 volts. One way to accomplish this is to include a 100,000-ohm potentiometer in series with a 100,000-ohm resistor across the positive supply. Remove *IC5, R18,* and *R19*. Connect C10 from *IC4* (pin 5) to ground. Connecting the wiper from the potentiometer to *IC4* (pin 5) will provide the desired variable voltage. For wide-band or hi-fi use, remove the two active filters. A control range of 50 dB can be obtained with low distortion. ◈

BUILD A "UNIVERSAL" DIGITAL PROBE



Tests virtually any digital logic family at speeds to 10 MHz.

BY JAMES P. TIERNEY

MANY different designs for digital logic test probes have appeared in the past few years. Most tend to favor a specific logic family, with TTL getting the most attention. Few, if any, are capable of checking ECL and MOS devices and circuits. The logic probe described here is designed for testing virtually all the logic families currently in use, including RTL, DTL, TTL, ECL, and MOS devices and circuits.

The universal logic probe, while larger than "ordinary" testers, is also completely self-contained. It has its own built-in battery power supply to simplify test hookups. (Most popular test probes derive their power from the circuit under test.)

An important factor to be considered in logic probe design is frequency response. Most testers will not respond to high frequencies. Thus extremely short duration pulses are lost and, in some cases, cause signal degradation in the circuit being tested. The universal probe solves this problem by being able to respond to frequencies in excess of 10 MHz. Furthermore, it will check for a logic 1 or logic 0 within 5 mV of a set value.

About the Circuit. The tester is made up of two parts: a small case containing all of the electronics (including two controls that permit you to preset the logic levels) and a probe assembly with attached cable. The probe itself contains a 7-segment LED display. The ground lead is attached to the body of the probe for easy connection to the circuit being tested.

The heart of the circuit is dual differential comparator integrated circuit *IC1* in Fig. 1. The *IC1B* half checks for a logic 1. Its pin-8 output is held low until the input on pin 5 from the probe is 5 mV (or greater) above the voltage applied to pin 6. The latter is determined by the setting of *R5* and ranges from −1 V to +5.25 V dc. When the input is greater than the voltage on pin 6, the output of the comparator sends *Q1* into conduction to cause a 1 to be displayed.

The 0 part of the circuit operates in the opposite manner. The input on pin 13 must be more negative than the preset voltage on pin 12, determined

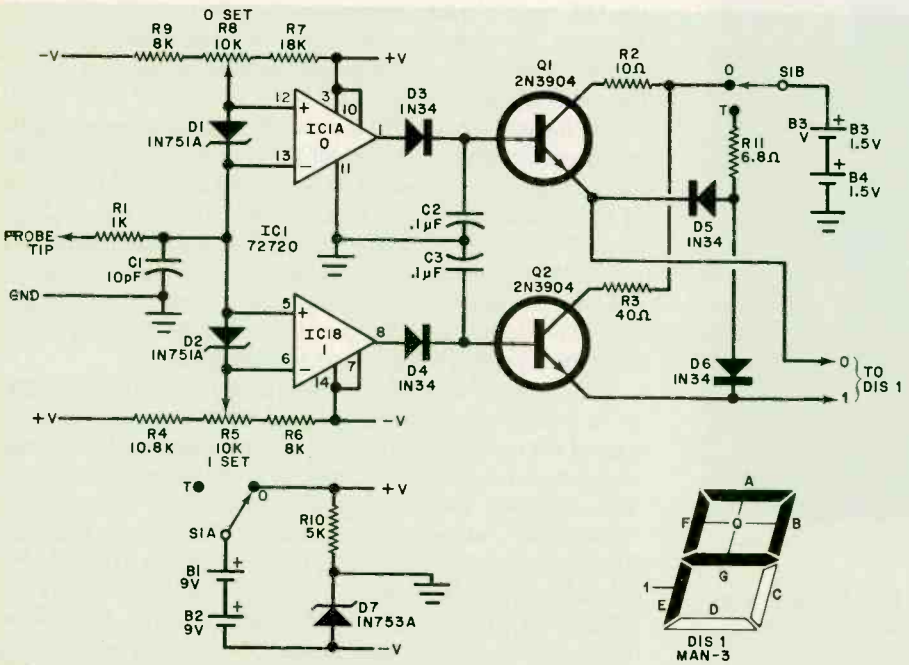


Fig. 1. Dual comparators sense the voltage at probe tip.

PARTS LIST

B1,B2—9-volt battery
B3,B4—1.5-volt battery (AA cell)
C1—10-pF, 10-volt capacitor
C2,C3—0.1-μF, 10-volt capacitor
D1,D2—1N751A zener diode
D3 to D6—1N34 diode (or similar)
D7—1N753A zener diode
DIS1—Seven-segment LED display (Monsanto MAN-3 or similar)
IC1—72720 dual differential comparator
Q1,Q2—2N3904 transistor (or similar)
The following resistors are ⅛ watt:
R1—1000 ohms
R2—10 ohms
R3—40 ohms
R4—10,800 ohms
R6,R9—8000 ohms
R7—18,000 ohms
R10—5000 ohms
R11—6.8 ohms
R5,R8—10,000 ohm miniature potentiometer
Misc.—Length of three-conductor shielded cable, plastic felt-tipped pen, cement, needle tip, knobs (2), press-on type, battery connectors, chassis, mounting hardware, etc.

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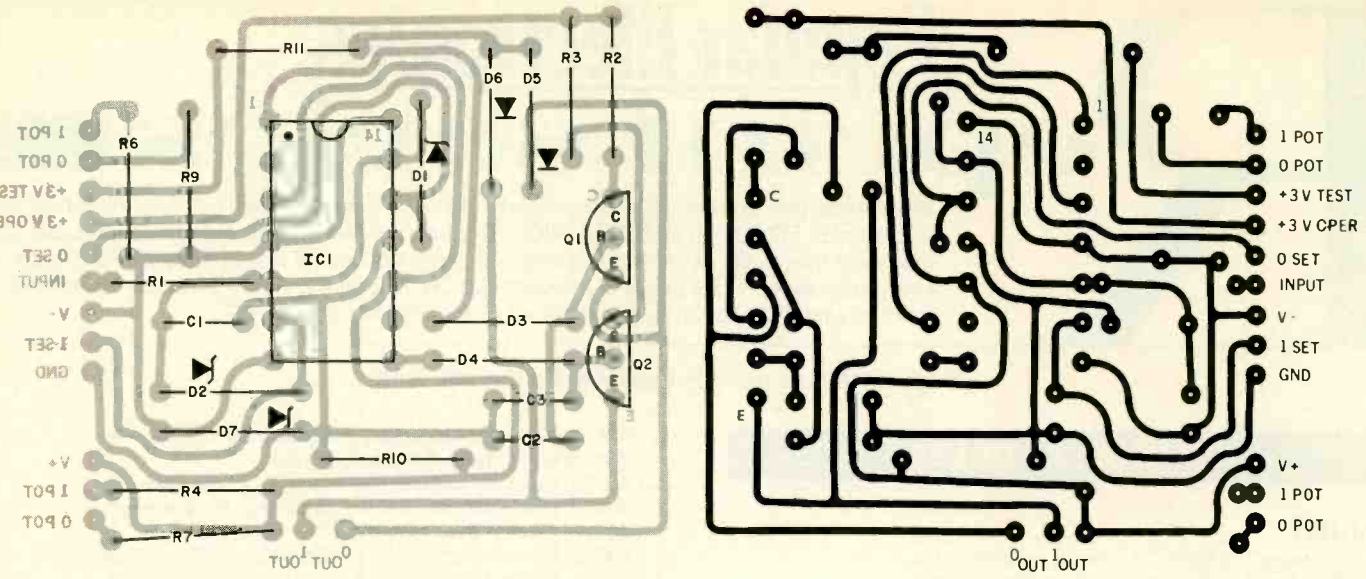


Fig. 2 Foil pattern (right) and component installation.

by the setting of *R8*. The range here is from −2 V to +3 V dc. When this section of the comparator turns on, *Q1* saturates, and the 0 portion of the display is illuminated.

Diodes *D3* and *D4*, in conjunction with capacitors *C2* and *C3*, ensure that, once the indicator is activated, it will remain on long enough to be seen, even with reasonably high pulse repetition frequencies. Resistors *R2*, *R3*, and *R11* provide current limiting for the display. Diodes *D5* and *D6* form a gate that allows testing the indicator before operation. Diodes *D1* and *D2* protect the IC inputs. Resistor *R10*, with *D7*, converts the 18 V from batteries *B1* and *B2* to −6 V and +12 V for the IC. Batteries *B3* and *B4* provide the higher current required for the seven-segment display.

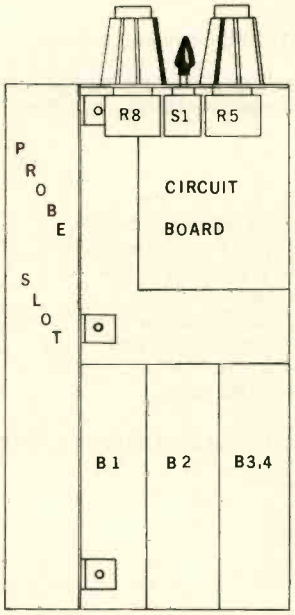


Fig. 3 Layout of chassis as used in prototype.

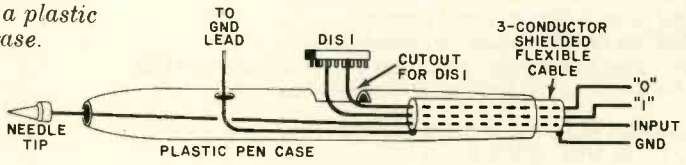
Construction. The tester can be assembled on a printed circuit board using the actual-size etching and drilling guide shown in Fig. 2. However, if care is exercised, the circuit could be assembled on perforated board using point-to-point wiring.

Mount the board and batteries in an enclosure approximately 1½" by 3" by 5½" as shown in Fig. 3. Note that part of the box is used to store the probe and cable when not in use. The two potentiometers and switch are mounted on one end of the chassis with appropriate identifications made with press-on type.

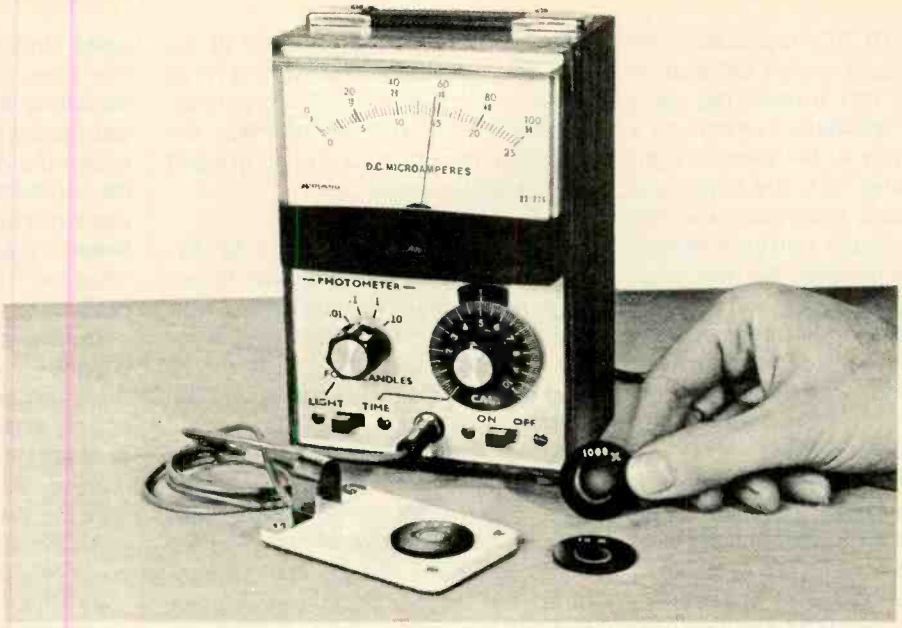
The probe can be made from a used plastic felt-tipped pen case as shown in Fig. 5. Using a three-conductor shielded flexible cable, identify the leads as 0, 1, and tip. Make the tip lead long enough to go through the end of the plastic case. Cut an opening on the side of the case slightly smaller than the LED display. Feed the 0 and 1 leads through this hole. On the display, interconnect segment leads A, B, F, and G. Solder the 0 lead to this combination. Solder the 1 lead to the E segment. Connect the display common to the coax shield. Feed the shield lead through a small hole below the readout and wrap it around the plastic case. Feed the tip lead through the front opening on the case. Seat the display in place and cement it securely. Fabricate a needle tip and solder it to the probe tip lead. Cement this in place.

When assembly is complete, connect a voltmeter between the rotor of potentiometer *R5* and ground. Rotate this potentiometer between its two extremes and mark the 1-volt calibration points on the front panel at the rotor of *R5*. Do the same for *R8*. Don't forget to indicate the polarity. Also make sure that the rotor of *R8* is always more negative than the rotor of *R5*.

Fig. 4. The probe can be fabricated from a plastic felt-tipped pen case.



Operation. To check a logic circuit, determine the high and low voltages for the 1's and 0's of the circuit being tested. Set the two potentiometers accordingly. Attach the probe ground to the circuit ground. Place *S1* in the test position (T). The display should indicate both a 0 and a 1 (which looks like the letter P). Place *S1* in the operate position and touch the probe tip to the circuit being tested. A logic 0 or a logic 1 should be properly displayed; or, if the circuit is transitioning between 0 and 1, both sections of the display will light. If the display remains blank, the test point is operating somewhere between 1 and 0, which means something is wrong. ◈



BUILD A

Wide-Range Photometer/Enlarger and Exposure Meter

BY A. A. MANGIERI

Valuable darkroom accessory covers broad spectrum of light intensities and exposure time ranges

IF YOU do any type of photographic enlarging, contact printing, light-intensity measuring, etc., you need a photometer/exposure-time meter. Here is a high-resolution instrument with 0.01-, 0.1-, 1.0 and 10-foot-candle (ft-c) ranges that are usable down to 0.0005 ft-c. Neutral-density filters can be used to extend the upper range to 10,000 ft-c.

Exposure-time ranges include 0 to 25, 50, and 100 seconds at any multiple or intermediate range desired. A calibration control accounts for differences in paper speed and other factors. And a number of contrast ranges assist in paper grade selection.

The assembled instrument features an illuminated meter scale, and a high-stability operational amplifier IC that has instant-on, zero drift, and immunity from line-voltage variations. A high-speed linear cadmium-sulfide photocell is used to sense the measured light.

About the Circuit. In the simplified light-measuring circuit shown in Fig. 1A, as the light intensity on *PC1* increases, the photocell's resistance decreases. This causes an increase in the input current, I_{in}. The feedback current in light-range resistor *R* produces a voltage, V_F, across this resistor which is the same as V_{out}. Consequently, *M1* indicates in direct proportion to the intensity of the light.

In the basic time-measuring circuit

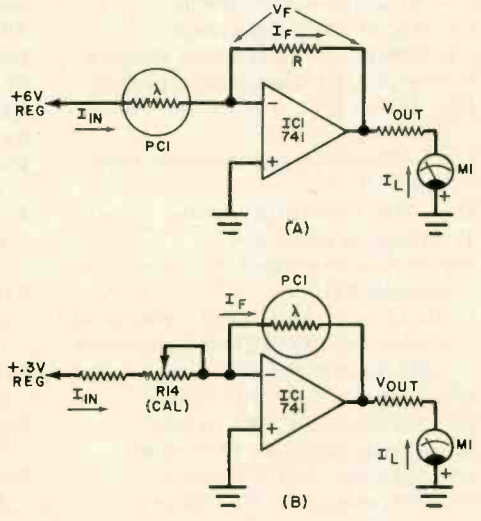


Fig. 1. Simplified op amp circuit for measuring light level (A) and exposure time (B).

shown in Fig. 1B, *PC1* is placed in the op amp's feedback circuit. Calibration potentiometer *R14* presets the input current—and feedback current—to a fixed level. With a decrease in light intensity striking *PC1*, the resistance of the photocell increases and the input and feedback currents remain equal and unchanged, but the feedback and output voltages increase. Thus, the meter indications are inversely proportional to the intensity of the light falling on *PC1*. An appropriate setting of *R14* provides a direct reading in seconds on *M1*.

The complete schematic diagram of the photometer/timer is shown in Fig. 2. Switch *S2* provides either light-level or time modes, while *S1* is used to select the light range. A split zener-diode power supply (*D1* and *D2*) provides the regulated voltages for *IC1*. Potentiometer *R16* sets the op amp's input bias, while *R15* is the offset-voltage null adjustment.

Meter movement protection is provided by the limiting (saturating) action of the op amp, while *C5* prevents rapid pegging of the meter's pointer. Capacitors *C1* and *C3* minimize the amplifier response to any ac present on the signal leads.

Construction. Except for *S1, S2, S3, R14, M1,* and *T1,* all components can be mounted on perforated board with push-in solder clips. Use a socket for *IC1*. Install *C1* and *C2* close to the IC socket. (A completely wired board assembly is shown in Fig. 3.)

Select an enclosure that is large enough to accommodate the meter and other front-panel controls, with enough depth to permit mounting the board assembly and *T1*. Start assembling the system by machining the enclosure's front panel to accept the controls and meter movement, and mount the parts in their respective holes. Do not forget to install phone jack *J1* on the front panel. Note that a two-circuit phone jack and plug are used. Only the tip and ring contacts of the plug (and their respective jack contacts) are used for the *PC1* lead connections. This is necessary because the photocell's leads must not be connected to ground. If you wish, use two-conductor shielded cable between *P1* and *PC1*, leaving the shield "floating" at the *PC1* end and connecting to the barrel contact on *P1*.

The meter scales (0-25 and 0-100) must be properly labeled to provide the appropriate meter readings. This can be accomplished with the aid of a dry-transfer lettering set. Carefully remove the snap-on cover from the meter movement and label the scales as shown in the lead photo. While the cover is off the movement, you can install the optional illumination lamps (*I1* and *I2*). Uniform scale illumination can be obtained by installing a bright reflective metal strip above the meter scales.

Use a well-subdivided scale for calibration potentiometer *R14*. Either

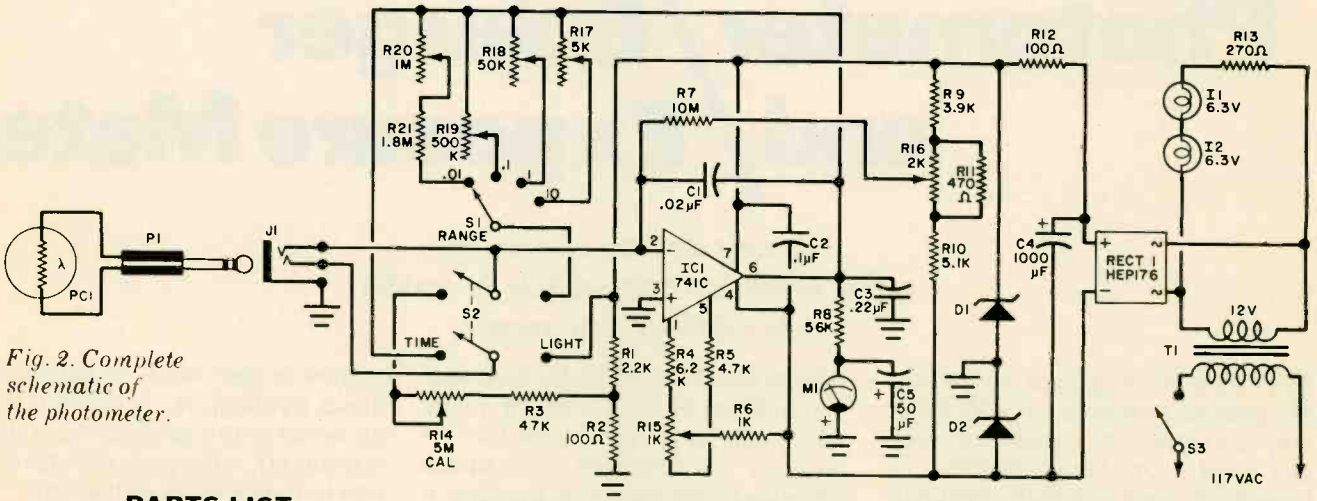


Fig. 2. Complete schematic of the photometer.

PARTS LIST

C1—0.02-μF, 25-V disc capacitor
C2—0.1-μF, 25-V disc capacitor
C3—0.22-μF, 25-V disc capacitor
C4—1000-μF, 35-V electrolytic capacitor
C5—50-μF, 15-V electrolytic capacitor
D1, D2—6.2-V, 1-W zener diode (HEP103 or similar)
I1, I2—Meter illumination lamp kit (Midland F71)*
IC1—741C operational amplifier
J1—Miniature phone jack
M1—0-50-microampere, 4-in. dc meter (Midland F64)*
PC1—Linear high-speed photocell (Clairex CL705HL) (Do not substitute)
P1—Miniature phone plug
R1—2200-ohm, ½-W, 10% resistor
R2—100-ohm, ½-W, 10% resistor
R3—47,000-ohm, ½-W, 10% resistor
R4—6200-ohm, ½-W 5% resistor
R5—4700-ohm, ½-W, 5% resistor
R6—1000-ohm, ½-W, 10% resistor
R7—10-megohm, ½-W, 10% resistor
R8—56,000-ohm, ½-W, 5% resistor
R9—3900-ohm, ½-W, 5% resistor
R10—5100-ohm, ½-W, 5% resistor
R11—470-ohm, ½-W, 10% resistor
R12—100-ohm, 1-W resistor (see text)
R13—270-ohm, 2-W resistor (see text)
R14—5-megohm, audio-taper potentiometer (Mallory U65 or similar)
R15—1000-ohm wirewound pc-type potentiometer (Centralab V-1000 or similar)
R16—2000-ohm wirewound pc-type potentiometer (Centralab V-2000 or similar)
R17—5000-ohm carbon pc-type potentiometer
R18—50,000-ohm carbon pc-type potentiometer
R19—500,000-ohm carbon pc-type potentiometer
R20—1-megohm carbon pc-type potentiometer
R21—1.8-megohm, ½-W resistor
RECT1—1-A, 200-V PIV bridge rectifier (HEP176 or similar)
S1—Single-pole, four-position, shorting-type rotary switch
S2—Dpdt slide switch
S3—Spst slide switch
T1—12-V, 0.3-A filament transformer (Radio Shack 273-1385 or similar)
Misc.—Perforated board; flea clips; case 3" x 4½" x 6½" (Vector W30-66-46); miniature shielded cable; line cord; dial plate; knobs; IC socket; 1/16" phenolic sheet; 22-megohm carbon resistors (2); 15,000-ohm carbon resistor; etc.

* The following are available from Electronics Distributors, Inc., 4900 N. Elston Ave., Chicago, IL 60630; meter (F64 less lamps), meter scale illumination kit (F71).

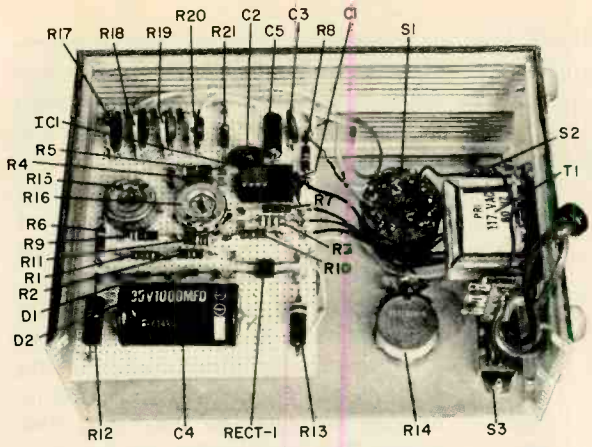


Fig. 3. Interior view of prototype showing placement of all parts.

a panel-mounted dial plate or a rotating dial flange can be used. Identify the front-panel controls with dry-transfer lettering.

Mount *PC1* between two pieces of thin phenolic board, allowing the sensitive surface of the cell to protrude through a hole in the upper board. The protrusion should be about 1/16 in. (1.59 mm) above the board's surface. After properly mating the boards, remove *PC1* and spray the outer surfaces a flat (matte) white paint.

Connect and solder the two inner conductors of a thin two-conductor shield cable to the leads of *PC1*. (Do *not* connect the shield to the photocell.) Insulate the solder joints with electrical tape. Place *PC1* in position and secure the two pieces of board together, with the cable sandwiched between them. A metal finger loop can be mounted on one end of the assembly for ease in positioning the sensor.

Connect the free end of the microphone cable to *P1*. The shield goes to the barrel contact, while the inner conductors go to the ring and tip contacts.

Power transformer *T1* can be mounted to the bottom or one wall of the enclosure with machine hardware. Connect its primary leads to a two-lug, *non*-grounding type terminal strip. Route the line cord through a rubber-grommet-lined hole drilled through the rear wall of the enclosure. Connect it to *S3* and *T1* as shown in Fig. 2.

Adjustment and Calibration. Using clip leads, connect a milliammeter in series with *R12*. If necessary, adjust the value of *R12* for an indicated current of approximately 70 mA. Install *R13* and measure the voltage drop at the meter lamp terminals; it should be 6.3 volts across both lamps. If not, adjust the value of *R13*. Check that there are about 20 volts dc across *C4*, and about 6 volts across *D1* and across *D2*.

To adjust the bias current of *IC1*, set *S2* to TIME, *R14* to maximum resistance, and remove *R1* from the circuit. Connect about 44 megohms of resistance (two 22-megohm carbon resistors in series) to a phone plug and insert it into *J1*. Then, adjust *R16* until *M1* indicates zero. If this cannot be accomplished, replace *R10* with a resistance between 3900 and 7500 ohms. Alternatively, you can increase (or omit) *R11* for a broader range.

The next adjustment compensates *IC1*'s input offset voltage. With 44 megohms plugged into *J1* and all other conditions as above, connect a 15,000-ohm, 10-percent resistor across pin 2 (input) and pin 3 (ground) of *IC1*. Adjust *R15* for a zero indication on *M1*. If this is not possible, slightly increase the value of *R5* and decrease *R4*, or vice versa. Maintain the sum of *R4* plus *R5*, at 8000 ohms or more.

Upon removing the 15,000-ohm resistor, *M1* should remain at zero. If not, repeat the input bias and offset adjustments. Install *R1* and check to see that there is a 0.3-volt dc drop across *R2*. Adjust *R1* or *R2* if necessary.

The final adjustments are made to calibrate the foot-candle ranges. The nominal resistance of *PC1* is 28,000 ohms at 2 ft-c and 56,000 ohms at 1 ft-c. Set range potentiometers *R17* through *R20* about halfway through their travels and set *S2* to LIGHT. Connect a 5600-ohm resistor to a phone plug and insert it in *J1*. This simulates the ideal resistance of *PC1* at 10 ft-c.

Set *S1* to the 10-ft-c range and adjust *R17* until *M1* indicates full-scale. Similarly, use a 56,000-ohm, a 560,000-ohm, and a 5.6-megohm resistor, respectively, to calibrate the 1-, 0.1-, and 0.01-ft-c ranges while adjusting the corresponding potentiometers. The simulating resistors used should have 5-percent or better tolerances. If an accurate photometer is available, you can use it to calibrate the light ranges.

Although neutral-density filters can be used to extend the light ranges, filters using film negatives are satisfactory for non-critical use. Using the enlarger as a light source, focus it and remove the film from the carrier. Place *PC1* on the enlarger easel and set *S1* to the 1-ft-c range. Stop down the lens until *M1* indicates 1 ft-c. For the X10 multiplier, select a portion of unwanted negative that, when placed over the sensor, causes the meter to indicate 0.1 ft-c. Affix the film to a thin blackened washer or disc that fits over the top of the photocell. Place the glossy side up to protect the emulsion from scratches. Selected film bits should be uniform and without detail.

Application. Measure light with *S2* set to LIGHT and *S1* set to the desired range. Measure time with *S2* set to TIME and *R14* set to a previously determined calibration setting for the particular application. The calibrating procedure for *R14* accounts for paper speeds, mode of operation, time scale in use, and processing factors. This is performed once for each set of conditions and recorded for future use. When calibrating or using the instrument, all darkroom lights must be off. Avoid directly illuminating *PC1* by the meter's lights.

Select an average negative and make the best possible print in the conventional manner using test strips. As an example, let us assume the best print required 15 seconds of exposure time at f/8 aperture. For the integrated light method, you will need a 2½-in. (6.35-cm) square piece of ground glass as a light scatterer. With the enlarger undisturbed, place *PC1* at the center of the projected image and set *S2* to TIME. Hold the light scatterer up to the enlarger's lens. Then adjust and record the settings of *R14* that result in 15 seconds indication on the 25-, 50-, and 100-second scales where possible. Also, record the data on the projection paper in use.

To use the exposure meter at a later date, set *R14* to the recorded setting for the particular paper and time scale. At almost any lens aperture and print magnification, use the light scatterer and observe the required exposure time. You can select the exposure time desired by varying lens aperture (or vice versa). A blackened paper tube

from a 35-mm film carton positioned over the sensor checks or eliminates the effect of stray light. During exposure, *S3* can be switched off.

Calibrate *R14* with the lens aperture set to one or two stops larger than the exposing aperture of the test print when using the instrument with small lamp enlargers. In the example, open the lens one full stop to f/5.6. Calibrate *R14* for 15 seconds indication on each time scale where possible. Using this mode of measurement, observe exposure time at any selected aperture and close down one stop before exposing. Alternatively, you can halve the indicated exposure and expose at the measuring aperture.

The spot method determines exposure time at print shadows without the use of a light scatterer. To calibrate, place *PC1* at important print shadows (bright portion of the projected image) and adjust *R14* until the meter indicates 15 seconds on each time scale. To use this mode, set *R14* as recorded for the paper and time scale, place *PC1* at the print shadows, and observe the required exposure time.

Contrast measurements use the light scales to determine the ratio of light levels at the bright and dark portions of the image. The table gives various contrast ranges with the setup

S1 Range (initial)	M1(%) (preset)	S1 Range (final)	Contrast Range
0.01	100	0.1	10
0.01	100	1	100
0.01	100	10	1000
0.1	40	0.1	2.5
0.1	40	1	25
0.1	40	10	250
0.1	20	0.1	5
0.1	20	1	50
0.1	20	10	500

requirements. Because it is used most frequently, set up the 0-to-25 range with *S2* on LIGHT and *S1* on the 0.1-ft-c range. Place *PC1* at the darkest area of the image and adjust the lens aperture until *M1* indicates 40 percent of full-scale. Advance *S1* one decade to the 1-ft-c range. Note that *M1* now indicates 1 on the 0-to-25 scale.

Move *PC1* to the brightest area of the image and read image contrast directly on *M1*. Middle contrasts of 8 to 15 indicate the use of normal-contrast paper. By keeping notes, relate contrast measurements with the required paper grade.

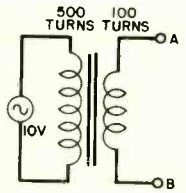
The integrated light method, preferably used with negatives of average balance, requires either a correction or recalibration of *R14* for negatives of predominantly light or dark scenes. The spot method, capable of handling almost any negative, assumes that projected print shadow areas are larger than the photocell's diameter.

By installing a photocell in the tip of a probe, you can take measurements on contact print boxes, viewing screens, etc. For camera applications, choose between the LIGHT and TIME scales. The TIME scales can be interpreted in any convenient manner, such as 0 to 2.5, 5, and 10 seconds or 0 to 250, 500, and 1000 milliseconds, and easily converted to fractional shutter speed if desired.

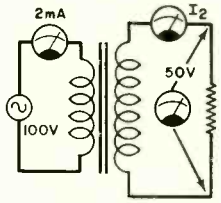
Bear in mind that CdS cells exhibit a memory effect related to previous light history. Therefore, avoid exposing *PC1* to sunlight or bright room lights prior to use. Also, response time increases with decreasing light levels. So, allow time for the meter indication to settle at very low light levels. Long-term meter drift proved to be nonexistent in use, but you can check meter zero by setting *S2* to LIGHT and removing *P1*. ◈

WHAT DO YOU KNOW ABOUT TRANSFORMERS?

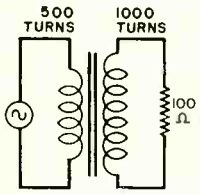
BY ROBERT P. BALIN



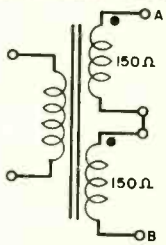
1. *Assuming no losses, the output voltage between A and B is ____ volts.*



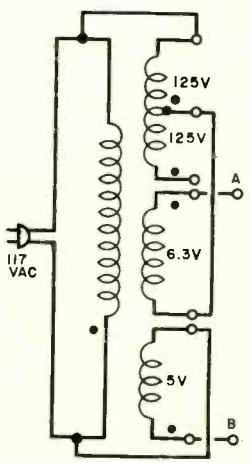
2. *Assuming no losses, secondary current I_2 is ____ mA.*



3. *The 100-ohm secondary load will look like ____ ohms to the primary voltage supply.*



4. *If the two 150-ohm windings are connected as shown, the output impedance between A and B will be ____ ohms.*



5. *Taking into account the way the windings are connected and their polarity markings, the output voltage between A and B will be ____ volts.*

Answers: 1. 2 volts; 2. 4 mA; 3. 25 ohms; 4. 600 ohms; 5. 9.3 volts.

Solid-state version uses LED's as the spinning ball.

BY ROBERT D. PASCOE

ELECTRONIC WHEEL OF FORTUNE

SIMULATES MECHANICAL GAME

THE WHEEL of fortune has always been one of the favorite games of chance. Perhaps it is because of the fascination of watching the wheel go around and around and not knowing where it will stop. You can build an electronic roulette which has little red lights going around and around, stopping eventually at a completely randomly selected number between 1 and 16. Players can select their number for each spin of the wheel, watch the lights, and collect their winnings if the light stops on their number. Like a mechanical wheel, the lights go fast at first and then slow down gradually before stopping at the winning number.

Circuit Operation. As shown in Fig. 1, a clock oscillator (*IC1*) operates at about 100 Hz when the SPIN pushbutton is depressed. When the switch is released, a time constant in the circuit causes the oscillator to slow down to a stop in about 10 seconds. The output of the clock is conditioned for the TTL logic by transistor *Q1*.

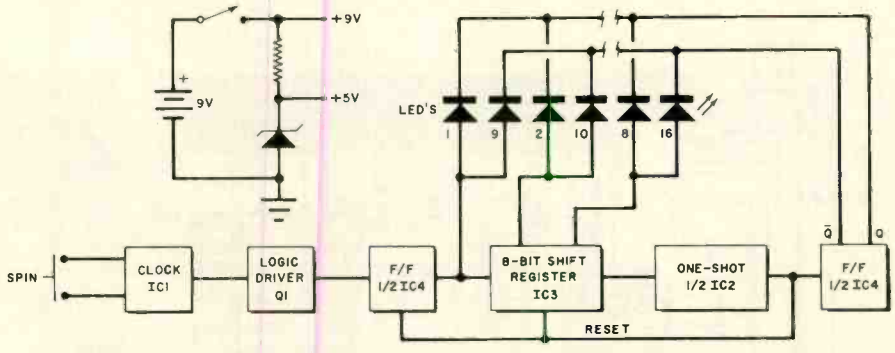


Fig. 1. Pressing the SPIN button starts the clock oscillator.

To understand how the 16 LED's are operated, note that the combinations of numbers 1 and 9, 2 and 10, through 8 and 16 are driven by the output of the first flip-flop and the 8-bit shift register. However, the selection of which of the eight combinations is in the circuit at one time is made by the state of the second flip-flop. As the clock delivers pulses to the first flip-flop, the digital one level is propagated from 1 through 8 on the LED's.

At the eighth clock pulse, the output of *IC3* operates a one-shot (*IC2*). This causes the output flip-flop to change states, so that the second eight LED's are selected. Simultaneously, the first flip-flop and the shift register are

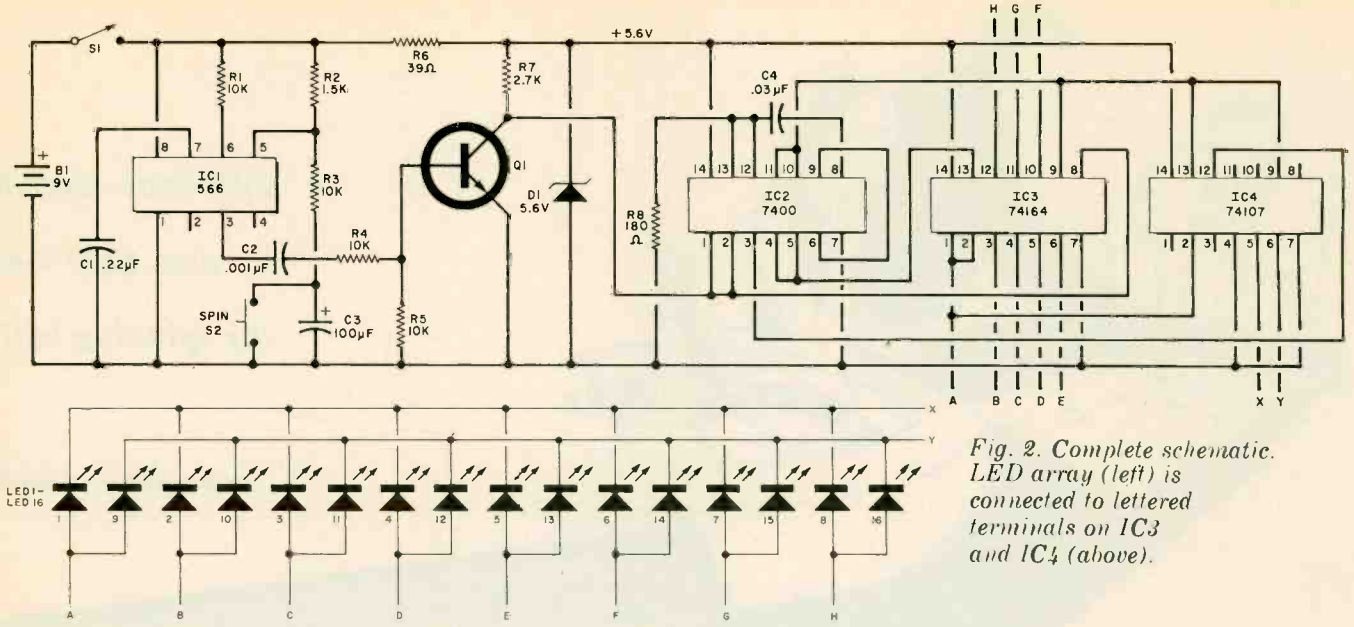


Fig. 2. Complete schematic. LED array (left) is connected to lettered terminals on IC3 and IC4 (above).

PARTS LIST

B1—9-volt battery (6 C cells)
C1—0.22-μF capacitor
C2—0.001-μF capacitor
C3—100-μF, 15-V electrolytic capacitor
C4—0.03-μF capacitor
D1—5.6-V zener diode
IC1—Function generator (566)
IC2—Quad 2-input NAND gate (7400)
IC3—8-bit shift register (74164)
IC4—Dual JK flip-flop (74107)
LED1 to LED16—Light emitting diode
Q1—Silicon npn transistor
R1, R3-R5—10,000-ohm, ¼-W resistor
R2—1500-ohm, ¼-W resistor
R6—39-ohm, ¼-W resistor
R7—2700-ohm, ¼-W resistor
R8—180-ohm, ¼-W resistor
S1—Spst switch
S2—Normally open spst pushbutton switch
Misc.—Suitable enclosure, press-on type, C-cell holders, insulated wire, mounting hardware, etc.

reset. In this way, the same logic is used for all 16 LED's. The complete schematic is shown in Fig. 2.

Construction. The circuit can be assembled on perforated board or on a pc board such as that shown in Fig. 3. Be sure to observe the polarities and coding on all components and use a low-power soldering iron. Note that there are three jumpers on the board.

The prototype was housed in a plastic enclosure 6½" × 3¾" × 2". As shown in the photo, the cover of the box was drilled for the 16 LED's arranged in a circle. The holes should be just large enough to fit the tops of the LED's. The lights can be identified at random using press-on type. The two switches can be mounted on the cover as shown.

Since the project has a current drain of about 100 mA, six C cells, in holders mounted on the bottom of the enclosure, can be used. This allows about 10 mA for the LED's. Any color can be used for the LED's, but it is advisable to have a few extras so that they can be selected to have all 16 glow with about the same brilliance. ◈

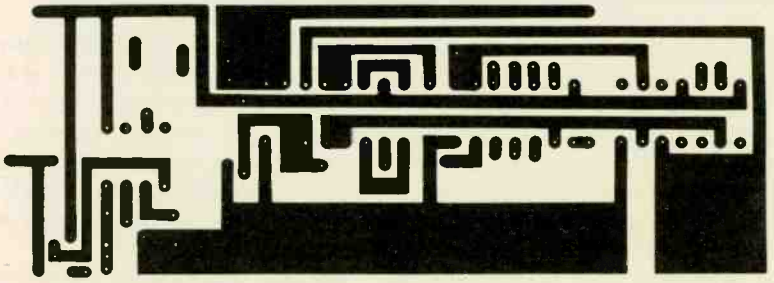


Fig. 3. Etching and drilling guide above; component layout below.

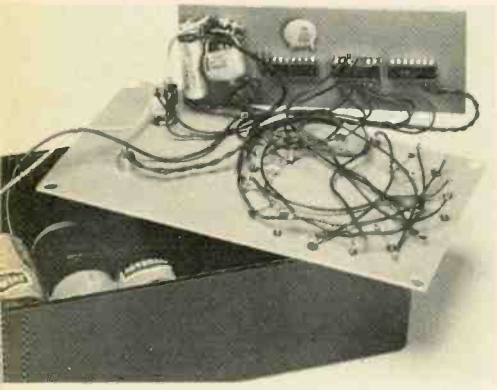
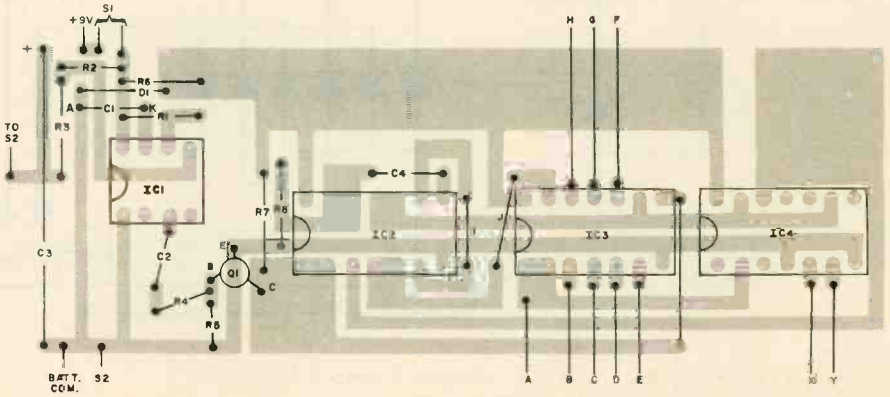


Photo shows how LED's were arranged on top of the enclosure.



CONSTRUCTION

THE POWER GUARD

Boosts voltage and eliminates TV picture shrinkage during summer brownouts

BY JULES H. GILDER

DURING the summer months, when power demands peak, brownouts are an all too common occurrence. As power companies cut back on the amount of voltage delivered to the ac outlets in your home, the picture on your TV receiver is likely to shrink and lose color, your lights might dim slightly, and some of your appliances may have difficulty operating on the unaccustomed low voltage. Some electrically operated appliances can even be irreparably damaged if they are operated on too low a voltage.

Most people just grit their teeth and try to bear with the inconveniences of the brownout situation. This is one way to approach the problem, but a more practical approach would be to use a device that will restore the line voltage level to normal. This is exactly what the Power Guard is designed to do. It is completely automatic. As the line voltage begins to fall below a predetermined level, the Power Guard compensates for the reduction by boosting the voltage available at its output. Then, when the power company restores normal service, the Power Guard switches itself out of the line, to remain ready to go into action again when the next brownout occurs.

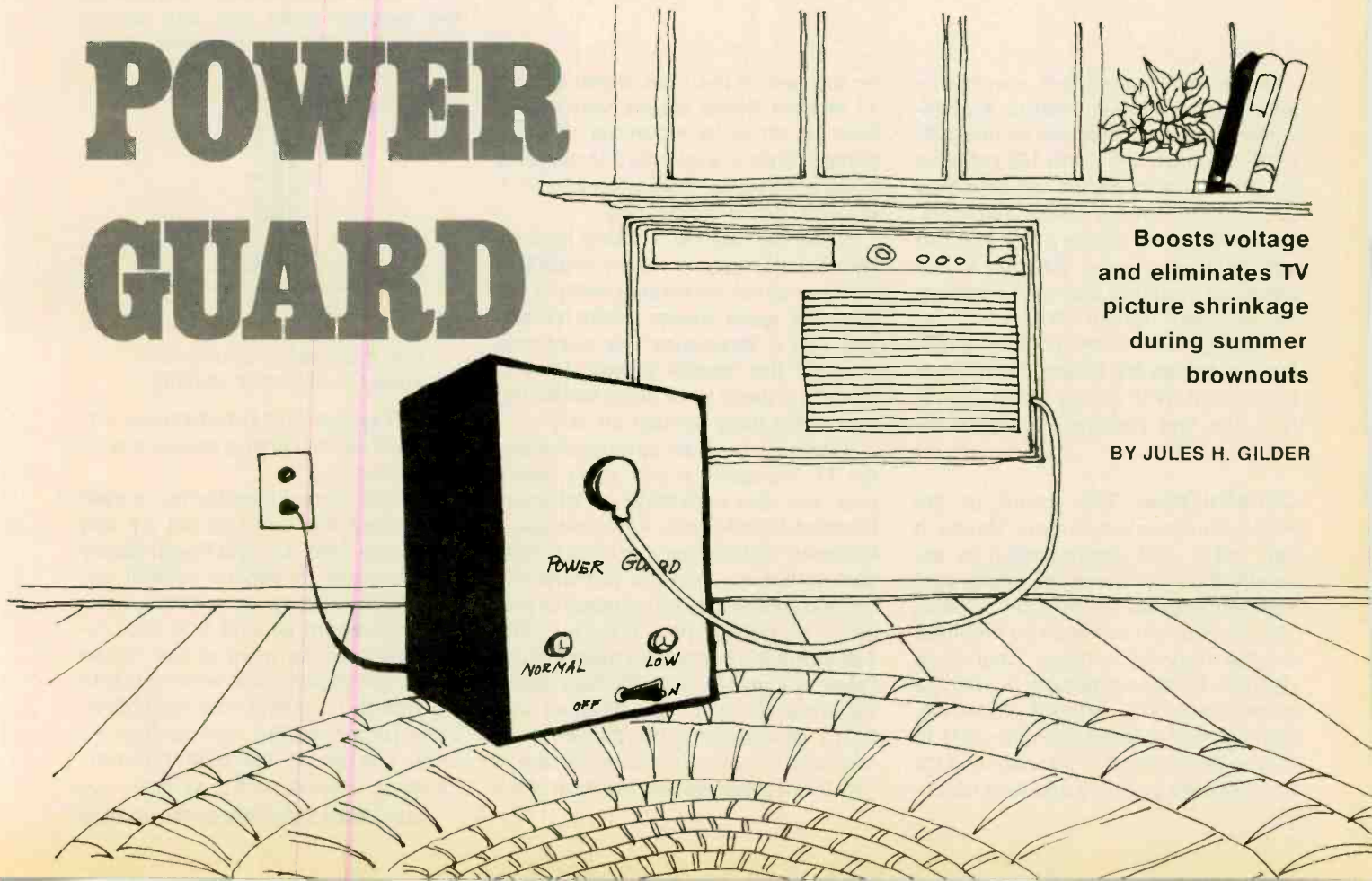
About the Circuit. A voltage-sensing circuit that operates a relay, causing it to switch a transformer in and out of the ac line is the heart of the Power Guard (see Fig. 1). The sensing circuit is made up of the voltage divider formed by *R1* and *R2*, neon lamp *I1*, and silicon controlled rectifier *SCR1*.

When switch *S1* is set to ON, line voltage is applied across the *R1*/*R2* divider network. Assuming that this potential is greater than 105 volts ac, *I1* will fire. This, in turn, indicates that the power available at the wall outlet is at a "normal" level. By adjusting *R2*, the line potential at which *I1* is triggered can be varied.

When *I1* comes on, it applies current to the gate of *SCR1*, triggering the silicon controlled rectifier into conduction and energizing relay *K1*. When this happens, the relay's lower set of contacts places output receptacle *SO1* directly across the ac line. Capacitor *C1* across the solenoid of *K1* eliminates the possibility of relay chatter that would normally be caused by the rectified voltage coming through *SCR1*.

When a brownout occurs and the line voltages drops below the value predetermined by the setting of *R2*, *I1* extinguishes and removes gate current from *SCR1*. This causes the SCR to cut off on the next zero crossing of the line voltage and deenergizes *K1*. This, in turn, switches the secondary of *T1* into the circuit, which is designed to add the primary and secondary voltages. This "boosted" voltage is then delivered to *SO1*. The magnitude of the voltage boost depends on the secondary voltage of *T1* at the reduced line voltage. The point at which the boost comes into play depends on the setting of *R2*. (Note also that, when the boost circuit is operating, *I2* comes on to provide a visual indication that line voltage is down.)

Tracking, the opening and closing of the relay's contacts caused by minor changes in line voltage, is eliminated by *I1*. The reason for this is that the neon lamp's firing voltage is higher than that required to maintain it in the ionized state. So, while the lamp requires about 110 volts to fire, it will not extinguish until the line voltage drops to 105 volts.



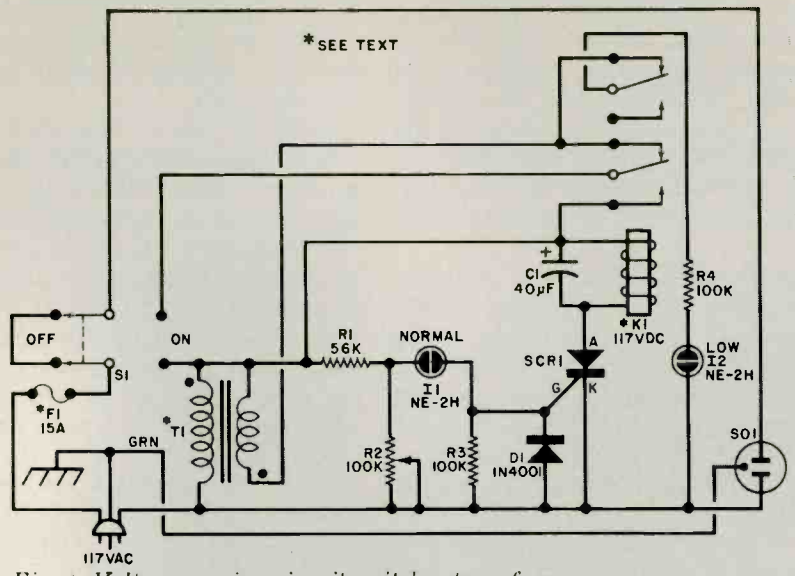


Fig. 1. Voltage-sensing circuit switches transformer in and out of circuit to keep voltage up during brownout.

PARTS LIST

C1—40-μF, 200-volt electrolytic capacitor
D1—Silicon rectifier (1N4001 or similar)
F1—15-ampere fuse (3AB, 15A)
I1, I2—NE-2H neon lamp
K1—117-volt dc relay with dpdt contacts rated at 20 amperes or more
R1—56,000-ohm, ½-watt resistor
R2—100,000-ohm trimmer potentiometer
R3, R4—100,000-ohm, ½-watt resistor
S1—Heavy-duty dpdt power switch rated at 25 amperes or more
SCR1—200-volt silicon controlled rectifier (HEP-R1211 or similar)
SO1—Three-contact chassis-mounting ac receptable
T1—Autotransformer (Allied Electronics Cat. No. 705-0144 16-ampere or 705-0104 8-ampere type) or high-current filament transformer (See text)
Misc.—Metal chassis box; heavy-duty three-wire line cord with plug attached; fuse holder for F1; perforated board and solder clips; machine hardware; hookup wire; solder; etc.

Since most electrical appliances and electronic instruments are designed to operate properly on line voltages ranging from 105 to 125 volts, no change in performance will be noted until the line drops below 105 volts. Using this as the trigger point, you can add between 10 and 20 volts to the potential available during the brownout to obtain normal service.

Placing *S1* in its OFF position effectively removes the Power Guard from the system. With *S1* set to OFF, therefore, the line voltage is coupled directly to *SO1*.

Construction. The circuit of the Power Guard is very simple. Hence, it can easily and conveniently be assembled on a piece of perforated epoxy-fiberglass or phenolic board. The transformer can then be mounted on the floor of a metal case large enough to accommodate it and the board assembly without crowding. Don't forget to leave room for *SO1* to mount on the front of the case and for the line cord exit hole and fuse holder on the rear of the case. If you build a 15-ampere Power Guard, you should have no difficulty mounting all of its components in a standard (preferably steel) metal case measuring 9″ × 7″ × 6″ (22.9 × 17.8 × 15.2 cm).

Since you will be working directly with line voltages, it is very important that you check all wiring carefully before you apply power. Make certain you use a three-wire line cord and connect the neutral (green) lead to chassis ground via a large solder lug and to the third contact on *SO1*.

It is best to use an autotransformer for *T1*. However, if you can't locate one, you can substitute an ordinary filament transformer. If you do use a filament transformer, you must take care to assure that the primary and secondary are properly phased to provide a boost in voltage. (The transformer's secondary must also be rated at a greater current than would be drawn by any load plugged into *SO1*.) To determine the proper phasing, wire the transformer as shown in Fig. 2 and measure the potential at the "output" leads. Transpose the secondary leads and again measure the output voltage. The connection scheme that yields the higher voltage is the proper phasing setup.

Setup and Use. To use the Power Guard properly, it is necessary to first adjust *R2* so that the system triggers *SCR1* at the correct voltage level. The simplest way to adjust *R2* is to plug the Power Guard into a variable transformer and decrease the potential applied to the system's power plug to 105 volts. If you don't have access to a variable transformer, a filament transformer connected as a "bucking" instead of "boosting" autotransformer can be used.

When the potential is 105 volts, adjust *R2* so that *I1* just extinguishes. At this point, the relay in the system should not be energized, and the booster winding in the Power Guard should be in the circuit. If you measure the voltage at *SO1* it should be between 110 and 120 volts ac.

Once *R2* has been adjusted for the proper triggering level, it need not be touched again. The Power Guard is ready to use.

Appliances can be permanently plugged into *SO1* and the Power Guard's switch set to OFF when no brownouts are expected. Then, during the months when you can expect brownouts, just flip the switch to ON,

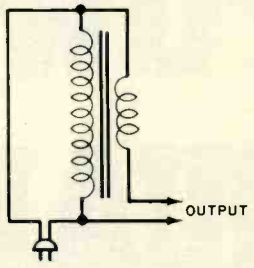


Fig. 2. Circuit to determine proper transformer phasing.

and the system will automatically adjust itself to the varying conditions as they occur.

If a high-current transformer is used for *T1* and the contacts on *K1* can handle the load, a single Power Guard can be used to service several appliances simultaneously. In this case, you can mount several *SO1*-type receptacles on the front of the Power Guard's front panel and wire them into the system in parallel with each other. Don't forget to also replace fuse *F1* when you go to the higher power-handling capacity of the system. ◈

HOME EMERGENCY LIGHT for "BLACKOUTS"

- *Automatic "on" when ac power fails*
- *Full-wave battery-charging circuit*
- *Doubles as lantern flashlight*
- *Compact, neat design*

BY WILLIAM OLDACRE

WHEN a power blackout occurs, one is likely to get caught in the dark without ready access to a flashlight or candle. Here is a hand emergency light to solve the problem, minimizing possible injury and fear due to darkness.

This emergency light goes on *automatically* whenever ac power is interrupted for one second or more, providing several hours of light before a recharge is needed. (The 1-second delay is built in to prevent flickering.) In addition, the system includes a battery charger which maintains full charge on ordinary nickel-cadmium batteries. It can also double as a portable flashlight and is designed into a neat, small package.

This home safety device is simple to build, requiring easy-to-get parts and modification of an inexpensive lantern-type flashlight.

How It Works. The schematic of the emergency light is shown in Fig. 1. Transformer *T1*, *RECT1* (a full-wave bridge rectifier), and filter capacitor *C1* form a low-voltage dc power supply. When line voltage is applied to the circuit, *LED1* glows. Current through *LED1* is limited by *R1*. The power supply provides charging current for battery *B1*, two NiCd cells. Diode *D1* prevents the battery from discharging back through the LED. Charging current is limited by either *R3* or *R4*. When switch *S1* is in the SLOW position, *R3* allows 33 mA to flow into the battery. When *S1* is placed in the FAST position, *R4* provides 100 mA, which charges *B1* more quickly.

The dc voltage also energizes relay *K1*. Since the relay coil is energized under normal (line voltage-on) conditions, it might tend to get very warm. To keep the coil cool, resistor *R2* is placed in series with it, lowering the amount of continuous current flow. The path between the battery and the light bulb (*I1*) is controlled by the relay contacts. Under line-on conditions, no current can flow through the bulb.

When the line power drops out, however, the relay coil is de-energized, and the contacts complete the circuit between the battery and the light bulb. The bulb automatically lights up, providing emergency illumination. To prevent the emergency light from flashing on and off whenever the line voltage drops for a fraction of a second (for example, when your refrigerator compressor kicks in), we take advantage of the fact that it takes about one second for the voltage across *C1* to decay to the point where the relay drops out. The exponential properties of the RC circuit smooth out any instantaneous variation in line voltage.

The flashlight is a self-contained unit which connects to the power supply through a three-conductor power plug-jack combination. When independent flashlight operation is desired, switch *S2* takes over the relay's switching operations by pro-

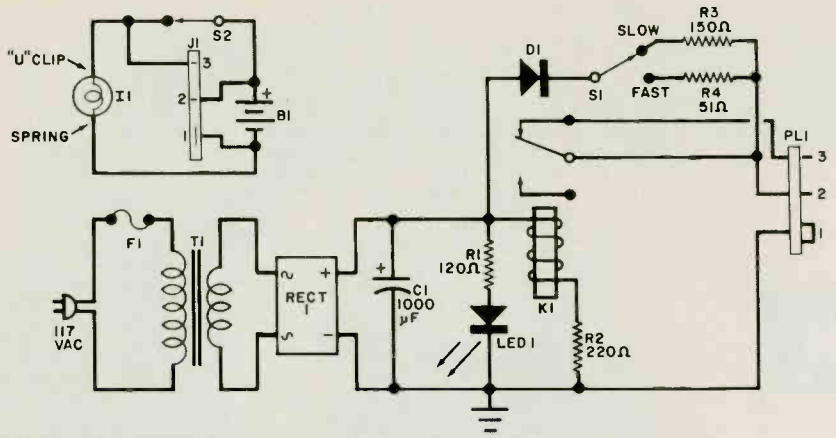


Fig. 1. Schematic of the emergency light. Power failure causes K1 to drop out, supplying power to I1.

PARTS LIST

B1—Two General Electric GC-3 1.25-volt, 1.2 A-hour nickel-cadmium batteries
C1—1000-μF, 16-volt upright electrolytic capacitor (Radio Shack 273-958 or equivalent)
D1—1-A, 50-PIV silicon rectifier
F1—¼-A fuse (Buss AGC ¼ or equivalent)
J1—Three-conductor power jack (Cinch-Jones S303AB or equivalent)
K1—6-volt SPDT relay (Radio Shack 275-004 or equivalent)
LED1—Light emitting diode (Sprague ED-123 or equivalent)
PL1—Three-conductor power plug (Cinch-Jones P303AB or equivalent)
R1—120-ohm, 1-watt resistor
R2—220-ohm, ½-watt resistor
R3—150-ohm, ½-watt resistor
R4—51-ohm, 2-watt resistor
RECT1—2-amp, 50-PIV bridge rectifier (Radio Shack 276-1151 or equivalent)
S1—SPDT miniature toggle switch
S2—SPST pushbutton switch (furnished with lantern)
T1—6.3-volt, 300-mA filament transformer (Radio Shack 273-1384 or equivalent)
Misc.—Chassis box 4" x 2⅜" x 6" (Radio Shack 27-252 or equiv.), lantern (Sears 4841, Ray-O-Vac L295 or equiv.), fuse clips (Buss 5682-41 or equiv.), metal battery holder (Radio Shack 270-1439 or equiv.), piece of 1" wood 4" sq., ¾" x ⅛" aluminum angle stock, ¼-inch metal spacers, printed circuit or perforated board, line cord, rubber grommets, battery holder, wood screws, machine hardware, brass shim stock, adhesive-backed decorative vinyl, dry-transfer lettering, hookup wire, solder, etc.

viding an alternate path for current flow from the battery to light bulb *I1*.

Construction. The emergency light is composed of two units: a portable flashlight and the base/recharger which it plugs into.

Components forming the recharger circuit should be mounted on a printed circuit or perforated board. Etching and drilling and component placement guides for pc board fabrication are shown in Fig. 2. Mount the components on the board, paying close attention to the polarities of *C1*, *D1*, the leads to *LED1*, and *RECT*. (Align the rectifier so that the dot on the top of the case faces north. The pin facing north is the +dc output. South is negative, east and west are the ac inputs from the secondary.) Fuse *F1* can be mounted either on the back panel using a panel-mount holder, or on the circuit board using standard fuse clips. The clips require 4-40 mounting hardware. The two 4-inch (10-cm) leads should be connected from *LED1* to the appropriate pads on the circuit board. Three 4-inch (10-cm) leads should be run from the board for *S1*, and three 10-inch (25.4-cm) leads for *PL1*. Drill holes in the utility box for pc board standoffs, rubber feet, *LED1*, *S1*, and the line cord. Insert the line cord through its hole using a grommet or strain relief and connect its leads to the transformer primary. Then mount the circuit board in the utility box using ⅜-inch (0.64-cm) metal spacers.

The prototype uses Cinch-Jones three-conductor power connectors, but substitutions are OK. Drill two mounting holes in the wood block and a hole for *PL1's* leads through the cover of the utility box. Install a grommet in the hole for the leads.

Plug *PL1* is mounted on a 3½" x 3½" x ¾" (8.9 x 8.9 x 1.9 cm) block of wood, which is covered with walnut grained adhesive-backed vinyl. Drill holes on the bottom side for mounting hardware (make sure these don't go all the way through), *PL1*, and the top two metal guide rails (completely through the block). These rails should be fashioned from ¾" x ⅛" (1.9 x 0.32 cm) aluminum angle stock. Round the corners of the aluminum, and drill two holes for securing hardware. Position

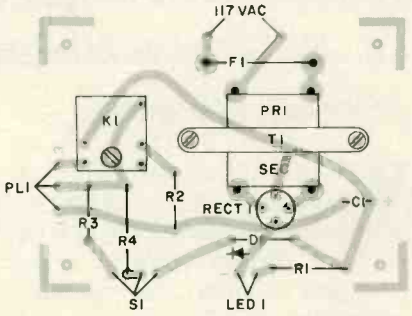
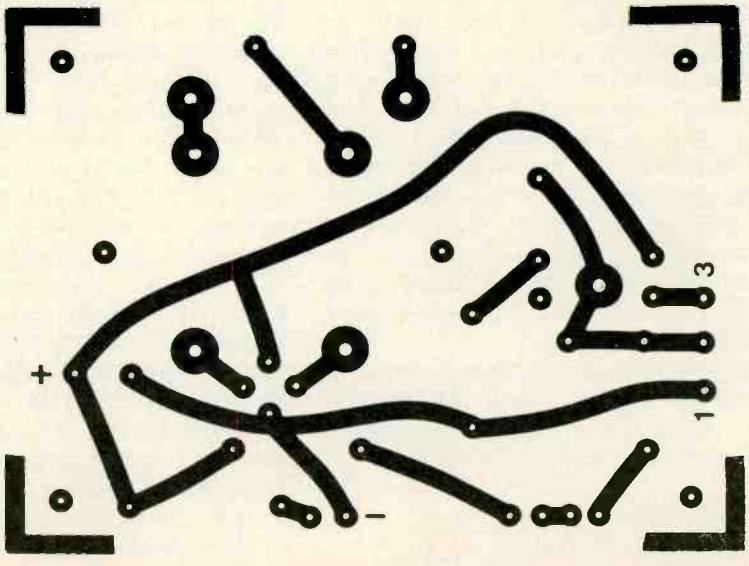


Fig. 2. Etching and drilling guide for pc board is below; component placement at right.



the rails so that they accept the flashlight you choose to use (the one in the photo is a Sears model), and then drill holes into the top of the wood block to match those in the guide rails. Give the rails a brushed appearance by rubbing them lengthwise with fine steel wool under running water. Then attach the rails to the block with ½" (1.25 cm) roundhead wood screws.

Secure plug *PL1* to the wood block and attach the appropriate leads from the circuit board. Mount the block on the top of the utility box's cover, lining up the holes you previously drilled. Secure the block to the cover with roundhead wood screws.

Final assembly of the base/recharger may now be accomplished. First, label the front panel as shown in the photo using dry-transfer letters. Then apply several light coats of clear acrylic spray. This will prevent the letters from being worn off. After the spray has dried, secure *S1* in its mounting hole. If your *LED1* has no mounting collar, use a ¼-inch (0.64-cm) O.D. rubber grommet to keep the LED secure. Slip the cover onto the utility box and secure it with the hardware provided for this purpose. This completes the assembly of the base/recharger.

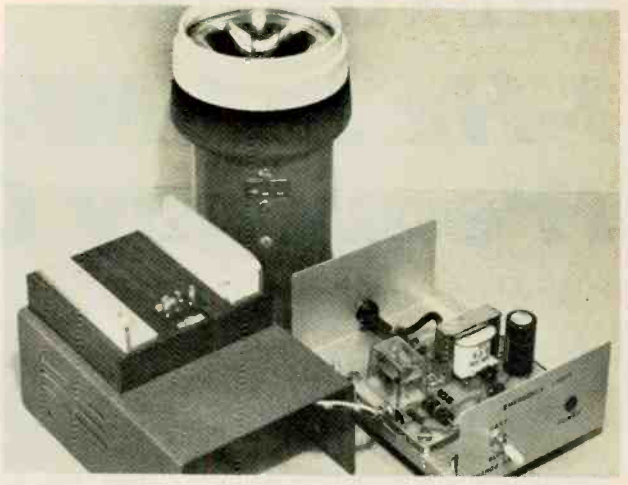


Fig. 3. Base with recharger is shown without cover. Flashlight plugs into socket on wooden block.

It is necessary to modify the hand lantern that you choose. Disassemble the lantern, and find the "molding line" running down the middle of the housing. This can be used to accurately center the power jack *J1*. Cut a hole in the bottom of the housing that conforms to the power jack you will install. Use a very sharp safety knife to cut the plastic. Drill holes for the mounting screws for the jack and for a metal battery holder. Rather than soldering inside the lantern housing, prewire the components outside the housing as shown in Fig. 4. Replace the light bulb with a lower voltage unit (see accompanying box).

Do *not* solder the light bulb lead to the brass rivet on the back of the bulb's nylon retainer nut. Instead, remove the compression spring and solder the lead to one loop of spring. Then replace the spring and feed the wire through the hole in the rivet. To make bulb replacement more convenient, install a small in-line connector in the lead between the spring and terminal of jack *J1*. A U-shaped clip which fits around the barrel of the lamp socket is furnished with the lantern. Solder two leads to the clip, one of which is connected to terminal 3 of *J1*. Connect the other to *S2* as shown in the schematic. Note that *S2* is the lamp's original ON/OFF switch. Fasten the U-shaped clip to the lamp socket base. Complete the wiring of *J1* and *S2*, and then install two 1.25-volt NiCd batteries in the metal holder. Reassemble the lantern.

Testing. Make one final check of all wiring before applying power to the unit. Then, setting the lantern aside, plug the line cord into a wall socket. A distinct click should be heard as the relay is energized, and *LED1* should glow. If all is well, plug the lantern into the base/recharger. If *I1* lights up, switch if off with *S2*. (If this doesn't turn *I1* off, disconnect the line cord and recheck all wiring.) Allow the batteries to charge for about ten minutes with *S1* in the FAST position. Then simulate a power failure by disconnecting the line cord. The lantern should light up after a one-second delay. If the lantern checks out OK, plug the line cord back into the wall socket, and allow the batteries to charge for at least 16 hours.

Operation. The lantern should be placed where fail-safe illumination is most needed. After the initial charge (with *S1* in the FAST position), use the SLOW charge rate, as this will offer extended battery life and slightly lower consumption. ◈

SELECTING AN INCANDESCENT BULB.

The battery power source used in the emergency light holds a power capacity of 1.2 ampere-hours at 2.5 volts (when fully charged). This means that it can keep a 1.2-A current flowing for one hour. Alternatively, it can sustain a 0.6-A current for two hours, 0.3-A for four hours, and so forth. Obviously, the smaller the current drain from the power source, the longer the flow can continue. You will have to decide for yourself how long you will need the light to function before the NiCd cells are completely discharged.

If you live in an area plagued with frequent (but brief) power blackouts, this discharge time is not too important. Alternatively, if your neighborhood gets rare (but prolonged) power losses, duration of the power source should be extended.

These factors will dictate your choice of lantern light bulb. The type PR-2 light bulb, which draws 0.5 A at 2.4 volts, will discharge the battery source in about 2 hours and a quarter. If you choose a PR-4 bulb instead, the NiCd cells will last about 45% longer, since it draws only 0.27 A at 2.3 volts. Although the PR-4 will produce less light than the PR-2, many builders will prefer it because it is easier on the supply. If even longer duration (and a lower light level) are desired, you can choose a less demanding bulb type or add current-limiting resistors in series with the bulb.

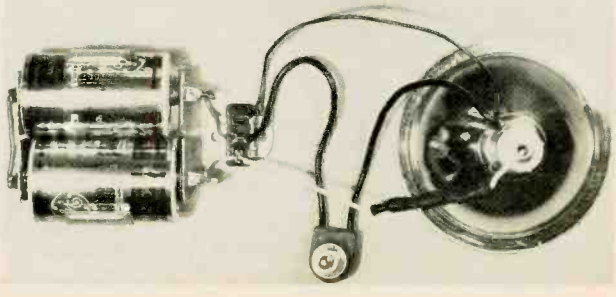


Fig. 4. Modifying flashlight is best done by working outside the flashlight housing.

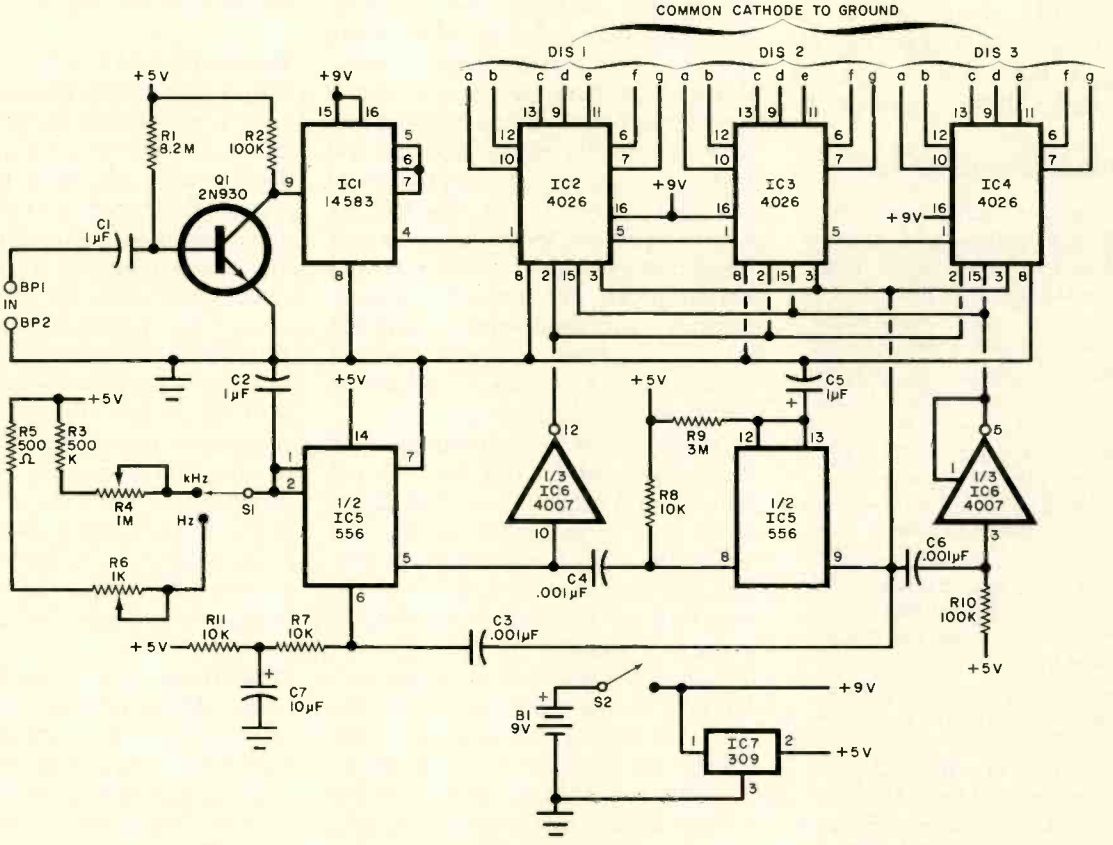
BUILD A LOW-COST 1-Hz to 1-MHz Frequency Counter

Sophisticated, low-cost counter with 3-digit readout uses state-of-art CMOS chips.

BY NORMAN P. HUFFNAGLE

A FREQUENCY counter can be as useful in working with electronic equipment as an oscilloscope, yet it is often the last piece of test gear the hobbyist and experimenter buys. The main reason for this save-for-last attitude stems from the fact that commercially made counters are relatively high priced. Now, however, the easy availability of inexpensive "surplus" IC's and low-current LED displays makes it possible for you to build a low-cost, three-digit frequency counter with a range from 1 Hz to about 1 MHz). By shopping carefully (see the ads at the back of this magazine), you should be able to build your frequency counter for just about $25 to $30.

Circuit Operation. A frequency counter consists of a wave shaper that should have a reasonably high input impedance and a series of decade counting units. The wave shaper "conditions" the input signal to give it the clean-edged waveform necessary to trigger the decade counting units. The outputs of the counters drive numeric displays. The entire operation is controlled by a time base that enables the counter for a precise period of time. During the enable in-



PARTS LIST

B1—9-volt alkaline battery
BP1,BP2—Binding post (one red, one black)
C1,C2,C5—1-µF ceramic, Mylar, or polystyrene capacitor
C3,C4,C6—0.001-µF disc capacitor
C7—10-µF, 16-V, electrolytic capacitor
DIS1 through DIS3—Common-cathode 7-segment LED display (Motorola HEK-5 or similar)
IC1—14583 Schmitt trigger IC
IC2,IC3,IC4—4026 decade counter IC
IC5—556 dual timer IC
IC6—4007 dual complementary pair and inverter IC
IC7—5-volt regulator IC (LM309 or similar)
Q1—2N930 or similar transistor
Following resistors are ¼ watt:
R1—8.2 megohms
R2,R10—100,000 ohms
R3—500,000 ohms
R5—500 ohms
R7,R8,R11—10,000 ohms
R9—3 megohms
R4—Subminiature 1-megohm potentiometer
R6—Subminiature 1000-ohm potentiometer
S1—Spdt switch
S2—Spst switch
Misc.—Perforated board; IC sockets (optional); battery holder; small Bakelite or plastic case; machine hardware; hookup wire; solder; etc.

terval, all events present at the input are counted and totalized. At the end of the count interval, the counts are stored and displayed. The counter is then inhibited from accumulating more counts until the display period ends. Then the frequency counter is reset and a new count cycle begins.

The complete circuit of the frequency counter is shown in the schematic. The input circuit can be modified according to the availability of components. Just keep in mind that the input should have a reasonably high impedance and that the input of the *IC2* decade counter should have a clean positive-going leading edge.

Integrated circuit *IC1* is a Schmitt trigger that conditions the input signal and converts it to logic levels suitable for the *IC2* through *IC4* counter chain. The tenth input count to *IC2*, at pin 1, generates a "carry" pulse at pin 5 to toggle *IC3*. At the instant the carry pulse is generated, *IC2* causes *DIS1* to display a 0, while *IC3* causes *DIS2* to display a 1. When a tenth input pulse is applied to the input of *IC3*, a carry pulse toggles *IC4* and *DIS2* displays a 0 and *DIS3* a 1. In this circuit, the carry output of *IC4* (pin 5) can be used to turn on the decimal point of *DIS1* to indicate an overrange condition.

The timing starts with half of the dual timer (*IC5*). Switch *S1* enables either a 1-s or a 1-ms timing interval. During this interval, the second half of *IC5* generates a 2- or 3-second display interval during which the counters are disconnected from the input and the display system is unblanked. At the end of the display, a reset pulse initiates the timing/counting interval.

Construction. Except for the input binding posts, switches, and displays, the entire circuit can be assembled on a piece of perforated board using point-to-point wiring. The only critical area of assembly is around *Q1* and the input of *IC1*, where high-frequency signals will be present. Mount *Q1* and *IC1* at the end of the board nearest where the input jacks will be mounted on the case.

The displays, switches, and input binding posts should mount on the front of the enclosure. Mount the displays side by side in a slot just large enough to accommodate them and cement them in place. Then mount the binding posts and switches and complete circuit wiring according to the schematic diagram.

Calibration. You can use any frequency counter of known accuracy and a signal generator to make all frequency adjustments. Simply set *S1* to the Hz position, drive the counter with some fairly low-frequency signal, and adjust the setting of *R6* for the correct indication. If you are using a highly accurate frequency counter to monitor the output of the signal generator, adjust *R6* so that the displayed numbers on both counters are the same. Repeat the procedure with a high-frequency signal.

If you do not have access to a highly accurate frequency counter, you can calibrate the dial of any audio signal generator using a 60-Hz source and Lissajous pattern (on an oscilloscope). Then use the outputs as a reasonably accurate signal source to calibrate the frequency counter.

If you have an older signal generator whose dial has a high degree of inaccuracy, you can build the low-cost frequency counter into it. Then you will always know at exactly what frequency the generator is operating.◈

BY ROBERT W. LLOYD

SEVERE WEATHER WARNING ALERTER

Low-cost add-on to weather receiver sounds the alarm if a weather "alert" is broadcast

TORNADOES, hurricanes, and other severe weather disturbances often strike in the middle of the night or at times when most people are not normally listening to the radio or watching TV. Consequently, they receive no advance warning and are unaware of the impending danger.

Residents of areas where disturbances often occur have taken to listening to transmissions from the National Weather Service stations operating on 162.40 or 162.55 MHz in most parts of the country. The receivers used for this purpose generally range from low-cost battery-powered units to vhf/FM scanners. There are also some expensive receivers with special circuitry to alert police stations, etc., to a forthcoming severe-weather announcement by the NWS.

The under-$15 circuit described here will enable you to duplicate the special alert provisions of the costlier NWS receivers. It decodes the 1050-Hz warning tone used for the alert (when it occurs) and automatically activates the normally quiet receiver. This puts your low-cost unit in the same class as the professional weather warning systems.

Circuit Operation. The circuit (Fig. 1) is essentially a controller for relay *K1*, whose normally open contacts are between the receiver audio output transformer (secondary) and the loudspeaker. Thus the speaker is normally disconnected and resistor *R1* provides a substitute load. Capacitor *C1* is used to isolate diodes *D1* and *D2*, which provide signal clipping to prevent overdrive of *IC1*. Capacitor *C2* isolates the diode clip-

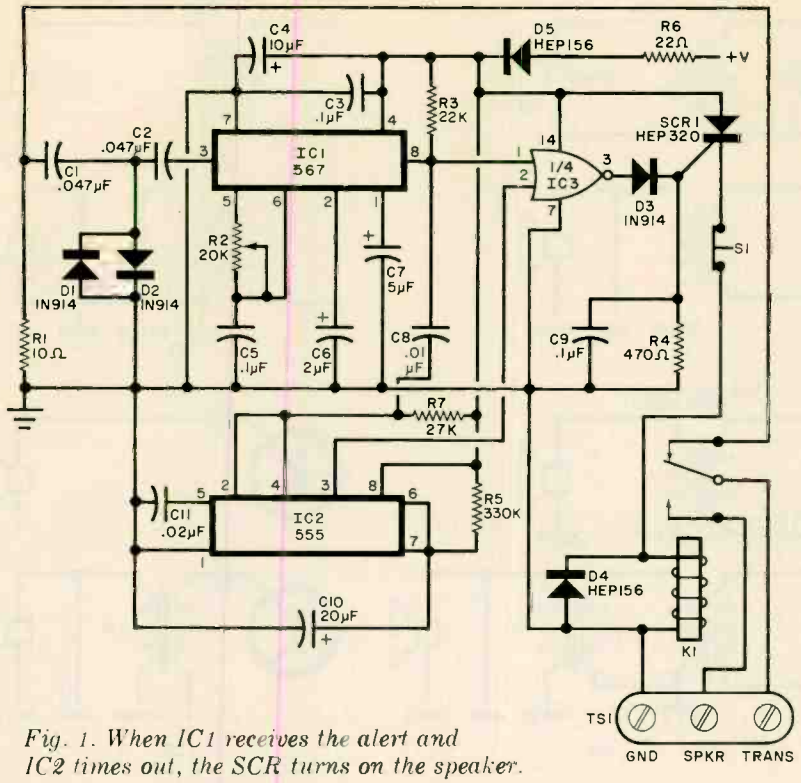


Fig. 1. When IC1 receives the alert and IC2 times out, the SCR turns on the speaker.

PARTS LIST

C1, C2—0.047-µF Mylar capacitor
C3,C9—0.1-µF disc capacitor
C4—10-µF, 15-V electrolytic capacitor
C5—0.1µF Mylar capacitor
C6—2-µF, 15-V electrolytic capacitor
C7—5-µF, 15-V electrolytic capacitor
C8—0.01-µF disc capacitor
C10—20-µF, 15-V electrolytic capacitor
C11—0.02-µF disc capacitor
D1,D2,D3—1N914 diode
D4,D5—HEP156 rectifier diode
IC1—567 phase-locked loop
IC2—555 timer
IC3—4001 CMOS
K1—6-12-V, 500-ohm coil, spdt relay (Radio Shack 275-004 or similar)
R1—10-ohm, 5-W resistor
R2—20,000-ohm trimmer potentiometer
R3—22,000-ohm, ½-W resistor
R4—470-ohm, ½-W resistor
R5—330,000-ohm, ½-W resistor
R6—22-ohm, 1-W resistor
R7—27,000-ohm, ½-W resistor
S1—Normally closed pushbutton switch
TS1—Three-connector terminal strip
Misc.—Suitable enclosure, power supply (see text), mounting hardware, IC sockets, etc.

per from *IC1*, since any dc component at the input to *IC1* could cause false decoding.

Trimmer potentiometer *R2*, in conjunction with *C5*, determines the decoding frequency (1050 Hz) while *C6* determines the bandwidth and *C7* sets the decoder timing. When not decoding, the output of *IC1* (pin 8) is high. When *IC1* receives a tone within its locking range, the output drops low. This output is applied to one input of a gate in *IC3*. The output is also coupled through *C8* to trigger *IC2*, a 555 timer.

The timer is required because false alarms can be produced by random receiver noise or voice announcements which occasionally are at 1050 Hz. Since the signals producing false alarms are usually of short duration, but the real alert tone is transmitted for at least 15 seconds, some form of timing circuit is needed.

The output of *IC1* is connected to pins 2 and 4 of *IC2*. When a pulse appears, *IC2* resets and starts its timing cycle. Resistor *R5* and capacitor *C10* set the length of the cycle (about 10 seconds). When *IC2* times out, its output (pin 3) goes low and is applied to the input of *IC3*. When (and only when) the two inputs of *IC3* are both low, its output goes high.

As long as the 1050-Hz tone is not present at the input of *IC1*, the circuit idles, with *SCR1* not conducting and the relay deenergized. When the 1050-Hz signal is received from NWS, the output of *IC1* goes low and *IC2* starts timing. At the end of the timing cycle, the output of *IC3* goes high and *SCR1* starts to conduct through the relay coil. Then the loudspeaker is connected to the receiver's audio output and the weather bulletin is heard. Diode *D4* reduces the back emf generated across the coil and *D5* prevents damage due to application of reverse power supply. Pushbutton switch *S1* is used to reset the decoder and turn off the speaker.

Construction. Parts placement is not critical and the circuit can be assembled on perforated board or a pc board. Sockets for the IC's are suggested. Do not install the IC's before reading the following instructions on tuning. Any enclosure of suitable size can be used.

The circuit operates from a 6-12 volt dc supply. In the nondecoding state, the current requirement is about 12 mA at 6 V. If your receiver power supply is in this voltage range, uses a negative ground, and can tolerate the current drain, you can power the alarm circuit from this source. If you have a battery-operated receiver, build a low-power dc supply between 6 and 12 volts.

If you have a transformer-operated, tube-type receiver, consider picking off the 6.3-volt filament supply (if one side is grounded) and using a silicon rectifier diode and a filter capacitor (about 1000 µF).

Testing. Start with the IC's out and the circuit not connected to the receiver.

Install *IC1* in its socket and connect a dc voltmeter between pin 8 and ground (positive side to pin 8). Turn on the dc power and note that the voltmeter indicates close to the supply voltage. Connect an audio signal generator ground to the circuit ground and the hot side to the TRANS terminal on *TS1*. With the relay deenergized, you should now have a signal on the input of *IC1*.

Set the signal generator as close as possible to 1050 Hz. Adjust *R2* until the voltmeter reading drops to near zero, indicating that *IC1* is decoding. Remove the signal generator, and the voltmeter should go back to the supply voltage reading. Perform this step several times to make sure that *IC1* is operating with each application of 1050 Hz. Turn off the audio generator and the dc power.

Remove IC1 from its socket and install *IC2* in its socket. Connect the dc voltmeter between pin 3 of *IC2* and ground. Turn on the dc power. Connect a jumper to circuit ground and touch the other end to pin 2 of *IC2*. Note that the voltmeter reading is the supply voltage. After about 10 seconds, the voltmeter should drop back to near zero, indicating that *IC2* has

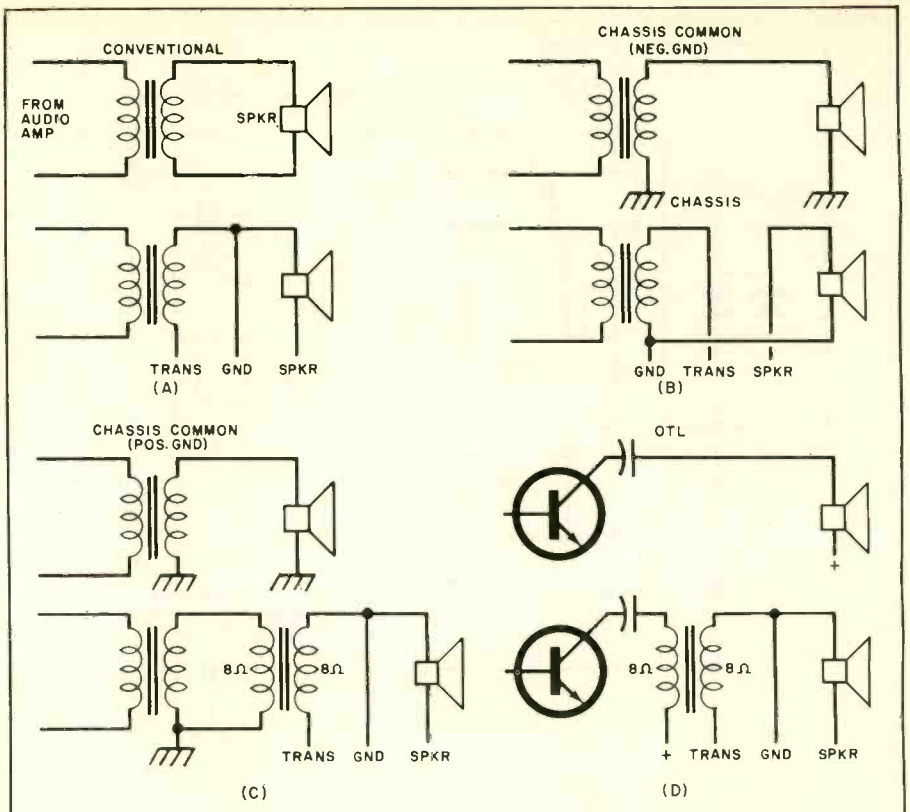


Fig. 2. Typical connections to the weather receiver speaker.

timed out. If the timing is too short, increase the value of *R5*. Conversely, if it is too long, reduce the value of *R5*. Check the timing cycle several times to make sure it is in a range of 7 to 14 seconds. Turn off the power supply and remove the jumper.

Remove *IC2* from its socket, and install *IC3* in its socket. Connect one end of a jumper to circuit ground and the other end to pins 1 and 2 of *IC3* simultaneously. Relay *K1* should close and lock in. Remove the jumper, depress *S1*, and note that the relay opens. Repeat this operation, ending with the relay closed. Remove the jumper, and connect it between the supply and either pin 1 or 2 of *IC3*. Depress *S1* and note that the relay opens and remains open after the switch is released. Remove the jumper and the dc supply.

Once all tests have been made, install all of the IC's. Apply the dc supply and put the 1050-Hz signal from the audio generator on the input. After *IC2* has timed out, the relay should close. Remove the signal input, depress *S1*, and the relay should open and remain open. The circuit is now ready for installation.

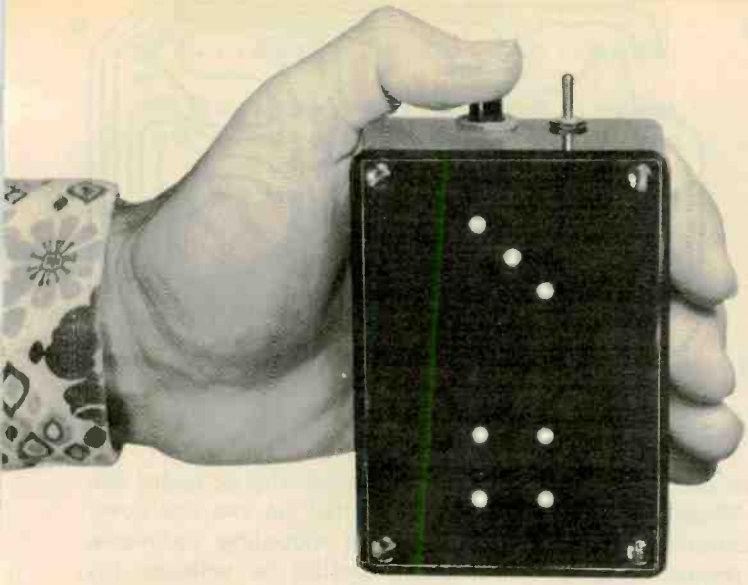
Installation. Connections to the weather receiver will vary depending on the receiver. Some typical connections are shown in Fig. 2. Note that a 1:1 8-ohm transformer is used for isolation in case the chassis of the receiver is used as the positive side of the supply (especially if you use the receiver power supply for the alerting circuit). The isolation transformer is also used in case the circuit is OTL.

If the receiver is used for other than weather reception, install a switch across the SPKR and TRANS terminals on *TS1*. Then be sure the switch is open to use the alerting circuit.

Operation. Turn on the weather radio. Tune it to your local NWS station and allow it to warm up so that it doesn't drift (assuming it doesn't have afc). Depress *S1* and you are ready to receive an alert warning. Since the speaker is now silent, you can turn up the volume to make sure that, if the alarm comes during the night, the sound will be sufficient to awaken you.

If you leave the receiver and the alerting circuit on 24 hours a day, it will be triggered between 10 and 11 a.m. each weekday when the NWS test signal is transmitted.

When a severe weather alert is broadcast, it is repeated every 10 minutes until the alert is over. This means the alarm will sound each time until you shut down the system. ◈



HAVE FUN WITH ELECTRONIC DICE

Electronic game of chance uses TTL & LED's

BY R. M. STITT

The rolling of dice is one of the oldest games known to man. In ancient times, dice were actually carved out of bones, with various characters on the six sides. Today, we have electronic dice. Though some of the character of the game may be lost in the transition from rolling the bones to pushing a button, the chances of winning and losing are still the same (sometimes better, since there are no mechanical irregularities to modify probabilities). Also, electronic dice can be used in the dark and don't emit rattling noises that can be disturbing to some people.

The electronic dice device described here is easily built and comes in a neat, simple package. It makes an ideal game for children and grownups whatever their ages.

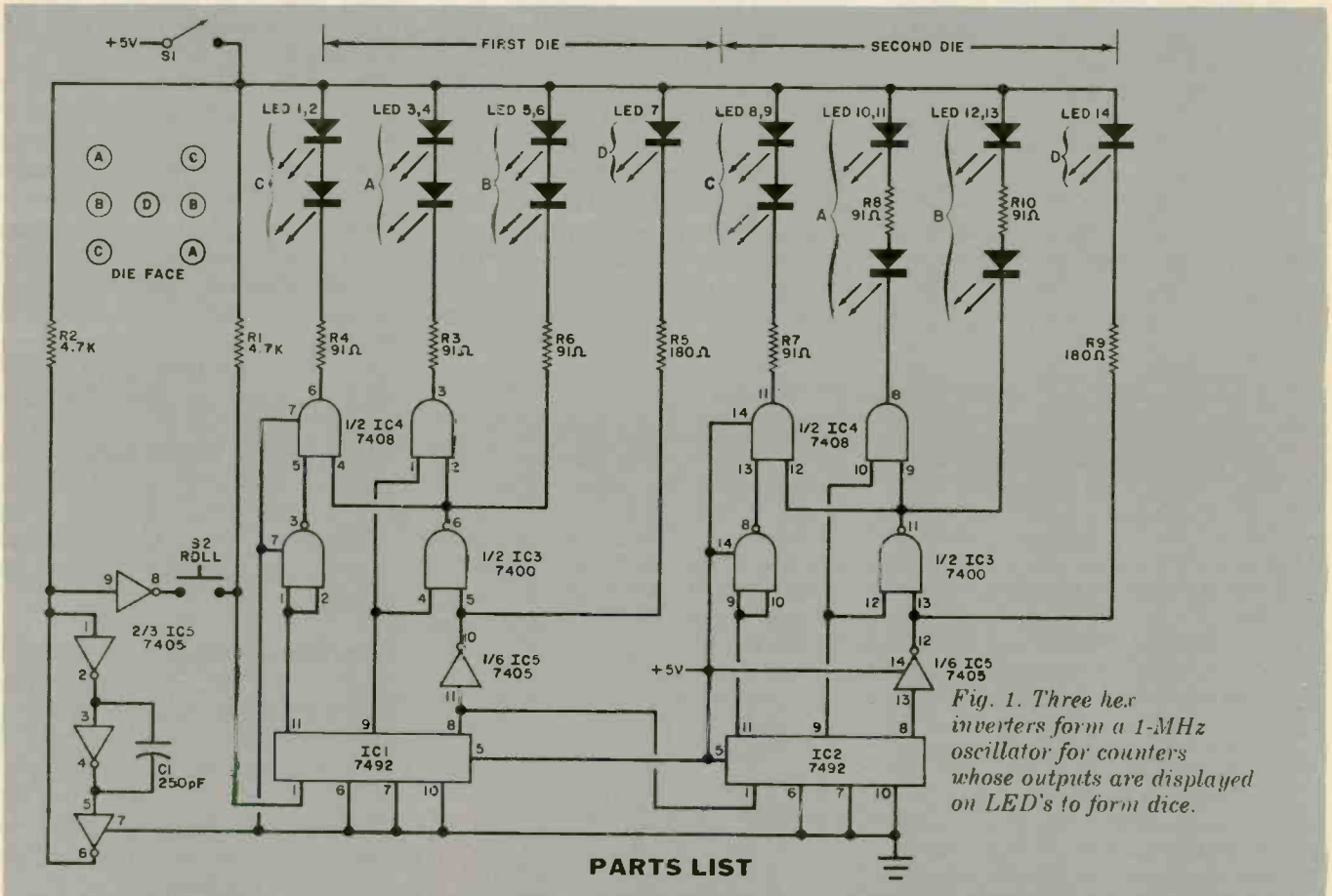


Fig. 1. Three hex inverters form a 1-MHz oscillator for counters whose outputs are displayed on LED's to form dice.

PARTS LIST

B1—Four AA cells (see text)
C1—250-pF, 10-V disc capacitor
IC1, IC2—7492 divide-by-12 counter
IC3—7400 quad 2-input NAND gate
IC4—7408 quad 2-input AND gate
IC5—7405 hex inverter
LED1 to LED14—Red LED (matched, see text)
R5, R9—180-ohm, ½-W, 5% resistor
S1—Spst switch
S2—Spst normally open pushbutton switch

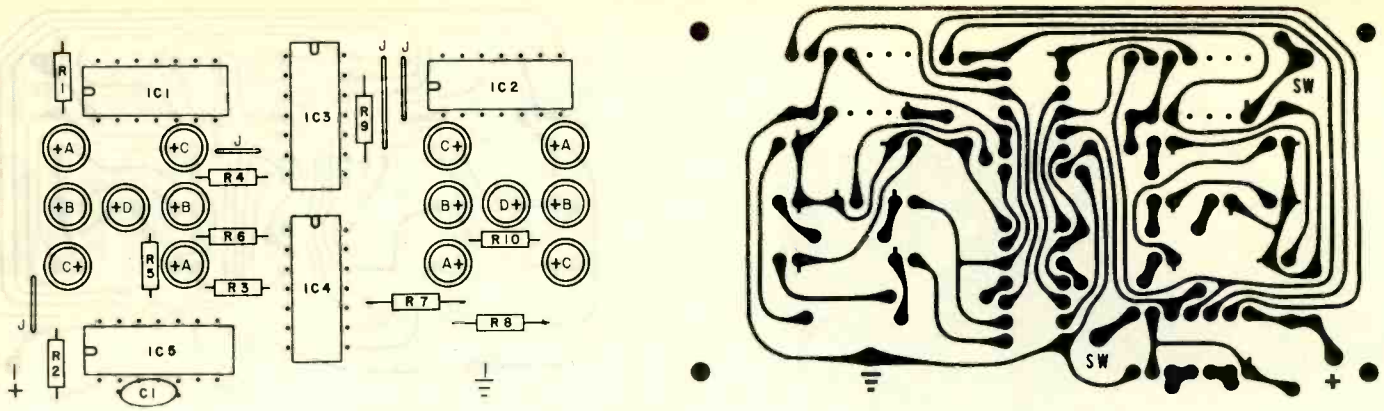


Fig. 2. Actual-size foil pattern is shown at right. Component installation at left.

Circuit Operation. As shown in Fig. 1, three of the six inverters in *IC5* are interconnected with *C1* and *R2* to form a clock oscillator running at about 1 MHz. A fourth inverter in *IC5* is used as a buffer to drive the first die circuit (*IC1*). This IC is a divide-by-12 counter consisting of a divide-by-2 (not used) and a divide-by-6 (used). The outputs of the counter are decoded by one inverter in *IC5*, two NAND gates in *IC3* and two AND gates in *IC4*. The decoded outputs then drive directly the six LED's which form the face of one die.

The output (carry) from the first die is used to drive the second die circuit formed by *IC2* and the remaining elements of the other IC's.

When the roll switch, *S2*, is operated, the clock oscillator is coupled to the first die, and its circuit runs through its states at a rate of 1 million times per second. The second die runs through its states at about 166,000 times per second. When *S2* is released, the LED indication is truly random, with the same probability as an actual pair of theoretically perfect dice would have.

Construction. Neither the circuit layout nor lead dress is particularly critical, but an effort should be made to minimize the length of the lead between the 1-MHz oscillator and the first counter (*IC1*). If desired, a pc board can be made, using the etching and drilling guide shown in Fig. 2.

There are two ways to mount the LED's. The first is to mount them directly on the pc board in their designated places, making sure that their tops are at least 3/16" to 1/4" above the tops of the integrated circuits. Then the top cover of the enclosure must be drilled so that the seven LED's for each die protrude through the holes. The pc board can then be mounted on the top cover using suitable mounting hardware. The LED's should be selected (by connecting them to a 5-volt dc source through a 180-ohm, ½-watt resistor) to make sure that they all glow with about the same brightness.

The pc board fits in the plastic case given in the parts list. When the top of this case has been drilled for the LED's, it is covered with a red antiglare filter that obscures the unlit LED's. This makes the face of each die clear.

The batteries (in their holder) are secured to the bottom of the case and a piece of foam rubber is placed on top of the batteries so that the pc board and LED's make a tight fit when the case is closed. The foam rubber keeps things from moving about. Of course, with this approach, the pc board need not be attached to the cover. In the prototype, nickle-cadmium cells were used. Although their initial price is high, they can be recharged many times.

The second way of mounting the LED's involves drilling the top cover and attaching the LED's to it with epoxy. Then lengths of insulated wire can be used to interconnect the LED's and the pc board.

Operation. When the power switch is first turned on, the dice should illuminate in combination. This initial state is determined primarily by the mismatches in the thresholds of the IC's and will vary with the IC's. Therefore, this "start-up" state is not random and should not be used as a "throw" of the dice.

When the roll pushbutton is depressed, all 14 LED's should go on. Some will be brighter than others due to the differences in their duty cycles. When the button is released, the display will be a random roll. ◈

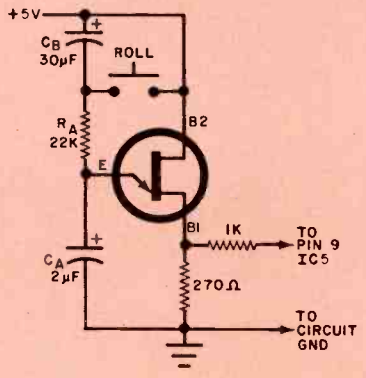
A ROLL-DOWN CIRCUIT

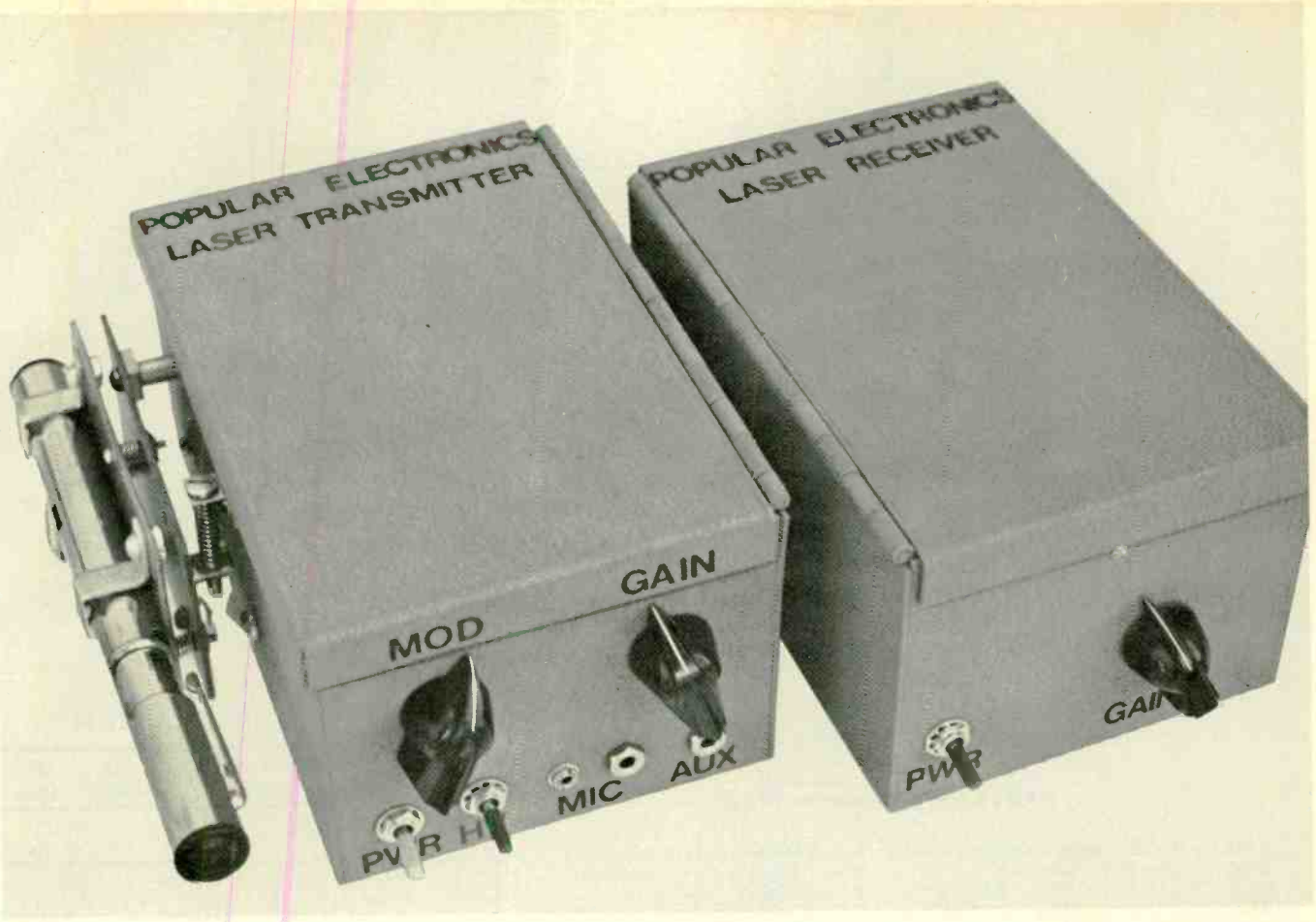
While testing the electronic dice, we experimented with finding a way to produce a "roll-down" similar to the effect obtained when regular dice are thrown. This can be done by using the circuit shown here to replace the three-inverter oscillator portion of Fig. 1.

The output of the UJT is coupled to pin 9 of *IC5*, while pin 8 of *IC5* is connected directly to the junction of *R1* and pin 1 of *IC1*. The *R1* of the original circuit is required because the 7405 (hex inverter) has an open collector on its output transistor. Note the new position of the roll pushbutton.

When the roll switch is pushed, the UJT forms a conventional oscillator with a frequency determined by R_A and C_A, whose values can be changed as desired. When the switch is released, the dc supply is removed from the timing circuit and C_B is included in the circuit. As the charge on C_B leaks off, less and less voltage is applied to the timing circuit and the oscillator frequency drops. This causes the dice display to "slow down" and, as the voltage drops to almost zero, the dice stop rolling. Reclosing the roll switch will start the roll again. The value of C_B can be changed to vary the duration of the roll-down time.

—The Editors





State-of-the art communicator

BUILD A

SEMICONDUCTOR LASER COMMUNICATIONS SYSTEM

uses pulse modulation to achieve a possible range greater than 3000 feet.

BY FORREST M. MIMS

COMMUNICATING on a light beam is fairly common with light-emitting diodes ("Experimenting With Light-Beam Communications," POPULAR ELECTRONICS, April 1975, p. 40), but for longer distances and greater efficiency, a laser light source is recommended. With the system described here, it is possible to get a range of more than one kilometer (3300 ft). Since it uses a PIN photodiode in the receiver, the system can be operated in daylight or darkness without an expensive infrared filter.

Though most light-beam communicators use amplitude or intensity modulation, this system employs pulse-frequency or pulse-rate modulation (PFM or PRM). This type of modulation is almost immune to transient atmospheric effects and noise from interfering light sources. Also, the output signal from the PFM receiver is constant in amplitude over the entire communicating range, while that from an AM system becomes progressively weaker as range is increased.

Transmitter. As shown in Fig. 1, a modular amplifier (*AMP1*) boosts the voice signals from a dynamic microphone. In a pulse-frequency modulator (*Q1* and *Q2*), *Q2* is a UJT connected in a relaxation-oscillator mode. With no input from *AMP1*, *Q1* is saturated (with very low emitter-to-collector resistance) and *Q2* oscillates at a frequency determined by the time constant of *C2* and *R6*. When an input is present on the base of *Q1*, the frequency of *Q2* is varied in direct proportion to the amplitude of the modula-

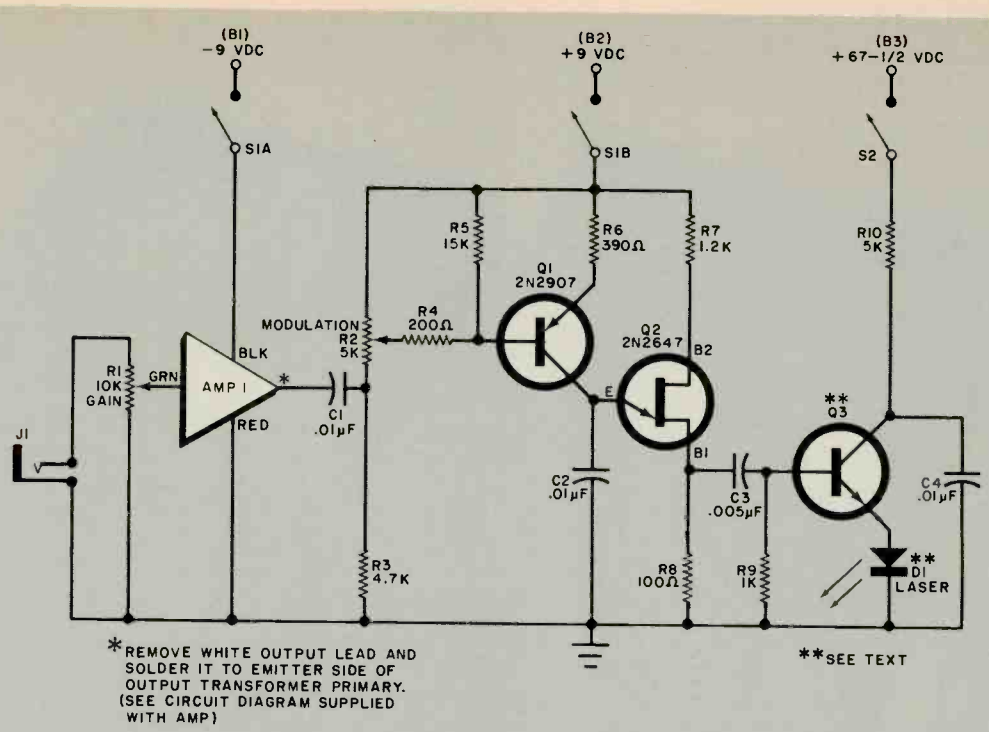


Fig. 1. A commercial modular audio amplifier modulates a UJT oscillator to drive the laser.

PARTS LIST (TRANSMITTER)

AMP1—Modular audio amplifier (Radio Shack 277-1240 or similar)
B1,B2—9-V transistor radio battery
B3—67½-V battery (Everready 457 or similar)
C1,C2—0.01-μF capacitor
C3—0.005-μF capacitor
C4—0.01-μF, 100-V capacitor (disc or paper only)
D1—Laser diode (see table at right)
J1—Microphone jack
Q1—2N2907 transistor
Q2—2N2647 UJT
Q3—Selected npn switching transistor (see text)
R1—10,000-ohm potentiometer
R2—5000-ohm potentiometer
R3—4700-ohm, ¼-W resistor
R4—200-ohm, ¼-W resistor
R5—15,000-ohm, ¼-W resistor
R6—390-ohm, ¼-W resistor
R7—1200-ohm, ¼-W resistor
R8—100-ohm, ¼-W resistor
R9—1000-ohm, ¼-W resistor
R10—5000-ohm, ½-W resistor
S1—Dpdt toggle switch
S2—Spdt toggle switch
Misc.—LMB B-H 643 enclosure, lens, battery retainers and clips, brass tubing, telescope, mounting hardware, 200-ohm dynamic microphone, epoxy, pc board, solder, etc.

SUITABLE LASERS

	RCA SG2001	RCA SG2002	RCA C30025	LDL LD22
Power output (W)*	1	2	0.5	6
Threshold current (A)	4	4	1.5	8
Peak current (A)	10	10	5	25

*Typical power output at peak forward current.

Note: The prototype laser has been successfully operated with all three of the RCA lasers listed above.

Addresses: The manufacturers will provide current prices and specifications upon request. Write to: RCA, Electronic Components, Box 1140, New Holland Pike, Lancaster, PA 17604; Laser Diode Laboratories (LDL), 205 Forrest St., Metuchen, NJ 08840.

tion frequency. The center frequency is determined by the setting of *R2*.

The resulting PFM signal across *R8* triggers a laser drive circuit comprised of relaxation oscillator *C4*, *Q3*, *R10*, and *D1*. Transistor *Q3* is an npn switching transistor operated in a nonconventional avalanche mode. A charge is placed on *C4* through *R10* until the breakdown voltage of *Q3* is reached. The capacitor then discharges through *Q3* and the laser. The pulse is very fast (50 ns) and high in current (5 to 10 A) to fire the laser. The cycle then repeats. The large current surge does not mean that the battery has to supply 5 or 10 amperes. The surge comes from the charge stored on the capacitor.

Transistor *Q3* oscillates independently of the modulator even when

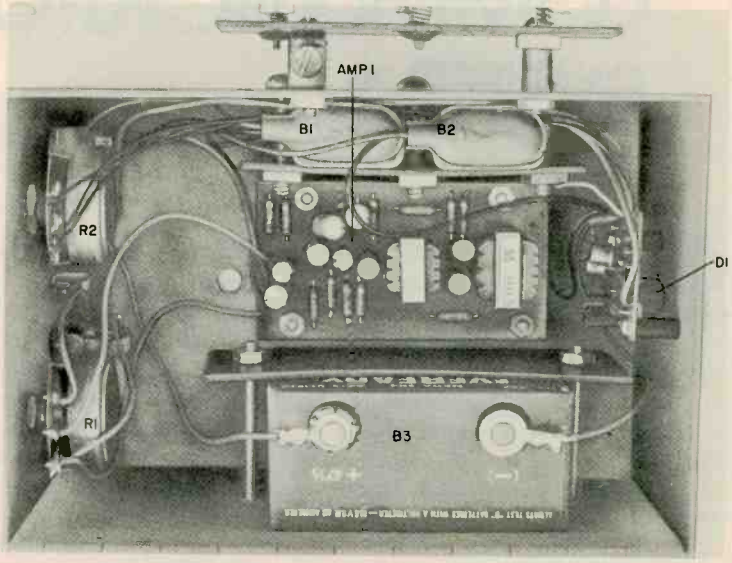
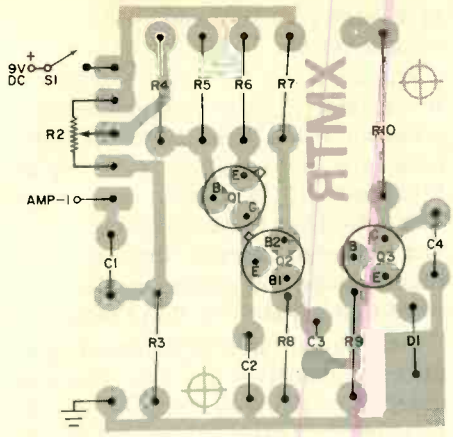


Photo shows layout of prototype transmitter. Mounting for boresighting telescope is at top.



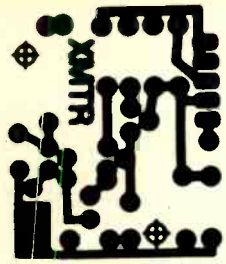


Fig. 2. Actual-size etching and drilling guide for transmitter is above, component layout at left.

the latter is in the relaxation mode. However, with an input, the oscillation varies with the signal. Potentiometer *R2* adjusts the carrier frequency to achieve the best modulation. A carrier of about 20 kHz gives the best results for the circuit used here. This is much higher than the 6 or 8 kHz required for acceptable voice transmission and insures good quality for both voice and music.

The transmitter is assembled on a printed circuit board as shown in Fig. 2. All components can be installed after the board is prepared, with the exception of *Q3* and the laser diode. Transistor *Q3* must be selected by using a test jig such as that shown in Fig. 3, which measures breakdown voltage. Ideally, a 15-MHz oscilloscope should be used to measure the current delivered by the transistor under test. This is done by measuring the pulse voltage across *R3* in the test circuit. Since this is a 1-ohm resistor, the voltage measured is equal to the current.

If a 15-MHz scope is not available, a lower-bandwidth scope, connected across *C1*, can be used to measure the transistor's breakdown voltage. The graph in Fig. 4 can be used to determine the peak current delivered by the transistor.

Not all transistors will oscillate in the test circuit. For best results, try common npn switching transistors such as 2N914, 2N2222, 2N3643, 2N4400, 2N5188, HEP50, etc. Select a transistor that gives a peak current between the laser's threshold and peak-allowable currents (as specified by the manufacturer). High currents give high output power. Install the transistor on the pc board and note its current for future reference.

Several lasers can be used, as listed in the table. Do not install the laser yet. Instead, connect an infrared LED (SSL-55C, TIL31, TIL27, etc.) in the circuit for preliminary testing. This permits you to get the circuit operating properly without the possibility of damaging the laser diode.

Receiver. In the receiver (Fig. 5), infrared radiation from the laser strikes PIN photodiode *D1* and generates a current which is amplified by *IC1*. Capacitive coupling between amplifier stages blocks dc signals from ambient sunlight and other light sources.

The output of *IC1* can be fed directly to an earphone for AM operation. For PFM, however, a threshold discriminator is necessary. The monostable multivibrator composed of *Q1* and *Q2* forms the threshold circuit. When an amplified pulse from *IC1* exceeds the trigger threshold of the multivibrator (a few tenths of a volt), *Q2* delivers a pulse of constant width and amplitude. This can be picked up at the collector of *Q2*, but best results are obtained by adding an amplifier (*AMP1*) for loudspeaker operation.

The pc board for the receiver is shown in Fig. 6. Use care when installing the IC to avoid bridging the copper portions.

Receiver sensitivity can be improved somewhat by the addition of potentiometer *R7*, which can be adjusted to reduce the threshold of the multivibrator and permit detection of weak signals. (There is no provision for *R7* on the pc board. It can be added by removing a short section of foil from the negative line to *Q1* and *Q2* and soldering the potentiometer's leads across the gap.)

The photodiode used in the prototype was a high-quality EG & G device costing about $15. This diode has a highly linear response and can be operated in broad daylight. Less expensive detectors (even ordinary silicon solar cells) can also be used; but light baffles, shields, or an infrared filter will be necessary for daylight operation.

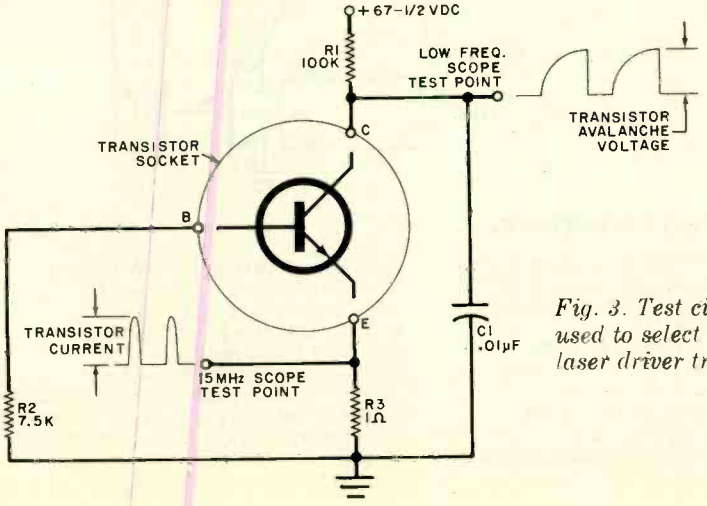


Fig. 3. Test circuit used to select laser driver transistor.

Assembly. Check the pc boards for errors and then mount them in suitable enclosures. The enclosures noted in the parts lists were used in the prototype because the hinged lids permit rapid access to the batteries and pc boards.

Assemble the receiver first. Use a chassis punch or nibbling tool to cut a hole in one end of the cabinet for the lens. A 2" plastic lens was used in the prototype, but most any simple lens can be used as long as its focal length is 4¼" or less. The larger the lens, the better its light gathering power.

Use L brackets to mount the pc board in the enclosure with the photodiode at the exact center of the lens opening. For the lens given in the parts list, the diode should be exactly 4¼" from the inside cabinet wall in which the lens hole is cut.

Mount the threshold adjust pot (*R7*, if used), gain control (*R15*), and power switch (*S1*) on the end of the case opposite the lens opening. Use appropriate mounting hardware for the

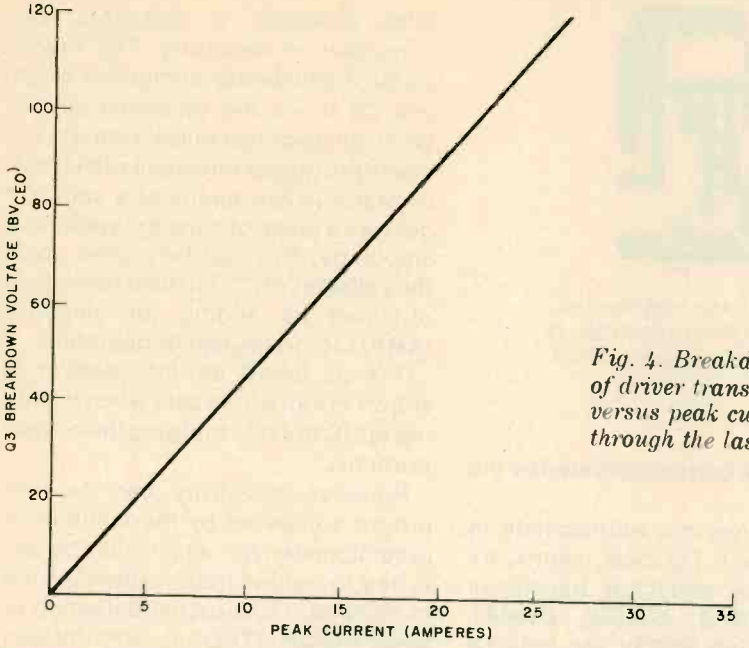


Fig. 4. Breakdown voltage of driver transistor versus peak current through the laser diode.

speaker, *AMP1*, and the two 9-volt batteries. Scraps of pc board 1" x 3" make good battery retainers. Use rubber grommets as standoffs for *AMP1*. Complete receiver assembly by wiring the various components to one another. Then mount the lens using a flexible adhesive such as Dow Corning Silastic®. The plastic lens mentioned in the parts list can be mounted by bending its shoulders with a hot soldering iron.

There are two steps to the transmitter assembly. First, prepare appropriate mounting holes for the controls, hardware, and lens tube assembly. A 9/16" hole should be adequate for the lens tube. Then install all components and batteries except the laser pc board. Make the necessary connections to the board but don't mount it.

Install an infrared LED (note proper polarity) instead of the laser. Test the receiver by pointing it toward a line-powered incandescent lamp. If the receiver is properly aligned with respect to the lamp, a 120-Hz buzz should be heard from the speaker.

Now point the transmitter LED toward the receiver lens and turn on the power. Talk into the microphone or place it near a radio while adjusting *R2*. It should be possible to get good-quality audio from the receiver. If not, make sure the transmitter LED is properly aligned with respect to the receiver. Then try adjusting *R7* in the

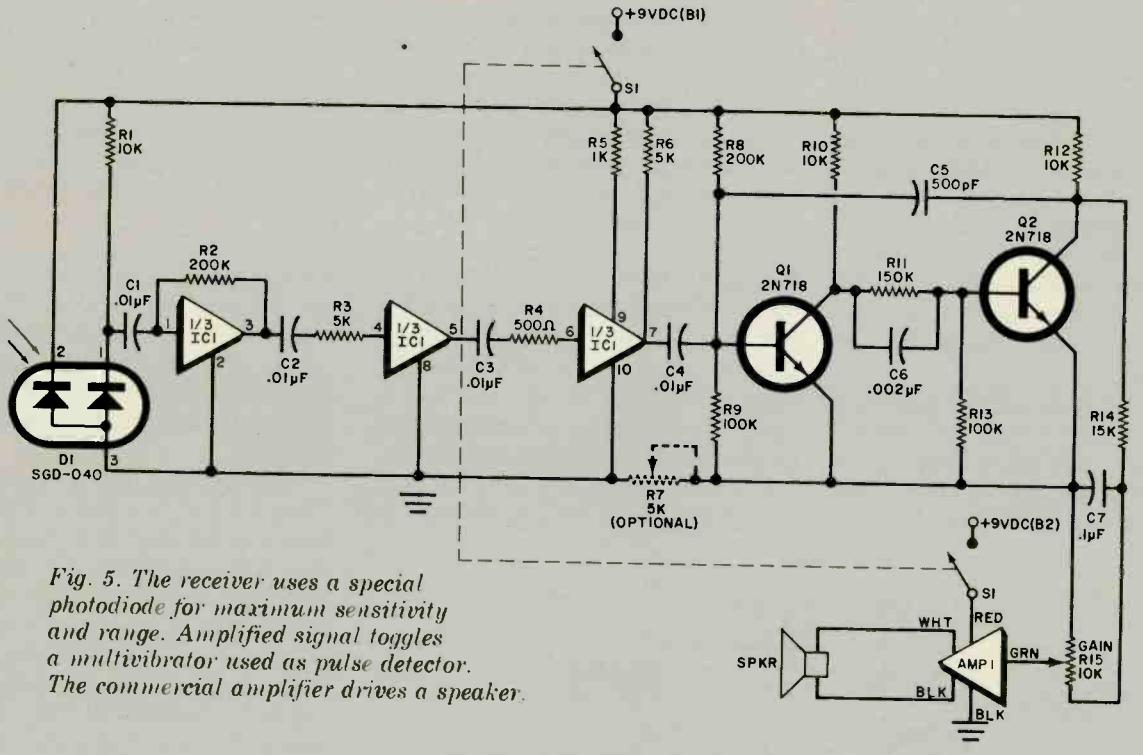


Fig. 5. The receiver uses a special photodiode for maximum sensitivity and range. Amplified signal toggles a multivibrator used as pulse detector. The commercial amplifier drives a speaker.

PARTS LIST (RECEIVER)

AMP1—Modular audio amplifier (Radio Shack 277-1240 or similar)
B1,B2—9-V transistor radio battery
C1 to C4—0.01-μF capacitor
C5—500-pF capacitor
C6—0.002-μF capacitor
C7—0.1-μF capacitor
D1—SGD-040B PIN photodiode (EG&G; available from Cramer Electronics, 85 Wells Ave., Newton, MA 02159, for $15 plus postage; see text)
IC1—CA3035 amplifier array (RCA)
Q1,Q2—2N718 npn switching transistor (or equivalent)
R1,R10,R12—10,000-ohm, ¼-W resistor
R2,R8—200,000-ohm, ¼-W resistor
R5—1000-ohm, ¼-W resistor
R3,R6—5000-ohm, ¼-W resistor
R4—500-ohm, ¼-W resistor
R7—5000-ohm potentiometer (optional, see text)
R9,R13—100,000-ohm, ¼-W resistor
R11-150,000-ohm, ¼-W resistor
R14—15,000-ohm, ¼-W resistor
R15—10,000-ohm potentiometer
S1—Dpst toggle switch
Spkr—8-ohm miniature speaker
Misc.—LMB B-H 643 enclosure, lens, battery retainers and clips, mounting hardware, cement, solder, pc board, etc.

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receiver. If no signal is heard, check the transmitter wiring. Also, the LED may be bad, *Q3* may not be oscillating, or one or more of the batteries may be weak.

If the receiver oscillates, it may be necessary to reduce the gain of the amplifier by increasing R3 or R4 somewhat. Adding R7 may also help eliminate receiver oscillation.

Proper operation of the system is obvious since a slight misalignment of the transmitter with respect to the receiver will cause loud noise and oscillation from the receiver and then silence. This illustrates the PFM mode of operation. Unlike simple AM systems, a PFM light-beam communicator gives constant receiver amplitude at all ranges out to the threshold cut-off point.

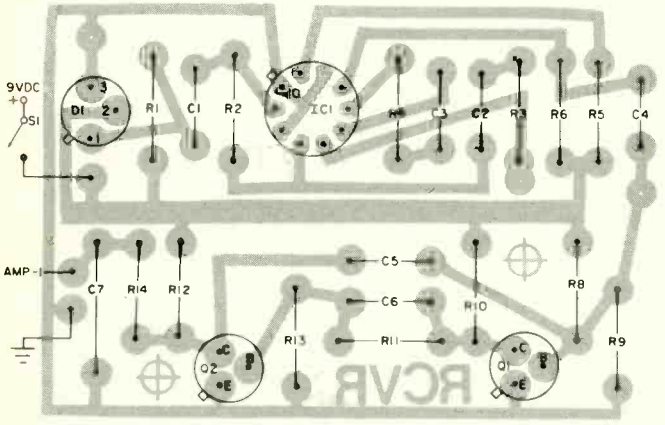
Final Transmitter Assembly. When the system is operating properly, remove the LED from the transmitter and install the laser. Mount the laser with its glass window on the back side of the pc board and secure it in place with a #8-32 nut. The plane of the laser junction should be parallel with the narrow side of the pc board. (See Fig. 7.) Next, carefully bend the laser's flying lead so that it goes into its mounting hole. Make sure the lead doesn't short against the laser mounting stud.

CAUTION: Do not connect a VOM to the laser diode. The small amount of current delivered by the meter will destroy the laser chip.

With the laser in place, test the system again. If it works properly, a ½" length of brass tubing (available from hobby shops) is carefully soldered to the back of the pc board with the laser chip at the exact center. Cut a slot from the tube as shown in Fig. 7 to prevent possible shorts. If the tube is not soldered properly the first time, try again until it is centered and level. This tube becomes the laser lens receptacle.

Next use two 7/16" standoffs to mount the laser pc board in the cabinet. A telescoping lens tube made as shown in Fig. 7 is inserted in the tube receptacle. Use a simple lens with a diameter of 12 to 15 mm and a similar focal length. Use epoxy to secure the lens in place.

Optical Alignment. Both transmitter and receiver must be aligned with infrared light for best results. This is no problem with the receiver if the lens called for in the parts list is used since its infrared focal length is 4¼". For other lenses, add perhaps a quarter of an inch to the visible focal length.



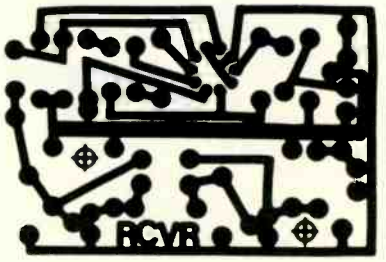


Fig. 6. Actual-size etching and drilling guide for receiver at right. Component layout is at left.

Alignment of the transmitter is more difficult due to the small size of the laser source. An approximate alignment can be made by placing the lens a millimeter or so farther from the laser chip than the visible focal length of the lens. An approximate alignment will give a broad beam suitable for communications up to about 1000 feet. For long ranges, the beam must be made nearly parallel by adjusting the lens for as small a beam spread as possible. This is easily done if an infrared image converter is available.

Surplus sniperscopes are ideal for

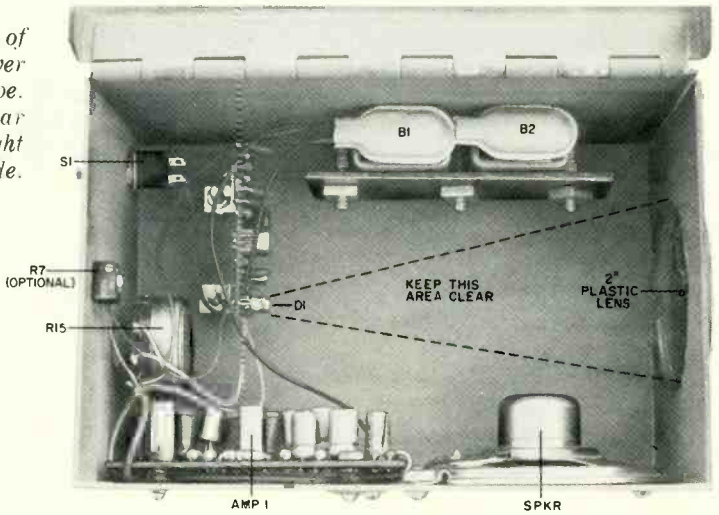


Photo of receiver prototype. Leave a clear path for light to hit diode.

SAFETY CONSIDERATIONS

The GaAs laser used in this system has a peak optical power output of a few watts if operated at maximum current. That is a lot of light compared to the output of low-power helium-neon lasers; but the optical pulses are brief so that the average power is far less than that of most helium-neon devices.

According to the U.S. Air Force School of Aerospace Medicine, GaAs lasers emitting 10 watts per pulse are not capable of producing detectable eye damage. Three principal factors contribute to this safety margin: the absorption of the infrared in the eye's vitreous humor, imperfect focusing of the infrared, and the laser's low average power.

Nevertheless, a few basic precautions must be followed to insure utmost safety:

1. As with any source of bright light, do not look directly into the laser beam.
2. Avoid pointing the laser at shiny surfaces (mirrors, unpainted metal, etc.) because reflected light can be as potentially dangerous as direct light.
3. Do not point the laser in a direction in which bystanders might look into the beam.
4. Turn off the laser transmitter when it is not in use, to preserve its life and that of the battery.

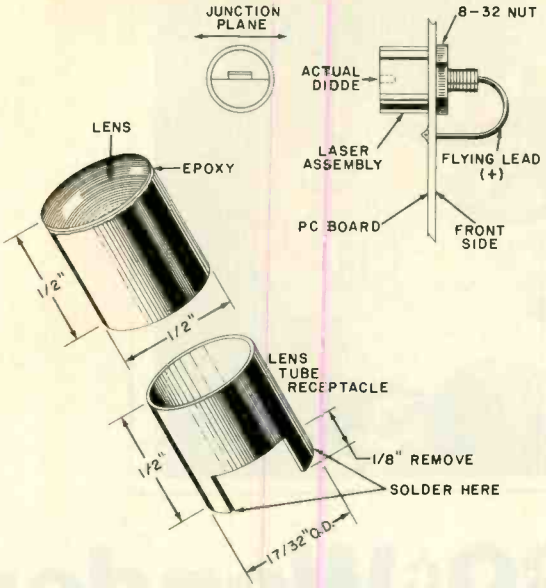


Fig. 7. Mounting details for laser and lens tube.

this purpose, but they are expensive. Kodak makes infrared-sensitive phosphor screens which glow orange when struck by a beam from an IR laser or LED. These screens cost about $25 (a lot less than electronic image systems). Write Special Product Sales, Kodak Apparatus Div., Eastman Kodak Co., Rochester, NY 14650 for details and prices.

Align the laser lens by pointing the beam at a white card (or the phosphor screen) at least 3 feet away and focus the lens for the smallest spot size. Use the infrared viewer to see the spot if the white card is used.

When the optimum focus point for the lens is found, use white glue to secure the lens in place and prevent need for realignment.

Telescope Alignment. Range tests of a few hundred feet are relatively straightforward, but long-range operation requires the addition of an alignment telescope for the transmitter. You can use any spotting or rifle telescope of 3X to 10X as long as it has a cross hair. For the sake of economy, in the prototype, an inexpensive 10X pocket telescope was obtained from Radio Shack for about $3 (Cat. No. 63-844). (Also available from other electronics outlets.) A cross hair was added by cementing two human hairs to a ⅜" washer which was then cemented to a shoulder inside the telescope eyepiece section.

The telescope must be boresighted with the laser. Make an adjustable mount similar to the one shown in Fig. 8. Use two sections of pc board for the mounting platform. Solder three nuts to the back of one board and use springs to permit adjustment.

Aligning the telescope is fairly easy if a phosphor screen or infrared viewer is available. The transmitter is mounted on a tripod with an appropriate nut and the laser is caused to illuminate a fixed spot at least 50 feet away. The telescope is then aligned until the crosshair falls on the target. Recheck the laser to make sure it still illuminates the target and alignment is complete. Perform the alignment at night for fast results and use a flashlight to illuminate the target when the telescope is being used.

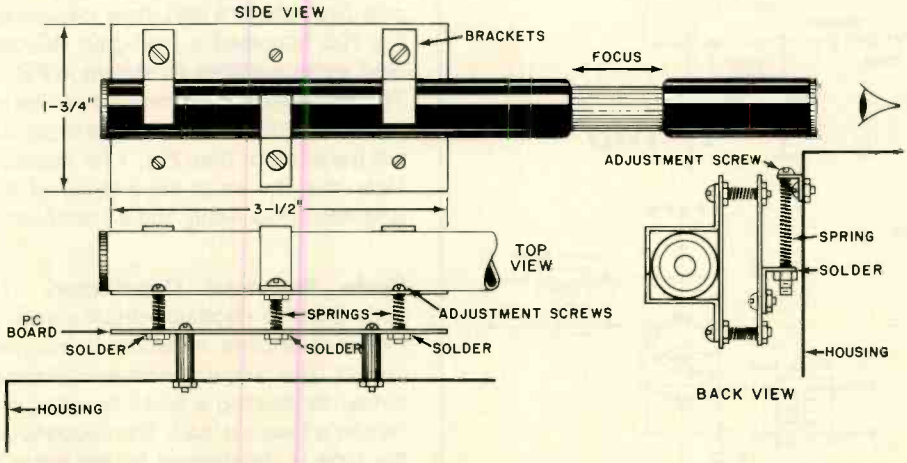


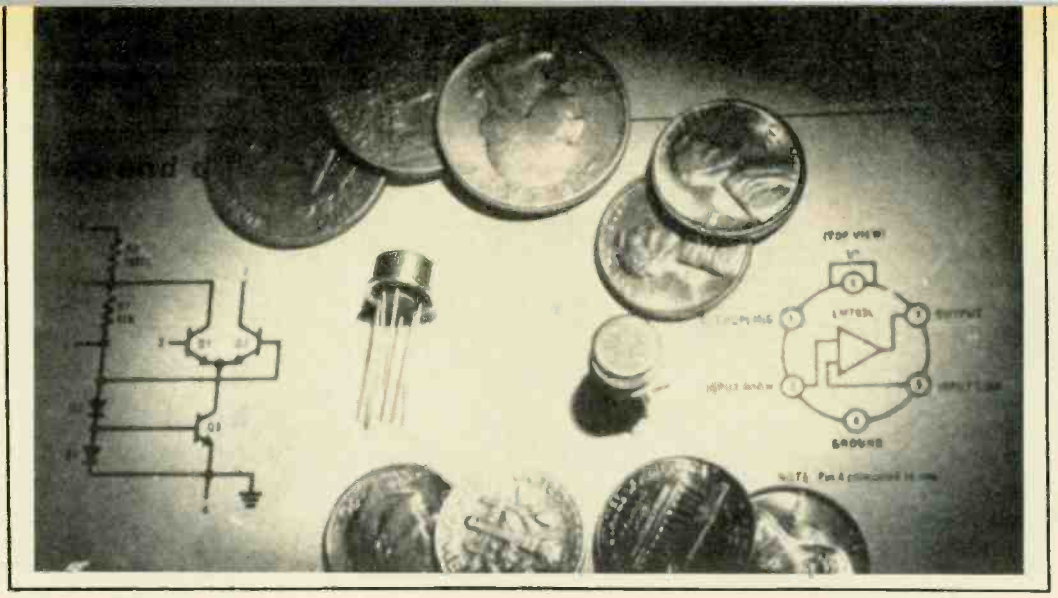
Fig. 8. Details for mounting the telescope which is used to boresight the transmitter.

Range Testing. When the telescope is boresighted with the laser, the system is ready for long-range testing. Begin by mounting the laser on a tripod and pointing the telescope at a fence post, car, or other object at least 1000 feet away. Place the microphone near a radio to get a continuous audio signal. Proceed to the target site, and point the receiver toward the transmitter. It will be necessary to move the receiver about until the optimum detection angle and point are found. If no signal is received, the laser beam has probably crossed the telescope field of view at a point beyond the range of the initial alignment target. Therefore, proceed a few feet toward the telescope side of the laser until the signal is received. An infrared viewer is helpful in finding the brightest spot in the projected beam (which is only a few feet across at ½ mile).

The prototype communicator has been used to achieve a range of 3380' (1.03 km). This could be increased to well over a mile by increasing the laser current, reducing the transmitter beam width, or increasing the receiver lens size. For example, the prototype uses a laser with a threshold current of 4.1 amperes. While the laser can be operated at a top peak of 10 A, transistor *Q3* delivers only about 5 A. Therefore, the laser output is only a few hundred milliwatts, while more than a watt would be available at 10 A. With the full 10-A current, the optical-communication range equation shows that range would be slightly more than doubled.

Similarly, a diverging beam of light follows the inverse square law, so doubling the diameter of the receiver lens from 2 to 4 inches will double the range.

More Information. For further reading on laser communications, see: *Semiconductor Diode Lasers*, R.W. Campbell and F.M. Mims, Howard W. Sams & Co., 1972; and *Light Beam Communications*, F.M. Mims, Howard W. Sams & Co., 1975. ◈



9 Uses for the 69¢ Wonder

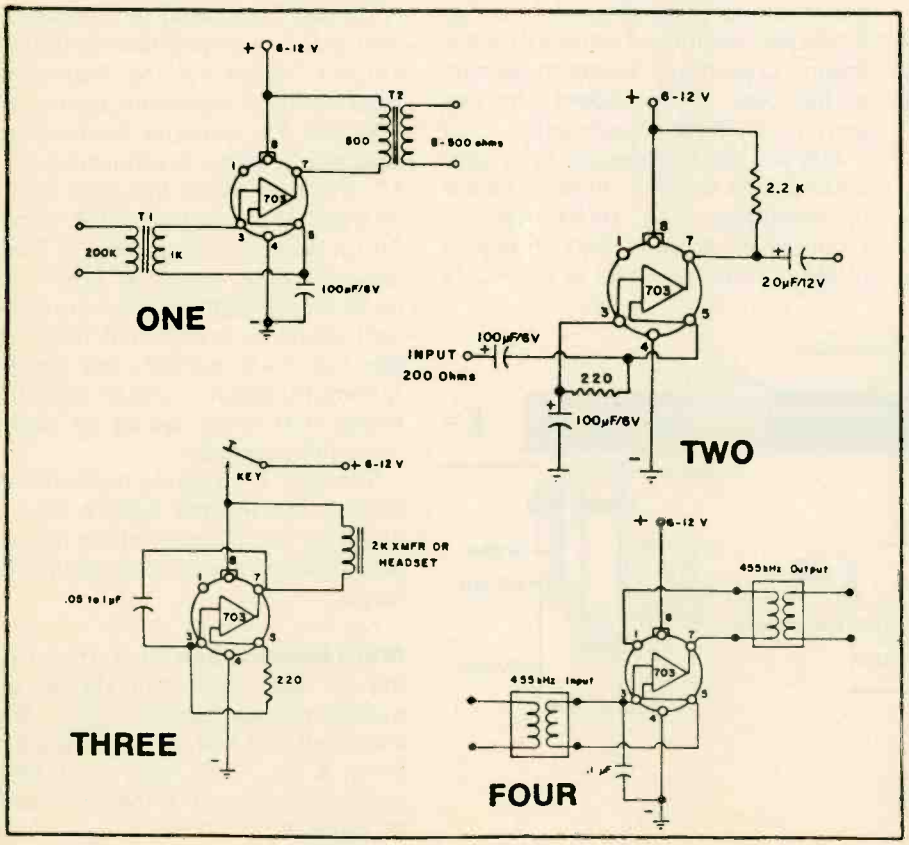
Tested experimenter circuits that can be built with the 703 monolithic amplifier.

BY JOE A. ROLF

A BUCK doesn't go very far these days. But it will still buy a lot of electronics. For example, for just 69¢, the readily available 703 integrated circuit (an emitter-coupled i-f/r-f amplifier) can be used in a multitude of circuits that require a minimum of parts.

The 703 is a highly stable, limited-gain chip that can be made to operate at frequencies of up to 150 MHz. Its efficient internal biasing system is easy to use and reduces power supply requirements and stage decoupling demands. For less than a buck, it's an experimenter's dream.

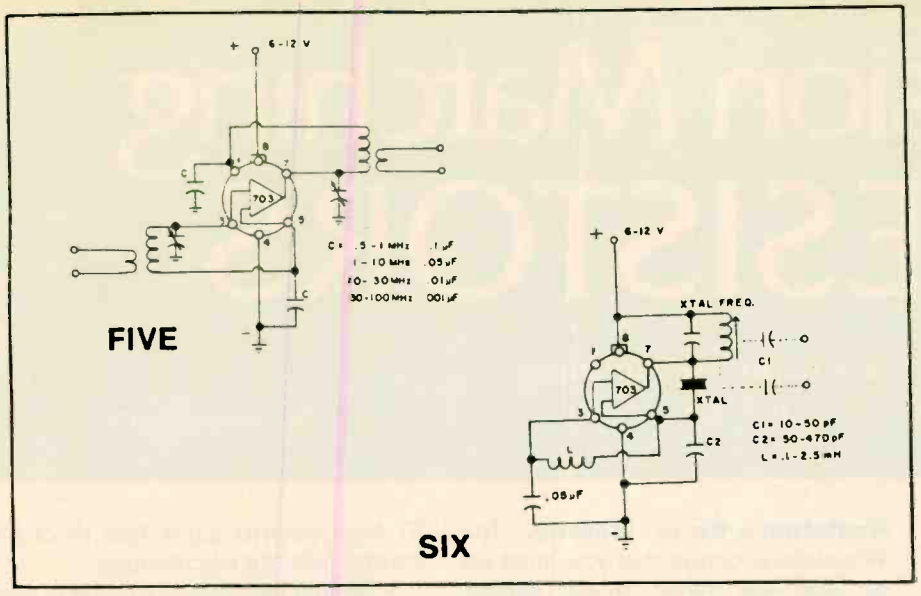
With this in mind, we present the following nine projects you can build around this popular IC. Three of the projects can be used alone; the remaining six can be used for experimenting or as add-ons to existing electronic devices.



High-Input-Impedance Amplifier. This circuit, shown in Fig. 1, will deliver up to 20 mW of audio output power at the secondary of T2. With a power gain of 30 dB, this circuit can be used as a high-gain preamplifier, a driver amplifier, or a low-power output stage. The transformers provide impedance matching. As such, they can be selected to suit the specific application intended for the circuit.

RC-Coupled A-F Amplifier. With only two resistors and three capacitors, the 703 becomes a high-gain RC-coupled audio amplifier as shown in Fig. 2. The 2200-ohm output resistor can be replaced by 2000-ohm headsets or an output transformer (see Fig. 1 for hookup). Note that the input impedance of this amplifier is low—only about 200 ohms.

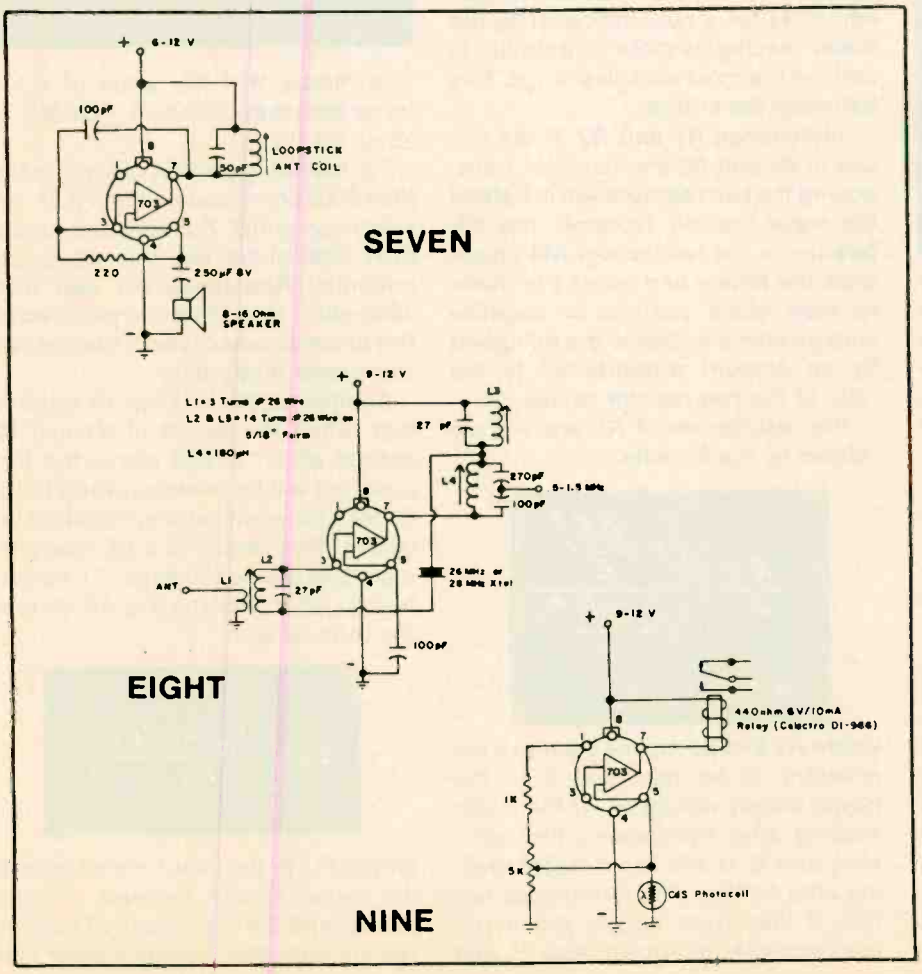
Code Practice Oscillator. The code practice oscillator circuit shown in Fig. 3 is another minimum-component project. The output can be a small transformer for feeding a small speaker, or it can be a headset load. The frequency of the tone is determined by the value of the feedback capacitor. To make an oscillator with "warble," use two capacitors



of different values and switch one in and out of the circuit. For an electronic siren, connect a 4700-10,000-ohm resistor between pin 8 of the 703 IC and the key and a 100-200-μF capacitor from pin 7 to pin 4.

455-kHz I-F Amplifier. In Fig. 4 is shown the schematic of a 455-kHz i-f amplifier made from four readily available components. By cascading several of these high-gain i-f amplifiers, you can make a complete i-f strip for use in a receiver project. The internal bias and limited-gain features of the 703 reduce the need for coupling when several stages are cascaded.

R-F Amplifier. The Fig. 5 r-f amplifier, designed to operate from 500 kHz to 1000 MHz, has its input and output circuits tuned by LC networks. As shown in the short accompanying table, the value of C in both cases must be selected for the frequency range desired. The tuning capacitors should be small trimmers to permit tuning for maximum response at a given frequency.



Crystal Oscillator. A 1-30-MHz crystal oscillator is easy to build when using a 703 IC (see Fig. 6). The values of *C1*, *C2*, and *L* are determined by the crystal and the operating frequency. Capacitor *C2* is the most critical component; it must be selected to provide just enough feedback for stable operation. Inductor *L* is used for bias decoupling and, in some cases, can be replaced with a 220-ohm resistor.

AM Wireless Microphone. The wireless microphone in Fig. 7 is designed to transmit voice signals by radio up to about 100 ft to an AM broadcast receiver. Here, the 703 IC is used as an oscillator and audio amplifier. Only a small transistor radio speaker is needed as a microphone. For use as a phono-oscillator, replace the speaker with a 50,000:1000-ohm transformer, and connect the high-impedance winding to the phono cartridge.

27-MHz CB Converter. With the circuit shown in Fig. 8, you can listen to CB calls on your AM broadcast-band receiver. The 27-MHz CB signals picked up by the antenna are converted in this circuit to a range of frequencies your BCB receiver can accommodate. The IC in this case functions as a reflex converter, operating both as a mixer and a local crystal-controlled oscillator. The circuit is simple to build and get to working if care is taken with layout and component leads are kept short. For improved selectivity and sensitivity, you can add the r-f amplifier circuit shown in Fig. 5 to the output of the converter.

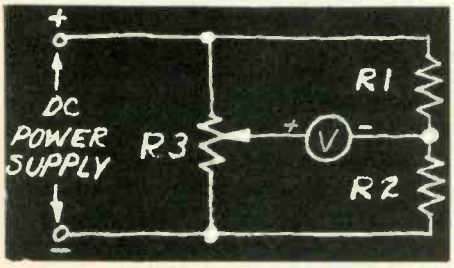
Photoelectric Control. The 703 IC can even be used as a dc amplifier as demonstrated by the photoelectric control shown in Fig. 9. This circuit has a 5000-ohm sensitivity control potentiometer that permits you to "tune" it to respond to a suitable light source 5 to 10 ft away. A small, sensitive relay must be used to drive whatever signaling load you desire. The current drain for this circuit is very small, making the photoelectric control ideal for battery operation. ◇

Precision Matching of RESISTORS

Home experimenter technique for matching resistors to better than 0.5%

BY JAMES DEMAS

PRECISION matching of resistor values is extremely important in such circuits as bridges and differential amplifiers. At first glance, you might think that an easy way to match values is to use expensive 1% or better precision resistors. A close look at the situation, however, will reveal a basic flaw in this plan. If you use 1% resistors, one resistor might be 1% higher and the other 1% lower than the nominal value required. Hence, the matched-pair tolerance would be 2% .



Ordinarily, when you need closely matched resistor pairs, the absolute resistance value is not as important as how close the values are to each other. Closely matched resistors whose absolute values are "in the ballpark" of those required will usually suffice for a given application.

While commercial manufacturers generally use expensive laboratory-type equipment, the home experimenter must find a more economical means for matching resistors. Fortunately, all he needs is a high-impedance multimeter, a 0-to-30-volt power supply, and a 10-turn potentiometer. The meter should have a 10-megohm or greater input impedance and a sensitive low-voltage range, preferably 0.6 volt or less full scale. Almost any value for the potentiometer's resistance between a few hundred and about 50,000 ohms will do for this test circuit.

Resistance-Ratio Method. The Wheatstone bridge that you must set up with the meter, power supply, potentiometer, and resistors to be matched is shown in the schematic diagram. With this setup, you can easily obtain resistance ratios that will permit you to match resistors to better than 0.5%.

The resistors to be matched in the diagram are *R1* and *R2*. These will form one voltage-divider leg of the bridge, while the potentiometer (*R3*) will form the other leg. When using this circuit, with *R1* and *R2* in place, adjust *R3* for a null, indicated by the meter reading as close as possible to zero on the most sensitive range. This balances the bridge.

Interchange *R1* and *R2*. If the values of *R1* and *R2* are identical, transposing the two resistors will not affect the meter reading. However, any difference in the resistances will unbalance the bridge and cause the meter to read some positive or negative voltage above or below the null point by an amount proportional to the ratio of the two resistor values.

The resistances of *R1* and *R2* are related by the formula

$$\frac{R2}{R1} = \frac{1 + \frac{\Delta E^*}{E}}{1 - \frac{\Delta E^*}{E}}$$

$$^*\Delta E = E_2 - E_1$$

where *R1* and *R2* are the values of the resistors to be matched, E is the power supply voltage, E_2 is the meter reading after transposing the resistors, and E_1 is the initial meter reading after nulling. The formula applies only if the power supply and meter are connected as shown. Also, E_2 and E_1 have polarity signs that must be carried into the calculations.

A sample calculation of how to use the formula is instructive. Assume two 175,000-ohm resistors are compared using an 18.5-volt supply potential. The initial null is at −1.0 mV (E_1) and the final voltage (E_2) is −1.96 V. This yields

$$\frac{\Delta E}{E} = \frac{-1.96\,V - (-0.001\,V)}{18.5\,V} = -0.1059$$

$$\therefore \frac{R2}{R1} = \frac{1 + (-0.1059)}{1 - (-0.1059)} = 0.8086$$

This means that the value of *R2* is lower than that of *R1* by 1 − 0.8086, or about 19.1%.

For matching resistor values greater than 5000 ohms, use an 18- or a 27-volt supply potential. For resistors of less than 5000 ohms, use a 9-volt supply potential. Resistances of less than 1000-ohms should not be matched by this procedure because of their excessive power dissipation.

Another point to keep in mind is that, when the values of *R1* and *R2* exceed about 50,000 ohms, the first equation will be in error, owing to the meter's inherent loading effect on the circuit. This results in a ΔE measurement that will be too small. To correct for the error, replace the ΔE entry in the formula with

$$\Delta E\left(\frac{R_m + 0.5R1}{R_m}\right)$$

Where R_m is the input impedance of the meter. Finally, because of noise pickup and the magnitude of the correction term, resistances greater than

10 megohms cannot be reliably matched.

With the resistance-ratio method, you can obtain matching accuracies of almost 0.05%. If you use a very sensitive meter—say a DMM with a 10-mV full-scale range—you will in all likelihood be able to match resistors to better than 0.01%.

Matching the Resistors. There's an obvious—but usually impractical—procedure for matching resistors: select one resistor from a batch having the same nominal value and proceed to measure ratios until you hit on a close match. A more practical procedure would be to trim one resistance to make it equal to the other.

The initial trimming is of two types. In series trimming, the lower resistance is increased by adding in series with it another resistor of the proper value. In parallel trimming, the larger resistance is decreased by connecting a resistor of the proper value in parallel. Series trimming is preferred where possible. When the lower-value resistor is a standard or reference that cannot be modified, however, you have no alternative but to employ parallel trimming.

In series trimming, if *R2* is greater in value than *R1* (you can always change your reference to make *R2* the smaller resistance), the necessary series resistance for *R1*, designated R_s, can be calculated by using the formula

$$R_S = R1\left(\frac{R2}{R1} - 1\right)$$

The absolute value of *R1* may not be known, requiring that you use the nominal value for computation. The closest commercially available value for R_s can be used. These two error sources, however, usually prevent the trimmed pair from being perfectly matched. But the matching will still be much better than if you just took two precision resistors of the same nominal value and used them.

With parallel trimming of the larger-value resistor, trimming resistor R_p's value can be computed by

$$R_P = \frac{R2}{\frac{R2}{R1} - 1}$$

Again, *R2*/*R1* is greater than 1, and the nominal value of *R2* is used in the calculation. This procedure works well if *R2*/*R1* is not too close to 1.000. As the ratio approaches unity, R_p becomes prohibitively large. Hence, with parallel trimming, use an R_p that is slightly lower in value than that calculated from the equation. This makes *R2* a little lower in value than *R1*. Then series trim as discussed above for any final adjustment of the ratio.

If the match is still inadequate, further trimming will make it approach the ideal. With series trimming, if R_s is too low, add another resistor of lower value in series with *R1* and R_s to correct the value. If R_s is too large, the combination of R_s and *R1* is greater than *R2*. Several solutions are possible. Series trim smaller resistance *R2*. Alternatively, connect a suitable resistance in parallel with R_s—NOT the series combination of R_s and *R1*—to reduce it to the correct value.

The required parallel trimming resistor, R_t, for R_s is calculated by

$$R_t = \frac{R_S\left(1 - \frac{R1}{R2}\right)}{\frac{R1 + R_S}{R2} - 1}$$

where *R1*/*R2* is just the inverse of the original ratio determined for the resistor pair, and $(R1 + R_s)/R2$ is the ratio determined after the first trim.

The most economical type of resistors to use for matching are 10% composition types. Using 10% composition resistors and the matching procedure outlined above, you can be sure of better than 1% matching for less than the cost of two 5% resistors. Absolute accuracy will be sacrificed, however. But if you buy your resistors all at one time and from the same place, they will usually be from the same batch. Resistors in a given batch are usually closely matched.

Matching composition resistors to better than 0.5% is possible, but such resistors have poor inherent long-term stability, especially for values exceeding 1 megohm. Stability can be improved by operating the resistors well below their rated power and by burning them in before matching. Once matched, treat the resistors as you would semiconductor devices. Don't overheat them and use a low-power soldering iron and heat sinks on the leads.

For the highest possible stability, wire-wound, oxide, and metal-film resistors are recommended. ◈

GUITAR SOUND INTENSIFIER

Improves frequency response, gives complete tone control.

By Ken Lang

THERE are few families with youngsters (or young-at-heart oldsters) that don't have guitars these days. The instrument may be the familiar acoustic type, whose shape and size have not changed much during its long history, or it may be a solid body electric type. With a smaller body, the electric guitar relies entirely on electronic amplification for its sound–and it is probably today's largest selling equipment.

The solid-body electric guitar has a resonant wooden section instead of a resonant box. Magnetic pickups are mounted inside the body under the metal strings. Without the nuances of body size and shape to provide differences in tone, most solid-body guitars sound pretty much alike. The combination of pickup, strings and electronic resonance provides a pure inductance, which contributes little to sound character and causes peak emphasis at one particular frequency (with attendant ringing and hangover). The subtle string overtones get lost because they can't compete with the sound output at circuit resonance.

Of course, special effects can be added to electric guitars, but a means of really changing the coloration of the sound is more desirable. Such a change can be achieved by adding this Guitar intensifier. It has its own volume, bass, and treble controls and can be mounted in the cavity of many solid-body electric guitars. Having independent tone-control arrangements, this approach gives the user a variety of tonal colorations and produces a wide frequency response. There is no loss of high-frequency overtones at low volume settings, but the GI provides the instrument with more "punch."

Circuit Operation. The signal induced in the guitar pickup (Fig. 1) is coupled through *S1* and *C1* to the base of *Q1*, a preamplifier. Potentiometer *R12* is a volume control, while *R13* and *R14* provide bass and treble control.

The complete bass cut-and-boost circuit is composed of *R5*, *R13*, *R6*, *C3*, and *C4*. The treble cut-and-boost consists of *C5*, *R14*, and *C7*. The contoured

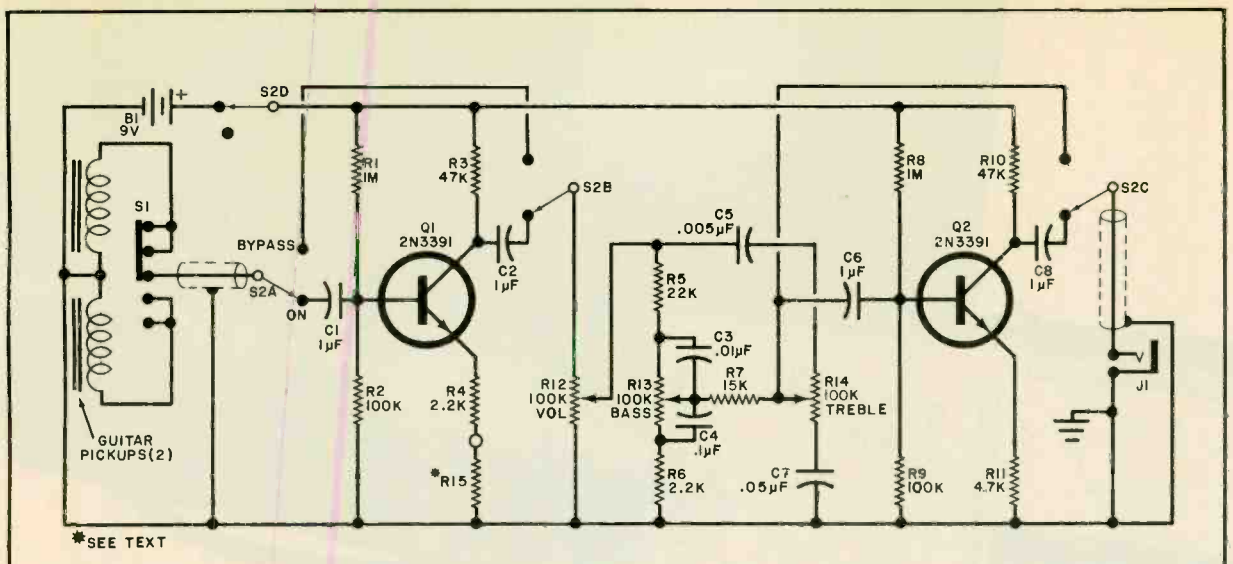


Fig. 1. Spectracom IGI™ circuit (patent applied for) is similar to discrete model.

PARTS LIST

B1—9-volt battery
C1,C2,C6,C8—1-µF tantalum capacitor
C3—0.01-µF, 20-volt, ceramic disc capacitor.
C4—0.1-µF, 20-volt, ceramic disc capacitor.
C5—0.005µF, 20-volt, ceramic disc capacitor.
C7—0.05-µF, 20-volt, ceramic disc capacitor
J1—Phone jack
Q1,Q2—2N3391A transistor
R1,R8—1-megohm, ¼-watt resistor
R2,R9—100,000-ohm, ¼-watt resistor
R3,R10—47,000-ohm, ¼-watt resistor
R4,R6—2200-ohm, ¼-watt resistor
R5—22,000-ohm, ¼-watt resistor
R7—15,000-ohm, ¼-watt resistor
R11—4700-ohm, ¼-watt resistor
R12-R14—100,000-ohm photentiometer
R15—See text
S1—On guitar
S2—4-pole, 2-position rotary switch
Misc.—Suitable chassis (if not put in guitar), knobs (3), battery holder, battery connector, mounting hardware.

signal is then applied to *Q2*, which is coupled to *J1* through *C8*.

When *S2* is placed in the bypass position, the transistor amplifier is turned off and the input signal goes through only the volume, bass, and treble controls.

Construction. The complete circuit can be assembled on a small pc board as shown in Fig. 2. If the unit is to be mounted in the cavity of a solid-body guitar, be sure all components are mounted so that they take up a minimum of height.

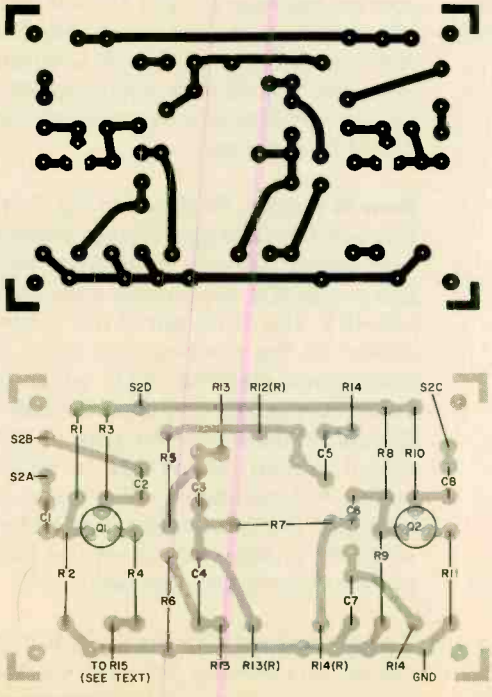


Fig. 2. Actual-size foil pattern (top left) for intensifier; component layout is shown below.

The value of *R15* must be selected so that it prevents distortion due to overloading of the first stage. Because of variations among guitar pickups, this resistor can be any value from zero to 10,000 ohms.

After determining that the amplifier operates with *S2* in the bypass position, connect the loose end of *R4* to ground and place *S2* in the position. If you get distortion, start by using 2200 ohms for *R15*. If the distortion continues, try 4700 ohms. Continue to increase the resistance if necessary.

Set the amplifier volume and tone controls as you normally do. Then play the guitar and test the operation of volume control *R12*, bass control *R13*, and treble control *R14*. The results should be very noticeable. Tone response is tailored by adjusting the bass and treble controls for a broad range of coloration. The wider frequency response gives both slashing chords and softly picked solo notes. The attack is fast and the sound is clean. Chord sustain is excellent. ◇

BUILD A $25 HIGH-FREQUENCY VOLTMETER

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

BY THOMAS H. SEAR

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

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

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

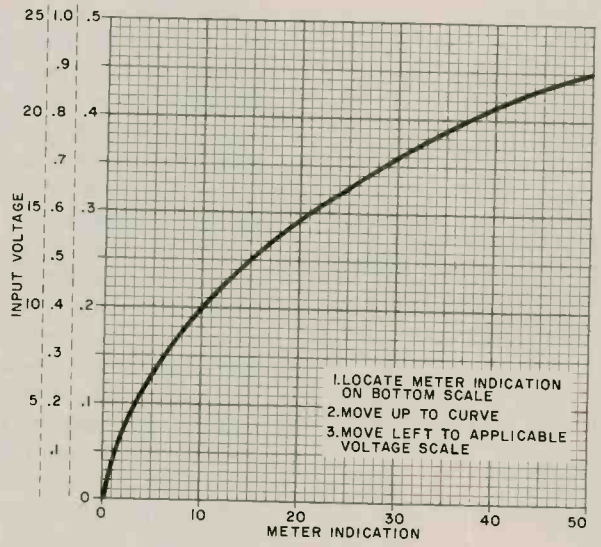


Fig. 1. Output of thermal converter varies with the square of the input. Use this curve to calibrate meter.

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

Construction. With the exception of the circuit involving the input voltage

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

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

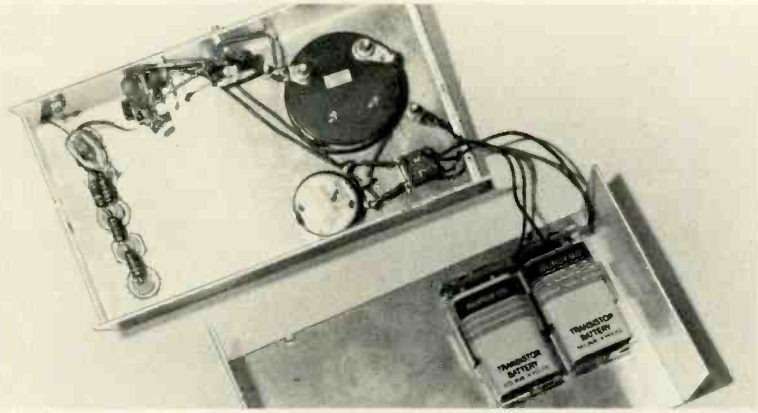


Photo of prototype shows layout of components.

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

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

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

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

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

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

PARTS LIST

B1,B2—9-volt battery
IC1—709 op amp
J1 to J5—BNC female connector (Amphenol UG-1094/U or similar)
M1—0-50-μA meter (Radio Shack 22-051 or similar)
R1—13,500-ohm, ½-W, 5% resistor (select 56,000 and 18,000 ohms in parallel)
R2—3600-ohm, ½-W, 5% resistor
R3—720-ohm, ½-W, 5% resistor (680 and 39 ohms in series)
R4—90-ohm, ½-W, 5% resistor (68 and 22 ohms in series)
R5—1000-ohm, ½-W, 5% resistor
R6—1-megohm, ½-W, 5% resistor
R7—250,000-ohm miniature potentiometer
R8—50,000-ohm potentiometer
S1—Dpst switch
TC1—Thermal converter (Best Products, Ltd., Model S-7. Available from Best Electrics Div., 1211 E. Denny Way, Seattle, WA 98122 at $9.90 each, plus postage.)
Misc.—Battery holder (2), suitable enclosure (LMB 138), knob (2), mounting hardware, etc.

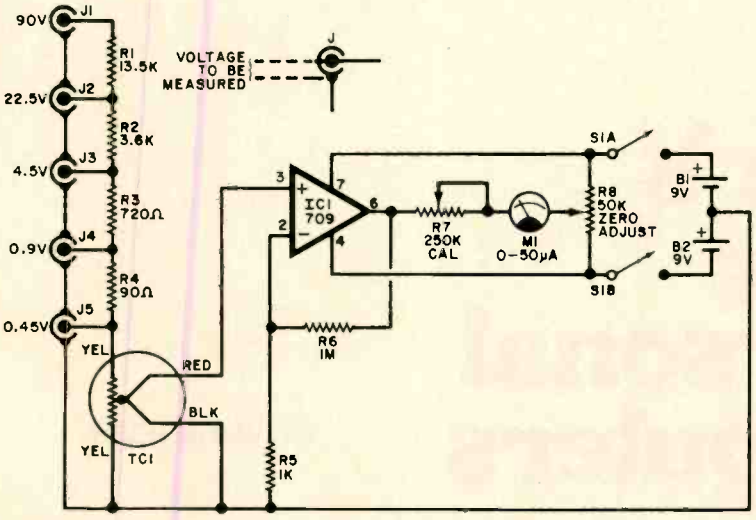


Fig. 2. Schematic of the voltmeter. Select and combine resistors to obtain proper values as given in Parts List.

BUYING YOUR own computer is a lot like buying hi-fi equipment. You're shopping for a *system*, not a single component. And the options available to you are much the same in both cases. You can start with a complete, multi-purpose system of awesome complexity or start small and build your system from that minimum. Moreover, you can build that minimum system from a number of different pieces or as one unit that is essentially complete in itself.

Still, the differences between hi-fi and computer systems are profound. Computers can perform a far wider range of tasks than hi-fi systems, so they require a much wider range of peripheral equipment in order to perform them. And where interconnecting a hi-fi system is as simple as plugging the cables from the turntable into a jack marked PHONO, connections for a computer are more complex. You not only need to have precisely the right kind of input or output for a given peripheral device, but you must program the computer to communicate properly with that peripheral.

The most important parts of a computer system are the MPU (Microprocessor unit), memory, I/O (input/output), cassette interface and recorder, power supply, video output, and CRT screen. Others, which are just becoming common in home systems, include a printer, a floppy-disk system, a modem for data communications by telephone, and device controllers.

There's almost no limit to the number of ways these system components can be packaged. The MPU, memory, I/O

A Beginner's Guide to personal Computers

BY IVAN BERGER

and power supply are usually packaged together. Keyboard, video output and CRT screen (or keyboard and printer) are often packaged together as a "terminal," but it's also fairly common for the keyboard, video output and sometimes the CRT to be incorporated as part of the computer itself. All the other parts can be found built into some computers or external to others.

Your choice of a beginning system will be affected by your budget, your level of computer knowledge, and the list of components you must begin with for your particular application. So it's well to begin by learning what those system components are, and what they do.

Parts of a Computer System. The best-known part of the computer system is, naturally enough, the part that does the actual computing. In a home system that will be a single integrated circuit called a *microprocessor*. But a microprocessor alone is useless without the other parts that make up a true computer system. And the most basic of these parts are the MPU (where the computing actually takes place), memory (where programs and data are stored), I/O (input/output—the computer's way of communicating with the outside world), and programs or "software."

The *MPU*, or microprocessor unit (sometimes called a CPU or central processing unit) itself consists of several parts: the microprocessor itself, several *registers* (memory units holding one number apiece for the processor's immediate use), and a *clock* to keep all parts of the system working in sync with one another.

Memory. The "scratchpad" registers of the MPU are only a tiny fraction of the memory the computer needs. There's no room in there to store, for example, the program that tells the computer what to do. And frequently the computer needs some place to store its register contents for a while in order to fill those registers with other data. Where there is a lot of data to be handled, the computer needs someplace to store that, too.

Most of these requirements are filled by a type of memory called *RAM*, or Random Access Memory. The contents of RAM can be changed by the computer at any time, which makes it very simple to revise programs or data whenever required. Unfortunately, when you turn the power off, the contents of RAM spontaneously scramble themselves. When you next turn the computer on again, whatever programs and data you have stored in RAM are irretrievably lost. The contents of RAM can be lost in other ways, too. For instance, an incorrectly written or entered program can accidentally over-write portions of itself. So, while some RAM is absolutely necessary, something more than RAM would be extremely useful. And two other types of memory—ROM and mass storage—are available to do the job.

ROM stands for Read-Only Memory. Unlike RAM, it's *non-volatile*; that is, it doesn't forget or scramble contents when the power is turned off. And the computer can't rewrite its contents, either. All the computer can do is read what's already there. This makes ROM a perfect place to store programs which the computer will need all the time. The most common application of ROM is storing *monitor* programs (also called "executive" or "operating system" programs), which the computer needs frequently in order to communicate with its I/O devices, and how to understand what it receives from them. In some personal computers, a "high-level language"—usually BASIC—is also stored in ROM to enable you to communicate with the computer on your terms.

Some ROM's ("masked ROM") are programmed at the time of manufacture, and can never be changed. Others, called PROM (Programmable ROM), EPROM (Erasable PROM) or EAROM (Electrically Alterable ROM) can be erased and reprogrammed. But you can't just change a single item as you can in RAM; instead, you have to erase the whole PROM (usually by exposure to a strong ultraviolet light, like a sunlamp) and reprogram it with a special "PROM programmer" attachment.

Both ROM and RAM are organized similarly. Data and program steps are stored in individual "words." (Most home computers use 8-bit words, called "bytes"; a few use 12-bit or 16-bit words, with each word stored in a separate, numbered location.) Most of the time, the computer works its way through these locations in sequence, acting on whatever it finds at each address before proceeding to the next one. Often, though, what it finds at a given address is an instruction to jump somewhere else in memory, whereupon it jumps and starts reading through memory in sequence from that point.

About the minimum amount of RAM or ROM you'll find on even the simplest, most limited computer is 256 bytes, or sometimes 512 or 1024 ("1K") bytes. But most computers have at least 4K of RAM or more, in 4K or 8K increments.

Mass Storage. Both RAM and ROM store programs and data within the computer itself. But RAM and ROM are too expensive to serve as permanent storage for all but the most frequently-used programs. Since it takes a fairly long time to enter most programs by hand, it's very useful to have some comparatively inexpensive way of storing these programs in a form the computer can read directly. Several such systems are available.

The oldest mass-storage system is *punched paper tape*. Many programs are sold on paper tape, since many computer hobbyists have Teletype terminals with built-in paper tape facilities, and because paper tape readers are inexpensive. But paper tape punches (unless included in a Teletype) are fairly expensive, and are always noisy. Also, both reading and punching paper tape is a comparatively slow process.

Therefore, most computer hobbyists use *audio cassette interfaces*, which record data and programs on ordinary tape recorders, using ordinary tape which can be erased and reused when necessary. This is faster than paper and inexpensive as well. The only drawback is that there are several different cassette data formats, and a computer set up for one such format can't make head or tail out of a tape in another format, even if it's from an otherwise identical computer. Faster still, but more expensive, are *floppy-disk* systems, a form of magnetic recording using disks of magnetically coated material rather than tapes.

It takes a bit longer to load a program from a floppy disk than to run one in ROM, longer still to load it from a cassette, and quite a bit longer to load one from paper tape. But these mass-storage media have some advantages, too: If you have more programs than can fit in your computer's memory at once, you must use mass storage to save the programs you're not currently running. It also makes it easier to upgrade your software, trading in an 8K BASIC, perhaps, for a 12K or 16K BASIC with more features. And it allows you to use different programs whose address space overlaps, provided you don't use both of them at once.

I/O can come in an even greater variety of forms. Most home computers have either built-in I/O devices with which you can communicate directly, "ports" for connection of external I/O

devices, or some combination of the two.

Built-in I/O devices take only a limited number of forms. For input, some computers have arrays of switches, others have calculator-like keypads, and still others have typewriter-like keyboards. For output, the range is from binary LED displays (lights that indicate the status of each "bit" of information in a computer word or memory address), usually associated with switch-array or keypad inputs, to digital LED's like those on a calculator (usually found with keypads) to video outputs that display several lines of letters and numbers on a built-in or external TV screen. Many home computers have built-in cassette interfaces, too. Though the cassettes function as a sort of memory, the interfaces that work with them are classed as a type of I/O.

Not all I/O involves letters and numbers, though. There are growing numbers of device control interfaces that can switch external devices on and off under program-controlled conditions. With such interfaces, your computer could, for instance, turn lights on and off while you're away to make it look as if someone were home.

More sophisticated interfaces between the computer and the real world are proportional controllers, using analog-to-digital (A/D) and digital-to-analog (D/A) converters. Most "real-world" information and processes are analog—the temperature, for instance, rises and falls continuously, rather than in discrete digital steps that the computer can understand. An A/D converter makes it computer-readable. Similarly, a D/A converter turns digital signals into varying voltages for proportional—instead of strict on/off—control of external devices.

There are also telephone interfaces, called "modems" (short for modulator-demodulators), which allow your computer to communicate by phone with other computers and remote terminals. External modems require an I/O port built into the computer. But there are also modem boards that fit directly into some computers.

I/O ports come in two varieties: parallel and serial. In a parallel port, each of the 8 bits in a character passes through its own line to the computer. In a serial port, the 8 bits pass through a single pair of wires one at a time, often with added bits to indicate where each character begins and ends. Parallel ports are usually faster and cheaper, but are impractical for long runs between devices because they require so many wires. Serial ports require only two wires, but are slower. There are two common types of serial ports, the "20-mA current loop" and "RS-232," each requiring a different plug pattern and voltage level. However, most serial ports (and most serial devices, except for Teletypes, which are 20-mA) can be wired for either standard.

Software. Though computing power is sometimes referred to as "intelligence," computers are dumb machines, which cannot do a thing without being told, in extreme detail, precisely what to do and how to do it. Without these programs of instruction, a computer is far less useful than a $4.95 calculator; its power and utility rest as much on its programs as on the hardware that those programs control.

The most important such program is the *monitor* or *operating system*. This program tells the computer where to go for information, what form to expect it in, and how to output it. A monitor will also tell the computer how to output, or "dump," sections of its memory contents to show what programs and data are stored there, and how to execute those programs. More sophisticated monitors will have additional features useful in writing, editing and debugging programs, such as "breakpoint" routines that stop the program at a specified step to see if it's reached that step without mishap, "search" commands that can find any byte or combination of bytes, and commands to move memory contents from one location to another.

Usually, this program is stored permanently in ROM memory. The computer is then ready to use as soon as it's turned on. Some computer monitor programs are on cassette tape or paper tape, which cannot be loaded in until the computer is first hand-fed a short program called a "bootstrap," which tells it how to read the tape. But ROM monitor boards are usually available as accessories for these computers.

Two other very important programs are *assemblers* and *high-level languages*. Using just a monitor, you have to program in *machine code*. This requires that you must learn the computer's own, rather roundabout ways of performing even simple tasks ("multiply 2 x 3," for instance, could require 7 commands or so on a typical home computer system). You must also learn to communicate in the computer's own vocabulary, a rather arcane mixture of C9's, DB's and the like. An assembler lets you write these programs in more comprehensible form, using such abbreviations as "IN" for input, and "ADD" for addition (though you still have to do things the computer's way rather than your own). The assembler program translates your instructions into the computer's vocabulary.

High-level languages, such as *BASIC* (the most popular in home use), let you talk to the computer in a form more closely resembling human communication. You can then devote much more of your time to telling the computer what you want done, and far less time to telling the computer how to do it. A BASIC program for dividing 2 by 3, for example, is: "PRINT 2/3." The "interpreter" then tells the computer what sequence of steps it needs to do to accomplish this.

Assemblers and interpreters, particularly the latter, require a great deal of memory in which to run. The more elaborate the program, and the more it can do for you, the more memory it takes. One computer manufacturer, for example, offers BASIC in versions occupying 4K, 8K, 12K and 16K of memory, each with more features than the last. Assemblers and short interpreters are sometimes available in ROM, but usually have to be loaded from a paper tape, cassette, or disk.

When buying programs, make sure they're compatible with your system. Most programs are designed to run in a given block of memory addresses, and will not run if relocated unless they're modified. You must have RAM memory at those addresses, and this RAM must not be occupied by other programs which will be in use at the same time (such as the monitor or disk operating system, in a few systems).

Programs written in BASIC or other high-level languages pose another problem. BASIC programs on tape or disk can only be used with the BASIC interpreters or compilers they were designed for; other BASICs will be unable to read these programs properly, if at all. A printed program, however, can be manually entered from the keyboard with any BASIC that has all of the commands that program uses.

Computer Types. Home computers run a wide gamut of designs. But basically, they fall into one of 6 main classes:

1. *Intelligent Terminals*. These include a microprocessor (the part that does the computing), some memory, a typewriter-like keyboard, and either a built-in video screen or an output to feed an optional,

accessory screen. Such computers are ready to use as soon as you plug them in. But they all provide for later expansion by the addition of more memory, other terminals, printers and so on. (Some of them, however, are easier to expand than others.) These are ready to use for data processing applications, games, teaching yourself programming and, in some cases, graphics.

2. *Micro-Mainframes.* These are designed to become the bases of larger systems than the intelligent terminals. Therefore, they are less complete (keyboard, video output or display, and ROM monitors are usually extra costs), but have more room for expansion.

There are two basic types of mainframes: those with a full quota of front-panel switches and controls, and those with few external controls except for power and reset switches. The front-panel controls let you program directly into the machine without any external terminals or keyboards, but the process is painstakingly slow; front panels are more useful in trouble-shooting programs, checking them step-by-step to see where troubles, if any, lie. Most front panels use arrays of LED's and switches, each corresponding to a single bit of data or address. A few, however, have calculator-like keypads and numerical displays, which make them simpler to use.

"Turnkey" computers—those without front-panel controls—are automatically programmed to work with such "peripherals" as external terminals or keyboards and displays. That's a major timesaver. But turnkey computers require those peripherals in order to be of any use at all in most applications.

Both front-panel and turnkey mainframes are built to hold a number of accessory boards for system expansion. Such boards might typically include more memory, additional input/output (I/O) ports for communication with such devices as printers or additional terminals, modems for communication via telephone with other computers and terminals, and a host of other devices.

Mainframes are, obviously, adaptable to virtually any purpose you have in mind; you can even adapt some of them to perform several tasks at once. This adaptability is only gained at the expense of higher cost, but there's quite a spread between the prices of the most and least expensive mainframes. And you can reduce the first cost by buying one stripped down to the bare essentials of MPU, memory and I/O (sometimes all available on one board) to keep the first cost low.

Many of these mainframes share the same "bus," the pattern of wires that the boards plug into and the pattern of signals and voltages they carry. Most common in the home computer field are the S-100 bus, which originated with the Altair 8800, and the SS-50 bus, which originated with the Southwest Technical Products 6800. There are other bus types, too, which are rarely compatible with each other. (Bus compatibility is indicated in the product directory that follows.) Some of the lines on the S-100 bus have never been officially defined, however, and may be used for different purposes by different manufacturers. Before buying S-100 equipment from several sources, it pays to check by writing to the manufacturers involved to see whether the equipment will all work harmoniously.

3. *Single-Board Systems.* These are both more and less complete than mainframe computers. They usually come complete with keypads for input and either binary or digital LED displays for output—features which most mainframes lack—but are usually supplied as bare boards with neither power supply nor case, features found as a matter of course in both mainframe and intelligent-terminal computers. (Some of the intelligent terminals are also available without case and power supply, as single board units.)

Single-board systems are often sold as computer trainers, and they are very useful for learning about computers. All circuitry is accessible, and the keypad and display simplify programming in machine language. They're also useful for dedicated (single-purpose) applications, such as controlling machinery or house systems, since they're so inexpensive. Moreover, some are designed expressly for this purpose, including on-board relays. They can be expanded, too, by the addition of more memory and connection of external terminals. But the amount of expansion that can easily be accommodated is rather limited.

4. *Single-Board MPU's.* As with single-board systems, these come with neither power supply nor case (and cases are frequently not available). But they do not include keypads or LED displays. Some have on-board interfaces for use with external terminals. Most provide for easy connection to additional boards with more memory, more I/O and other functions—easier, in many cases, than with single-board systems. In several cases, whole families of plug-together boards from several manufacturers have grownup around certain manufacturers' computer boards.

These boards were mostly designed for use by engineers in evaluating specific microprocessors for inclusion in their own companies' products. As a result, they're built to industrial, heavy-duty standards (which raises their cost, frequently beyond that of single-board systems, even though the latter do more). And their instructions tend to be oriented toward the engineer, with more technical background and less hand-holding than instructions aimed at the non-engineer and hobbyist.

Conclusion. Sales of personal computers for home, experimental, and small-business uses are burgeoning. With prices ranging from well under $100 to many thousands, virtually everyone can enter this exciting field at any level. The following product directory will give you a full picture of the type and variety of personal computers on the market today. ◈

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2758(5v)	23.40

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2107B-4	3.95
TMS4027	4.00
MM5270	4.50
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21L02	1.75	1.50
2101-1	2.95	2.60
2111-1	3.25	3.00
2112-1	2.95	2.65
2114L	9.50	8.00
2114L	10.50	9.00
TMS4044	8.95	8.00
TMS4044	9.95	8.75
4200A	10.95	9.25

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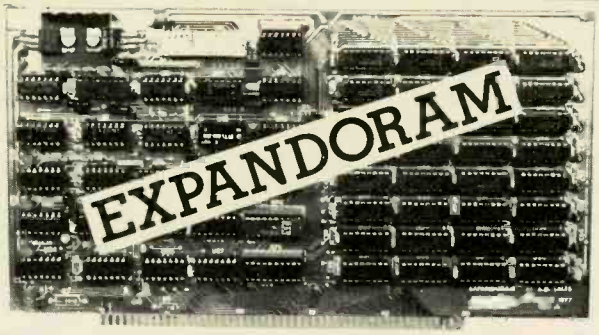

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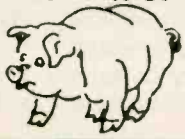

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Bare Board	$35.00

MD-690a CPU BOARD

S-100 Compatible 6800 MPU
1K x 8 RAM, PROM expandable to 10K.

$199.95

TU-1

Convert your T.V. set into a Video Monitor

Kit $8.95

JADE VIDEO INTERFACE

S-100 Compatible Serial Interface with Sockets Included.

Kit	$117.95
Assm. & Tested	$159.95
Bare Board with manual	$35.00

SHUGART DISK DRIVES

SA 400 $295.00
Single-density 5¼", 35 track drive.

SA801R $495.00
Single-sided 8" floppy disc drive.

DM 2700-S $750.00
Includes SA801R disk drive, 10" x 10" x 16" cabinet, power supply, data cable, fan, AC line filter.

STATIC RAM BOARDS JADE 8K

Kit JG8K (450ns)	$125.95
Assm. & Tested JG8KA (250ns)	$139.75
Kit JG8K (250ns)	$149.75
Assm. & Tested JG8KA (250ns)	$169.75
Bare Board without parts	$25.00

16K -Uses 2114's (lo power)

Assm & Tested RAM 16 (250ns)	$375.00
Assm. & Tested 16B (450ns)	$325.00
Mem-2 Kit (250ns)	$285.00

16K Static with memory management

Assem.& Tested RAM 65 (250ns)	$390.00
Assm. & Tested RAM 65B (450ns)	$350.00

Seals 32K

Assm. & Tested JG32 (250ns)	$795.00
Assm. & Tested JG32B (450ns)	$725.00
Kit JG32K (250ns)	$575.00

Digital Electronics/Microcomputers

PRODUCT DIRECTORY

The listing covers only computers and those peripherals and module boards made by a manufacturer for its own computers and not fitting other makes. Modules, peripherals and accessories made for those computers by other companies, or fitting several makes of computer, will be found in the appropriate sections of this directory.

Wherever possible, we have indicated mutual compatibility among products of different manufacturers by one of the following bus symbols: (AP)=Apple II,(DG)=Digital Group, (EX)=Motorola EXORcisor M6800, (H8)=Heathkit H-8, (I8)=Intellec 8, (IEE)=IEEE-488 bus, (KM)=KIM-1; (LS)=LSI-11, (MB)=Intel SBC Multibus, (PT)=PET, (RS)=Radio Shack TRS-80; (S1)=S-100 (Altair) bus, (S3)=SWTP 6800 30-pin I/O bus, (S5)=SWTP 6800 SS-50 50-pin bus, (UB)=DEC Unibus.

ALPHA MICRO SYSTEMS

AM-100 16-BIT CPU (S1)
MPU board implementing WD-16 16-bit processor on S-100 board. Supports most S-100 peripherals, including static memory, I/O and video. MPU features 11-digit floating-point arithmetic in hardware; eight 16-bit general registers; real-time clock; multiple-level DMA and vectored interrupts; up to 10 times the throughput of most 8-bit systems. Software provided includes: AMOS operating system with time-sharing, multi-tasking, multi-user, disk-management and memory-management (to 256K bytes) capabilities, device-independent I/O structure; macro assembler, ALPHABASIC with special business features, ALPHALISP, ALPHAFORTH and ALPHAPASCAL $1495

ANDROMEDA SYSTEMS

11/B COMPUTER SYSTEM (LS)
LSI-11 MPU; turnkey system; 20K words (40K bytes) RAM, expandable to 28K words; dual floppy-disk system with 512K bytes on-line; includes Lear-Siegler ADM-3a 80-char × 24-line CRT terminal; RT-11 OS; FOTRAN, FOCAL and BASIC available; 8-slot quad card cage; serial interface; power supply $8317
11/B-LA36. With DECwriter LA36 instead of ADM-3a $9002

APPLE COMPUTER

APPLE][(AP)
6502-MPU computer with built-in keyboard, 6K BASIC and 2K monitor in ROM, 4K-48K RAM, interfaces for cassette (1500 char/sec), color video (text, graphics, or mixed) and video-game paddles or joysticks. Video output, 40 characters x 24 lines, upper-case; normal, inverse, or flashing; full cursor control. Graphics 40 x 48 resolution (40 x 40 with four lines text) in 15 colors; high-resolution graphics (requires 12K memory), 280 x 192 (280 x 160 with four lines text) in black, white, and two colors. Apple BASIC has special color, graphics, and game commands. Assembled, in case. Weight 10 lb. With 4K/16K/32K/48K ..... $970/$1195/$1495/$1795
Apple II Board. Same, less case, power supply, and keyboard. With 4K/16K/32K/48K ..... $645/$870/$1170/$1470
Parallel Printer Interface card. ROM firmware answers BASIC commands; allows up to 255 char/line, upper/lowercase, special symbols; printers up to 5K char/sec; interfaces to most printers through parallel port $180
Communications Interface Card. RS-232 port with PROM firmware on card; for use with serial peripherals and modems; passes lower-case or converts to upper-case, at user's option: 110 or 300 baud: half-duplex $180
High-speed Serial Interface Card. Similar to C.I. card, but 75-19.2k baud: switch-selectable speed, line length, auto line feed, carriage return delay $195
Applesoft II Firmware Card. Has expanded Microsoft floating-point BASIC in firmware; 9-digit arithmetic, large function library, 3 data types, fixed-point or scientific notation, string operations, and high-resolution graphics; user-programmable error messages: will run in 4K RAM; 16K required for high-resolution graphics $100
Applesoft II on cassette ..... $ 20
Programmer's Aid #1 Firmware. ROM-based library of routines for: high-resolution graphics; program renumbering and linking; tape verification; music; RAM tests; machine-language program relocation $50
Prototyping/Hobby Card. For user's custom circuits; includes system bus description $24
Disk II Floppy-Disk Subsystem. Interface card, mini-floppy drives. (Computer handles up to 7 cards, 14 drives.) Holds up to 116K bytes (formatted) per disk, soft-sectored.
With one drive and controller $495
Printer II. Printer interface plus Centronics P1 printer; 80 char/line, 150 lines/min., dot-matrix, electric-discharge on aluminized, 4.75" paper $695
Printer IIA. Interface plus Centronics 779; 132 char/line, 60 char/second, dot-matrix, impact, paper to 9.8", tractor feed, upper-case $1445
Memory Expansion Modules. 4K/16K ..... $ 75/$300

BYTE

BYT-8 (S1)
Chassis only, with motherboard and power supply, no MPU. See Accessories section for details .. $229

CGRS MICROTECH

SYSTEM 6000 (S1)
6502-MPU computer system using S-100 bus. Modular system, all parts available separately.
6000 Level I: Tutorial. 6502 MPU; 256 bytes RAM; front panel with 7-segment hex displays, single-step, memory protect. Kit/wired ..... $200/$240
6000 Level II: Introductory. All features of Level I, except 1K RAM, plus TTL support logic for S-100 interface. Kit/wired ..... $260/$330
6000 Level III: Standard. All Level II features except front panel, plus I/O board with T.I.M. "Terminal Interface Monitor" ROM for use with terminals; S-100 motherboard; power supply (±16V @ 1 A, −8V @ 10A). Kit/wired ..... $370/$470
6000 Level IV: Advanced. Level III features plus front panel; 2K RAM. Kit/Wired ..... $500/$600
6000 Level V: Professional. Level IV features plus cabinet and EXOS extended operating system firmware. Kit/wired ..... $795/$995
6000 Level X: Turnkey. Keyboard input and video output; no front panel. 1K RAM, "VIP" operating system with screen control; other features as for Level V. Kit/wired ..... $895/$995
6000 Level XI: Portable. Similar to Level X, but in portable briefcase; power supply ±16V @ 1A, −8V @ 6A; S-100 motherboard, with room for additional cards. Kit/wired ..... $745/$895

MPU BOARDS (S1)
6502-MPU boards for S-100 systems.
Level I. MPU with 1-MHz crystal clock; power-up restart circuitry; 50-pin front-panel connector; slow-memory and S-100 interface logic.
Bare board/kit/wired ..... $50/$150/$180
Level II. Similar, plus 2K RAM, 4K 2708 EPROM. Kit/wired ..... $240/$280
2-Mhz option. For above boards and computers, $50

Note: Compatibility listings for other S-100 boards are available from CGRS Microtech.

CENTRAL DATA

2650 COMPUTER SYSTEM BOARD
2650-MPU computer, including 80-character, 16-line video output, 300-baud Kansas-City-standard cassette interface, 1024-byte PROM supervisor with breakpoint and cassette routines, PROM expandable on-board to 4096 bytes. Includes 64-character uppercase character generator, space for additional 64 user-created characters, 750 bytes user-available RAM. Requires 5 V, 7.7-5.3A, according to PROM population. Wired $275
Kit $225
S-100 Bus Motherboard. Expansion board for 2650 computer, accepts Altair-bus memory or I/O boards $110
Kit $95
Software. Editor/assembler and BASIC, on cassette. Each $20
Editor/Assembler, BASIC, Debugger, Character Generator Program ..... $20 each
12K BASIC, Assembly Language Package $30 ea.

COMMODORE

PET COMPUTER 2001 (PT) (IEE)
6502-MPU, self-contained computer, includes built-in keyboard with 64-character ASCII uppercase

plus 64 graphics-related characters; 9-in. video display for graphics, 40-character × 25-line alphanumerics, or both; 8K RAM memory, expandable to 32K; 12K ROM including 8K BASIC interpreter and 4K operating system; built-in audio-cassette recorder (file management system in BASIC); interfaces for additional recorder and IEEE-488 instrument interface bus. Wired.
4K/8K ..... $595/$795

2020 PRINTER (PT)
Prints up to 80 char/line on 8½" roll or fan-fold paper; prints complete PET alphanumeric and graphic character set; 120 char/sec; can be programmed to print extended characters or unique characters such as corporate logo $695
C2NT Second cassette recorder $100

COMMODORE/MOS

KIM-1 MICROCOMPUTER (KM)
6502 MPU, single-board computer with 1.1K RAM, 2K ROM monitor, 20-mA serial interface, 23-key control and hex data-entry keypad (terminals provided for additional, remote keypad), six-digit LED hex display of address and data, audio cassette interface, 15 I/O lines, interval timer under software control. Can be used as stand-alone microcomputer (requires 5V @ 1.2 A, 12 V @ 100 mA), or expanded
with modules below. Assembled $245
KIM-3. 8K static memory $289
KIM-4. Motherboard. Interfaces KIM-1 with up to six system expansion modules, with all required buffering (motherboard not required to interface KIM-1 with a single expansion board). Includes + 5V, + 12V regulators (external power supply required)..... $119
KIM-5. Firmware resident assembler/editor $198
KIM-6. Prototyping board, wirewrap, for user-defined system expansion $39

COMPTRONICS

1080 F-8 MICROCOMPUTER (S1)
F-8 MPU on single-board computer. Includes FAIRBUG Program Storage Unit, Static Memory Interface, 2K RAM, 2.0-MHz crystal, 1K EPROM, 4K EPROM sockets. Connectors for S-100 memory expansion, 1 serial and four parallel I/O ports. Controls for memory page select, memory protect, I/O or terminal select, high-speed paper tape select, monitor/user-program select, reset. Requires ±5, +12 V dc.
Kit/wired ..... $239/$275

COMPUCOLOR

COMPUCOLOR II
8080-MPU intelligent-terminal type computer with 8-color integral display on 13" CRT. Typewriter keyboard with 3-key rollover, 4K to 32K RAM, built-in mini-disk option; 16K PROM, with sockets for additional PROM; 64 char/line display; firmware includes disk BASIC, file control system, and terminal software, designed for up to 512 ports, with 25 ports implemented in standard unit; RS-232C optional. Editing features; disk capacity 51.2K/disk (formatted).
Model 1. (available 1979) 4K RAM, 16-line display. $795

Model 2. (available 1979) 8K RAM, 16-line display. $995
Model 3. 32-line display, 8K RAM, graphics, RS-232C $1495
Model 4. Same, but 16K $1795
Model 5. Same, but 32K $2395

COMPUTER POWER AND LIGHT

COMPAL-80 (S2)
8080-MPU computer; includes power supply, motherboard, real-time clock, vectored interrupt, ROM system monitor, 16K RAM, serial port (RS-232 or current loop), motherboard*, 300/2400 baud cassette interface, 16-line × 64-character video display output (full ASCII plus 48 × 128 graphics modes), keyboard in separate housing, 9-in. CRT monitor and system cabinet, plus BASIC, clock and PLOT functions. Wide range of peripherals and software available. Wired only. With 16K/24/32K memory.....$2300/$2675/$2875

CROMEMCO

SYSTEM THREE (S1)
Z-80A-MPU with dual-disk drive (4-drive controller), 32K RAM with bank select (expandable to 512K). 30A power supply; 21-board capacity; jump-on-reset to 1K PROM monitor; includes serial (110-76,800 baud) and parallel interface. Rack Mount $5990
Option 001. Front-panel PROM programmer for 2708 ..... $495
Option 002. Additional dual-disk drive $2395
Option 003. Additional 16K memory $795
Z3-WCB. Walnut floor cabinet, 29" x 21" x 30"...$595
Z3-CAB. Aluminum cabinet with foldaway handles. 13" x 20" x 26" $195
Software available: 16K Z-80 BASIC, FORTRAN IV, Z-80 macro assembler and linking loader.

Z-1 (S1)
Z-80 MPU computer with front panel controls and indicators. Uses selected, high-speed Z-80 MPU chip. 21-slot motherboard, PROM programmer with 8K capacity (2708), 32-A power supply, 8k RAM memory, RS-232 serial interface, 1K monitor, Wired $2495

Z-2 (S1)
Similar, but without front panel. Power-on jump circuitry begins automatic program execution when power is turned on. Rack-mount design (cabinet optional) with 60-A power supply for cards and other peripherals; special 21-slot Blitz-Bus motherboard design to reduce ground-current noise. Kit/wired.....$595/$995

Z-2D (S1)
Similar to Z-2, but with built-in mini-floppy (5") disk drives. Disk controller has 4-drive capability. With one drive. Kit/wired .....$1495/$2095
Z3D-FDD. Additional disk drive $495
Retro kit. Converts Z-2 to Z-2D. Kit/wired ..... $935/$1135
Z2-WCB. Walnut floor cabinet $595

SYSTEM TWO (S1)
Consists of Z-2D with 2 drives, RS-232 interface, 32KB RAM, PR1 printer interface.
Model CS-2 ..... $3990

SINGLE CARD COMPUTER (S1)
Z-80 MPU plus 8K 2716 PROM; 1K RAM; serial (RS-232 or 20 mA) port; 24 bits parallel I/O; vectored interrupts; 5 programmable timers. Requires +8V @ 1.4A, +18 V @ 70 mA; −18 V @ 25 mA.
SCC. Kit/wired ..... $395/$495
MCB-216. 12-command monitor and 3K Control BASIC in two 2716 PROMs $90
Z80-CPU. MPU replacement only, no on-board memory or I/O. See Module Boards section. Kit/wired .....$295/$395

DIGI-KEY

NIBBLER
SC/MP-MPU, single-board computer. Includes NIBL 4K BASIC interpreter in ROM, 2K RAM (expandable to 28K), 110-baud TTL serial I/0. On 4¼" × 6½" board with 72-pin edge connection; includes manual. Wired $150
Power-supply board. Provides 5V @ 1A and ±12V @ 100 mA for NIBBLER; also converts TTL serial I/0 to both 20-mA TTY and RS-232 .....$40

DIGITAL MICROSYSTEMS

DSC-2 MICROCOMPUTER
Z-80 MPU; 32K RAM standard, 64K optional; dual-density disk system with two 8" drives built-in (double-sided optional); expandable to four drives; CP/M included; 4 RS-232 serial interfaces; real-time clock; no backplane.
With 2 single-sided drives, 32K/64K RAM .....
.....$4995/$6090
With 2 double-sided drives, 32K/64K .$5695/$6795
With 4 single-sided drives, 32K/64K . $7040/$8145

DIGITAL SERVICE & DESIGN

DSD 1802 (S5)
1802-MPU computer system. Uses SS-50 bus, (but not compatible with 6800 MPU or SWTP-compatible serial I/O which use 6800 MPU for baud-rate generation). Full 65K addressing; all EF flags, Q, N and DMA lines brought out to bus. 4K (2708) or 8K (2716) EPROM memory; ±5V and −12V regulators; RS-232C or TTY interface option. All modules sold as bare boards with edge connectors.
DSD 1802-4K-8K. MPU card $27
DSD 1802-I/O I/O network card; supports 9 cards $29
DSD S6011. Serial Card $12
DSD SS-50-5. 5-slot motherboard $29
DSD 2114-16K. 16K RAM card* $27
DSD P8212. Parallel I/O card $12
DSD C I/O-2M. Cassette interface $12
DSD 1802. Package of one each of the above, with documentation $125
CDP1802CD. CPU $20
MPO42. Baud-rate crystal $4.50
R50-E2-Y1. Cassette motor relay $2.80
WYN-MON. DSD monitor in 2708 ..... $30
*Fully compatible with 6800 SS-50 systems.

DIGITAL SPORT SYSTEMS

INFORMER 2
Two-piece computer: one disk/mainframe unit, one keyboard console. Requires TV set or video monitor. Includes: 32K RAM; 2 serial RS-232 ports; 2K PROM; floppy controller and mini drive; power supply; BASIC on disk; 63-key keyboard; TV interface $1695
16K RAM addition $385
4-port serial board $256
4-port parallel board $321
PROM board (holds up to 8K) ..... $ 97
Additional mini-floppy drive $550
PROM burner (for 2708) $256
RS-232 add-on for original serial port ..... $ 33
Game and business software available on disk.

UC2000 MICROCOMPUTER (S1)
8080A-MPU, terminal-type microcomputer. (Available without MPU if desired). Mainframe includes: 12" 14-MHz video monitor; 8-slot S-100 motherboard with customizing area; 18A power supply; blower; standard keyboard; cabinet with room for mini-floppy drive.
System A. As above, no cards $995
System B. With 8080A CPU, Video interface (96-char. upper/lowercase ASCII; 64 char. x 16 li.; graphics capability); cassette interface (bi-phase or K.C.) $2266
System C. With 16K RAM, extended keyboard

NOTICE TO READERS

We consider it a valuable service to our readers to continue, as we have in previous editions of this guide, to print the price set by the manufacturer or distributor for each item described as available at presstime. However, almost all manufacturers and distributors provide that prices are subject to change without notice.

We would like to call our readers attention to the fact that during recent years the Federal Trade Commission of the U.S. Government has conducted investigations of the practices of certain industries, in fixing and advertising list prices. It is the position of the Federal Trade Commission that it is deceptive to the public, and against the law, for list prices of any product to be specified or advertised in a trade area, if the majority of sales of that product in that trade area are made at less than the list prices.

It is obvious that our publication cannot quote the sales price applicable to each trading area in the United States. Accordingly, prices are listed as furnished to us by the manufacturer or distributor. It may be possible to purchase some items in your trading area at a price that differs from the price that is reported in this edition.

The Publisher

.....$2582
System D. With 16K RAM, extended keyboard, 1 floppy $3649
System E. RS-232 printer interface, dual floppy, all System C features $4666
MFIO-1. Firmware monitor ..... $ 66
Option 001. 230V 50 Hz operation ..... $ 25
Option 002. RS-232 and 20/60 mA-interface $160

DYNABYTE

DB8 **(S1)**
Z-80-MPU. 12-position card cage and shielded backplane, regulated 30A power supply; cast aluminum enclosure (wood enclosure tops optional); 32K RAM; 2 serial RS-232, 1 parallel I/O ports; vectored interrupts; real-time clock; EPROM programmer.
DB8/1 ..... $2195
DB8/2. Similar, but with 5-inch mini-floppy; dual density floppy-disk controller allows addition of double-density drives.

DB8/2-1. Two drives single-sided $4395
DB8/2-2. Double-sided $5195
DB8-4. Similar, but with double-density 8" floppy.
DB8/4-1. Two, single-sided drives $2995
DB8/4-2. Two double-sided $3595

PZ8. SELF-CONTAINED COMPUTER **(S1)**
Z-80 MPU single-board computer for S-100 bus. Can include MPU, 2 RS-232 serial and 1 parallel I/O ports 1K static RAM, 4K EPROM with programmer; vectored interrupts, real-time clock, reset jump.
PZ81-1. As above, less RAM, serial ports, EPROM $555
PZ81-X1. 1K RAM option $40
PZ81-X2. 2K EPROM $55
PZ81-X3. 1 serial port $40
PZ81-X4. 2 serial ports $75

BASIC CONTROLLER
Single-board computer for high-level programming of control applications. Uses ZIBL control BASIC. Has all facilities of PZ8 except S-100 bus, plus 8-bit status-light port, four .75-A relays, four 5-A relays, 32 flag outputs, 32 sense inputs, cassette I/O with file handling, 64-char × 16-line video interface; 8K RAM, expandable to 16K.
BC1-1 .....$1095
BC1-X1. Power supply $85
BC1-X2. Plexiglas cover with legends $15
BC1-X3. Additional 4K RAM $110
BC1-X8. Application program cassettes $12

E&L

MMD-1 MINI-MICRO COMPUTER
8080A MPU educational microcomputer system with built-in breadboard sockets; comes with Bug-

book self-teaching training course. Features octal keyboard and binary display, power supply, 256-byte PROM operating system (expandable on-board to 512 bytes); 512-byte RAM (expansion available). Kit/assembled .....$375/$525
MMD-1/MI. Memory/interface board with TTY and 300-baud cassette interfaces, 1K RAM expandable on-board to 2K + 1K ROM. Powered by MMD-1. Kit/wired .....$195/$250
Also available are outboard octal and hex displays, ports, single-step adapter, programmable timer/counter, PROM (1702) programmer, others.

ELECTRO-ATOMIC PRODUCTS

UHC-68
8-bit computer system with upper-case ASCII key board, cassette recorder built-in, color video interface, game I/O interface, BASIC interpreter. Video interface offers text mode, plus color graphics mode with 4 text lines at screen bottom; 4K RAM expandable to 65K; software includes assembler, monitor, BASIC with graphics instructions in ROM, games on cassette tape $749

ELECTRONIC CONTROL TECHNOLOGY

ECT-100 COMPUTER **(S1)**
In card cage for 19" rack mounting. Choice of 8080 or Z-80 MPU with jump on reset. 20-slot motherboard standard. Unregulated ±16V @ 3 A ea., +8V @ 30A; 115 V input, with taps for 105 V and 125 V (220/208/240V on special order).
ECT-100-F-8080. With 8080 MPU, 20 sets connectors and guides. Kit/wired ..... $425/$595
ECT-100-F-Z80. Same, with Z-80 MPU .... $525/$695

TABLE-TOP COMPUTER
Similar, but in table-top cabinet with 10-slot motherboard, 16K RAM optional. 15A power supply.
TT-8080-S. 8080, with RAM Kit/wired .. $1050/$1200
TT-8080. Less RAM ..... $440/$570
TT-Z80-S. Z-80, with RAM ..... $1150/$1300
TT-Z80. Less RAM ..... $540/$670

ELECTRONIC PRODUCT ASSOCIATES

MICRO-68b **(EX)**
6800-MPU computer with 16-key hex keypad, six-digit hex LED display; 8K RAM memory expandable to 64K; 25-A power supply; ROM monitor, editor, and I/O; TTY/RS-232 and Kansas-City-standard cassette interfaces. In fan-cooled cabinet with 13-slot motherboard (also accepts Motorola EXORcisor cards). Available with extra I/O and bus connections at front panel. M68b. Wired $1878

MICRO-68
6800-MPU, with hex keypad and display, 128 bytes of RAM, 512-byte ROM monitor/editor, power supply, one I/O port. In wood/plexiglass cabinet with room for 640 words additional ROM; other options below.
M68C. Wired $595
X68C. Expanded version with 8K RAM, 3.5-A power supply, additional ROM for TTY, TTY/RS-232 and cassette interface, expansion cabinet $1186
RAM8K. 8K static memory $390
RAM4K. 4K static memory $290
R6810. Additional 128-byte RAM for Micro-68 ..... $6
PEB1. 16K PROM board for 7641/3624 PROMs $240
PROM512. 512-byte PROM for above (programming available) $24
PEB2. 512-byte PROM board for Micro-68 ..... $18
PROM256. 256-byte PROM for above (programming available) $10
MB6830L7. MIKBUG ROM for TTY $29
TTY4. TTY PROM $24
GP1. General purpose prototyping board $30
TCC3. I/O for Byte-standard cassette, RS-232 terminal and TTY (requires TTY4 or MIKBUG ROM) $129
TVA-1. Video interface and TV adapter for 29-line, 30-character display. Includes keyboard input and RS-232 interface. For X68C $245
IMP-68X. Interface for IMP1 printer (see Peripherals) $22
ADC-1. 12-bit analog-to-digital converter $382

ELECTRONIC TOOL

ETC-1000
6502-MPU computer accepts wide variety of processors (Z-80, 8080A, M6800, and F8) for alternate or multiprocessor use. Basic system includes 6502 control processor, 256-byte ROM (expandable on processor board to 4K), 1K RAM, eight-digit LED display, hex and control function keys, eight I/O device-control lines, two serial I/O lines, and interrupt system with eight levels, plus choice of two power supplies. Space in cabinet for up to 16 expansion options, such as additional MPUs, ROM, RAM, peripheral controllers and external interface modules for real-time control. Memory map option allows expansion to 4M. Other options include 220-V and low-voltage power supplies, bus expansions, and peripherals. Wired $775
1000S. Stretch chassis option for above (32-slot) $100
1003. 28-A power option $75
1011. Power-on restart, user-addressable $55
1013-4. Battery backup $270
(S1) 1023. Altair-compatible bus extension for use of Altair-bus-compatible modules with ETC system $90
1046. Cassette I/O $65
1100. 4K RAM $235
1120. 8K RAM $385
1406. 16K PROM module $215
1407. 8080A MPU with 1K private RAM, ROM ..$325
1408. M6800 MPU with control ROM $255
1411. F8 MPU with ROM and 1K RAM $325
1413. 6502 MPU with ROM and 1K RAM $325
1414. Z-80 MPU $299
1415. Z-80 MPU with ROM, 1K RAM, room for additional 1K ROM $425
1501. Video interface, 16 × 64 characters $385
1503. Alphanumeric keyboard $125

ETC-1000/D 32K DISK SYSTEM
Similar to above, incorporating options 1003, 1000S, 1120(4), plus 2-channel EIA Communications Interface, programmable write-protection, and dual-drive IBM-compatible disks and controller, with DOS; includes 32K RAM, 500K disk storage, keyboard. 8-digit display, cassette I/O $5680

ENVIRONMENTAL TECHNOLOGY

LITTLE BIT
Single-card F8 microcomputer designed for controller-type applications. On 4½" × 6" card with 44-pin edge connector; features 32 bidirectional, TTL I/O lines; 2 daisy-chained external interrupt lines; automatic power-on restart; 1K EPROM, 64 bytes RAM; 2 software-programmable interrupt timers; crystal clock; on-board regulators (5V regulator can supply up to 300 mA, for operating external circuitry); over-temperature protection and current limiting.
10154. With 1K 2708 EPROM $153
10728. With 4K 2732 ..... $153
10626 Little Bit More: 320 bytes RAM, 2K EPROM, 40 I/O lines $240
10742 Mighty Byte: 8K EPROM, 1K+64 RAM, 48 I/O lines $240
10688. Universal Display, 6-digit LED. ..... $ 59
10692. Hex keyboard ..... $ 59

EXIDY

SORCERER **(S1)**
Z-80 MPU; intelligent-terminal type computer, with keyboard and video output. Memory 8K RAM, ex-

pandable to 32K; 4K ROM standard, ROM cartridges up to 16K available. Dual cassette I/O at 300 or 1200 baud, remote motor on/off; RS-232 serial I/O at 300 or 1200 baud; edge-card connection for S-100 bus expansion unit. Video output: 30 lines × 64 char (1920 char/screen), full 128-character ASCII set; 64 pre-defined and 64 user-defined graphic characters (all 128 may be user-defined); 512(h) × 240(v) graphic resolution; automatic scroll, delete character, erase end-of-line, end-of-screen; clear screen; full cursor control $895
Exidy 12" video monitor $299
16K RAM expansion $299

S-100 Expansion Unit. Self-contained 6-slot chassis, styled to match Sorcerer; with interconnect cable and S-100 translation interface $299
S-100 I/O Expansion Kit. Cable and S-100 translation interface, to interconnect any S-100 chassis to Sorcerer $149
ROM PAC Cartridges. User EPROM Pac $49
BASIC, Development or Word Processing Pac ..$99

F&D ASSOCIATES

PIC-1 PROGRAMMABLE CONTROLLER
For 6802 or 6502 MPU. Compact (4½" x 6") board for control applications. Has provision for RAM (256-384 bytes) 2K EPROM, crystal, choice of interface devices, 16 I/O and 4 handshake lines, 2 hardware interval timers, serial-parallel/parallel-serial shift register, programmable-frequency square waves, external-pulse counters; may be linked in multiple-board systems; accepts 2708 or 2716 EPROM. Comes with extensive 6802 test program listing, short 6502 test program, both available on EPROM.
PIC-1. Bare board and documentation $29
PIC-1E65. 6502 EPROM $15
PIC-1E68. 6802 EPROM $15

FIRE BIRD

SMARTS II **(S1)**
Z-80 MPU computer with built-in Mini-floppy drive, 32K RAM, 2K PROM and color video interface (64 char × 16 li) with sound, separate 63-key (upper/lower-case) ASCII keyboard. Memory expandable to 512K RAM, 8K PROM (16K PROM with optional interface); 2.5-MHz clock; S-100 bus, 6 cards; video 7×9 matrix, 8 colors (expandable), limited graphics; floppy-disk system expandable to 3 mini drives, two standard-size disk drives optional; includes one RS-232 interface, expandable to 4; "Game I/O" for up to 6 joysticks; power supply 8V @ 8A, 12V @ 4A, −12V @ 1A. Wired $1595
1RS32. Serial add-on I/O port $31
1KPRM. 1K PROM add-on $18
8KPRM. 8K PROM board (less PROMs) $82

GIMIX

GIMIX GHOST 6800 **(S5)**
6800-MPU system with SS-50 bus. Has fifteen 50-pin slots plus eight DIP-switch-addressable, 30-pin I/O slots configurable to 4 or 8 decoded addresses: DMA capability through cycle-stealing or halt; separate crystals for CPU and baud-rate generator; sockets for 4K 2708 PROM; DIP-switch-addressable for SWTP or MSI software. In cabinet with keylock power/reset switch, cooling fan, video board, GMXBUG 2K ROM monitor, 2-port buffered parallel I/O board, 8K RAM (upgradable to 16K on-board); space and power for dual mini-floppy (not included). Options include: 3 independent software-programmable timers; 8K additional RAM with or without software-programmable RAM address, write protect, disable/enable.
8K, no options $1195
CPU timer option $63
8K added RAM (16K total) $156
8K added RAM with software control $229

HEATH

H8 **(H8)**
Computer with 8080A MPU; 1K ROM monitor for load-dump and front-panel operations; front panel

with octal keypad and digital display. With 10-slot cabinet using Heath 50-pin bus; power supply capable of handling up to 32K of memory and two I/O interfaces; programmable speaker and LED status lights. Kit, with wired and tested CPU; BASIC, assembler, editor and debug programs on audio cassette. Requires H8-1 memory board (see Module Boards) to operate. Kit $375
WH-8. Wired version $475
"Minimum" System. H8 with 8K RAM, serial I/O, cassette interface, H9 video terminal, and cassette recorder/player $1221
"Recommended" System. Similar, but with 16K RAM, Extended BASIC on cassette $1439

H11 **(LS)**
Computer with LSI-11 16-bit MPU accepting PDP-11 software; 4K × 16 dynamic RAM expandable to 20K; 6-slot backplane; power supply with switching regulators and full circuit protection; I/O interface; DEC software package with editor; PAL-11 assembler, linker, on-line debugger, I/O executive, BASIC and FOCAL. Kit, with assembled MPU $1295

WH11. Wired version $1595
H11 System One. Includes H11, 8K RAM, parallel interface, serial interface, H9 video terminal, H10 paper tape reader/punch $2461
HS-11 Computer System. Similar, but with LA36 DECwriter II printing terminal instead of video terminal $3300

H11-6 EXTENDED ARITHMETIC CHIP
Adds hardware arithmetic instructions to LSI-11, including fixed-point ×, ÷ and extended shifts, plus floating-point +, −, ×, ÷. DIP 40-pin package plugs into socket on LSI-11 boards $159

MICROPROCESSOR TRAINER
6800-MPU computer kit designed for circuit-training purposes. Includes 1K ROM monitor, 6-digit hex LED display, 17-key hex keypad, 256 bytes RAM (expandable to 512), breadboarding socket, 8 buffered LED's for display of breadboard logic states, DIP switches for binary input to breadboard, power supply (+5, ±12 V), all buses buffered and terminated on front panel, provision for 40-pin external connector for extending memory and I/O.
Kit ET-3400 .....$190
ETS-3400. Combination of ET-3400 trainer and EE-3401 microprocessor training course; includes additional 256 bytes RAM (512 bytes total), plus additional electronic components including PIA interface chip and 1406 digital/analog converter $270

IASIS

ia7301
8080 MPU, single-board computer with built-in hex keyboard and display, 1K PROM monitor (space for 2K), 1K RAM, two I/O ports plus audio cassette interface. LEDs signal end of tape read or write operations. Requires +5 V, +12 V only (−5 V derived internally); power supply optional. Computer is built into a 500-page, looseleaf programming course manual; computer board has plexiglass cover with cutout for keys. Wired $450
6-PAC. Set of 6 software cassettes $75

IMSAI

I-8080 TABLE-TOP COMPUTER **(S1)**
8080A MPU; MPU board includes clock, tri-state bus drivers and control-signal timing. Plug-in front-panel control board with large, paddle-handle address/data switches and LED masks; color-coded switches allow kit-version switches to be color-grouped for octal or hex, hex groupings on assembled version; 22-slot motherboard; aluminum cabinet; many mechanical options (fan, connectors, cables) available; many S-100 hardware and software options available. Power supply delivers 8 V up to 28 A, ±16 V @ 3A.
I-8080 (PCS 80/10). Kit/wired .....$699/$931
I-8080-OEM (PCS-80/11). Without front-panel ..... $629/$749
RM. Rack-mount option $20
FM. Cooling fan ..... $29/$39

PCS-80/15 TABLE TOP 8085 SYSTEM **(S1)**
Similar to I-8080-OEM, but with 8085 MPU, 10-slot terminated and regulated motherboard; MPU board

includes 256 bytes RAM, 1K ROM, parallel and serial I/O ports. Kit/wired $799/949

PCS-80/30 SYSTEM WITH CRT **(S1)**
Similar to PCS-80/15, but with 5" CRT built into cabinet front, video interface (upper/lower-case), and KB-1 intelligent keyboard (see Peripherals section). Kit/wired ..... $1199/$1499

PCS-80/34 DISK SYSTEM **(S1)**
Similar to PCS-80/30. but with CRT replaced by one mini-floppy drive. Kit/wired ..... $1649/$1899
PCS-80/35. Same, with two drives ..... $1995/$2245

PCS-80/100 SYSTEM **(S1)**
Consists of PCS-80/30 5" CRT system, 16K RAM, Tarbell-standard audio cassette recorder interface and 8K Cassette BASIC, Cassette Operating System, 2 parallel, 1 serial port, all cables. Kit/wired .....$1886/$2670

PCS-80/200 SYSTEM **(S1)**
Consists of PCS 80/34 disk system, 16K RAM, video output, DOS, intelligent keyboard. Kit/wired ... .$2610/$3357

VDP-80 VIDEO DATA PROCESSOR **(S1)**
8085 MPU, integrated computer system with 12" CRT, ASCII keyboard with numeric keypad, control keyboard and cursor controls, dual floppy disks, 32K RAM, all interfaces, in single cabinet. Disk system uses PerSci drives, single or double density, 1-megabyte capacity expandable to 4M; RAM expandable to 196K; serial and parallel ports; IMDOS software included.
VDP-80/1000. Wired $6995
VDP-80/1050. With 64K RAM. Wired $7745

VDP-40 **(S1)**
Similar to VDP-80, but with 5¼" mini-floppies, 9" CRT (80 × 24 display), 2K ROM monitor; system expandable to 4.5 megabyte disk storage. Wired. With 32K/64K RAM ..... $4495/$5295

8048 SINGLE-BOARD COMPUTER
Programmable computer and process controller. 22 I/O lines, 5 heavy-duty relays, TTY and cassette interface, 24-key hex keypad; 9-digit hex LED. Requires PS-3A power supply.
8048CC-EROM. EROM version. Kit/wired. .....$499/$549
8048CC-ROM. ROM version. Kit/wired .... $299/$349
8048-RAM. 1K RAM expansion for 8048 ..... $35/$45
PS-3A. 5-V, 3-A open-frame power supply for 8048CC. Wired $99

IMSAI EXPRESS CONTROL COMPUTER
Similar to 8048, but with cabinet, power supply, software and documentation. Wired $499

INDUSTRIAL MICRO SYSTEMS

COMPUTER **(S1)**
8080 MPU; 2 serial ports with independently-adjustable, software-controlled baud rates; real-time clock with maskable interrupt; vectored-interrupt logic; 2708 EPROM; 32K-64K RAM with memory-mapping; 2 Shugart 801R floppy drives with controller; 110/220-V operation.
55-0022. With 32K. Wired $3432
With 48K $3736
With 64K $4040

INTELLIGENT SYSTEMS

INTECOLOR 8031 **(I8)**
8080A-MPU system with integral 13" color CRT display, built-in mini-floppy drive, detachable keyboard. Intellec-8 bus structure. Includes: 31 internal

I/O and 1 RS-232 serial ports; keyboard-selectable baud rates (110-9600); 16K Ram, 11K ROM firmware; DISK BASIC 8002 with file handling; 48 line x 80 char. display; graphics plot hardware and software; upper/lower-case; 8 selectable background colors; page rollup; character and line editing; numeric and color clusters on keyboard $4495

(I8)

8032. Similar to 8031, but with dual mini-floppies $4995

(I8)

8051. Similar to 8031, but with 19" CRT; mini-floppy drive in separate housing $4495

(I8)

8052. Similar to 8051, but with dual drives $4995

INTECOLOR 8070 BUSINESS SYSTEM (I8)

Similar to 8052, but with matrix printer; no graphics; 8" dual floppy drive; extended disk BASIC; 17K ROM; with payroll program for up to 500 employees $7000

8071. Similar, but with 13" CRT, single mini drive as well as dual full-size floppies $7500

INTECOLOR 8080 DEVELOPMENT SYSTEM (I8)

Similar to 8070, but without insert/delete-character/line feature or extended BASIC; has 3K ROM text editor, 3K 8080 ROM assembler; OS and debug ROM; EPROM programmer; dual mini-disk drive $6500

INTECOLOR 8090. (I8)

Similar to 8080, but with dual 8" double-headed disk drive, light pen, 24K RAM, File-Handling Disk BASIC. Includes most features mentioned for all above models, including graphics, editing, screen field-protect, Disk Extended BASIC, additional 16K RAM 16 additional function keys; additional RS-232 serial port; EPROM/PROM programmer; maintenance manual; source diskettes and listing for terminal control, text editor, file control and assembler software; 64 standard ISA characters. No mini-disk facilities. $12,000

INTECOLOR 8001 TERMINAL (I8)

Intelligent color terminal with limited user-programmability; see Peripherals section $1650

8001G. Similar, but with graphics; see Peripherals $2750

SPECIAL OPTIONS: Most features listed for any model above may be added to any other model; 220V operation available; 50-Hz disk conversions available for 8" disk systems; all systems available in Arabic/English or Farsi/English configurations; FORTRAN-IV; ROM or RAM expansions; 20-mA current loop; additional ports.

INTERACT ELECTRONICS

MODEL ONE HOME COMPUTER

8080A-based single-unit computer, includes MPU, cassette deck, 1K ROM, 8K RAM, RF audio/video output to conventional TV; power supply. Color output on TV channel 3, RF switchbox included; audio software and hardware includes 3-octave music synthesizer, tape generation. Cassette interface up to 2000 byte/sec, can output sound from tape. Keyboard 53-key, typewriter-layout. Includes joystick X/Y controls. Software available includes BASIC, calculator, data management, mailing list, account ledger, music, educational and games.

With 2 programs $499

Additional programs from $10

INTERSIL

INTERCEPT, JR.

Tutorial microcomputer system using Intersil's IM6100 CMOS 12-bit microprocessor and related CMOS devices. Uses DEC PDP-8/E instruction set. Multi-function octal keyboard and octal display. Includes 1K × 12 ROM monitor plus socket for additional ROM, 256 × 12-bit CMOS RAM. On-board battery for battery operation or non-volatile memory; connections for external 5-V or 10-V supply.

6950. ..... $281

6951. 1K × 12 CMOS RAM module, with battery backup $145

6952. 2K × 12 ROM/PROM module $75

6953. Serial I/O (RS-232 or 20 mA), with ROM bootstrap for DEC BIN-format media $82

6957. Audio-visual module with switch register input, binary and octal readouts, volume-controlled speaker $125

MICROPRODUCTS

SUPERKIM (KM) (AP)
6502-MPU, single-board computer with detachable hex keypad and 6-digit hex display. Modeled after Commodore/MOS KIM-1, but more RAM, EPROM and prototype area in approximately same size. Software-compatible with KIM-1; compatible with most KIM-1 and Apple II hardware interfaces; can use Apple II as software development system. Includes: 4K RAM sockets, 1K RAM; 2K KIM ROM monitor; 4 EPROM sockets for 16K 2732, or 8K 2716; power-on reset; interface and jacks for cassette (KIM-compatible); serial RS-232 interface; on-board regulator, rectifier and filters, requires only 12V ac, C.T. @ 2A; sockets for 4 6522 I/O chips, 1 provided; can support up to 9 bi-directional 8-bit parallel ports with handshaking; 8 counter timers; 8 latched priority interrupts, software re-settable; DMA possible; EPROM addressable anywhere from 2000 to FFFF; large prototyping area for A/D chips, etc $395

MICRO DATA SYSTEMS

MDS-690A SINGLE-BOARD COMPUTER (S1)
6802-MPU (uses 6800 instruction set), but also compatible with upcoming Motorola 6809; with 16-bit internal registers, hardware multiplication, 18 addressing modes, and 5X throughput of 6800. Has 2400-baud cassette interface; 1K RAM; 10K ROM space; 16 I/O lines plus 4 control lines; provision for RS-232 interface; DMA capability. MONBUG 1K PROM monitor is software-compatible with MIKBUG but will interface with memory-mapped video and graphics cards, has "memory window" for examining and altering memory contents, interrupt-driven keyboard routines, video handler with cursor control.
Kit/wired ..... $198/$258

MDS-2 SYSTEM (S1)
Includes MDS-690A MPU, power supply, motherboard, video/graphics card and custom keyboard, in hand-finished redwood case.
Kit/wired ..... $569/$749
MDS-1. Same, less keyboard and video. Kit $298
MDS-3. MDS-2 with 8K RAM. Kit $699

MIDWEST SCIENTIFIC

MSI 6800 (S3)(S5)
6800-MPU computer using SS-50 bus architecture. Includes power supply (5 V @ 20 A, ±15 V @ 3 A); CPU with 4K EPROM, 128 bytes RAM, restart-vector PROM, baud rate generator, MSIBUG monitor (MIKBUG-compatible); interface adapter board with eight I/O slots (S3) strappable for 4 or 8 decoded addresses per slot; 16-slot (S5) motherboard; 8K RAM, serial (RS-232/20-mA) interface. Kit/wired ..... $595/$895
Group 1 Package For users having their own terminals. Includes MSI 6800 with 16K RAM, audio-cassette interface, MSI tape BASIC. Kit/wired ..... $960/$1400
Group 2 Package Includes MSI-6800 with 32K RAM, dual-drive floppy disk, MSI Disk Extended BASIC Interpreter, MSI BASIC Compiler, CRT terminal, high-speed printer. Kit/wired ..... $6339/$7330

MINITERM ASSOCIATES

SYSTEM 80/2-1 (S1)
Z-80-based system with eight-slot card-cage and motherboard, 16K dynamic RAM (no wait @ 4 MHz), 90-key keyboard, 10-A power supply, mini-floppy interface for up to three drives, one miniflopy drive, software and firmware. Wired $2699

MODERN MICROCOMPUTERS

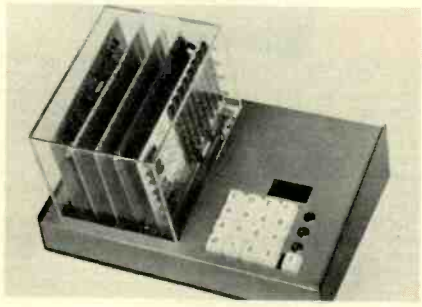
TERMINAL COMPUTER (S1)
8085-MPU computer with built-in 9" CRT monitor, keyboard, 32K RAM, single or dual floppy disks. Upper/lower-case ASCII; separate numeric keypad; 24-li × 80-char display; Micropolis disk drives and extended BASIC. Includes business software; will customize as required. Features 10-slot S-100 motherboard; 53-key keyboard with 2-key rollover; power supply for +8 V @ 15 A, ±18 V @ 3A each: two cooling fans; beige or blue cabinet.
With 1 floppy (143K on line) $3250
With 2 floppies (630K) $4500
With dual floppies, 1.2 megabytes $4950

MORROW COMPUTER & ELECTRONIC DESIGN

MCED SYNAPSE/10
8080-MPU computer with 8K RAM, 8K EPROM, 48 parallel I/O lines, 2 independent serial ports, priority interrupts, real-time clock, fancooled 30W power supply in self-contained metal enclosure. Designed for data acquisition, industrial control, communications interfacing, etc; custom versions available in quantity. Quantity 100, ea $1800

NETRONICS

ELF II
1802 MPU, single-board, animated graphics computer, on five-slot motherboard. With hex keypad,



video 64 × 32 graphics display output, 256-byte RAM. 60-terminal ELF bus for expansion of memory (to 64K) and I/O. Requires 6.-V ac Kit $100
Power Supply. (6.3 V ac, 1.5 A) $5

ELF II GIANT BOARD
Plug-in expansion board with: cassette, RS-232/TTY and 8-bit parallel I/O; decoders for 14 I/O instructions; system monitor/editor. Kit $40

4K STATIC RAM.
Addressable to any 4K page; chip-select circuit allows original 256 bytes to be used; buffered; regulated. Kit $90

PROTOTYPE (KLUGE) BOARD
Accepts up to 36 IC's, all sizes; space for on-board regulator $17

ELF II FULL ASCII KEYBOARD. Kit $65

EXPANSION POWER SUPPLY
5-A; powers entire Elf II: required if adding 4K RAM boards. Kit $35

CASE for ELF II with all expansions $30

NORTH STAR

HORIZON-1 (S1)
Z-80-MPU computer with mini-floppy disk drive, 4-MHz processor, 16K RAM, one serial I/O port, and North Star extended disk BASIC and DOS. Motherboard has slots for up to 12 S-100 boards (3 slots used in normal configuration); serial I/0, real-time clock and disk power on motherboard; other ports may be added to motherboard. Power supply 8V @ 15A, ±16V @ 6A; panel space for up to 3 mini-floppy drives. Options include serial and I/0 ports on motherboard, 1K PROM (on processor board), additional disk drives. With three 100-pin connectors on motherboard, space for 9 more. In wood or blue metal cabinet.
Horizon-1. Kit/wired ..... $1599/$1899
Horizon-2. Similar, except with 2 drives ..... $1999/$2349
HRZ-O-OK. Chassis, cabinet, processor, serial I/0, three 100-pin edge connectors, motherboard and power supply only. Requires additional boards to become usable. Kit/wired ..... $599/$799
HRZ-SIO. Additional serial I/0. (Available assembled only when ordering as part of assembled Horizon). Kit/wired ..... $39/$59
HRZ-PIO. 8-bit parallel I/0, as above ..... $39/$59
HRZ-DRV. Add-on drive to convert Horizon-1 to Horizon-2 ..... $400/$450
MDS-DRV. Third drive for Horizon-2 ..... $400/$450
HRZ-CABLE. Cable set for use with MDS-DRV. Kit $49

NORTHWEST MICROCOMPUTER

NMS 85 DESKTOP COMPUTER
8085A-MPU (3-MHz) computer with built-in CRT and keyboard, provision for built-in disk. Base system includes desk-top cabinet; MPU, CRT (24 li. × 80 char), 32K RAM, serial and parallel ports. Wired $3445

NMS 85/P
Similar, but with dual-drive, double-density floppies (1 megabytes) with DMA data transfer (double-sided optional); 54K user RAM plus 10K system RAM, 103-key Hall-effect keyboard; two serial ports, two parallel ports. Software includes CP/M, disk BASIC, Fortran and PASCAL compiler/interpreter, wood cabinet $7495

NOVAL

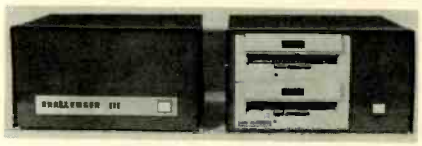
NOVAL 760 DESK COMPUTER
Z-80 MPU computer with CRT, keyboard, printer and tape system; flip-up mounting in wood desk. Computer features 32K RAM, 3K PROM, additional 4K display RAM, eight I/O ports; black & white display screen; drawer-mounted ASCII keyboard with user-assignable keys; dot-matrix printer; PhiDeck, computer-controlled cassette system at 2500 bits/sec; 28 × 32-char graphics, using 8 × 8 matrix graphics characters; color capability for use with external monitor. Wired $3795

THE NUCLEUS

CPU/SERIAL BOARD (S1)
8080A MPU board with on-board RS-232/20-mA serial port, 110-9600 baud; usable with and without front panel; two data rates software selectable.
8000-1. Wired $195

OHIO SCIENTIFIC

CHALLENGER
6502-MPU computers using Ohio Scientific OSI 48-line bus, Microsoft BASIC in ROM or on dlsk, PROM



monitor. Additional, non-6502 MPUs available on some models. Assembled.
C2-0 Model 500. Single-board computer; includes 8K BASIC in ROM, 4K RAM, serial port, PROM monitor. Expandable with backplane and accessory boards (see below). Requires power supply, case and terminal $298
C2-1 Model 500-1. Similar, but complete with power supply, case, two EIA connectors for loop-through operation. Requires terminal, may be used with time-share-type remote terminals $498
C2-8S Challenger II. All features of Model 500 CPU boards, plus serial port, larger cabinet, power supply, 8-slot backplane with 7 slots op-n for expansion $545
C2-4P Challenger II-P. Similar, but with audio cassette interface, cooling fan, keyboard and Model 540 video board (upper/lower-case, 160 graphics characters); 4-slot backplane with two free slots; requires video monitor or modified TV, accepts cassette recorder for program storage. In integrated, single cabinet $598
C2-8P Challenger II-P. Similar to C2-4P, but with greater expansion capability: larger cabinet, heavy-duty power supply, 8-slot backplane; keyboard in remote console $825
C3-S1 and C3-OEM Challenger III. Contains Z-80 and 6800 MPUs in addition to 6502. Includes Disk Operating System- 6502 BASIC on disk, MPU selector software, parallel port, 1-megabyte memory management, scratchpad RAM for user-programmed interrupt vectors, and dual floppy-disk drives. Extensive applications and business software available. Specify C3-S1 (in two matching cabinets) or C3-OEM (integrated into a single, larger cabinet) $3590
C3-B. Similar to C3-OEM, but with addition of 74-megabyte Winchester-type hard disk drive, 48K static RAM, 16-slot motherboard with only 7 slots

occupied,; with rack, OS-65U multiple-terminal operating system and one CRT terminal $13,000

Module Boards and Accessories: Available from OSI. Include 4K-24K static RAM, 16K-48K dynamic RAM, 8K and 4K EPROM boards, K.C.-standard audio cassette ports, serial and parallel ports, voice I/O board with Votrax module; 32×32-char. and 64×64-char. video interfaces, 8" floppy-disk and Winchester hard-disk systems; prototyping boards, card extenders, etc. Special options include 12-bit memory, multi-processor board with PDP-8 and Z-80 compatibility, RAM with 20-bit addressing; multi-terminal operating system.

Superboard II. Single-board computer; includes 8K BASIC in ROM; 8K static RAM; 53-key, user-programmable, upper/lower-case keyboard; K.C.-standard cassette interface; video display with upper/lower-case, gaming and graphics characters; displays 24 char × 24 li on TVs with overscan display, 30 × 30 on TVs without, 256 × 256-point graphics. Options include extender board with 24K RAM, dual mini-floppy inter—face, serial ports and software. Requires +5 V @ 3 A.....$279

Challenger 1P. Superboard II with power supply and case.....$349

PAIA

8700 COMPUTER/CONTROLLER

Single-board computer, 6503 MPU, designed primarily for control applications. Includes hexadecimal keypad, connected by flat ribbon cable. Requires 5 V (@ 1.2 A, 12 V (@ 150 mA. Kit.....$150

μPMEM

8080 SUPER CPU (S1)

Single-board computer with 8080 MPU, PROM, RAM and I/O, on S-100 board. Includes: serial I/O (RS-232, TTY or TTL); 1K memory (can be all ROM or half RAM); power-on jump; 5 interval timers; vectored interrupts; socket for front-panel connection (IMSAI plug-compatible). Sold as bare board with parts list and documentation; estimated total cost with parts, under $150.

Bare board $36

PACIFIC CYBER/METRIX

PCM-12A 12-BIT MICROCOMPUTER

Intersil IM6100 MPU, software-compatible with DEC PDP-8. Separate control-panel memory makes entire main memory available for user's program; built-in binary bootstrap loader for paper or magnetic tape; control panel with single-clock and decrement-address functions; PCM-12 bus; built-in baud-rate generator; DMA and vectored priority interrupt provisions; 80-line TTL bus with 18 unassigned lines; addresses up to 63 I/O devices; card cage separable for OEM use, heavy-duty power supply. Basic PCM-12A system includes MPU, front panel, 15-slot backplane, power supply (5V @ 12 A, ±12V @ 1.7A), cabinet and manuals. Kit/wired .....$699/$989

Accessories available:

Additional RAM; serial, parallel and opto-isolated parallel interfaces; audio cassette interface; paper tape interface; prototyping card; extender board; CMOS memory with battery-backup; power-fail module; EPROM/RAM board; printers; positive-bus converter.

PARASITIC

EQUINOX 100 (S1)

8080A-MPU computer with 20-slot motherboard shielded against noise and crosstalk; 26-A, constant-voltage power supply. Integrated MPU/front panel (takes one slot) with octal keypad and display, reset switch; halt, run, reset, examine and deposit for all registers, memory locations and I/O devices; single-step and slow-step modes; display of any desired data (including time) under program control. Power-on reset. Case has sliding access panels, black vinyl and smoked plexiglass trim, carrying handle, wiring channel, tilt-up stand for desk-top use, and 2 edge connectors. Kit/wired .$799/$1099

EQUIBOX (S1)

Similar, but without CPU/Front panel, for those who wish to use another MPU. Kit/wired ..... $576/$801

OPTIONS:

Full set of edge connectors (18 additional) $80

Hinged cabinet top $25

50 Hz, 110/220-V constant-voltage supply $45

POLYMORPHIC

POLY-88 (S1)

8080 MPU, in cabinet with five slots, 7-A power supply; up to four independently powered chassis may be plugged together; memory may be left on while boards in other cabinets are shut off for debugging. MPU board also includes on-board, real-time clock, eight-level vectored interrupts, 512 bytes of RAM, up to 3K PROM (2708 type) including 1K monitor; optional serial I/O port Mini-card Cassette and Printer interfaces fit on MPU card. Resets to address zero on power-up.

System 16. Assembled, with MPU board, video circuit card, cassette interface, 16K RAM, cabinet, power supply, fan, keyboard, 9-in. TV monitor, and cassette recorder, with 11K BASIC and assembler software on cassette $2250

System 6. Same, in kit form, less TV monitor and cassette recorder $1575

System 12. Same as System 16, less TV monitor, cassette recorder, and memory. Wired $1175

System 2. System 12 in kit form, less keyboard and fan $735

Cabinet. With five-slot backplane and power supply, power and reset switches. Kit/wired ..... $235/$355

Printer Interface Card. (Fits Poly-88 only). RS-232 or 20 mA. Kit/wired ..... $65/$80

Cassette Interface. (Fits Poly-88 only.) Kansas-City standard (300 or 600 baud) or Poly-Phase (1200 or 2400 baud). Kit/wired ..... $65/$85

PROCESSOR TECHNOLOGY

SOL-20 TERMINAL COMPUTER (S1)

8080-MPU computer system in housing with built-in keyboard. Includes 16-line, 64-character video in-

terface, RAM, 1K ROM monitor, 85-key keyboard with upper and lowercase, cursor keys and arithmetic keypad; 1200 bit/second CUTS cassette interface, two parallel and one serial I/O ports, 5-slot backplane 8.8-A power supply, fan, room for five expansion module U.C. boards. With BASIC (5K) and two video-game programs on cassette, SOLOS personality module (see below) in ROM.

Sol-20/16. As above, with 16K RAM. Kit/wired .....$2850/$2095

Sol-20/32. With 32K RAM .....$2150/$2395

Sol System I-A. Includes Sol 20/16, PT-872 11" video monitor, RQ-413A cassette recorder, Extended Cassette BASIC.

Wired only $2495

Sol System II-A. Includes Sol 20/32; otherwise similar to I-A $2795

Sol System III. Includes Sol-20 with 50K RAM, Helios dual-drive floppy-disk system, PT=872 video monitor, Extended Disk BASIC $5995

Sol System IV. Similar to System III, but with 4-drive Helios disk system $7995

SOL-PC SINGLE-BOARD COMPUTER (S1)

8080-MPU, plus: 2K RAM, 1K PROM (space for 1K more), video display as above, serial and parallel interfaces, keyboard interface, SOLOS personality module. Kit/Wired .....$575/$745

BOOTLOAD PERSONALITY MODULE

2K PROM program loads PTDOS from disk. (Included in System III or IV) $100

SOL-HYTYPE PRINTER INTERFACES

Interfaces Diablo Hytype printers to Sol Parallel Data Interface connector; software drivers included. Specify Sol-Hytype I for Diablo 1200 series, II for Diablo 1300 .....$150

QUAY

QUAY 80AI TWO-BOARD SYSTEM (S1)

Z-80 MPU (2.5 MHz), 1K RAM, 4K EPROM (2708) sockets, EPROM programmer, PROM monitor, serial (RS-232 or 20m A) I/O with automatic baud-rate setting; parallel input (for parallel keyboard input, monitor provides software echo to user-supplied Processor-Technology VDM-1 video interface). May be used as stand-alone computer, as MPU for S-100 computer (2 piggyback boards, require only one bus connector); strappable for use without front panel, but provided with connectors for Altair and Imsai front panels. Wired $350

Q80AI/TB. Same, with tiny BASIC (2.5K) in 2708 EPROM $425

QUAY 8000 COMPUTER (S1)

Complete system, including 80AI, 8K static memory, 12-slot motherboard with connectors and 18A power supply, wood-grain cabinet, 2.5K BASIC in 2708 PROM, chassis fan .....

..... $1195

90 MPS (S1)*

Z-80 MPU, single-board computer, with on-board EPROM programmer. Features 4K to 64K on-board RAM (in 4K or 16K increments); 2.5-MHz clock; 1K EPROM monitor expandable to 7K EPROM total; 32 to 64 I/O lines, one serial (RS-232/20 mA) interface, up to four parallel ports (support Z-80 vectored mode), four programmable counter/timers (support Z-80 interrupt). External bus signals accessed via DIP 60-pin connectors. Requires +5 V @ 3.5-5 A, 5 V @ 100 mA-1.5 A, +12 V @ 300 mA-3 A, and +28 V @ 200 mA (for PROM 2708 programmer).

90 MPS-0 With 4K RAM, (expandable to 16K) .....

..... $695

94 MPS-0 Same, with 4-MHz clock $795

90 MPS-1. With 16K RAM (expandable to 64K) .....

..... $1075

94 MPS-1. Same, with 4-MHz clock $1175

OPTIONS:

Q/4K X 8 DRM. 4K dynamic RAM. $95

Q/16K x 8 DRM. 16K $380

Q90/94PSU. Power supply: ±5 V @ 3A, +12 V @ 0.5 A, +28 V @ 0.5 A; 105-125V ac @ 47-63 Hz; with power cord, switch, fuse, wood-grain base, provi-

sions for 90/94MPS system and power connector $295

*** QS100BA-I.** S-100 bus adapter for 90/94MPS $120

*** QS100BA-II.** Similar, but allows MPS board to use S-100 bus power supply $165

90 SERIES WORK STATIONS
Includes MPU, power supply, RAM, mounted for system-development, with hinged Plexiglas cover.
Q/90MWS-0. With 90MPS-0 system, 4K RAM .. $945
Q/94 MWS-0. With 94MPS-0,4K $1045
Q/90MWS-1. With 90MPS-1, 16K (expandable to 64K) $1295
Q/94MWS-1. With 94MPS-1, 16K $1395

90F/MPS SINGLE-BOARD FLOPPY SYSTEM
Z-80-MPU, single-board system with resident floppy-disk controller. Supports from one to four 5¼" or 8", single-density floppy disks, IBM-3740 compatible format; selectable 128-byte or variable record length. Other details as per 90/MPS and 94/MPS systems above.
94/MPS-0. 2.5 MHz, 4K RAM $995
94F/MPS-0. 4 MHz, 4K $1095
90F/MPS-1. 2.5 MHz, 16K $1375
94F/MPS-1. 4 MHz, 16K $1475

QUEST

SUPER ELF (S1)*
1802-single-board computer with hex keypad input and video graphics output, ROM monitor. Not S-100, but S-100 memory interface optional (see below). Basic computer includes pushbutton selection of all 4 MPU modes, LED indicators of current mode and 4 MPU states, single-step, power supply, 256 bytes RAM, audio amp and speaker, sockets for all parts. Without options, Kit/wired....$107/$132
Low/High address display options ..... $10/$9
Hardwood cabinet with drilled front panel $20
Nicad battery backup kit $5
4K Elf Expansion Board. Contains 4K bytes RAM and cassette interface; board same size (8" x 10") as Super Elf. Accepts on-board options listed below.
Kit $80
1K Super ROM monitor $20
Parallel I/O port $8
RS-232 I/O $2
*** S-100 Memory interface** $4.50
Power Supply Kit (±V, +12V, 5A) $25
Tiny BASIC for 1802.
Cassette/ROM/listing or paper tape ..... $10/$38/$5.50

RCA

COSMAC MICROTUTOR II
1802 MPU, compact system with regulated power supply, 8-bit binary switch input; 2-digit LED hex display plus Q-line logic-state LED; additional

switches for load, run, input, and memory protect; 256 bytes CMOS RAM; prewired socket and connector holes for system expansion; DMA eliminates need for bootstrap.
CDP18S012. Wired $195

COSMAC VIP
1802 MPU, single-board computer with on-board graphic video output, audio cassette interface, hex keypad, status indicators, 2K RAM, 512-byte ROM. With case and power supply. Wired $249

EVALUATION KIT
1802 MPU, single-board computer; 256-byte RAM (expandable on board to 4K), 512-byte ROM monitor, serial (20 mA or RS-232) interface, binary LED display, battery backup option made possible by CMOS circuitry; byte input and output ports; continuous and single-step operation; breadboarding space for user circuits.
CDP18S020. Kit $249

RADIO SHACK

TRS-80 MICROCOMPUTER (RS)
Z-80-MPU computer in compact keyboard housing; basic system includes 4K ROM with monitor and

Level 1 BASIC with string variables, video graphics and cassette save and load; 4K RAM; internally expandable to 12K ROM plus 16K RAM; total memory capability 62K; includes cassette I/O and video output interfaces; TRS-80 expansion bus for future peripherals; has cursor control, automatic scrolling and rubout $400
With 12-in CRT monitor (16 lines × 64 char), 300-baud cassette recorder, and backgammon/blackjack software cassette $599
With 16K Ram. With/without video monitor and cassette ..... $690/$890

TRS-80 LEVEL II (RS)
With more powerful BASIC, in 12K ROM. Additional features include print formatting, keyboard rollover, string functions, more arithmetic functions, user control of program errors, faster graphics, editing, and 16-digit accuracy. With 4K RAM $698
With 4K RAM, CRT monitor, and cassette $988
16K RAM expansion $290
Level-II BASIC (ROM) $99

TRS-80 "EDUCATOR" SYSTEM (RS)
Includes TRS-80 with 4K RAM, Level-I BASIC, CRT, cassette recorder, and TRS-80 Screen Printer $1198

TRS-80 "PROFESSIONAL" SYSTEM (RS)
Includes TRS-80 with 16K RAM, Level-II BASIC, CRT, cassette, screen printer, expansion interface and Mini-Disk system $2385

TRS-80 "BUSINESS" SYSTEM (RS)
Includes all features of "Professional" system, plus TRS-80 Line Printer, dual Mini-Disk systems, additional 16K RAM (32K total) $3874

ROCKWELL

AIM 65 PRINTING COMPUTER (KM)
6502 MPU. Single-board computer with built-in 20-character alphanumeric display and 20-column dot matrix printer, separate 54-key terminal-style keyboard. Includes: dual cassette and TTY interfaces; 8K ROM with text editor, monitor and debug, sockets for 16K ROM; 1K or 4K RAM; 2 bi-directional 8-bit ports; expansion and I/O connectors compatible with KIM-1. Wired, 1K/4K ..... $375/$450
ROM Assembler $85
ROM BASIC (8K) $100

SDS TECHNICAL DEVICES

TDS-M68 (S5) (S3)
6800-MPU. Incorporates SWTPC processor and 8K RAM boards, plus console board with SWTPC-compatible I/O, in attache case. Can hold up to 16K RAM, 8K EPROM; console board includes hex keypad and display, plus indicators, 6 I/O slots.
TDS-M68. Kit/wired ..... $750/$895
TDS-M68b. Without attache case ..... $650/$785

SILVER SPUR

S44 MICROCOMPUTER SYSTEMS (S4)
Modular system, built around industry-standard 4½" × 6½" cards with 44-pin connectors; fully buffered data and address bus. Boards below represent only some components of system:
CPU board. 6502 or 6802 processor, 2K ROM, programming ability, optional $17
READYBUG monitor. Kit/wired ..... $100/$110
Tape Interface board. KC standard, plus two serial ports. Kit/wired ..... $38/$48
Hex Keyboard/Display board ..... $90/$100
Video Display Module ..... $130/$140

SOUTHWEST TECH. PRODUCTS

6800 (S5)(S3)
Based on Motorola 6800 MPU and its family of support devices. Chassis; motherboard; memory card with 2K bytes of eight-bit static RAM; serial 20-mA TTY/RS-232 interface card; power supply; crystal-controlled clock for baud rates from 110 to 1200; 6820 peripheral interface adapter (PIA); ROM-stored mini-operating system features tape load/dump routine, memory, and register examine and/or change function, and execute user's program command. Documentation package includes Motorola 6800 Programming Manual plus SWTP 200-page notebook, diagnostic and game programs, and application to join Motorola 6800 User Group. All boards are "plug in" type and contain on-board voltage regulators. Any combination of up to seven serial/parallel interface boards may be plugged in.
6800/1. Kit $395

6800/2. With 4K RAM (expandable to 8K on board), sockets for up to 8K EPROM; easier address assignments, SWTBUG monitor, faster serial baud rates. Kit/wired ..... $439/$495
With 8K. Wired $595
With 40K. Wired $1195

SYSTEM B (S3)(S5)
Includes 6800/2 with 40K RAM, dual 8" floppy-disk system with 1.2 megabytes storage; CT-64 terminal with upper/lower-case and full control-character decoding (see Peripherals section for details), DOS and BASIC with random and sequential files; in desk with laminated plastic surface $4495

MP-R EPROM PROGRAMMER OPTION
Plugs into socket near top edge of motherboard; for programming 2716 EPROM's; on-board dc-to-dc high-voltage supply; requires 0.4A while programming, 0.15A when idle. Kit $45

SPACE BYTE

8085 CPU (S1)
Single-board computer for S-100 bus. 8085 CPU, runs 8080 instructions at 3 MHz, uses 450-ns memory; on-board space for 3K (2708) or 6K (2716) EPROM; 3K system monitor with de-bug, FDOS, Tarbell and video driver routines; 2 RS-232 serial I/O ports; parallel I/O ports (interface directly with iCOM floppy-disk systems); 256 bytes RAM; 4 vectored interrupts; programmable 14-bit binary timer/counter; optional EPROM programmer. Wired $499
EPROM programmer attachment $399

MODULAR BUSINESS COMPUTER (S1)
Includes Hazeltine terminal, 8085 system as above with 16K RAM (48K capacity); dual iCOM floppy-disk sytem and FDOS III; desk stand; BIZPAK disk business software package $5900

MODULAR SOFTWARE DEVELOPMENT SYSTEM (S1)
Same as business system above, but with addition of 2708/2716 EPROM programmer; software includes FDOS III, 8080 and Z-80 macro assembler, utilities, OS and 3870/F8 cross assembler; optional Disk Extended BASIC, CP/M, FORTRAN-80, and

BIZPAK $5995

SYNERTEK

VIM-1 (KM)
6502-MPU, single-board computer with on-board double-function keypad and 6-digit hex display. Has 4K ROM monitor, 1K RAM (expandable on-board to 4K, total system max 65K), 3 user PROM/ROM (2316/2332/2716E) expansion sockets; interfaces for audio cassette recorder (8 byte/sec KIM-1 compatible, 185 byte/sec high-speed), 20mA Teletype and RS232 serial interfaces with automatic baud rate selection; TV controller board interface, application port with 15 bi-directional TTL lines and expansion capability, and system expansion bus. Other features include: 5 on-board programmable interval timers; 28 double-function keys, including up to 30 "special" functions, some user-definable; audible keypad response; option boards plug in directly; complete KIM-1 compatibility, including plug-ins to KIM motherboard and card cages; requires only 5V power; has output line for oscilloscope single-line display; assembler, editor and BASIC firmware available. Software allows write-protect of selectable memory areas, decimal point prompt on hex display, break and breakpoint, debug. Wired $269

SUPER JOLT
Single-board computer with 6502 MPU, 1K RAM, 32 bi-directional I/O lines, DMA capability, sockets for 2K PROM or 4K ROM (1K DEbug MONitor supplied), 20 mA and RS-232 serial interfaces, interval timer, 4 interrupts. Wired $375

JOLT SYSTEM CARDS
JOLT 2K PROM. Wired $149
JOLT 4K RAM. Kit/wired $199/285
JOLT Universal Card. Blank, drilled for 14-, 16-, 24- or 40-pin sockets $40
JOLT Tiny BASIC. Resides in 2304 bytes of memory. PROM version requires two 2K PROM cards (nine PROM's). Paper tape/PROM ..... $25/$275

TANO

OUTPOST II
Terminal-type computer with full ASCII keyboard, 2480 CRT display; 32K RAM, 6800 MPU, mini-floppy disk drive and controller $1995

TECHNICO

SUPER STARTER SYSTEM
Based on TI9900, 16-bit MPU; single-board computer with 1K PROM, 512 bytes RAM, EPROM programmer, serial (RS-232/20 mA) I/O on-board. Expandable to 2K RAM, 2K PROM, 2K EPROM on-board, to 65k total memory with expansion boards. Peripheral boards available include 32K-byte memory expansion board, video/audio cassette interface, keyboards, floppy disk, power supply, interface board, chassis with limited or full front panel, CRT, printers. Kit/wired ..... $299/$399

TEXAS INSTRUMENTS

TM990/100M
Based on TMS9900, 16-bit MPU. Single-board computer with 1K, 16-bit words of EPROM with TI-BUG monitor, 256 × 16-bit RAM, expandable on board to 4K × 16 EPROM, 512 × 16-bit RAM. Parallel and serial (RS-232/20 mA) I/O, two programmable interval timers, 15 external hardware interrupts, and blank board area and extra sockets for prototyping. Will work with TI990/4 prototyping system. Hexadecimal microterminal, four-slot chassis and other peripherals to come. Requires power supply (5V @ 1.3 A, + 12 V @ 0.2 A, – 12 V @ 0.3 A). Wired $450

TM990/101M
Similar to 100M. Has two serial ports, 1K (×16) EPROM, 1K (×16) RAM $625

VECTOR GRAPHIC

VECTOR 1 (S1)
8080 MPU, 18-slot computer (with six connectors installed), 20-A power supply, whisper fan, PROM/RAM board with 1K RAM, room for 2K 1702A ROM. 512-byte monitor for use with Tarbell cassette and Altair, IMSAI, or Polymorphic I/O boards. Kit/wired. ..... $619/$849
Without PROM/RAM ..... $519/$619
Without CPU ..... $499/$699
Without CPU or PROM/RAM ..... $349/$499

VECTOR MZ (S1)
Similar to Vector 1, but with Z-80 MPU, two quad-density Micropolis mini-floppy disk drives and controller; Bit Streamer I/O board with 1 serial, 2 parallel ports, 32K RAM, 12K PROM/RAM board with extended monitor, complete DOS and extended disk BASIC. Wired $3750

MEMORITE WORD PROCESSOR (S1)
Consists of Vector 1 with drive, Hitachi 12" CRT monitor, Diablo HyTerm printer with 1620-3 serial print mechanism, word-processing software, disk BASIC. Wired $8500

VECTOR 2 (S1)
Z-80 MPU system with built-in keyboard; 10-slot S-100 motherboard; 32K RAM; PROM/RAM board with extended monitor; Flashwriter video board with 64-char x 16-li. display, limited graphics; power supply for ±8 V @ 12 A, ±16 V @ 4 A; 72-key keyboard with numeric keypad and user-definable keys. Wired ..... under $2000

VIDEOBRAIN

VB-101 HOME COMPUTER
F-8 MPU computer with integral alphanumeric keyboard; video r-f interface; real-time, time-of-day clock with alarm; two joysticks. Program entry through ROM cartridges; requires no user programming, but application-language program cartridges available. System 100. With Financier cartridge $500
Expander 1. Interfaces VB-101 to audio cassette recorders for storage of data or user programs, plus RS-232 port for communication with printers and modems $175
Expander 2. Acoustic coupler/modem, for use of VB-101 as computer terminal $325
CM01 Timeshare Cartridge. For use in accessing data banks and timeshare systems $80
VB-59 Programmable Cartridge. STRUCTURE BASIC programming language $125

OTHER SOFTWARE
Money Management Series: Finance, money-management, budget and data-base programs ..... $70-$80
Education Series: Math, music, art, history and vocabulary cartridges ..... $20-$40
Entertainment Series: pinball, tennis, checkers, blackjack, football and others ..... $20-$40

WESTERN DATA SYSTEMS

DATA HANDLER (S1)
6502-MPU computer with variable-speed clock, 2400-baud cassette interface, 1K on-board RAM, one parallel I/O port, hex keypad entry with binary display, I/O control switches; solder-pads provided for connection to a single Altair-bus peripheral board or motherboard for multiple-board use. In wood case. Requires power supply (under 2 A @ 5 V). Available as unpopulated "bare-bones" kit/kit with all components/assembled .... $80/$200/$225
Metal Case. Black anodized, with tracks for Data Handler and expansion board $19
Dust Cover. Hinged plexiglass dust cover with cutout for switch and keypad access $14
PRO/EX 1 Expansion Board. Includes 4K RAM expandable to 16K; 2K EPROM (expandable to 8K) with resident cassette operating system and video drivers; 50-char × 20-line video display with r-f modulator for use with standard TV set; can display 80 char × 25 lines on monitor or TV with direct video input.
P/E1. Kit/wired ..... $296/$324
P/E1-4K. Additional 4K RAM $56
2716 EPROM Programmer. Connects to Pro/Ex-1 and Data Handler parallel port. Kit $45

WINTEK

WINCE MICRO MODULES
6800-MPU, modular system, consisting of the following:
Wince Control Module. 6800-MPU board with 128 bytes RAM, one serial or parallel port, space for up to 512 bytes RAM, one serial and two parallel ports. Minimum configuration (128 bytes, one port) .. $149
Maximum configuration (512 bytes, three ports) $199
Back-Planes
Four-socket $39
Eight-socket $79
Power Supplies
5 V @ 2 A, ± 12 V @ 200 mA $89
5 V @ 5 A, ± 12 V @ 1.6 A $179
Console Module
Keyboard and digital displays; provision for up to 25 key switches, up to 16 display digits; real-time clock provides interrupts $199
Flexible Silastic boot option $19
Dynamic RAM Memories
RAM refresh module $99
RAM board with: 4K $199
RAM board with: 8K $277
RAM board with: 12K $339
RAM board with: 16K $399
CMOS RAM/Battery Module
With battery backup to protect memory contents during power off. Accommodates up to 2K bytes.
With 256 bytes $129
Each additional 256 bytes add $39
With 2K bytes $349
Battery option $49
ROM Module. For up to 16K EPROM (2708) or ROM $82
EPROM Programmer Module with software on cassette or paper tape $199
Programmer software on 2704 EPROM $49
FANTOM-II. 1K ROM monitor $29
Interfaces
RS-232C. For Control Module serial port $39
Cassette Interface. 300 and 2400 baud; shares Control Module serial port with RS-232 ..... $139
Modem. For data communications via telephone line; includes touch-tone dialing tones, auto receive $1499
Floppy-Disk Interface. for iCOM/PERTEC $119
Analog Interface. Less MUX, ADC, DAC $99
16-channel MUX $129
Eight-bit DAC (two, max). Each $29
Eight-bit ADC $59
Twelve-bit DAC $129
Driver/Sensor Module. For external device control (by relay) and sensing. Supplied less drivers and sensors, but with 16 ports $79
Driver (requires one port) $4
Sensor (requires two ports) $12

WYLE

8080-MPU SYSTEM
Totally modular, on 3¼" × 4½" plug-boards. Mount in card files with from seven to 28 slots, including 19-in. rack-mount versions, or 84-slot card drawer for 19-in. rack. System options include: RAM and EPROM memory; parallel, serial, analog, IEEE-488 and opto-isolator I/O; priority interrupt; time clock; front panel; interface for DEC PDP-11; power supply; paper-tape reader; wrapped-wire module; plus a wide variety of plug-compatible individual logic modules. Price depends on system configuration.

XITAN

ALPHA COMPUTERS (1)
Z-80 MPU with 8-slot mainframe including power-on clear, MWRITE and reset circuitry; front-panel reset switch with LED pilot light; internal DIP switch replaces front-panel sense switches; slot space for ribbon cables; rear-mounted power switch; power supply with 110-120 V or 220-240 V input; delivers +8 V 3 @ 6 A, ±16 V @ 1 A each. Wired.
Alpha 1. With 2 serial I/O ports, 1K RAM (expandable to 2K on board), 2K Zapple monitor in ROM; 4K EPROM space; 1 audio cassette interface; parallel port, 8K BASIC $979
Alpha 2. Similar, but with 16K additional RAM; software includes BASIC, Zapple text editor, Text Output Processor, Macro Assembler $1579
Alpha 3. Similar to Alpha 2 but with 80-char 25-line, two-page video display and keyboard port instead of 16K RAM; video driver routines in EPROM; upper/lower-case display with character blink and invert, 160 × 75 graphics mode with 64 graphics characters $1469
Alpha 4. Similar to Alpha 3, but with 16K additional RAM. $1929
Alpha 5. Similar to Alpha 3, but with 32K additional RAM instead of 16K $1939
Alpha 5 Plus. Similar to Alpha 4, but with 32K additional RAM $2289

COMPUTER PERIPHERALS

ALF PRODUCTS

AD8 MUSIC SYNTHESIZERS
Computer-operated synthesizer system consisting of up to 8 single-tone synthesis boards plus an intelligent controller or S-100 bus adapter. All synthesis boards independently programmable. Facilities include 256-level volume control; 256-level envelope-parameter control; 128-frequencies (8 octaves, 12 pitches/octave, plus 4 pitches/octave of external input); mono or stereo output under computer control. 8080 software available.

AD8 System. Intelligent controller/motherboard, interfacing via ribbon cable to one or more AD8 synthesizer boards, and to SIMP-A (Standard Interface for Micro Peripherals) interface in computer.

10-5-4. Synthesizer board for AD8 system. Kit/wired ..... $225/$265

AD8 Micro-Bus System. Similar, but synthesizer boards interface via ribbon-cable backplane to S-100 adapter.

10-5-11. Micro-Bus synthesizer board. Kit/wired ..... $225/$265

10-5-12. S-100 to AD8 Micro-Bus adapter. Wired $120

ANDERSON JACOBSON

AJ 841 I/O PRINTING TERMINAL
I/O Selectric terminal with RS-232 or parallel interface, ASCII code. Impact printer, interchangeable typefonts, 14.9 char/sec printout; may be used off-line as typewriter. Generates full 128 ASCII codes; 47-key keyboard; upper-case alpha lock; prints 88 characters (upper/lower-case); 130 char/line; paper widths to 14.8"; half/full duplex; require EBCD or Correspondence (standard Selectric) typeballs. Factory-refurbished $995

ARTISAN

85 MICROCALCULATOR BOARD
Hardware scientific-calculator board; interfaces through 8-bit bi-directional parallel port. Accepts instructions from processor, outputs 14-digit results to processor for storage or display; software driver requires less than 256 bytes. Includes logs, trig functions, polar/rectangular conversions, multiple storage registers, pi, e, metric/U.S. conversions, mean and standard deviation, square root. Removable 14-digit display on board. With display and interface cable $189

PTR1 PRINTER
110 char/s; impact type; 8½"-W standard paper; complete with power supply, enclosure, parallel interface. Kit/wired ..... $645/$795

FL1 MINI FLOPPY **(S1)**
Dual 5" mini-floppy drive; cabinet; power supply; S-100 controller card; EXDOS-M 6502 DOS. Kit/wired ..... $995/$1195

FL2 FLOPPY
Dual Persci 277 8" drive; cabinet; power supply; Persci 1070 controller card; CGRS S-100 adaptor card; EXDOS/TIM DOS/terminal monitor (6502). Wired only ..... $2495.

ATV RESEARCH

MICRO-VERTER
Interfaces computer video signals to any unmodified TV with UHF reception, avoids low-band VHF interference from computer circuits. Tunable over 4 UHF channels. Usually requires no direct connection to antenna terminals. Color-compatible (Apple-approved). Operates 1000 hours on 4 AA batteries (not supplied). MVX-500 ..... $35

PIXE-PLEXER
Modulator/r-f-oscillator for interfacing computer video signals to VHF TV channels 2-6. Accepts analog or digital signals. May be operated as monochrome character display or as multiplexer-modulator for color-difference plus audio-subcarrier inputs. Uses 3.5 MHz color-subcarrier, 4.5-MHz audio subcarrier with varactor diode modulator for FM sound insertion. Circuit board 1.5" × 3". Requires +15V or −12V/+5V; max current 50 mA; no power supply or case provided. PXP-4500. Kit $24.50

Pixe-Verter. Similar to Pixe-Plexer, but without audio and 3.58-MHz color subcarriers or color-difference inputs.
PXV-2A. Kit $8.50

Note: Use of above devices may not meet FCC requirements.

AXIOM

EX-801 MICROPRINTERS
Stand-alone, dot-matrix printers; 80, 40 or 20 char/line; electro-sensitive paper; 120 lines/min; 96-char ASCII, expandable to 256-char input buffer, expandable to 2K; software selection of 3 character sizes, may be mixed on same line; software selection of reverse printing.
EX-801 P. Parallel ASCII input $395
EX-801S. Parallel and RS-232/20-mA serial input; 50-1200 baud $495
EX-801 HS. High-speed serial input, 50-9600 baud $549
EX-801. Serial and parallel $655

EX-810 GRAPHICS PRINTER
Full-graphics dot printer using electrosensitivie paper; prints 8192 dots/sec, up to 512 dots/row; can also function as 80-col alphanumeric line printer with speeds to 160 char/sec; parallel input; 5-V, 100-mA output available for external circuitry; paper width 5" $795

EX-820 MICROPLOTTER
Similar to EX-810. Three, software-controlled horizontal dot resolutions up to 128 dots/in; 96-char ASCII, expandable to 256 char with user-programmable fonts; serial and parallel input; 512-character input buffer, expandable to 2K; 3, software selectable character sizes, can be mixed on same line; can mix alphanumerics and graphics on any line; vertical dot resolution 65 dots/in; provision for automatic histogram generation $795

BO-SHERREL

M-1 SHORT-HAUL MODEM
Asynchronous transmission; for local communication; max. data rate varies with distance, from 9600 baud under 2 miles to 600 baud under 10 mi (reduce distances by factor of 3 if shielded cable used); optical-coupler isolation; RS-232. Wired, in cabinet $149

M-1 card system: Card frame fits 19" rack, occupies 7" rack space, will accomodate 15 M-1 cards.
Card frame $300
M-1 cards $125

M-2 SYNCHRONOUS SHORT-HAUL MODEM
Similar to M-1, but for full-duplex, synchronous communication. Range/data-rates from 1 mile/9600 bit/s to 4 miles/2400 bit/s. $395

BYTE

BYTE-TVT
Stand-alone TV typewriter card; video signal output, ASCII keyboard input, parallel computer I/O, 32-char × 32-line (16-lines visible); scrolling; can be modified for 64-char × 16-line and serial I/O: connection by DIP sockets. Requires +5V @ 1.5A, @ −12V @ 100 mA $175

CALIFORNIA COMPUTER PRODUCTS

CALCOMP 142M FLOPPY DRIVE
Single-sided drive for 8" floppy discs. Capacity (IBM 3740 format) 243 Kbytes/side; unformatted, 401 Kb single-density, 802 Kb double-density. Hard-sector capacity 325 Kb/side (double-density). Switch-selected hard or soft sectoring. Other jumper- and switch-selected options. Requires ±24 V dc, 1.5 A; +5 V, 1.0 A; 90-127 V ac, 60-Hz, 1.7 A $625

CALCOMP 143M FLOPPY DRIVE. Double-sided. Capacity (IBM-3740 format) 512 kB/disc; unformatted, 801 Kb single-density, 1.6 Mb double-density. No hard-sector option $750

1143M FLOPPY DISK DRIVE CONTROLLER **(S1) (LS)**
Intelligent controller for up to four 142M or 143M drives. On-board intelligence; 1K buffer memory. Choice of 26, 15 or 8 sectors/track; word, byte or serial transfer. Accepts up to two host adapters simultaneously.
1143M Controller $660
With S-100 or RS-232 interface $1110
With LSI-11 interface $1310

CENTRONICS

MICROPRINTER
Non-impact, discharge printers; 5×8 dot matrix characters, 150 lines per minute; uses aluminized

paper 4.75" wide requires no toners or ribbons; 96-character upper/lower-case ASCII; software selection of 5, 10 or 20 char/in.; elongated characters and underlining; only 4 moving parts; 5 lines/in. vertical; audio alarm for paper empty; auto motor control turns motor off when no data received; available in serial and parallel versions.
P1-Parallel interface. TTL-compatible I/O, 7-bit ASCII. Wired $495
S1-Serial interface, RS-232C, with parity selection; switch selectable 50-9600 baud; 192-char. FIFO buffer. Wired $595

CGRS MICROTECH

AUDIO INTERFACE
Adds audio-casette mass storage to RS-232 port or terminal extension port. Reads and records Kansas City or Tarbell Bi-Sync tapes. Bare board/kit/wired ..... $10/$30/$50

COMMODORE

PET 2020 PRINTER **(PT)**
See under "Computers."
PET C2NT CASSETTE RECORDER **(PT)**
See under "Computers."

COMPUCOLOR

8001 COLOR TERMINAL
8080A-MPU intelligent color terminal with Intellec-8 bus structure; 19" color CRT; keyboard in separate housing. Includes 4K RAM refresh memory ...$1650

8001G COLOR GRAPHICS TERMINAL
Similar to 8001, but with special color graphics package. Includes graphics plot hardware and software; 8-color background selection; 64 standard ISA characters, page rollup, color and numeric keypads $2750

Special options: See Computers section.

COMPUTERWARE, INC.

10-MEGABYTE DISK SUBSYSTEM **(S1) (EX)**
"Midi-cartridge" drive with S-100 or M6800 EXORcisor controller and interface. Removable hard disk is in 2.8-lb, 11"-square cartridge, disk diameter 10.5". Capacity 5 megabytes per surface, 10 megabytes/disk (unformatted); direct-drive motor, no belts or pulleys; servo tracking; auto head-unload if power fails. Includes power supply, controller and either interface; cabinets and rack-mounts optional $6995

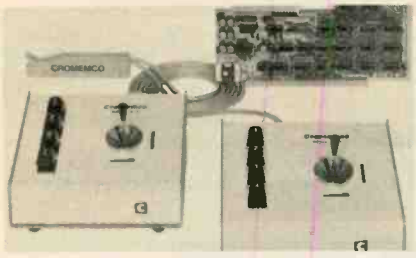
CONNECTICUT MICROCOMPUTER

RS-232-TO-CURRENT-LOOP/TTL ADAPTER
Board with circuits converting RS-232 to 20-mA current-loop signals, and 20-mA to current-loop. Allows TTY ports to drive RS-232 terminals and vice versa. Easily modified to adapt RS-232 to TTL instead of 20-mA. ±9V.
ADA 400S with solder-pad connections $25
ADA 400B with barrier-strip connections $30

IEEE-488-TO RS-232 ADAPTER (IEE)
Adapts IEEE-488 bus (e.g., Pet) to RS-232, output only. Use as RS-232 printer adapter for Pet, etc.
ADA 1200B. Wired, less power supply, case or RS-232 connector $99
ADA 1200S. With power supply, case, and connector $169

CROMEMCO

JOYSTICK CONSOLE
Joystick (2-axis) with speaker and amplifier, plus four user-defined pushbutton switches. Joysticks



±2 V each axis, spring return to center. For games, graphics, and similar applications. For use with Cromemco D+7A or similar analog interfaces. Joystick console. Kit/wired ..... $65/$95

3100 CRT TERMINAL
Solid-state capacitive keyboard; separate numeric and cursor keypads. 80 char x 24-line display; upper/lower case; remote video output jack; auxiliary I/O port; RS-232 interface. With 10-foot cable $1595

3101 CRT TERMINAL
Similar, but also has: 16 software-assignable function keys; local editing mode; screen formatting including dual-intensity characters, blinking characters, protected fields; block-transfer mode transmits entire screen of characters to computer $1995

3779 DOT-MATRIX PRINTER
60 char/sec; 12" platen; continuously-variable character pitch allows up to 132 char/line; tractor feed $2495

3703 DOT-MATRIX PRINTER
180 char/sec; 18" platen; 132 columns. Form feed, bi-directional printing, double buffering; tractor feed $1495

3355 DAISY-WHEEL PRINTER
55 char/sec; 15" platen; tractor feed and friction platen. $3995

PR1 PRINTER INTERFACE (S1)
Interfaces one daisy-wheel, one dot-matrix printer to S-100 bus. $195

WFD MINI DISK DRIVE
5"-minifloppy drive; soft-sectored IBM format; 92 KB/side. Operates from 4FDC Disk Controller $495

PFD DUAL DISK DRIVE
8"-floppy drive; holds two disks, 256 KB each (512 KB total); soft-sectored IBM format; includes power supply and cables, oiled-walnut case. Kit/wired ..... $1995/$2495

SOFTWARE DISKS: FORTRAN IV, 16K BASIC, Z-80 assembler, Dazzler games; specify 5" or 8". Per disk $95

CURTIS ELECTRO DEVICES

HAM S-100 (S1)
Computerized Morse and Baudot code operating system for ham radio. Receives, decodes, and displays (on user's CRT) Morse or 5-level Baudot TTY at 10-100 or 60-100 wpm. Also serves as keyboard or paddle with CRT display of transmitted text. Contains 7K EPROM with SOL firmware (patchable for other 8080 systems), 1K RAM $700

TI-100 STATION INTERFACE
For use with HAM S-100. Contains relays for transmitter PTT and keyline, 60-mA 175V Baudot receiver and driver, monitor side-tone amplifier and speaker; paddle key jack, high-low baud rate switch $150

RFI KIT
One-piece, shielded cover for SOL-20, plus interface electrical filters for RFI suppression $100

DIGITAL EQUIPMENT CO

LA36 DECwriter II
Dot-matrix printer terminal; 30 char/sec throughput (uses 16-char buffer and 60 char/sec catch-up

mode); adjustable width tractor feed for 3" to 14-⅞" forms; 132-col.; 10 char/in. horizontal; 6 line/in. vertical; 128-char ASCII upper/lower-case (95 printing characters); 48-dB noise level; adjustable tractors for margin positioning; 90-132 V operation ensures reliability in brown-out conditions; head shifts after printing or last-character visibility; integral stand; multi-key rollover keyboard; caps-lock switch; 20-mA serial interface. Many options available .. $2100

DIGITAL MICRO SYSTEMS

CRT LOWER-CASE KITS
Add lower-case letters to terminals specified below. Assembled. Takes 15 minutes to install.
ADM3LC. For Lear-Siegler ADM-3 and ADM-3a . $36
SORLC. For SOROC $18

BEEPER FOR VIDEO BOARDS
Adds beep signal to memory-mapped video boards for end-of-line or control-G signal. Assembled, requires only connection to video board and mounting. Draws 18 mA @ 5V.
VBEEP $16

FDS-1 FLOPPY-DISK SYSTEM (S1)
Dual-drive, floppy-disk system with S-100 interface. IBM-compatible format, TTL-compatible interface; command and status registers available via programmed I/O; hardware bootstrap; CP/M available.
FDS-1 System. Includes FDC-1 controller, S-100 interface, disk drives, cabinet, power supply and cables. Wired. With 1 drive/2 drives .....$1845/$2545
FDC-1 Controller Board. For Shugart drives. With cables $650
CP/M Software $70

FDC-3 DUAL-DENSITY SYSTEM (S1)
Similar, but double or single density recording, hardware or software selectable; 571K bytes/disk double density, 256K IBM-compatible format.
Dual/four drive .....$2745/$4790
FDC-3 Controller Board $850

DIGITAL RESEARCH & ENGINEERING

RETRO-GRAPHICS
Graphics card for Lear-Siegler ADM-3A; has own on-board Z-80 intelligence; point plotting and automatic vector generational 512 × 250 dot matrix; direct plug-in connection to ADM-3a, no modifications necessary; optional Textronix software compatibility $825

ECONOMY TERMINALS

ET1
Displays 24 lines of 80 characters, upper-case AS-

CII (transmits upper and lower) on 12-in. CRT. RS-232 and 20-mA interfaces; 63-key keyboard; scroll and page modes; 16 selectable baud rates to 19,200; blinking underline cursor, addressable; automatic repeat on all keys; tab fixed every eight characters; 2K RAM, 1½K ROM, 1 serial port. Wired $1045

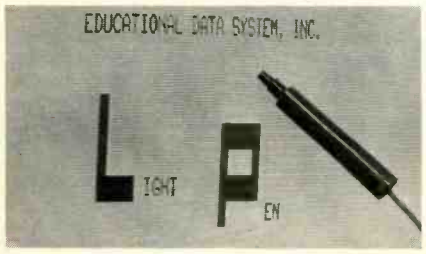
ET2
Similar, but with 3K operating system ROM, 2 serial ports, full 128-character ASCII upper/lowercase; added 4-key configuration pad (local, page/scroll, caps lock, print port); auxiliary port for printer; choice of inverse, half-intensity, or blink $1145

ET2/D
Similar to ET2, but with detachable keyboard with numeric pad, 4-key configuration pad $1295

ET4.
Similar to ET2, but with 8K ROM, 4-32K RAM, 3 serial ports, field-loadable alternate character sets, limited graphics, choice of 40/80/132 char. lines $1295

EDUCATIONAL DATA SYSTEMS OF VA

LIGHT PEN
For interactive graphics; allows user to "write" on screen. Requires 8080 system with TTL parallel in-



put port and memory-mapped video board (Processor Tech, Polymorphic, Merlin, etc.). Two software drivers: 760-byte driver uses high-speed, 4-way search to find where pen is pointing, has predefined tables for video boards mentioned above, coding instructions for other boards; 300-byte driver uses slower, two-dimensional Walsh-transform search; both drivers return pen address in HL register. Wired $32

ELECTRONIC PRODUCT ASSOCIATES

IMP-1A PRINTER **(EX) (S1)**
Line printer, 40-column, bidirectional, 5 × 7 dot-matrix impact type, 50 characters per second with 80 char/sec bursts. Prints 12-char/inch on 3 ⅞-in paper.....$450
IMP-68X. Interface for EPA Micro-68b computer..$22
(EX) IMP-EXOR. Interface for EXORcisor.....$22
(S1) IMP-ALT/IMS. Interface for Altair, etc.....$79

FLOPPY DISK
Floppy disk systems for 6800 MPU. IBM-compatible format, 250K bytes per disk. With cabinet and power supplies.
Single-Drive System $2595
Dual-Drive System $3295

ELECTRONIC SYSTEMS

T.V. TYPEWRITER
Stand-alone TVT board. Composite-video output, 64-character lower-case ASCII character set; 16 lines x 32 char (can be modified for 64 char) on-screen, plus 16 lines in off-screen memory. Addressable cursor, blink, auto scroll, erase to end-of-line or end-of-screen. On-board ASCII parallel ports for keyboard and computer input, special memory output port for computer inspection of on-board memory contents. Requires +5V @ 1.5A, −12V @ 30 mA.
Part No. 106. Bare board/board with parts .....$39/$145
Part No. 800. Similar, but 128-character upper/lower-case ASCII set, 24 lines x 80 char., reverse characters selectable. Bare board/with parts . $39/$180

UART & BAUD RATE GENERATOR
Converts serial to parallel and parallel to serial; on-board generator for baud rates 110, 150, 200, 600, 1200 and 2400; TTL compatible. 44-pin edge connector. Requires +5, −12 V.
Part No. 101. Board/board with parts ..... $12/$35
Edge connector $4

RF MODULATOR
Converts video to Channel 2-3 r-f signal. On-board regulated power supply; Apple-approved. Requires 12V ac center-tapped, or +5V dc.
Part No. 107. Bare board/with parts ..$7.60/$13.50

RS 232/TTY INTERFACE
Converts RS-232 to 20mA current loop, and vice versa, using two separate circuits. Requires ±12V.
Part No. 600. Bare board/with parts .....$4.50/$7

RS 232/TTL INTERFACE
Converts TTL serial ro TS-232, and vice versa, using two separate circuits. Uses 10-pin edge connector.
Part No. 232. Bare board/with parts .....$4.50/$7
Connector $3

TAPE INTERFACE
For recording and playing Kansas-City standard tapes on low-cost audio recorders at up to 1200 baud. TTL-serial digital I/O; audio I/O connects to recorder mic in and earphone out. No coils. Requires ±5 V, low power drain.
Part No. 111. Board/with parts ..... $7.60/$27.50

MODEM
Originate/answer modem, for full or half duplex at up to 300 baud. No coils. TTL serial I/O; connections for 8-ohm speaker and crystal mike. Uses XR FSK demodulator. Requires +5V.
Part No. 109. Bare board/with parts . $7.60/$27.50

ESCON PRODUCTS

SELECTRIC CONVERSION KIT **(S1)**
Converts IBM Selectric typewriters into computer printers. Requires no drilling or cutting; does not affect typewriter profile or operation. Uses S-100 interface. Requires 30 V dc @ 2 A; power supply available.
E-A. Mechanical parts, solenoids and instruction manual for installation in typewriter. Kit $250
E-B. Power supply and solenoid-drivers. Kit/wired .....$120/$195
E-C. S-100 interface card. Kit/wired ..... $135/$220
E-T. Complete set, Kit form $456

EXPANDOR

"BLACK BOX" PRINTER
Prints 10 char/sec, 80 char/line, uppercase ASCII set, on 8½-in paper. For friction or sprocket-fed paper, parallel port. Line spacing, six lines/inch. Impact printer, can make multiple copies (six max.)
Wired $396
Cover $30

F&D ASSOCIATES

EPROM PROGRAMMER
For 2704/2708 EPROMs. Software timing and control; requires 3 ICs, 6 transistors plus power supply. Designed primarily for SWTPC 6800, but can be adapted to I/O ports of other MPUs. With software for SWTPC system with console. EPB-2. Bare board and documentation $29

GEORGE RISK INDUSTRIES

GRI 753 KEYBOARD
53-key, ASR-33 format; tri-mode MOS encoding; two-key rollover; upper-case lockout; selectable parity; data and strobe inversion options; custom keycaps; 3 user-definable keys; MOS/DTL/TTL-compatible outputs.
Draws less than 1 W. Kit/wired ..... $60/$71
701. ABS plastic enclosure $15
702. Steel enclosure $30

GRI 756 KEYBOARD
57-key; dc-level and pulse-strobe signals for easier connection to 8-bit parallel ports. Alpha-lock (upper-case only) and shift lock. Optional numeric pad.
Kit/wired ..... $65/$76
702. Steel enclosure $30
710. Numeric pad $10
756MF. Mounting frame ..... $ 9

GRI 771 KEYBOARD
Similar to 756, but with separate numeric and cursor control pad; automatic repeat on all characters; built-in power supply options; parallel buffered output via D-25 connector; in two-tone steel enclosure.
Wired ..... $150.

GRI 716 HEX KEYPAD
Fully-encoded hex keypad; 2-key rollover, latched data outputs, full debouncing, user-selectable ± logic, data and strobe signals. Kit/wired .....$25/$27.50

GIMIX

GHOST POWER CONTROL SYSTEM
Allows remote device on/off control, manually or with any computer. Following modules may be used alone or together:

GHOST RELAY DRIVER BOARD
Controls up to 31 GE RR8 relays; scanning circuitry determines relay status; usable with any computer; up to 4 boards (124 relays) can operate from one 20mA current-loop serial port; provision for manual control as normal low-voltage switching system, even without computer. System fits in 30x6x12-in. electrical cabinet.
Relay driver board $449
Transformer, 2A, 24V, to power boards and relays. $14
G.E. RR8 Relays. 24V, mechanical-latching, can handle up to 20A, 277V ac. U.L. approved $9.45
Relay bracket $28

GHOST OPTO-ISOLATED INPUT BOARD **(S5)**
Detects up to 34 different switch closures. Input voltages from 5 to 24V; FIFO buffer memory, switch debouncing; self-scanning. For remote-control device monitoring via any 8-bit parallel input port with handshake lines. Can mount to and draw power from SS-50 bus if available $349

16-BUTTON REMOTE 2-WIRE KEYBOARD SYST. (S5)
Allows remote control from any number of keyboards, using only one #24, twisted-pair phone line (up to 1 mile distance). When one keyboard is in use, others are locked out. Tone Receiver Board powers and controls the keyboards, and converts their signals into binary. For any computer with 8-bit parallel input port with handshake lines; can mount to and draw power from SS-50 bus, if available.
Tone Receiver Board (one required) $249
16-button keyboard (0-9, A-D,*,#) ..... $ 99

GRE

PRINTERFACE II **(S1)**
Dot-matrix printer with S-100 interface. Character set features upper-/lower-case, with/without descenders, enhanced characters, superscripts and subscripts, foreign punctuation, page boundaries, and optional APL characters. Character throughput more than 50 char/sec: 80-column; longer lines automatically wrap around; 7x9 matrix; × 8½" roll paper; impact; auto-reversing ribbon drive with re-inking rollers. Can be configured to emulate almost all serial and parallel-interface boards; had on-board control processor with 156 bytes RAM, 1K ROM (neither addressable by CPU); custom character sets can be field programmed into ROM with included character assembler. With interface, printer mechanism, power supply and cables $895

HEATH

H9 CRT TERMINAL

Displays 12 lines of 80 characters on 12-in screen, formattable to four columns of 12 lines × 20 characters; cursor control; batch transmit; plot mode; 110-9600 baud; serial RS-232, 20 mA, and TTL interfaces. Kit $530

H10 PAPER TAPE READER/PUNCH
Uses standard 1-in wide paper tape (roll or fanfold); reads at 50 char/sec; punches at 10 char/sec; punch and reader circuits are independent and operated simultaneously; code mode for tape duplication; power supply; parallel TTL interface.
Kit $350

WH17 FLOPPY-DISK SYSTEM (H8)
Mini-floppy disk system for Heath H8 computer. Controller circuit board plugs into H8 mainframe.

Uses hard-sectored, 40-track, 5¼" diskette; Wangco 82 drive; capacity 102K/disk. Wired $675
H17-1. Second drive $295
H8-17 Software. Includes HDOS operating system with diagnostics, BUG-8 console debugger, TED-8 text editor, HASL-8 assembly language, and extended Benton Harbor BASIC. With extra diskette. $100
WHS170. Single-drive system with software $695
WHS171. Dual-drive system with software $975

LA36 DECwriter II PRINTER TERMINAL.
See Digital Equipment Co.

HOUSTON INSTRUMENT

HIPLOT DIGITAL X-Y PLOTTER
Digital plotter with 0.005" or 0.001" resolution. Computer controls pen position on X and Y axes, plus pen lift and setdown. plots 7" × 10" on 8½" × 11" or DIN A4 paper; RS-232C and 6-line parallel interfaces; supplied with 8 fibre-tip disposable pens, one box of chart paper. Wired $1085

HIPAD X-Y DIGITIZER
Graphic input device; converts graphic information into digital values at up to 100 X-Y coordinate pairs per second when manually traced with freely moving cursor; origin (X=Y=0) relocatable to any point on board; cursor programmable for point mode (coordinates registered only when cursor is pressed down) or stream mode (cursor positions continuously registered); registered cursor positions can be marked for reference. Digitizing area 11 × 11 in.; resolution 0.005"; binary and BCD output, selectable inch or metric; selectable RS-232 serial or 8-bit parallel interface; optional 4-digit coordinate display. Wired $795

IMSAI

INTELLIGENT KEYBOARD
Microprocessor-based intelligent keyboard with on-board ROM; parallel and RS-232 interfaces; user-

programmable key functions; upper/lower-case ASCII; upper-case only mode; scan mode; with six-ft. cable.
IKB-1. Wired $275

SERIAL PRINTER
Daisy-wheel character printer; 45 char/sec; 132-col; interchangeable fonts; parallel input; impact.
PTR-45A. Wired $2400
PTR-45A-TF. With tractor-feed option $2600

LINE PRINTER
Impact printer; 300 lines/min; requires serial or DMA interface: solid characters; tractor feed.
PTR-300A. 80 char/line. Wired $2610
PTR-300B. 132 char/line. Wired $3656
(S1) LIF. S-100 DMA interface. Kit/wired ..... $399/$599
If ordered without printer ..... $599/$799

MINI LINE PRINTER
Dot-matrix printer; 44-col; 55 char/sec; uses standard paper; requires parallel interface.
AP-44. Kit/wired ..... $499/$599

DAISY-WHEEL PRINTER TERMINAL
Hard-copy terminal with tractor feed, keyboard, 45 char/sec; 132-col; HyType II mechanism; six-ft. cable; requires serial I/O.
HCT-45A-TF. Wired $3395

MODEM/ACOUSTIC COUPLER
Available in 300- and 1200-baud versions.
MDM-300A. 300-baud. Wired $299
MDM-1200A. 1200-baud. Wired $995

FLOPPY-DISK SYSTEMS
Dual PerSci floppy-disk drive, single-density format, (IBM-compatible), with power supply, in table-top cabinet, with DIO non-DMA Disk Interface.
PCS-80/25A. Wired $2170
PCS-80/25B. Same, but double-density. $2395
PCS-80/26A. Expansion unit for PCS-80/25A; with drives, power supply, cabinet, no interface ... $1695
PCS-80/26B. Expansion for PCS-80.25B $2095
PDC-A. Same as PCS-80/25A, less cabinet and power supply $1770
PDC-B. Same as PDC-A, but double-density . $2170
RM. Rack Mount for PCS-80/25 or /26 ..... $20
DHMO. Double-high mounting option. Will mount two PCS-80 floppy or computer cabinets, in two-high configuration, with single cover for both; includes tilt bracket for convenient position of 1KB-1. ..... $50

TAPE DRIVE SYSTEMS
Available for 7 or 9 tracks; 800, 1600 or 800/1600 BPI; 7", 8½" or 10½" reel sizes. From $6974

INTELLIGENT BREADBOARD CONSOLE (S1)
Connects to any S-100 computer for design of digital logic circuitry. Requires six 8-bit parallel I/O ports; provides access to 48 lines of TTL I/O; with power regulators, LED level indicators; 6 component strips, sockets for forty 16-pin IC's.
BBC-5. Kit/wired ..... $435/$625
BBC-3. Similar, but with three component strips; requires three I/O ports, accesses 24 lines I/O. Kit/wired ..... $325/$532
BBCM. Expands BBC-3 to BBC-5. Kit $135

INDUSTRIAL MICRO SYSTEMS

FLOPPY-DISK SYSTEM (S1)
In portable, self-contained enclosure with Shugart 801R drive; single-board S-100 controller compatible with Altair BASIC and CP/M; 110/220-V operation; fused ac and dc.
61-0041 ..... $1045
61-0051. Similar, but in 19" rack mount with slides expandable to 3 drives (unused slots covered); cooling fan $1170
61-0061. Same as -0051, but less slides, and with wood enclosure sides $1215
61-0020. 2-drive rack-mount enclosure with power supply and clides; for Shugart 800-series, PerSci 277 drives $305
61-0030. Desk top version, with wood sides $385

INNOTRONICS

INNOVEX 410/420 FLOPPY DRIVES
Full-size (8") floppy drives; mount 2 horizontally or 4 vertically in standard rack; single and double-density (3200 and 6400 BPI, inner track), unformatted capacity 400K/800K per diskette. Available in IBM-compatible, soft-sectored (410) and hard-sectored (420) versions; 220/240V and 100/115V 50 Hz versions also available.
410. Soft-sectored $495
420. Hard-sectored $505
400-2046. Triple-voltage power supply for two-drive system $110

3400 DUAL DISKETTE SUBSYSTEM (LS)
Includes two Innovex 410 or 420 drives, power supply, rack-mount enclosure (10.5" panel height) with forced cooling, ac line filter, mounting for controller or interface board $1555
3401. With Controller for LSI-11 ..... $2955
3401-D. Double-density version $3155
3430. With general-purpose 8-bit interface ... $2250
3440. Double-density version $2590
400-2047. Solid wood table top cabinet for any of above 3400-series subsystems. (Choice of wood available) $125

OPTIONS
Write Protect. Per spindle $25
Remote Eject. Per spindle $25
Dual Density. Per spindle $75
RS-232 Serial Interface $100

INTEGRAL DATA SYSTEMS

IP-125 IMPACT PRINTER
Impact dot-matrix (7×7) printer with integral microprocessor controller, RS-232 serial and TTL parallel interfaces; built-in diagnostics program; full 96-char. ASCII upper/lower-case; uses roll, fan-fold or single sheet plain paper up to 8½ in. wide; standard line length 80 col. @ 10 char/in; optional 8.3, 10, 12 and 16.5 char/in., for up to 132 col.; serial baud rates to 1200 bits/sec; multiple-line, 256-char buffer standard, full-CRT (2048 char) buffer optional; instantaneous print rate to 100 char/sec, sustained throughput to 50 char/sec standard, optional to 80 char/sec; re-inking ribbon mechanism, rated ribbon life 10M char. Other options include: graphics options (preferably for IP-225); form-feed with automatic page-boundary skip (standard on IP-225); 1024 and 2048-char. line buffers. In table top console with front-panel line-feed, paper, test and power controls. Wired $799
IP-225. With tractor feed, form-feed, and automatic page-boundary skip $949

INTERNATIONAL TECHNICAL SYSTEMS

PEM-8K (PT)
Self-contained, self-powered 8K RAM addition for PET; with financial, math, algebra software $279

INTERTEC

INTERTUBE
CRT terminal with 12" screen, 80 char × 24 lines, 25th line for status messages. ASCII 128-char set, upper/lower-case; 11 special graphics symbols; protected, constant and print-only fields; blinking, underline, reverse video, half intensity; character, line or page transmission; TTY-compatible keyboard plus 14-key pad, local mode, erase, 16 programmable function keys; cursor position and addressing controls; RS-32 or 20/60-mA current loop; RS-232/20-mA printer port. Wired $874

SUPERTERM
132-column matrix impact printing terminal; 10-60 char/sec standards, 120 and 200 optional; Selectric-configured keyboard, alphanumeric key pad; RS-232/current-loop serial interface; horizontal and vertical tabs; automatic top-of-form positioning. Optional: super- and subscripting, variable vertical pitch, direct X/Y addressing, adjustable L and R margins, automatic reverse printing, double-width characters, auto CR on line end, font-programmable char-set, 1200-baud communications package, APL/ASCII. Less options $1995
Supercette. Built-in micro-cassette option $900

SUPERDEC THROUGHPUT OPTIMIZER
For installation in DECwriter II teleprinter; increases speed up to 6 times; adds bidirectional printing, manual and auto top-of-form, addressable and absolute hor. & vert. tabs, adjustable R and L margins, RS-232 interface, double-wide character set, up to 32 user-programmable characters. Direct, plug-in replacement for DEC writer electronics. Optional APL character set, selective addressing, answer-

back. Less options $495

JHM MARKETING

VOTRAX VOICE SYNTHESIZER
Produces continuous speech analog input from instructions representing phonemes; RS-232 input $1400

LARKS ELECTRONICS & DATA

ACCELEWRITER
Module to modify DECwriter LA36 from 110/150/300 baud to 110/300/600. Plug-in installation $95

LEAR SIEGLER

ADM-3a "DUMB TERMINAL"
CRT terminal; 80 characters × 24 lines on built-in, 12-in-diagonal screen. Standard 64-character AS-

CII uppercase character set supplied; 90-character upper-lower-case set optional. Switch-selectable cursor modes: Underline cursor homing to lower left of screen, with automatic scrolling; and page mode with reverse-character cursor homing to upper left. End-of-line tone. Full and half-duplex modes, 11 communication rates from 75 to 19,200 baud. Switch-selectable RS-232 and 20-mA interface to computer; extension RS-232C port for printer, recorder, or additional terminals (20 mA optional). Cursor can be directly addressed to any part of screen by keyboard or computer, in page mode. Kit/wired ..... $795/$895
Lowercase option. $50
Arithmetic keypad, with cable and connector $85

ADM-31 SMART TERMINAL
Similar to ADM-3, but with two-page memory (can display either page); 90-key keyboard with integral numeric pad, tab, upper-case lock, character and line edit keys, line and page erase keys; field protection with dual-intensity; optional RS-232 extension or printer interfaces; keyboard-selectable transmission mode (page, line or message); visible control characters; polling-addressing option. Wired $1450

ADM-42 SMART TERMINAL
Two-piece terminal (keypad detachable from CRT). Two-page memory (expandable to 8 pages) with independent protect, write/protect, program mode and cursor retention; 15" CRT display with dual-intensity, blinking, blanking and protected fields; 24-line display with 25th line for status indicators; multiple tab modes; numeric keypad, cursor keys and 16 shiftable function keys; programmable function keys optional. Other options include: alternate 128-character set; extension, printer and internal system bus interfaces; communications protocol; line drawing. Wired $1795

BALLISTIC PRINTER
180-char/sec matrix impact printer. Built-in microprocessor provides 15 switch-selectable form lengths, 15 perforation-skipover formats, complete vertical and horizontal tab control; print and font controls allow up to 2 sets of 128 characters alternatable line by line; auto space and blank character compression saves buffer space and speeds tabbing; standard buffer lengths 512 char (serial), 256 (parallel), both expandable to 2048 char; resident, non-volatile format-retention system with 96-hour battery backup. 9×7 matrix characters in 9×9 matrix, allows underlining and lower-case descenders. Wired. Serial/Parallel interface versions .... $2045/$1995

LENWOOD

TVT-II SCROLLER
Adds scrolling to TVT-II type terminals, such as SWTPC CT-1024. Consists of assembled circuit board (1¾" × 2¼") with instructions on how to install. Installation requires 14 wire connections and cutting of six traces.
SM-2 ..... $19

EXTENDED CHARACTER GENERATOR KIT-I
Extends character set of TVT-II type terminals. Adds up to 64 extra characters, programmable via EPROM. EPROMs available with lower-case and 32 weighted graphic characters, lower case and 32 special symbols, or 64 weighted graphics characters. Kit includes pc board, IC's and installation instructions (EPROM extra).
ECGK-I $39

M&R

PENNYWHISTLE 103 MODEM
May be used as acoustic coupler (with telephone handset) or wired directly into the telephone via a direct-access adapter. Operates in both half-duplex (unidirectional) or full-duplex (bidirectional) modes. Records data to and from audio tape; communicates directly with another modem and terminal; can record data from a remote source over the phone line and enter the data into the memory of a computer. Kit $130

SUP'R'MOD II UHF INTERFACE **(AP)**
R-f modulator. Displays video output of all computers (plugs into Apple II) on unmodified TV set, over UHF channel 33. Color-compatible; includes coaxial cable and antenna transformer $30

MALIBU DESIGN GROUP

MALIBU 160 LINE PRINTER **(S1)**
Dot-matrix impact printer with graphics capabilities. Operates bidirectionally at 165 char/sec on paper from 4-15" wide; 132 char/line. Optional S-100 and RS-232 interfaces; 96-character ASCII upper-/lower-case set with descenders; all print wires of 9-pin print head under software control, allowing changes to other character sets or symbols; tractor line feed, normally 1/6", but software controllable to 1/60", permitting graphics (with software printhead control): double-width characters programmable; programmable top-of-form control; selectable 115/230V, 50/60 Hz; includes software form-handler and character generation (1K); with parallel interface. In wood-grain Formica cabinet $1995
MPIO. S-100 interface card with all necessary ports, including ROM and RAM for printer $330
MPIO Without memory $200
MPC. Intelligent (Z-80) controller card allowing stand-alone operation; interface either parallel ASCII with hand-shake, or serial (20 mA or RS-232) with baud rates to 9600 ..... $425
Printer Stand $160
Replacement Ribbons, package $24

MAXI-SWITCH

MAX KEYBOARD
60-key, with full 128-character ASCII set; includes two non-encoded function keys for user assignment, relegendable keytops; alpha-lock transmits upper-case only; cursor-control keys optional (coding already included); MOS encoder; 2-key rollover. Requires +5 V @ 90 mA; −12 V @ 13 mA. Wired $70
Cursor-control kit $4

MECA

ALPHA-1 MASS STORAGE SYSTEM **(S1)**
Dual cassette system operating under computer control. S-100 interface supports up to 4 drives; 750 Kbyte/drive; 780 byte/sec.; high-speed search at 100 in/sec.; will access any position on C-30 cassette in 20 sec.; independent motion control and read/write electronics for simplified tape copying, look-ahead tape queuing, and file management; additional track for audio recording; with 8080 assembler, editor, debugger, and operating system. Other software available, including BASIC and patches to 4.0-4.1 mits Extended BASIC. System with controller, power supply, enclosure, cabling and software:
Single drive. Kit/wired ..... $495/$595
Dual drive ..... $695/$845
Triple Drive ..... $995/$1185
Quad drive ..... $1195/$1415
1702 Bootstrap Loader. (Does not include PROM board) $25
Audio play/record option. Wired $120
All components available separately.

MEMSPEC

6800 SELECTRIC INTERFACE
Interfaces IBM 1980 Selectric to standard ASCII serial 20-mA and RS-232 interfaces. Has on-board, 6800 intelligence; output baud rate can be set to 300 baud; standard model for 48 V dc interface, others on request; max cable length 500' input, 1000' output (20 mA), 25' (RS-232); uses tab input to control shift to lower-case, index input for return to upper-case, others usable as option; self-contained, in cabinet with 120-V ac power supply, auxiliary ac outlet socket for printer terminal. Wired $900

MICROAGE

MKB-2 KEYBOARD
Keyboard with upper and lower case, numeric keypad, cursor control keys, 1-key rollover, auto repeat on all keys; in steel case with parallel interface, strobe or pulse, on-board regulation (5 V, ±12 V) DB25 connector $149

MICRO COMPUTER DEVICES

SELECTRA-TERM
IBM Selectric II typewriter, adapted for use as printer for computer output. Uses ASCII code, parallel port interface. Supplied with ASCII character ball; 31 other type-font balls available, including OCR, script, and italics. Full upper- and lowercase. Retains IBM warranty and is still usable as typewriter, though keyboard does not communicate to computer. Standard is 10 char/in, 15-in writing line; 12 char/in (155/line) available on special order, no extra charge. Wired and tested $1750
Dual-pitch option (10 and 12 char/in) $125
Correction feature $125

SPINTERM
Higher-speed terminal, based on NEC Spinwriter, with proportional spacing. Impact printing, using 128-character, interchangeable print-wheel; half or full duplex at 110-1200 baud, with parity; 256-character input buffer, 16-character keyboard buffer; interface configuration under operational control; replaceable black and black/red ribbons; film ribbon for reproduction; prints up to 55 char/s; 136 columns at 10 char/in, 163 col @ 12 char/in; noise level 60 dBA (with covers on); 3-position hammer impression control; 1/120" horizontal, 1/48" vertical resolution allow graphics, subscripting and superscripting; 46-key keyboard, plus 4 operator function keys and 15-key numeric keypad; word-processing software available; tractor feed.
Without keyboard/with keyboard ..... $2915/$3235

MICRO DATA SYSTEMS

MD-692 KEYBOARD.
Full upper/lower case keyboard with all control characters, upper-case lock and repeat key. In plexiglass enclosure with redwood ends. Kit/wired ..... $139/$159
With built-in, 6-slot, S-100 motherboard and power supply $259
MD-694 K.C. CASSETTE INTERFACE
300-baud K.C.-formatted data input and output, with on-card clock; small, non-S-100 board; requires one serial I/O port. Kit/wired ..... $15/$20

MICRO DIVERSIONS

MICRO-SLICE SINGLE-BOARD **(S1)**
Z-80 single-board computer; power-on jump to any 256-byte boundary; 8 software-prioritized interrupt inputs; switch-selectable global wait-state option; 4K 2716 EPROM (upgradable to 2732) and 4K RAM, both switch-addressable to any 4K boundary; 1 serial port (RS-232/20 mA); 2 fully-buffered parallel I/O ports; front-panel firmware including block transer and search. Requires +8 V @ 2 A, ±18 V @ 100 mA. Note: does not generate S-100 signals required by certain dynamic RAM boards, or others requiring non-standard bus timing signals; list of bus lines and signals used available on request. Kit/wired ..... $389/$489

MICRO PERIPHERALS INC.

MPI PRINTER
40-column, impact dot matrix printer. 75 lines/min., line-length 3.33 in. on adding-machine roll paper to 3⅞" W. Available with serial, parallel ASCII, and parallel programmable interfaces; 64-character upper-case ASCII. Option "A" provides strappable data formats, double-wide characters under software control, and reverse-field printing on parity errors; option "B" provides the above, plus fast paper-feed option (5 line/sec line-feed). Interface boards and printer mechanism with interface available separately; prices shown are for assembled and tested printers with power supply and case.
MP-40, parallel ASCII printer $425
SSP-40, Serial $575
SSP-40 with Option A $625
SSP-40 with Option B $650

MICRO SYSTEMS DEVELOPMENT

MSDD-100 FLOPPY DISK SYSTEM (S1)
Mini-floppy (5¼") system with Shugart SA-400 drive. Soft-sector format; requires six user-selectable port addresses (software supplied uses ports 60-65 octal); programmed I/O; controller may optionally interrupt main CPU when disk controller needs service; sector size user-selectable (MSD software uses 18 128-byte sectors); includes utility software and patches for Altair BASIC; system supports 3 drives. Drive requires 12 V @ 2 A and 5 V @ 1A; controller powered from S-100 bus.
Kit/wired ..... $499/$599
Additional drives $350

MICRO-TERM

ACT-IA AFFORDABLE COMPUTER TERMINAL
Two-piece CRT terminal. Generates ASCII 128-char set, displays 96-char ASCII, with lower-case descenders; 64 char × 16 li; cursor control forward and back; scrolling; RS-232C (20-mA optional); keyboard has caps lock for TTY emulation; 110-19, 200 baud. Wired $400

VTB VIDEO TERMINAL BOARD
All electronics of the ACT-IA on a 20 × 25-cm circuit board; requires parallel-data ASCII keyboard and cabinet. With ac power supply. Wired $200

ACT-IIA TERMINAL
ACT-IA with integral modem and acoustic-coupler; modem has separate serial I/O, allowing modem use independent of keyboard $550

ACT-IV TERMINALS
Available as single unit with numeric keypad (ACT-IV B) and two-piece unit (ACT-IV A). 80 char × 24 li display, with lower-case descenders, control-character display; half or full intensity programmable for each char; keyboard has full-ASCII and TTY-emulation modes; cursor control and page transmit keys; cursor-control, space and period keys auto-repeat; other keys auto-repeat when pressed with space bar: relative and absolute cursor control; cursor indicates character being transmitted in block mode; trailing spaces not transmitted; editing features include erase to end-of-line and end-of-screen;
ACT-IVA. (Requires external monitor) $550
ACT-IVB. W. 12" CRT $800
Printer port. With independent data rate $50

MICROPOLIS

MACROFLOPPY (S1)
Double-density (5162 BPI) system for 5¼", hard-sectored diskettes. Records 143K bytes per diskette. System includes S-100 controller for up to 4 drives, cable, and diskettes with BASIC (requires 24K RAM) and DOS (16K required). Has built-in bootstrap and file project.
1041-I Macrofloppy. Can be installed in S-100 chassis (with optional dc voltage-regulator kit). With one drive $695
1041-II. two drives $1045
1042-I Macrofloppy. Includes power supply and cabinet, for stand-alone mounting $795
1021-I. Add-on drive with enclosure; requires daisy-chain cable and regulator kit $445
1022-I. Add-on drive with enclosure, and power supply; requires daisy-chain cable $545
1091-01. Regulator kit for 1041 ..... $20

METAFLOPPY (S1)
"Quad density" 5¼" floppy systems, using double-density (5162 BPI) recording on 77 (not 35) tracks. Capacity 315K per drive. Other features similar to MacroFloppy.
1043-II. One-disk system $1145
1053-II. Two-disk system $1895
1054-II. Four-disk system $3220
1023-II. Single add-on disk. Requires daisy chain cable $645
1033-II. Dual-disk add-on; requires cable $1325

MIDWEST SCIENTIFIC INSTRUMENTS

FD-8 FLOPPY-DISK
300K bytes per disk (formatted), hard-sectored. Single-drive system interfaces to any parallel port (parallel interface card available for SS-50 I/O bus). Read after write for error-check. Complete disk operating system available for 6800-based systems; disk-driver and Mini-DOS routines may be integrated with BASIC for 8080 systems. Includes controller for up to four drives. Kit/wired ..... $1150/$1395
Dual-Drive System. Kit/wired ..... $1950/$2295
MINI-DOS system on PROM (1702) $250
FDOS/BASIC on diskette $65
FDOS Bootstrap only, 1702 PROM $125
Additional drives $900
(S3) PIA-1. Parallel interface card for SWTP 6800 computer system. Kit, less diodes/wired $50/65

MCRT-E TVT ENCLOSURES
Holds terminal, keyboard, and CRT; as used in CRT-1 terminal. Removable keyboard mounting routed to accept SWTP KBD-5 keyboard $90

TVTE TVT ENCLOSURE
Designed for SWTP CT-1024 TV typewriter. Keyboard plate routed for SWTP KBD-5 keyboard, with space at right for additional control keys or number pad; space on top for setting CRT monitor $55

779 HIGH-SPEED PRINTER
Dot-matrix impact printer (five copies max.), 80 char/line, six lines/in, 60 char/sec. Sprocket-fed paper up to 9½-in wide. Buffered input. Full alphanumeric uppercase, normal, and elongated characters. Less interface $1195

PR-1 PROM PROGRAMMER/VERIFIER
Programs 17-2 A PROMs directly from computer memory via parallel port. Reads and compares PROM after writing to verify contents; displays discrepancies and error message on terminal.
Kit/wired $325/475

PR-2 EPROM PROGRAMMER (S3)
Programs 2708 and 2716 EPROMs; plugs into SS-50 interface bus (S3); zero-insertion-force socket mounts outside computer chassis. Includes 2708 software. Kit/wired ..... $125/$190

MINITERM ASSOCIATES

WORD-PROCESSING KEYBOARD
Ninety keys, with tactile feedback, 100-million-operation-guaranteed keyswitches. Upper- and lower-case, 12-function keys, numeric pad, four on/off keys, and auto-repeat. Wired, in enclosure $235

MOUNTAIN HARDWARE

INTROL REMOTE CONTROL SYSTEM (S1) (AP)*
Turns 110V ac devices on and off under computer control; transmits control signals over house wiring; adapters for S-100 or Apple computers. System consists of ac controller, ac interface adapter, and dual-channel ac remote, described below, plus software subroutines for most BASICs. Time control available with clock board.
***AC Controller.** Controls up to 64 channels remotely, up to ½ mile or to local transformer, via 50-kHz PCM; bi-directional system, allows polling of remote channels; transmissions checked for parity, framing, overruns and address errors. Specify S-100 model (occupies 1 bus slot, 2 ports) or Apple II (occupies one I/O expansion slot). Includes ac Interface Adapter, which connects controller to ac wiring, isolates controller and computer from 115-V power, but allows control signals to pass. Kit/wired ..... $149/$189
Dual-channel AC Remote Station. Walnut case with two, independent 500-W channels; manual override switch and internal fuse for each channel; self-calibration circuit for alignment to controller; address selection via on-board jumpers. Kit/wired ..... $99/$149
Introl BASIC. Tiny BASIC with added commands for Introl Remote Control system and Clock Board; requires 8080/Z-80, 12K RAM from 0000 (8K for PROM version).
In 6734 EPROMs (8 PROMs, programmed) $100
CUTS cassette or paper tape $15
CP/M or North Star diskette $25

MYKRO

K.C. I/O MODEM
Uses "Kansas City" standard (2400-Hz logic "1", 1200-Hz logic "0", 300 baud). Connects between serial port (standard DB25 connector) and cassette

recorder: has hold circuit to enable unformatted record/play without start-up error; Includes tape with IAPS (International ASCII Publication Standard) formatting for 8080/Z80; can be called from Cromemco Z80 monitor.
Wired, with assembled cables and connectors $129
With unassembled cables and connectors $109

NATIONAL MULTIPLEX

3M3 DIGITAL DATA RECORDER
Uses 3M Data Cartridge, Model DC-300; records nearly two megabytes per cartridge, on four tracks, phase encoded, at 9600 baud. Has inter-record gap light, full software or manual control of all functions including fast-forward and rewind; has high-speed search for inter-record gap. Comes with software. Uses "Uniboard" cartridge drive construction. Requires serial I/O port with two parallel bits for control. 2SIO(R) board (see below) recommended for S-100 or SS-50 bus systems. Wired $250

CC-8 DIGITAL COMPACT-CASSETTE RECORDER
Direct digital recorder (no audio-cassette interface required) using standard Philips-type Compact Cassettes. Handshake signals when motor is up to speed. RS-232 I/O standard, TTL optional (user changeable); speed adjustable. Uses Binary NRZ asynchronous single-track digital recording on half-track format (flip cassette over for second track). Adaptable for 12-V operation. Use of 2SIO(R) board recommended for S-100-bus computers. Motor start/stop by remote or local control. Fast forward and rewind. Manual only.
75-1200 baud version (1.6 ips) $185
1200-4800 baud version (3.0 ips) $185
2400-9600 baud version (6.0 ips) $195

CONTROLLER **(S1) (S3)**
I/O board with EPROM monitor and tape/file-handling routines: 1 serial, 2 cassette ports; usable for phase-encoded, K.C., MITS and IMSAI tapes: high-speed search and tape motion controls for 3M3 and other digital tape units, start/stop for CC-8 and audio cassette.
2SIO(R). Specify S-100 or SS-50 version. Wired $190

NEWO

WRITEHANDER
Dome-shaped, one-hand, full-ASCII keyboard. Uses one key per finger, plus 4 key pairs for thumb; key combinations yield full 128 ASCII characters, including control characters. Requires parallel port (7-bit) and 5V power. Single ribbon contains data, power, return, strobe and key-pressed pulses and fixed parity levels: Leaves other hand free. Available for right or left hand, in large (for hand spanning 8½" or more from thumb pad to little finger pad) and small sizes $98

NORTH STAR

MDS-A MICRO-DISK SYSTEM **(S1)**
Uses Shugart Mini-Floppy drive, 100K bytes per diskette. Controller on one Altair-bus board, with bootstrap software in PROM. Supplied with DOS and disk BASIC software, all connectors and cables. Power requirements. 0.9 A @ 5V, 1.6 A @ 12 V, can be supplied by computer or optional power supply. Drive assembled, controller available Kit/wired .....$699/$799
Power Supply Kit $39
Cabinet Kit $39
Additional drive Kit/wired ..... $400/$450
MDS-A-ND. System less drive, for use with previously purchased SA-400 drive .....$449/$549

OLIVER

OP-80A PAPER TAPE READER
High-speed optical tape reader; no moving parts. Reads punched paper tape up to 5000 char/sec. Includes optical sensor array, high-speed data buffers, handshake logic for interfacing with parallel I/O. Kit/wired .....$85/$100

2708/16 PROM PROGRAMMER
Programs 2708 and new 2716 PROMs. Interfaces to parallel port; requires very little software—data is dumped via the output port to program the ROM. Requires 1-A, 8-12-V power supply. Takes less than 100 seconds to program 2708, less than 200 for 2716. Kit/wired .....$249/$295
Kit, less regulators $199

OPTIMAL TECHNOLOGY

EP-2A EPROM PROGRAMMERS
For 2704, 2708, TMS-2708, 2758, and 2716 EPROMs and others where specified. Require 12-bit parallel I/O. Configured to match various MPUs (see below); replace "-x-" in model number with appropriate MPU code when ordering.

EP-2A SERIES
On 4.3" × 2.2" circuit card, with 44-pin edge connector. Requires +5 V @ 150 mA +28 V @ 50 mA (all PROMs), +12 V @ 100 mA and −5 V @ 100 mA (2704/08, TMS 2708/16 only).
EP-2A-X-01. With low-insertion-force socket. Kit/wired .....$50/$60
EP-2A-X-02. With lower-force socket. Wired $64
EP-2A-X-03. With off-board, zero-force socket. Wired $70
EP-2A-G-05. General software instructions only. Kit $33
EP-2A-X-04. General software instructions only. Wired $43

EP-2A-78 SERIES
Similar to EP-2A, but also programs TMS2532, TMS2716, and 2732 PROMs; card size 4.3" × 2.4"; PROM type selected with jumpers at card edge connector.
EP-2A-78-x-01. With zero-force socket. Wired $80
EP-2A-78-x-02. With same socket as EP-2A-x-02 .....$74

EP-2A-79
Similar to EP-2A-78, but stand-alone type, with power supply and enclosure; PROM type selected by plug-in personality module (one supplied, others $15 each).
EP-2A-79-x. Wired $145

MPU code. For letter "-x-" substitute: K for 6502; M for 6800; I8 for 8080, 8085, Z-80; R for 1802; F for F-8.

ANALOG I/O CARD
8-channel, A/D and 2-channel D/A converter; ±5V full scale; requires 50 mA @ ±12-15V; interfaces via 2 I/O ports; 8-bit accuracy; 10-meg input impedance; on 4.25" × 3.75" card.
I/O 802. Wired $99
I/O 802-A. 8-channel A/D only. Wired $79

OTTO ELECTRONICS

OE 1000 TERMINAL
Video terminal with composite-video output; requires monitor. Screen format 16 li x 64 char: upper/lower-case and TTY modes; will display 96 ASCII characters and 32 special characters; full cursor control, automatic scroll, erase to end of line, erase to end of screen, and clear-screen. Interfaces to 300-baud full-duplex serial port, 20-mA or RS-232. Has 57-key keyboard, plastic case; requires 115V ac power. Kit/wired .....$275/$350

PACIFIC CYBER/METRIX

PC/M 660 CMOS EPROM PROGRAMMER
Programs Intersil 6603 and 6604 EPROMs; operates from its own front-panel controls, with a terminal, or as a computer peripheral; 20 mA and RS-232 interfaces; internal 4K buffer; accepts all standard paper-tape formats; uses any desired number base from 2 to 16; punches binary-format paper tape for permanent data storage; built-in buffer-editing capabilities. $795

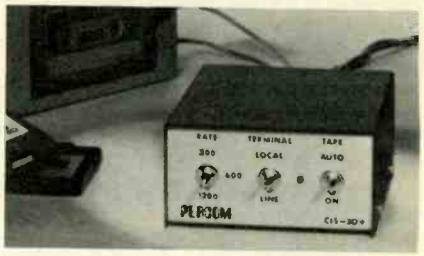
PAIA

8782 DIGITALLY ENCODED KEYBOARD
Piano-type, 37-note keyboard for computers and electronic music systems. Includes power supply and software instructions. Can be used as infinite-hold Sample-and-Hold device, with PAIA 8780 D/A converter. Kit $120

8780 DIGITAL-ANALOG CONVERTER
Equally tempered D/A converter; based on multiplying principle, rather than conventional ladder-type circuits, to generate stair-step exponential function required for equally tempered musical intervals. Generates over five octaves of control voltage from only six bits of data; remaining two bits usable for trigger flags, range extensions, or micro-tonal tuning. Interfaces to any microprocessor, with or without handshaking logic. Can be used with 8782 keyboard for infinite-hold Sample-and-Hold. Kit.....$35
In addition to computer, above modules interface to a complete series of synthesizer-module kits.

PERCOM DATA

CIS-30+ CASSETTE INTERFACE
Self-clocking audio cassette interface, functioning at 120, 60 or 30 bytes/s. Usable with any computer



having a serial port, but designed for SWTPC 6800: uses MIKBUG for all ordinary functions except 120 byte/s loading, plays unmodified SWTPC cassette software, and is finished in matching colors. Includes RS-232 data terminal interface, allowing both tape and terminal to use one serial port; user-selectable 1200, 600 or 300 baud terminal interface. Independent record/play circuits permit dual cassette operation; uses phase-locked (biphase/M) data and clock recovery; optional kit allows program control of recorders; local/line switch for off-line sending of recorder programs to terminal only. Requires regulated +5V @ 50 mA, +12V @ 10 mA, both available from SWTPC 6800. Kit/wired .....$80/$100
IC Sockets $5
Remote-control kit $15
Test Cassette $5

CI-812 CASSETTE INTERFACE **(S1)**
Similar, but board for S-100 bus. Kit/wired ..... $100-$130

LFD-400 MINIDISK SYSTEM **(S5)**
Mini-floppy system for SS-50 bus (does not use I/O slots), up to 3 drives. Consists of SS-50 controller board with space for 3K PROM, Shugart SA-400 drive, power supply, cabinet, software and firmware. Controller turns drive motors off if system is inactive more than 3 seconds; has 1K miniDOS use of existing software (patches provided), disk protection; also available are miniDOS+, supporting named files (miniDOS is sector-referenced) and FMS-6800 file-management system (requires 4-8K RAM support). Wired only.
One-drive system $600
Two-drive system $1000
Three-drive system $1400
miniDOS+ Firmware (2708) $45
All system components also available separately.

PERIPHICON

TYPE 511 IMAGE DIGITIZER
Video camera/digitizer; creates 32 × 32-element image; 14mm, f/1.9 lens focuses from 0.2m to infinity; in machined aluminum case with standard ¼-20 tripod screw mount $200

PERSCI

DISKETTE DRIVES
For full-size (8") diskettes; IBM-3740 compatible. Voice-coil head positioning, for fast access (76-track seek in 100 ms, 33 ms random average seek); diskette load/unload can be controlled by computer; double-density capability; single-density capacity 400K/side unformatted, 243K formatted: double density 800K/side unformatted (6536 bpi). Dual-drive versions only 4.4" wide.
70. Single drive.....$695
277. Dual drive.....$1295
299. Double-sided dual drive.....$1595

1070 SINGLE-DENSITY DISKETTE CONTROLLER
Stand-alone diskette drive controller with 8-bit parallel computer interface, optional RS-232 serial; includes 4K ROM file-management firmware, 1K RAM for I/O buffering. Supports up to 4 single or two dual drives.....$740

1170 DOUBLE-DENSITY CONTROLLER (S1)
Similar to 1070, but S-100 compatible; 2K RAM buffer; supports up to 4 single, 2 dual drives in drive-select mode, or up to eight 299 drives (32 diskette sides) in multiplex mode; maximum subsystem formatted data storage capacity 16M bytes. $1050

PHONICS

LOW-COST SPEECH INPUT
Self-contained, microprocessor-based speech recognition board; will identify up to 16 spoken words or short phrases of user's choice; parallel I/O port interface. Requires +5 @ 750 mA, ±12 @ 200mA ea.
SR/8 .....$550

PICKLES & TROUT

TVM-41 TV MOD KIT
Kit adapts Hitachi and other TV sets using Hitachi "SX" chassis for use as 9-in. or 12-in. video monitors; switch allows normal TV use. Up to 90 char/line; for EIA-format video signals with amplitudes of 0.6V, 1.1 V or higher. Has onboard regulator, draws about 12 mA $20

PET-488 CABLE ASSEMBLY (IEE)
IEEE-48 plug-compatible cable for PET. Adapts PET computer's IEEE-48 edge connector to standard IEEE-48 devices. Edge-connector keyed to ensure correct insertion; cable length 18" (others on special order); available with male (PET-488M) and female (PET-488F) connectors $30

POLY PAKS

ASCII KEYBOARD & ENCODER
64-key; 7-bit ASCII output from MOS encoder ROM; 7 LED test features; ASCII 128-character set; 2-key rollover; electronic shift lock and carriage return; normal, control, shift, and shift/control modes, additional functions user-assignable. Requires +5, −12 V, 200 mA. Kit/wired.....$65/$75

HEXADECIMAL KEYBOARD
4-bit binary/hex output, plus strobe; 2-key rollover; 20 keys 16-encoded and 4 user-definable; 4-LED binary output display: Requires +5, −12 V. Kit/wired.....$35/$40

PROCESSOR TECHNOLOGY

HELIOS II DISK SYSTEM (S1)
Includes dual PerSci 270, full-size floppy drive or drives with cabinet, fan, S-100 controller, power supply and system diskette with PTDOS software. Wired only.
HELIOS II, MODEL 2. One dual drive $2995
HELIOS II, MODEL 4. Two dual drives $4995
BOOTLOAD. 2K PROM bootstrap for PTDOS ...$100

RADIO SHACK

TRS-80 SCREEN PRINTER (RS)
Electrostatic printer for TRS-80; uses 4" paper; prints 220 char/sec; hard-copy of any CRT-screen contents, including graphic; requires only 4K RAM and Level-I BASIC $599

TRS-80 EXPANSION INTERFACE (RS)
For TRS-80 system expansion. Contains sockets for added 16K or 32K RAM; disk controller for up to 4 Mini-Disks; software-selectable dual cassettes; real-time clock; card-slot for future interface options; parallel port for Centronics printer. Usually requires Level-II BASIC; required for all peripherals below $299

TRS-80 LINE PRINTER (RS)
Impact printer; 60-110 char/sec; 5×7 dot matrix; character density 10-16.5 char/in.; for roll paper up to 9.8" W; top-of-form software control, friction feed. Requires 4K RAM, Level-II BASIC and Expansion Interface $1299

TRS-80 MINI-DISK SYSTEM (RS)
Holds 8K bytes/disk; includes TRS-80 DOS software; adds 15 additional features to Level-II BASIC. Requires 16K RAM, Level-II BASIC, Expansion Interface $499

RCA

COSMAC MICROTERMINAL
Hand-held, machine-language terminal with hex keypad input with 8-digit LED displays; control keys for reset, run utility, run program, start program, increment, clear address, data/address entry select, continuous/single-step select; utility firmware. Designed for 1802 systems; direct plug-in to COSMAC Evaluation Kit, EK/Design Kit, and Development System II.
CDP18S021. Wired $140

COSMAC MICROMONITOR
In-circuit debugger for 1802 systems. Connects between MPU and socket. Has built-in keyboard, display and status indicators; interfaces to external terminals; allows real-time run with breaks, plus operation for specified numbers of machine or instruction cycles; programmable break conditions, with register preservation and trace; control of memory, I/O and all registers and flags; inhibits or allows system-generated DMA and interrupt requests.
CDP18S030. Wired $1600

COSMAC FLOPPY-DISK SYSTEM II
Dual-drive system designed for direct plug-in to COSMAC Development System. Includes system diskette (IBM-compatible format) with editor, assembler, diagnostic, and utility programs.
CDP18S805V1. Wired $3200

RO-CHE SYSTEMS

MULTI-CASSETTE CONTROLLER (S1)
Controls up to four audio cassette recorders, including write, read, and start/stop, through one interface. Plugs directly into and is controlled through, the Tarbell cassette interface. (See Module Boards) Includes operating system software and basic I/O driver with cassette selection, multiple files with update and merge, split and duplicate; two-pass assembler, record compression, and other useful subroutines. Optional software: text file editor.
MBB-4B. With four cassette ports. Kit/wired .....$140/$190
MBB-2B. With two ports .....$110/$150
MBB-RA. Two-port add-on $32
Text File Editor and manual $10
File maint. system $10

SANYO

BLACK & WHITE MONITOR/RECEIVER
13"-diagonal, black & white receiver with 75-ohm (switchable to high impedance) video input/output bridging connectors for computer or similar connection, 8-pin connector for VTR, front panel TV/monitor switch; audio input/output bridging connections. Horizontal resolution 500 lines.
VM-4310 .....$340

BLACK & WHITE MONITORS
600-line horizontal resolution; continuous DC restoration; video input and output connectors permit "loop-through" with other monitors; switch selectable high or 75-ohm impedance; up-front controls with locking positions. Optional single and multiple rack-mounting frames available.
VM-4209. 9"-diagonal screen.....$220
VM-4215. 15" screen.....$310
VM-4219. 19" screen.....$395
VM-4205. Three, 5-inch monitors on single chassis; in desk-mount cabinet, with rack mounting brackets included.....$775

COLOR TELEMONITORS
Similar to VM-4310, but color.
31C40. 13" screen.....$390
51C60. 15" screen.....$400
91C62. 19" screen.....$450

SHUGART

SA400 MINIFLOPPY DISK DRIVE
Uses 5¼" diskettes, 110K storage capacity (unformatted). Write protect circuitry; DC servomotor; stepping-motor actuator; positive media insertion keeps door from closing on media; 300 rpm. For hard or soft-sector formats. Wired $355

SA4400 MINISTREAKER CONTROLLER
For up to 3 SA400 drives; includes general-purpose host interface; has overlapped head seek, 128-byte buffer, IBM-3740 format with modified gap structure; responds to 8 macro control functions. Mounts on SA-400 drive. Wired $490

SA450 DOUBLE-SIDED, DOUBLE DENSITY MINIFLOPPY
Same size and features as SA400, but records single or double density on both sides of disk to 440 K (unformatted). $450

SA800/801 FLOPPY DISK DRIVES
Use 8" diskettes. Single or double density, unformatted capacity 400K single density, 800K double; formatted capacity 250K IBM-format, single-density. Available in IBM-compatible (SA800) and hard-sector (SA801) versions; also available in narrow-chassis versions (SA800R/801R) for side-by-side mounting in 19" racks. $610

SA850/851 DOUBLE-SIDED DISKETTE DRIVES
Double-head versions of SA800/801. Same size as SA800/801, and plug compatible; media-compatible with IBM single- and double-sided drives. Fastflex metal band actuator; heads may be loaded simultaneously on both sides of diskette; programmable door lock and write protect; sensor differentiates single from two-sided diskettes; single or double density, unformatted capacities 800K single, 1600K double density, per disk; IBM extended format (max) 606/diskette single, 1212K double. Wired.
SA850/SA851 .....$755/$780

SA4000 FIXED DISK DRIVE
With single or double disks, capacity 14.5 megabytes/disk. Rack mountable; require same power supply voltages and similar interfaces as SA800/850 floppy drives, for easy mixing. Uses Winchester technology, Fastflex actuator.
SA4004. single-disk, 14.5MB $2550
SA4008. double-disk, 29 MB $3500
Head-per-track option (adds 144K capacity) ... $350

SMOKE SIGNAL BROADCASTING

BFD-68 MINI-FLOPPY DISK SYSTEM (S5)
SS-50 controller supporting up to 3 drives, 3-drive cabinet with space and power supply for 3 drives, DOS-68 and Disk File Basic DFB-8 software; other software available.
BFD-68. Single-drive version $795
BFD-68-2. Dual-drive system $1139
BFD-68-3. Triple-drive system $1479
SA-400. Additional Shugart drive for BFD-68 or BFD-68-2 .....$355
ABFD-68. Single-drive system less cabinet and power supply $649

POP-1 EPROM PROGRAMMER (S5)
Self-contained 2708 programmer, designed to interface with Smoke Signal P-38-1 EPROM board. With software $129
P-38-1. 8K EPROM board with interface for POP-1. See Module Board section for details. Wired ... $174

SOROC TECHNOLOGY

IQ-120 TERMINAL
Displays 24 lines, 80 char/line, on built-in 12-in CRT. Includes keyboard with cursor control, numeric keypad, tab, auto-repeat. ASCII 96-character upper/lower-case set. RS-232 interfaces to computer and extension port (optional) for printer, etc. Has protect mode; displays protected data in reduced intensity. Can erase to end of line, end of field, end of memory, all unprotected data, or complete screen. Switch-selectable baud rates, 75-19,200. Wired .....
.....$995

IQ-125 TERMINAL
Similar to IQ-120, but with descenders on lowercase characters, block-mode transmit option, printer port with independently-selectable baud rates. Wired $1095

IQ-140 TERMINAL
Simliar to IQ-125, but with detachable, 117-key keyboard, including 16 function keys, separate numeric keypad; full screen edit capablity and block mode transmit; reverse video, underline, blink, blank security fields; polling option. Wired $1495

SOUTHWEST TECH. PRODUCTS

CT-64 TERMINAL
CRT terminal, 16 lines of 32 or 64 characters per line; scrolling or page mode operation; upper-and lowercase characters, with switchable lowercase

defeat; reversed character printing; control character display, with defeat switch; cursor control; complete control character decoding. Usable with any eight-bit ASCII computer. With power supply, keyboard, serial interface, beeper, chassis, and cover. Kit $325

CT-VM. Video monitor for above, in matching case. Requires CT-64's power supply. Wired $175

CT-EA Screen Read Board. Allows block transmission of screen contents after editing. Kit $18

CT-82 TERMINAL

CRT terminal with 9", green-phosphor screen; 82 char × 16 or 20 lines, software-selectable; dual-intensity upper/lower-cause characters, graphics optional; protected fields; cursor addressing with 12-key cursor control pad, page or block transmit; driver for Centronics PR-40 parallel printer; decodes reader and punch on/off control characters; socket for optional 2716-pinout custom character generator; optional light pen; 110-34, 800 baud. Control functions include scrolling by screen or quadrants, up and down, left and right slide; erase to end or beginning of line or frame, or erase quadrant; line and character insert-delete. Operates on 100, 120, 220, 240 V ac, 50-60 Hz.

Wired $795

AC-30 AUDIO CASSETTE INTERFACE

Interfaces between computer and terminal (requires accessible, 16× clock and 300 baud rate, RS-232 serial). Provides independent control for two recorders, including automatic start/stop; either cassette may record while the other plays back data. LED indicators display record/read status and data flow. Local/remote switch permits using recorder with terminal alone. Kansas-City standard. Kit $80

GT-6144 GRAPHICS TERMINAL

Cell array is 64 wide by 96 high; each cell addressable by computer; programming allows fixed or moving images. Data can be loaded in less than 2 μsec. Image reversal for white on black or reverse; standard 525-line format; 6144-bit static RAM. Operates with any computer whose parallel interface outputs an eight-bit word and data-ready strobe; this includes any 8080 or 6800 machine. Does not include chassis or video monitor. Programming allows display of graphics, CT-1024 alphanumerics or combination of both. Kit $99

CT-P. Power supply. Kit $16

Joystick potentiometer digitizer $40

Slide-potentiometer digitizer $36

PR-40 ALPHANUMERIC PRINTER

Alphanumeric printer with 64 upper case characters, 40 characters per line, 75 lines per minute.

Uses standard 3⅞-in adding-machine paper. Has internal 40-character line-buffer memory; printing takes place at carriage return or when line-buffer memory is filled; 5 × 7 dot-matrix impact printing. Accepts data up to one character per microsecond or slower; seven parallel data lines are TTL-compatible and enabled by data-ready signal. Used with any computer having eight-bit parallel interface, including 8080 and 6800 machines. Internal power supply.

Size 8¾"H × 10½"D × 9⅝"W Kit $250

PR-4L. Extra ribbon $5

MF-68 DISK SYSTEM **(S3)**

Dul minifloppy (5¼") disk system for SWTPC 6800 and similar computers. Controller plugs into I/O slot 6, support up to 4 drives; includes SWTPC 8K BASIC ver. 2, modified for disk save/load, plus FDOS; stores up to 85K bytes/disk; requires 16K memory in computer; with chassis, cover; power supply. Kit, with 2 assembled Shugart SA-400 drives $995

MF-6X Expansion Kit. With power supply, enclosure, 2 drives $850

DMAF1 FLOPPY **(S5)**

Full-size (8") floppy-disk system with DMA controller for up to 4 drives; 600K bytes/disk; with two CalComp 143M double-density-rated disk drives; other features similar to MF-68 system. Kit/wired ..... $2000/$2095

DMFXA Drive Expansion $1850

SUMMAGRAPHICS

BIT PAD DIGITIZER

Converts graphics data into digital X-Y addresses. System consists of 15 x 15-in. digitizer board with

11-in. square live area, pen-size stylus, and small console cabinet with controls. Records single coordinate pairs, streams, or coordinate pairs updated only when stylus touches graphic material. Specify 0.005" or 0.1 mm resolution. Requires +5V @ .05A, +12V @ .07A, −12V @ .05A, all regulated.

BP-11. With 8-bit parallel output $555

RS-232 serial output option $125

CSR-1. Single-button cursor option $75

Power supply (in separate housing) $95

On-board regulator 3 ..... $30

Spare stylus $40

MULTIBUS BIT PAD **(MB)**

Similar, but with direct plug-in interface for Multibus (SBC) systems; all electronics located on one SBC card, controls and status indicators in small handheld console $625

SYLVANHILLS LAB

X-Y PLOTTER

Plotter and interface kit (mechanics assembled), for interface to any eight-bit TTL parallel port. Pen holder accepts any writing instrument or stylus 7-11 mm diameter; encoded for 0.01-in/pulse, but 0.005-in optional. Pen travel speed 2.5-in/sec max. with 24-V supply, 4.25-in/sec with 36 V. Includes control of pen lift, X and Y motion, start and stop. Drawing surface and power supply not included.

DFT-1. Plotter kit, 11" x 17" drawing area $795

DFT-1M. Mechanical system only $699

DFT-2/-2M. 17" x 22" ..... $950/$825

UPS-24. Power supply, 24 V, 1.5A, regulated $50

CON-1. Console for DFT-1 ..... $110

CON-2. Console for DFT-2 ..... $130

X-Y PLOTTER UNIT

Plotter, drawing surface and power supply, for interface to any 8-bit TTL parallel port. Pen holder accepts any writing instrument or stylus 7-11 mm dia.; encoded for 0.01" pulse, 0.005" optional. Pen travel speed 2.5"/sec max, with 24V supply, 4.25"/sec max with 36V. Includes control of pen lift, X and Y motion, start and stop. Wired, including console and power supply.

UNIT-1. 11" x 17" drawing area $1049

UNIT-2. 17" x 22" drawing area $1249

TED

REAL TIME CLOCK

Time-of-day clock, connects to TTL parallel I/O port of any computer system; requires +5, +12V. Push-button time setting; can run off separate power supply or battery (crystal-controlled). Wired only $50

TELE SPEED COMMUNICATIONS

MODEL 81 PRINTER

Dot-matrix printer using pressure-sensitive paper. 64-character ASCII (upper-case), bidirectional printing at 80 char/sec; 80 columns, 10 char/in.; 6 line/in; totally visible print line. Jumper access to stepper motor drives and print drivers, for graphic and plotting applications; optional tractor mechanism, 80-column bidirectional buffer, RS-232 interface. In desk-top cabinet, with parallel ASCII input $615

TELPAR

PS-48C PRINTER/TERMINAL

Printer with optional keyboard for use as full KSR printing terminal. Thermal print mechanism, dot matrix upper/lower-case ASCII 96-character set; 110 or 300 baud serial RS-232, 20-mA or TTL; TTL parallel up to 960 char/sec; prints 48 columns, with automatic printing of excess on next line; recognizes negative vertical tab command from computer; uses 5½" paper.

PS-48C Printer. Wired $666

KB-59C Alphabetic keyboard $222

Paper. 5½" x 164' roll $3

PS-40 THERMAL PRINTER

Similar to PS-48C, but without power supply and case. Prints 24 char/sec with 110 or 300-baud transmission rates. Includes interface.

PS-40. Wired $400

Power supply $100

Case $100

TERMIFLEX

HAND-HELD TERMINALS

Hand-held ASCII terminals with multi-function, calculator-type keyboard, LED dot-matrix display, RS-232 interfaces. Keypad with 3 shift keys generates 128 ASCII characters, plus "break", has multi-key lockout; 120 char/sec; full duplex; display buffer: requires +5V.

HT/3. One 12-char line, 12-char buffer $795

HT/4. Two 12-char lines, 24-char buffer $1195

HT/6. One 20-char line, 940-char buffer, full/half duplex, 10-120 char/sec $1795

TERMINAL DATA

CRT TERMINAL

High-speed TTY-replacement terminal with separate, 9" CRT monitor. RS-232 interface; 64 char × 16-line display; 110-9600 baud; half or full duplex; auto carriage return/line feed; automatic rollup; available with built-in acoustic coupler.

675. ..... $725

675-1. With acoustic coupler $925

675-2. With coupler, case and stand $1050

DATA SPLITTER

Diode network providing dual-output interface from RS-232 port; allows printer and modem, printer and plotter, etc. to share a port, and isolates the two output lines from each other. Can be daisy chained.

1200K. Kit/wired ..... $49/$99

1204K. Similar, but 4 in, 1 out ..... $89/$150

TERRAPIN

TURTLE ROBOT

Computer-controlled robot, operating on 10' cable from standard parallel interface. Moves at 6 in/sec, turns at 120°/sec; emits 2 tones from built-in speaker (more, with music generator in computer).

Requires 12-18V unregulated, @ 1A; 8 bits in, 4 bits out. Kit/wired ..... $300/$500

S-100 interface kit $40

THINKER TOYS

DISCUS I **(S1)**

Full-size, 8" floppy-disk system. IBM-compatible, soft-sectored format, 256K bytes/disk. Software initialized to use on-board, memory-mapped serial I/O port, can be reinitialized to other ports. Controller can accommodate up to 8 drives, occupies 1K starting at 340:000 octal/E000 hex (other addresses on special order). Complete with Shugart 800R drive, power supply, cabinet, BASIC-V, DISK/ATE DOS/Assembler/Text Editor, and patches for CP/M.

Single-drive system; Wired $995

Additional drive. With power supply, line cord cabinet $795

Additional connector. For multiple drives $25

Dual-drive system. Wired $1750

Software (with purchase)

CP/M DOS $70
Microsoft Extended Disk BASIC $199
Microsoft FORTRAN $349
Disk Jockey I Controller kit only $179

U.S. ROBOTICS

USR-310 ORIGINATE ACOUSTIC COUPLER
Asynchronous, half/full-duplex, originate-only acoustic coupler for terminal communication to computer; data rates 0-300 baud; RS-232 computer interface; acoustic connection via standard telephones; with case and power supply $139

USR-320 AUTO-ANSWER MODEM
Auto-answer modem, for computer to answer remote terminal; Requires Data Access Arrangement, available from U.S.R. or rentable from phone company (ca $5/mo., plus installation). Other specifications same as USR-310.
With RS-232 or 20mA interface, no DAA $160
With RS-232 or 20mA interface and DAA $299
Dual interface option, RS-232 and 20 mA $10

URS-330 ORIGINATE/AUTO-ANSWER MODEM
Similar to USR-320, but for both originate (terminal) and answer (computer) modes.
With RS-232 or 20mA, without/with DAA ..... $185/$324
Dual interface option $10

VAMP

ACVM-1 VIDEO ADAPTER
Television modification kit for direct video input. For transformer-isolated or "hot-chassis" sets; allows displays up to 80 char/line, with bypass switch for normal TV reception; provides isolation to protect video source; provides positive or negative video directly to TV set's video amp $25

VECTOR GRAPHIC

DUAL-STOR FLOPPY-DISK SYSTEM (S1)
Dual PerSci 277 drive (243 bytes/disk, IBM-compatible); uses programmed data transfer; will operate with both static and dynamic memories at 250K bits/sec; includes controller, chassis, power supply, cabinet, CP/M and BASIC-E software. Wired $2650

VOLKER-CRAIG

VC303A TERMINAL
TTY-compatible computer terminal; stand-alone unit with 1920-char screen; upper/lower-case; 12" CRT; RS-232 interface; 24 li × 80 char; cursor control keys and direct X-Y cursor addressing; composite video output for slave monitor. Auxiliary serial and parallel interfaces optional $1195

VC404 STANDARD TERMINAL
Similar to VC-303A, but with detachable keyboard; clear to end-of-line and end-of-screen; transparent/tape mode; switch-reversable video. Options listed below.
VC404 ..... $1195
VC404/RO. Same, less detachable keyboard; receive-only $1050

VC414 EDITOR
Similar to VC404, but with block mode. Allows formatted data entry and complete local editing before transmitting all or variable data; multi-level display; blinking/reverse video; horizontal tabs; character/line insert and delete; character highlighting; protected/unprotected data; line-drawing capability $1395

VC424 TERMULATOR
Similar to VC414. Complete editing terminal with polling and independent printer port $1595

OPTIONS FOR 400 SERIES
SPI. Switches serial peripheral interface $75
KB1. Numeric pad and function keys $75
APL. Front-panel switch-selectable ASCII and APL character sets, typewriter-paired (no overstrikes) $250
PIP. Auxiliary parallel input $75
CDS. Colored anti-glare display screen (specify green or amber) $50
MTI. Multiple Terminal Interface. Switching box, connects up to 5 VC-series terminals to serial printer $250
BRI. Bar code reader interface for Monarch 2243 scanner $315

COMPUTER MODULE BOARDS

Module boards for standard bus systems (including combinations of the above) are listed here.

ADVANCED COMPUTER PRODS.

8040 DISK I/O BOARD (S1)
For 8" floppy drives; CP/M compatible. Kit/wired ..... $165/$210

PROTOTYPE BOARD (S1)
ACP-PT $28

EXTENDER BOARD (S1)
A-EXT. With connector. Kit/wired ..... $16/$30

Ai CYBERNETIC SYSTEMS

MODEL 1000 SPEECH SYNTHESIZER (S1)
Forms words and sentences of standard American English from phonemes requested by ASCII characters. Speech rate and vocal pitch adjustable. Requires less than 50 bytes of assembly or five lines of BASIC for programming, data rate typically 25 bytes/sec. Requires less than 2.3 W maximum. Outputs to any amplifier or recorder. ..... $380.

ALF PRODUCTS

QCPG QUAD CHROMATIC PITCH GENERATOR (S1)
8-octave, 96-pitch generator, producing 1-4 tones simultaneously. Requires 2-MHz from bus pin 49, or option P1 crystal clock. Kits available with 1-4 channels, wired 4-channel only.
10-5-9 (A1,K). Single-channel, kit $111
Additional channels, each $16
10-5-8 (A4). Wired, 4-channel $185
P1. 2-MHz clock option $16
(Also available in non-S100 form for parallel interfacing. See "Peripherals" section.)

AD8 MICRO-BUS ADAPTER (S1)
Adapts AD8 Micro-Bus Synthesizer System to S-100 bus. (See "Peripherals" section for details.)
10-5-12. Wired $120

QCPG QUAD CHROMATIC PITCH GENERATOR
Produces 1-4 tones simultaneously; 8-octave, 96-pitch range; parallel interface; requires +8, +16V unregulated (option P2) or +5, +12V regulated (option P3). In kit form with 1-4 channels; wired with 4-channels only; requires Option P1 clock if no 2-MHz available from computer.
10-5-10 (A1, K). Single-channel, kit $111
Additional channels, each $16
P1. On-board 2-MHz clock option $16
10-5-10 (A4). Wired, 4-channel $185

S-100 QCPG (S1)
Similar to above, but for S-100 bus. Prices same; change model numbers from 10-5-10 to 10-5-9.

ALPHA MICRO SYSTEMS

AM-100 16-BIT CPU (S1)
16-bit MPU board for S-100 bus. Includes software. See "Computers" section for details $1495

AM-200 FLOPPY-DISK CONTROLLER (S1)
DMA floppy-disk controller for AM-100 16-bit and 8080 8-bit MPU's. Includes disk formatting; full and partial sector reading from drive; multiple drive control; multi-level interrupt capabilities. Supports PerSci 277 disk drive and Wango 80 disk drive subsystem $695
CP/M operating system for 8080, with manuals ..$85
CP/M PROM $30
2708 PROM for IBM, AMS or CP/M formats $30

AM-400 HARD-DISK SUBSYSTEM (S1)
Interfaces S-100 bus to Calcomp Trident series of hard-surfaced (3330 type) disk drives; drives available in 25, 50, 80, 200 and 300 Mbyte configurations; 4 drives can be intermixed on-line-average access time, 28 ms. Can be used with AM-100 or 8080 MPU's; CP/M to be available for 8080.
AM-400 controller $2000

AM-500 HARD-DISK SUBSYSTEM (S1)
Interface formatter/controller from S100 bus to 10-MB hard-disk drive; can support up to 40 MB. Compatible with AM-100 or 8080; CP/M available for 8080 ..... $7995

ANDROMEDA SYSTEMS

FDC-11 FLOPPY-DISK CONTROLLER (LS)
Controls up to four drives, e.g. Pertec FD511 or Shugart SA-800; personality cards available for other drives such as Pertec FD400 or FD500 ..... $850
PC400. Personality Card $80

MDC11 MINIDISK CONTROLLER (LS)
Similar to FDC-11, but for up to three Shugart SA-400 minidisk drives; with sockets for up to 4K EPROM $510

PRTC11 PROGRAMMABLE REAL-TIME CLOCK (LS)
Programmable timer/counter for LSI-11; timing rates from 1 MHz to .0002778 Hz (1 hour) $600
CB11-B. Rack-mounting connector box to interface exernal devices to PRTC11 ..... $150

DAC11 DIGITAL TO ANALOG CONVERTER (LS)
Up to 4 D/A channels; 12-bit resolution $700
CB-11C. Rack-mount connector box $150

ADC11 ANALOG TO DIGITAL CONVERTER (LS)
16 single-ended or eight differential input channels; 12-bit resolution $850
CB11-A. Rack-mount connector box $150

LPI11 LINE PRINTER INTERFACE (LS)
Q-bus interface for a variety of popular printers; with 15-foot cable.
LPI11. For DEC LA180 printer $295
LPI11-A. For Centronics $340
LPI11-B. For Diablo 1300 (HyType II) $450

MSI11 MULTIPLE SERIAL INTERFACE (LS)
Up to four serial interfaces per card; parallel printer interface may substitute for one serial channel; 50-19.2K baud, remotely selectable; RS-232/20 mA.
MSI11-1P. One serial interface $440
MSI11-3P. Three serial interface $640

GENERAL-PURPOSE PROTOTYPING BOARD (S1)
Provides space for up to thirty-one 16-pin and three 24-pin or two 40-pin DIP devices; holes drilled for wire-wrap sockets.
GP-88. Kit/wired ..... $39/$47

8080 MPU Board (S1)
8080A microprocessor board with support chips.
MPU-A. Kit/wired ..... $190/$350

DISK INTERFACE (S1)
Non-DMA; can drive up to four standard floppy disks or 3 minifloppies simultaneously; single or double density; program-controllable. Requires 2 slots.
DIO Kit/wired ..... $599/$799

FLOPPY DISK INTERFACE (S1)
DMA-type. For use with Calcomp 142M drives; must order DOS-A; requires two slots.
FIF. Kit/wired ..... $599/$799

LINE PRINTER INTERFACE (S1)
Two-board set with DMA; permits high-speed line printers to be interrupt-driven, allowing spooling.
LIF Kit/wired ..... $599/$799

MULTIPROCESSING/SHARED MEMORY FACILITY (S1)
Allows up to 6 mathframes to access some memory. Consists of following boards (all configurations must be reviewed by factory)
SMS. Port Access Board. Kit/wired ..... $325/$399
SMC. Port Timing Board ..... $225/$305
SMB. Buffer Board (order one per processor) ..... $113/$175
SMT. Terminator Board ..... $98/$148

ASSOCIATE COMPUTER CONSULTANTS

UNIBUS ADAPTOR (UB/LS)
Allows connection of multiple Unibus devices to LSI-11 or PDP-11/03 system. Can support 20 Unibus loads; data transfer rates to 650,000 words/sec. Mounts anywhere in LSI-11 system backplane.

recessed Unibus connector equivalent to CPU end of PDP-11 Unibus $650

UMC-Z80 (UB)
Z-80 microprocessor board for PDP-11 Unibus. Can load programs from PDP-11 or from PROM on the UMC board. External Z-80 bus connector for memory expansion and custom interfacing, plus on-board space for serial I/O modules. 1K diagnostic and program-load PROM, can be disabled by PDP-11. Suggested applications include communications protocol processing, data acquisition, translation, formatting and processing, peripheral interfacing, etc. Memory expansion board available to 64K bytes $2495

AUM-IDEAS

HOBBYIST'S DUAL BUS BOARD (S1) (S5)
Prototyping board with full S-100 bus compatibility, electrical compatibility with SS-50 bus; board can be stacked in vertical or horizontal plane, eliminating dependency on particular motherboards; provision for up to 100 DIP ICs (14-pin; accepts 20 40-pin ICs, or other combinations of 28-, 24-, 16-pin ICs); also provides for four voltage regulators with independent power and ground lines, space for up to 38 additional discrete components, two card ejectors, filter capacitors, etc. Ground and power planes on both sides of board. Kit, with heat sinks, layout sheets, and wire-guide wires $30

AUTOMATED INDUSTRIAL MEASUREMENTS

AIM-1005 8-BIT FREQUENCY METER (S1)
Frequency-meter board for 8-bit computers; S-100 adapter available. Measures 13 bits plus overrange, accurate ± count, 0°–70°C. On-board 5-MHz clock. Measures frequencies from DC to 25 MHz; comparator input with up to ±15 V common mode, input down to 100 mV usable to 2 MHz. Uses memory-mapped I/O, in any of 14 locations. Allows external reset for real-time measurements. On 4" × 4½" board. 250 mA @ 8V.
AIM-1005 ..... $1789
(S1) S-100 Mounting Board for AIM-1005 ..... $30

AIM-1006 16-CHANNEL DIGITAL MULTIPLEXER (S1)
For use with AIM-1005. Allows 16 different frequencies to be measured; has memory to store data output from AIM-1005; jumper-programmable for use with fewer channels; may be interfaced with microcomputers directly as standard or memory-mapped I/O.
AIM-1006 ..... $143
(S1) S-100 Mounting card with extra socket for AIM-1006 ..... $35

BASE$_2$

DIGITAL GROUP/S-100 ADAPTER (S1/DG)
Allows use of up to four S-100 boards within Digital Group mainframe, in addition to existing D.G. boards. Includes "intelligent" motherboard, ribbon cables, and power wiring harness. Fits 5-3/4" × 12" empty space in standard D.G. cabinet. Kit only $295

Z-80 CPU BOARD (S1)
Z-80 MPU; 2708 EPROM socket addressable to any 4K boundary above 32K; power-on jump; can run without front panel in 8080 or Z-80 mode; wait state may be added to M1 cycle.
CPZ-1. 2-MHz Z-80 CPU card. Kit/wired ..$110/$135
CPZ-2. 4-MHz Z-80A CPU card. Kit/wired ..... $125/$150

BYTE

BYTE MPU (S1)
8080A MPU with vector interrupt optional by insertion of 8214 chip (real-time clock already in Byt-8 chassis—see Accessories section for details); requires +8V, ±18 V. $120

BYTE CONTROL PANEL (S1)
Displays 48 bits of information: address, data, status, I/O, machine state; control of run, stop, reset, clear, deposit, next, examine, examine next, protect, unprotect, single-step, hardware breakpoint; stop-on-compare of any address switch-selected, requires +8 V. Plugs into S-100 bus $190
Byt-FP. Metal front panel to mate with above $15

BYTE-EXT (S1)
Extender board for S-100 bus $25

CANADA

CL2400 REAL-TIME CLOCK (S1)
Keeps time in 24-hour format (hr/min/sec); direct output to processor; time automatically updated without using processor time; generates periodic interrupts at programmable rates. Can be used as clock, event/software timer, computer use log, real-time control system. Usable with assembly language or BASIC. Requires 300 mA @ +8 V, 50 mA @ +16 V. Kit wired ..... $98/$135

POWER CONTROL SYSTEM (S1)
Interface board for power control of external devices, double isolated for safety. Low-voltage on-board switching controls external power switching unit. Controllable by BASIC or assembly statements. Consists of:
PC3216. Control logic interface board, 16 independently addressable control channels accessed through a single, user-selectable peripheral address. Requires +8 V @ 270 mA, + 16 V @ 170-250 mA. Kit/wired ..... $189/$240
PC3202. Power control unit. Single-outlet remote power control unit, switches 120-V-a.c. loads up to 400 W; compatible with PC3216 control board. Kit/wired ..... $40/$52

PULSE OUTPUT INTERFACE (S1)
For stepper motor control or any system requiring pulse/step outputs. Generates from 1 to 8 simultaneous pulses with single output instruction; on-board timing logic for driving Calcomp, Houston and similar digital plotters; includes 1K RAM, sockets for up to 4K PROM. Requires +8V @ 600 mA, +16V @ 600 mA; −16V @ 50 mA.
PG8000. Kit/wired ..... $189/$235

CGRS MICROTECH

FRONT PANEL (S1) (EX)
Address, data, reset, memory protect, single-step and run switches; status LED's and 7-segment hex displays. For CGRS System 6000, (S-100), but also plug-compatible with Motorola EXORcisor boards. Bare board/kit/wired ..... $40/$140/$200
6502 MPU Boards. See Computer section.

PETREX S-100 ADAPTOR (S1/PT)
Adapts S-100 bus to PET computer with cable provided; can be adapted to KIM, Motorola EVII and other 6502 or 6800 computers with appropriate connector cables. Board fits S-100 card slot, generates all required S-100 control signals, such as psync, I/O address, wait states. Cable fits PET memory-expansion connector. Wired $196

COMMODORE/MOS

KIM-3B MEMORY EXTENSION (KM)
8K static memory for KIM-1; 450-ns; write-protect and memory disable switch-selectable. Requires 5 V @ 1800 mA. Plugs directly into KIM-1; motherboard (see Accessories) required for multiple extensions.
KIM-6 ..... $289

KIM-5 ROM BOARD (KM)
KIM-compatible ROM board with 8 sockets; includes 3 MCS6540 ROMs with resident assembler/editor, addressed E000-F7FF.
KIM-5 ..... $198

PROTOTYPING BOARD (KM)
Wire-wrap board for user-defined extension of a KIM system.
KIM-6 ..... $39

COMPUTALKER

CT-1 SPEECH SYNTHESIZER (S1)
Voice generator board; produces speech output from acoustic-phonetic parameters transmitted at 900 bytes/second. Two operating modes: precoded vocabulary for higher speech quality, optional CSR1 phoneme-conversion software for simpler operation. Data tapes and CTEDIT parameter editor included with CT-1. Requires +8V @ 250 mA, ±16V @ 100 mA $395
CSR1. Synthesis-by-rule software (8080) $35

COMPUTER KITS

PS-1 POWER-START
Auto-load board; restarts computer at address of ROM monitor or bootstrap loader upon power-up or re-set. Can be switched out when desired; has on-board switches substituting for front-panel sense switches for terminal options, etc. Available with on-board ROM, or without for use in systems with ROM. Can be located anywhere in memory address space. With ROM. Kit/wired ..... $165/$265
PS-1. Without ROM. Kit/wired. ..... $135/$235

COMPUTER MART SYSTEMS

PME-1 RAM EXPANSION (PT)
Dynamic RAM, 16K-32K (expandable at factory); 400-ns; no wait states; mounts inside PET computer; derives power from PET transformer, but does not use PET power supply.
16K $550
24K $650
32K $750

COMPUTERWARE, INC

REAL-TIME CLOCK (S1)
Real-time clock board for S-100. Wired $186

Z-80 CPU (S1)
Z-80 CPU with provisions for on-board 2708 (unprogrammed), and power-on jump. Wired. 2-MHz/4-MHz ..... $171/$186

CONTROLEX

CM324 CORE MEMORY (LS)
Non-volatile core memory; 56K (32K and 48K versions available); for LSI-11 "Q" bus; 1.1 μs cycle. Requires +12V @ 2.7A, +5V @ 2A. Wired $2100

CM203 ND CORE MEMORY
Non-volatile NDRO (Non-destruct read-out) core memory, 4K. Exceptional noise immunity, no power-sequencing required; recommended for severe-evironment industrial controls, etc. Has 350-ns access time, 1 μ cycle time; 3-bit bank select. For custom interfacing to 8-bit processors. Requires +12 V @ 1 A, −12 V @ 250 mA, +5 V @ 2 A $950

CONVENIENCE LIVING

EXPANDAPET (PT/KM/AP/S1)
General-purpose expansion system for 6502 computer systems including KIM, VIM, APPLE and PET. Includes motherboard with dynamic memory and invisible refresh, power supplies and daughter-board buffered sockets. Can mount inside PET.
Standard system. 16K RAM, mounting slots for 4 daughter boards, cables and brackets; daughter-board with 4K EPROM sockets, 2 parallel I/O ports with handshake $435
Less daughter board $395

DAUGHTERBOARDS
EPHROM/Parallel-port board, as above $50
S-100 I/O driver board. (Maps PET memory locations into 8080/Z-80 I/O instructions) $50
Serial I/O board. Software controllable $50
Experimenter's blank board $20

OTHER OPTIONS:
8K Additional RAM $110
16K Additional RAM $200
KIM-1 or KIM-4 adapter $25

CROMEMCO

CGI TV DAZZLER (S1)
Graphics interface; 128 × 128, 64 × 64, or 32 × 32 element resolution, software selectable; output in color (eight colors available) or black and white (16 gray-scale intensities). Alphanumeric output also available. Requires RF converter or direct video input. Uses two bus slots, draws 1.4 A @ +8 V, 50 mA @ −18 V. Kit/wired ..... $215/$350
Programs. Punched tape with documentation (14 available), each $15
Dazzler Programs. Dazzler games on 5" or 8" diskette $95
Dazzler Graphics on 5" or 8" diskette $95

D +7A ANALOG INTERFACE (S1)
I/O board with seven channels of eight-bit analog-to-digital conversion for input, seven channels D/A for output, plus one eight-bit parallel digital I/O port. For process control, digital filtering, games, oscilloscope graphics, speech and music uses. Analog signal range, −2.56 to +2.54 V. Takes 0.4 A @ +8 V, 30 mA @ +18 V, 60 mA @ +18 V. Kit/wired ..... $145/$245

4-MHz Z-80 CPU CARD (S1)
Extra-high-speed Z-80 microprocessor card, using Z-80 Specially selected for 4-MHz clock-rate operation. Clock switchable, 2 or 4 MHz. Automatically jumps to any desired 4K memory boundary when turned on; no front panel required. Monitor program supplied in paper tape, available in ROM for $50 more. Kit/wired .....$295/$395

SCC. SINGLE-CARD COMPUTER (S1).
Z-80 with ROM, RAM and I/O. See Computers section. Kit/wired .....$395/$495

DISK CONTROLLER (S1)
Interfaces 3 mini-floppy (5") or 4 floppy (8") drives to S-100 bus. Built-in 1K bootstrap monitor; serial port (RS-232/20 mA); 5 interval timers. Requires + 8 V @ 1A, ±18 @ 100 mA ea.
4 FDC. Kit/wired .....$395/$595
PerSci 8" dual drive, kit/wired .....$1995/$2495

CURTIS ELECTRO DEVICES

HAM S-100 (S1)
Morse/Baudot decoder board with SOL firmware (patchable to other 8080 systems). Requires TI-100 Station Interface. See Accessories section for details $700

CYBERNETIC MICRO SYSTEMS

FLOPPY-DISK CONTROLLER (MB)
Controller for up to 8 single-sided, single-density disk drives. Will interface to any computer or stand-alone terminal over an RS-232-C or 20 mA current loop serial channel (8-bit parallel I/O optional); fits industry-standard SBC-80 Multibus. On-board DOS requires no bootstrapping or disk space; allows system to support dumb terminal or TTY without a host computer. Features file-based structure with automatic "housekeeping," self-contained directory, ASCII high-level commands, IBM 3740 format with modified gap structure.
1FC-8400 .....$795

ANALOG-TO-DIGITAL CONVERTER SYSTEM (MB)
Multibus-compatible analog-to-digital converter board. Has 12-bit resolution, 32 single-ended or 16 differential analog input channels; memory or I/O mapped; jumper selectable program-control, status-control, interrupt-control, external-control; multiple boards may be triggered in parallel for simultaneous samples of multiple signals.
AD3212 .....$495

FLOATING-POINT UNIT (MB)
Extends 8080 instruction set to include: binary-to-floating point decimal conversion; trig functions, including inverse and hyperbolic; logs and powers; 12-digit +, −, ÷, ×; rectangular/polar transformations; mean and standard deviation.
FPU #1. Complete with two 2708 PROMs containing FPU driver and symbolic interpreter allowing MDS or SBC computers to be used in on-line calculator mode; function macros supplied on paper tape for assembly-language program generation. $595
FPU #2. Contains FPU driver PROM only, plus socket for symbolic interpreter upgrade $470
FPU #3. No PROMs included—paper tape macros and FPU driver allow unit to be driven from RAM. For **MDS-based systems** $345

DATABYTE

DATALYZER (S1)
24-channel logic-analyzer board for S-100 bus. 256 samples per channel; displays disassembled program flow on user's system output device, in binary or hex; requires no oscilloscope; digital probes have status lights; 8-MHz sample rate; 0-16 bit trigger-word format and/or external qualifier. Includes 2 S-100 boards, 3 probe pods with 10 clips each, manual with source listing, and software on Intel-format paper tape (starts at 8000H). Kit/wired .....$595/$695
Software on disc $30
Software on cassette $7.50
EPROM firmware $125
Program relocation $35
Short jumpers (3) $10

DIGITAL MICRO SYSTEMS

S-100 TERMINATOR BOARD (S1)
Terminates bus lines with 190-ohm impedance, to match bus output-driver impedances, and reduce ringing, reflection, overshoot and noise.
DMTB $25

S-100 EXTENDER BOARD KIT (S1)
Raises boards 5" for access by test instruments; jumpers in power supply lines for current measurements; provisions for pilot LED; can remain in machine with cover on.
DMXB $16

DIGITAL PATHWAYS

TCU-50 TIMING CONTROL UNIT (LS)
Time/date board for LSI-11; battery supported during power-down for up to 3 months; on-board, independent crystal oscillator. Can be interrogated by computer to give month, day, hour, minute and second.
TCU-50Q. On quad-size board, with room for customer options such as millisecond or year counters $325
TCU-50D. On smaller, dual-size board $295

RMA-032 RAM (LS)
32K-64K RAM for DEC "Q" bus; 450-ns dynamic; addressable in independent 4K blocks; with BSC-256 bank switch controller module, can extend to 2048K bytes; standby power option. Requires +5V, +12V.
32K $700
Factory upgrade to 64K $600
64K $1200

EDUCATIONAL DATA SYSTEMS OF VA.

S-100 WIRE-WRAP KITS (S1)
Component kits with software listings, designed to be used with any S-100 wire-wrap board. All kits listed below will fit together on one Vector 880V board.
Bus Buffering Input-Output Kit. Buffers S-100 bus to reduce noise, has board address selection logic, 8 individually-addressable 1-bit input and 8 1-bit output ports; required by all kits below except MIN and ADD.
BUF. Without/with sockets and wrap pins ...$25/$32

MINIMUM INPUT BUFFERING KIT
Subset of BUF kit; provides 8, 1-bit TTL input ports plus board select logic and partial bus buffering; sufficient to interface a light pen (see Peripherals), or kits MUS and TI, using INTE line for output.
MIN. Without/with sockets .....$16/$19
ADD. Upgrades MIN kit to BUF .....$12/$15

ONE-BIT MUSIC KIT
Provides 0.1-W audio output into 8-ohm speaker or amplifier from single-bit output of BUF or interrupt-enable line of MIN; includes software for playing musical tunes using software timing loops.
MUS. With/without sockets and pins .....$9/$10

REAL TIME CLOCK
Counts down the processor clock to obtain clock rates as low as 50 Hz; can directly drive RST7 interrupt, or connect to INT vectored interrupt kit; provides 400-kHz clock required by FPP floating-point processor kit; software provided for maintaining time-of-day clock from the interrupt; will accept 2-MHz or 4-MHz system clocks.
RTC .....$10/$12

FLOATING-POINT PROCESSOR
Hardware +, −, ÷, × and trig functions; with 4-level rollable stack; calculations can go on concurrently with 8080 processing; 8 significant digits plus 2-digit exponent; with regulator, interface logic and driver software including BASIC interpreter.
FPP. With/without sockets .....$60/$66

FOUR-PORT INPUT MULTIPLEXER
Provides 32 bits of TTL input, available to program as 4 8-bit input ports.
MUX. With/without sockets .....$20/$23

DUAL LATCHED OUTPUT PORTS
Provides two, 8-bit latched TTL output ports.
DOP .....$15/$17

VECTORED INTERRUPT KIT
Accepts up to 8 interrupt requests and arbitrates on

priority basis; interrupts generated to restart points in low memory.
INT ..... $15/$17

BD VECTOR WIRE-WRAP BOARD (S1)
Kit consisting of Vector 8800V board, with +5V regulator, decoupling capacitors, and set of T46-4 wire-wrap pins for power, ground and bus connections. Kit $30

ELECTRICOM

NON-VOLATILE HIGH-SPEED RAM (S1)
For S-100 or user-defined interface. Usable as 2K × 8 or 1K × 16; on-board batteries and charger, with user-adjusted power-state monitors for automatic protect; 3-month minimum data retention time; remote and on-board write-protect; 250-ns max access time. Connections terminate in wire-wrap lines, user-connectable to S-100 edge contacts on board, also accepts ribbon-cable connectors onto wire-wrap pins. Wired $287
2K × 9-bit option $10

ELECTRONIC CONTROL TECHNOLOGY

8080 CPU (S1)
8080 CPU card with jump on reset. Kit/wired ..... $120/$175

PB-1 PROTOTYPING BOARD (S1)
With heat sink and 5V regulator
Kit $28

XT-100 EXTENDER CARD (S1)
Kit/wired ..... $24/$34

ELECTRONIC SOLUTIONS

SBC 80/10 EXTENDER CARD (MB)
Includes both main and auxiliary connectors $54

ELECTRONIC SYSTEMS

TIDMA (S1)
Tape Interface Direct Memory Access. Has FSK encoder.decoder for direct connections to low-cost audio tape recorders at 1200 baud, plus direct connections for inputs and outputs to digital recorder at any baud rate.
Part No. 112. Bare board/with parts ..... $35/$110

APPLE II SERIAL I/O INTERFACE (AP)
Serial I/O port works up to 30,000 baud. Plugs into Apple II peripheral connector. RS-232 serial I/O. Software includes I/O routines from Apple monitor or BASIC, programs for using Apple II as video or intelligent terminal; can output in correspondence code for some Selectrics.
Part No. 2. Bare Board/with parts/wired ..... $25/$42/$62

ENVIRONMENTAL INTERFACES

FAST SCAN VIDEO DIGITIZER (S1)
Digitizes black-and-white video camera output for DMA entry into S-100 computer. Horizontal resolution switch-selectable at 64/128/256/512 pixels/line; vertical resolution switch-selectable full-frame (256 li) or every 2nd, 3d or 4th line of frame, to reduce memory requirements; encodes in 16 gray levels (4 bits/pixel); on-board contrast control. Wired $595
With monitor interface, allows simultaneous CRT display during input. Wired $850

ESCON PRODUCTS

E-O SELECTRIC INTERFACE CARD (S1)
S-100 interface card for ESCON Selectric terminal conversion kit. (See Peripherals section.) Kit/wired ..... $135/$220
Terminal conversion kit $456

F&D ASSOCIATES

CPU-1 CENTRAL PROCESSOR (S5)
6502 MPU board for SWTPC 6800 or SS-50 bus. Includes TIM monitor ROM, 1-MHz crystal, 1 serial interface (RS-232 or TTY), 8-bit bi-directional parallel port with two handshake lines (TIM can use this port for high-speed input); provision for 2704/2708 or 2716 PROM; jump on restart, if desired. Bare board with documentation $29

CPU-2 CENTRAL PROCESSOR (S5)
6802 MPU board for SS-50 bus. Similar to above, but with dual crystals, two 8-bit I/O parallel ports, 128-byte RAM at F400-F47F for stack and registers, plus 128-byte RAM at 0000-007F; provision for 2708 or 2716 PROM. Optional FADBUG monitor supports serial port, ASCII keyboard, and video display, plus cassette routines in MIKBUG format. Bare board with documentation $35
FAD-1E. EPHROM with FADBUG monitor $18

KBT-1 KEY/TIM MONITOR
For combining CPU-1 with ASCII keyboard, motherboard (see below) and VDB-1 video board (see Video Board chart) into a system; can also operate as standard TIM system with terminal.
KBT-1. Documentation and program listing $5
KBT-1E. KBT-programmed EPROM $15

FDT-1 FANCY DATA TERMINAL
Similar to above, to form serial video terminal. EPROM resides on CPU-1. Power may be taken from SWTPC 6800 or power supply providing ±13V and +8V. Displays 32 char × 16 lines, with auto scrolling.
FDT-1. Documentation and EPROM listing $5
FDT-1E. FDT-programmed EPROM $15

MOTHERBOARDS (S5)
MB-1-6. Six-slot SS-50 mother board $19
MB-1-3. Three-slot $12

NCU-1 NUMBER-CRUNCHING UNIT
Scientific and floating-point calculator interface using National MM57109 number-crunching IC. Handles all common math and trig functions in hardware. Plugs into one I/O slot of SWTPC 6800 for power, connects to MP-L or MP-LA board for communication; adaptable to general-purpose ports of other micros. Includes 6800 control subroutines, and exerciser program allowing use of terminal as calculator. Bare board/wired ..... $19/$49

FORETHOUGHT PRODUCTS

KIMSI INTERFACE/MOTHERBOARD (S1/KM)
S-100-bus motherboard for KIM-1 computer; allows use of S-100 peripheral boards with KIM-1 6502 system; can also be connected to other 6502 and 6800 systems. Power supply regulators on board, power supply extra. With one 100-pin connector. Kit/wired ..... $125/$165
KIMSI-PLUS. Power supply. 12A Kit/wired. $69/$89
Additional 100-pin connector. Kit/installed ..... $5/$8

BETSI INTERFACE/MOTHERBOARD (S1/PT)
S-100 bus interface for PET computer; allows use of S-100 peripherals and module boards, including high-density dynamic RAM. Includes on-board PROM sockets for firmware expansion. Plug-in connection. Requires +8V @ 100 mA. Kit, with one 100-pin connector $105
Wired, with four connectors $160

JAB JOLT ADAPTOR BOARD (S1)
Plug-in adaptor to connect JOLT computer to KIMSI S/100 Interface/Motherboard. Supplies to JOLT from KIMSI. Kit $19

GRE

8085 HARDSHARE SYSTEM (S1)
Software-dependent program timesharing system allowing two programs to run concurrently at the same or different addresses; hardware executive dynamically allocates CPU time to each program according to its relative activity; system throughout of on-board, 4-MHz 8085 equals that of two conventional 8080's. Board addresses 128K bytes directly, but has no minimum RAM requirement; memory blocks isolated by hardware, minimizing program-to-program interaction; includes mini-monitor in phantom ROM (becomes invisible after initialization), any RAM, ROM or I/O may be shared, to reduce system duplication. Requires additional address line or paging system on RAM boards $295

GARRY MANUFACTURING

WIRE-WRAP BOARDS (S1) (UB) (LS) (MB) (EX)
Plug-compatible boards for custom circuits. Part numbers shown are for 3-level, .703-in. profile wire-wrap pin. Also available for 2-level .565-in. or 1-level .425-in., at same price; change "–3" in model number to "–2" or "–1". Available for following computer bus systems:
S-100. EP100-56/9-031-3BSNC. $189
Unibus Quad. C1P4/11-32-15-3BSNC $254
Unibus Dual. CIP2/11-16-15-3BSNC $125
LSI-11 Unibus. CIP4/11/32-15-3BSNC $254
Unibus Hex. CIP6/11-48-15-3BSNC $375
SBC Multibus. (Various models) ..... $210-$254
M6800 Exorcisor. EP86-30-15-3BSNC $187
Cosmac CDP1800. EP44-12-15-3BSNC $78
SC/MP. ECM72-24-24-3BSNC $46
TI 990. TILINE MTI-152-44-3BSNC $146

GIMIX

GIMIX CPU BOARD (S5)
6800-MPU board with DIP-switch addressing (including E000/FC00 dual access for MIKBUG), DMA capability, baud-rate generator, 4K PROM sockets,
128-byte RAM $225
With 3 software-programmable timers $288

GIMIX MOTHERBOARD (S5)
Fifteen 50-pin slots, plus eight switch-addressable 30-pin I/O slots configurable to 4 or 8 decoded addresses. Barrier-block power connections $225
SWTP-Type Motherboard. Thirteen 50-pin slots only $89
Extender board. 50-pin $25

OPTO-ISOLATED INPUT BOARD (S5)
For remote-control device monitoring via any 8-bit parallel input port with handshake lines. Can mount to and draw power from SS-50 bus, if available. See Peripherals section for details $349

2-WIRE REMOTE KEYBOARD SYSTEM (S5)
Allows remote control over up to 1 mile of twisted-pair wire. Port, power and mounting as for input board above. See Peripherals section $249

GODBOUT

ECONORAM VI (H8)
12K static RAM for Heathkit H8 computer; 450-ns; addressable and write-protectable in independent 4K and 8K blocks; board deselect switch. Requires 2.25A power. Kit $235

TRS-80 CONVERSION KIT (RS)
Set of chips and DIP shunts to upgrade TRS-80 from 4K to 16K. With instructions $190

D.C. HAYES

DATA COMMUNICATIONS ADAPTER (S1)
S-100 serial modem board for telephone data communications. Auto-dial and auto-answer; originate or answer modes; 110-300 bit/sec data rates; compatible with teletypes and time-share modems; full Telco compatability when attached to DAA; all-digital modulation and demodulation, no adjustments.
80-103A. Wired $280

HEATH

H8-1 MEMORY BOARD (H8)
8K static RAM board, with 4K RAM, for H8.
Kit $125
H8-3 Chip Set. 4K RAM chips, expands H8-1 to 8K. $85

H8-2 PARALLEL INTERFACE (H8)
Connects H8 to parallel I/O devices (required for H10 punch/reader). 3 8-bit, bidirectional I/O ports, with handshake. Kit $150

H8-5. SERIAL AND CASSETTE INTERFACE (H8)
Connects H8 to serial devices. One serial port (RS-232 or 20 mA), 110-9600 baud; interface for audio cassette, using Byte/Manchester format at 1200 baud, with control lines off remote start/stop of 2 cassette units. Kit $110
ECP-3801. Recommended cassette recorder. Wired $60

H11-1 4K MEMORY EXPANSION MODULE (LS)
Plugs into H11 backplane, adds 4Kx16-bit capacity. Static. Kit/wired ..... $225/$275

H11-2 PARALLEL INTERFACE (LS)
16 latched input and 16 latched output lines, for 16-bit word or 8-bit byte data transfer; LSI-11 bus interface with control logic for interrupt processing and vectored addressing; 4 control lines for data status logic. (Required for H10 punch/reader.)
Kit/wired ..... $95/$150

H11-5 SERIAL INTERFACE (LS)
With optically-isolated 20-mA and RS-232 interfaces; 50-9600 baud. Kit/wired ..... $95/$150

HUH ELECTRONICS

MEMORY & PERIPHERALS ADAPTER (S1/PT/AP)
Interfaces PET 2001 or Apple II to S-100 bus for memory and I/O expansion. S-100 board, with cable for PET memory-expansion connector; allows full DMA (S-100 bus protocol); can be used with Cromemco Dazzler. Apple II cable extra.
S-100 MPA. Kit/wired ..... $200/$280
Apple II Cable $35

6502 PROCESSOR BOARD (S1)
Consists of MPA board plus 6502 Stand-alone option. Emulates complete S-100 bus signals. Kit/wired ..... $250/$330
Stand-alone option for MPA board $50

VIDEO BUFFER (PT)
Allows video monitors or TV sets to be used with Commodore PET for larger screen displays or remote viewing. Plugs into PET user port, and provides standard 75-ohm composite-video output (PET has separated sync and video). For use with unmodified TV sets, space is provided for M&R SUP'R'MOD II RF modulator. Wired $30
With SUP'R'MOD II option and 60-dB antenna isolation switch. Wired $60

(Note: Use of modulator may not meet FCC requirements.)

PETUNIA (PT)
8-bit digital-to-analog board for PET. Can be used as music generator (up to 4 notes at once), or for graphics, control and other applications. Plugs into PET user port. Requires external amplifier and speaker; phono jack connection. Wired $30

COMBO (PT)
Combines Video Buffer and Petunia on one board, wired and tested $50
With SUP'R'MOD II modulator $80

BEEPER (PT)
Automatically beeps at file headers and program endings when reading or writing PET tapes; audible warning when computer is ready after save or load; can also beep under program control. Plugs into PET; has volume control. Wired $25

IMSAI

PRIORITY INTERRUPT BOARD (S1)
Includes programmable interval clock; provides up to eight levels of vectored priority interrupt.
PIC-8. Kit/wired ..... $125/$238

EXTENDER BOARD (S1)
Extends motherboard above card cage for service access.
EXT. Kit/wired ..... $39/$49

INDUSTRIAL MICRO SYSTEMS

DISK CONTROLLER BOARD (S1)
Single-board disk controller; syntax-compatible with Altair BASIC and CP/M.
C00300 ..... $265

INNOVATIVE TECHNOLOGY

AD-68A ANALOG-TO-DIGITAL CONVERTER (S3)
Analog-to-digital converter for SWTPC 6800 and similar computers; occupies one I/O slot. 8 analog input channels; input range 0-2.5V dc; requires +8V @ 82 mA max, +13V @ 3 mA max, −13 V @ 26 mA max. Wired $40

INTERNATIONAL TECH. SYSTEMS

PEM-8K RAM EXPANSION (PT)
Self-contained 8K RAM for PET. Static RAM; 475-ns; addressable in independent 4K blocks; with 115V/60 Hz power supply (220/50 Hz available) $297

ITHACA AUDIO

Z-80 CPU (S1)
Z-80 MPU with on-board 2708 EPROM, power-on jump to any 4K boundary above 32K; MWRITE for operation without front-panel; selectable wait states on M1, memory request, on-board ROM, input and output cycles; selectable 8080 or Z-80 I/O addressing modes; clock-generator provides 8080-like signals for S-100 bus. Requires +8 V @ 1.0 A; with optional 2708, requires +16 V @ 100 mA and −16 V @ 50 mA also.
CPZ80. Bare board $35
With 2-MHz/4-MHz Z-80 ..... $175/$205
Wire-Wrap Protoboard (S-100) $25

JADE

8080A CPU KIT (S1)
8080A-MPU. On-board interrupt circuitry need not be built up until system has real-time clock board; up to 8 levels of priority vector interrupt available. Bare board/kit/wired ..... $30/$100/$150

Z80 KIT (S1)
Z-80 MPU with on-board 2708 EPROM, power-on-jump. Selectable I/O address mode: 8080 mode, with peripheral address duplicated on high and low address bytes; Z-80 mode with peripheral byte on low byte, accumulator contents on high byte, for simultaneous I/O. MWRITE generation allows operation without front panel; 8080 look-alike clock and status signals; wait states can be added to M1, memory request, on-board ROM, input or output cycles. on-board 2708 EPROM (included) addressable to any 4K boundary above 32K; power-on jump to any 4K boundary above 32K.
Bare board $35
2-MHz version. Kit/wired ..... $135/$185
4-MHz version. Kit/wired ..... $150/$200
Z-80 monitor. 2708 ..... $17
2-4MHz upgrade $50
Upgrade kit, with trade of your 2-MHz Z-80 chip and 8224 clock driver $18

8K 6800 ADAPTER
Adapts Jade 8K RAM board (see RAM tables) to Motorola D-2 6800 evaluation kit. Kit $13

REAL TIME CLOCK (S1)
Real-time clock; with 1-MHz crystal oscillator, 16-bit counter in 10-μsec steps, decade counter 100-μsec to 10 sec, both software programmable.
Bare board/kit/wired ..... $30/$125/$180

JHM MARKETING

VOTRAX VOICE SYNTHESIZER (S1)
Produces continuous speech analog output from phoneme instructions. On S-100 board $695

MARINCHIP SYSTEMS

M9900 16-BIT MPU BOARD (S1)
TMS9900 16-bit MPU on S-100 board. Processor features hardware multiply-divide, 16 general registers, ability to extend hardware instruction set. Board features: automatic translation of 16-bit memory accesses into pairs of S-100 8-bit memory cycles; translates 9900 memory-mapped I/O into S-100 compatible I/O; 8-level vectored interrupts; S-100-compatible DMA; allows use of both 8-bit and 16-bit memory. Not compatible with front-panel EXAMINE and DEPOSIT switches. Includes Disc Executive, BASIC, text editor, assembler, linker, debugger. PASCAL optional.
Kit/wired ..... $550/$700
PASCAL compilers $150

MATROX

VIDEO RAMS
Video controller modules addressed as RAM memory, each on-screen character equivalent to a one-byte memory location. Controllers available as plastic-packaged modules, or as complete module boards.

ALT-2480 ALPHANUMERIC DISPLAY INTERFACE (S1)
4K video RAM providing 24 lines × 80 characters, strappable for two pages of 40 char/line (recommended mode for use with ordinary TV, or other monitors with less than 10 kHz bandwidth); compatible with ALT-256 for combined alpha/graphic display; built-in refresh; available as 128-char upper/lowercase ASCII 7× 9 matrix, or uppercase only in 5×7 matrix; inverse and blinking under software control; available in American or European standards interlaced or noninterlaced; interlaced display requires long-persistence phosphor CRT; can drive up to 10 monitors, up to 500-ft. cable run. Wired $295

ALT-256 GRAPHICS DISPLAY (S1)
256×256 graphic card, addressed as 4 output ports and one input port (port addresses strappable; ports control dot coordinates, intensity, color and screen-clear; multiple ALT-256 cards may be combined for grey scale or color capability; may be used with ALT-2480 for combined alpha/graphic display. Other specifications similar to ALT-2480. Wired $395
MTX-816. Video RAM for eight lines, 16 characters, uppercase ASCII (128 bytes) $179
MTX-1632. 512-byte VRAM, 16 lines × 32 characters. upper-/lowercase ASCII. Drives up to 25 TV monitors $225
MTX-1632SL. Externally synchronized version, allows output to be mixed with or superimposed on other images $225
MTX-2480. 24 lines × 80 characters, upper- and lowercase, half-intensity, blink, inverse video (lowercase requires long-persistence CRT phosphor) $395
MTX-2562.** Graphics board; 256 × 256, individually addressable dots. Color or grey-scale available. Light pen, cursor plot, point plot, alphanumerics, and ROM screen patterns may be implemented. On pc board, with 44-pin edge connector $630
Character fonts. 1632 and 2480 may be supplied with upper-/lowercase ASCII, uppercase ASCII/Greek, General European, and French character fonts at no extra charge. Japanese (Kata-Kana), British, German, math symbols, etc., available for $150 per order. Custom-designed character fonts available.

MEMTECH

ARITHMETIC PROCESSING UNIT (S1)
Hardware arithmetic processing unit, designed for use with BASIC-E, but usable without if user writes own software. Performs floating-point, multiply in 42 μ vs. 3000 μ in software; performs parallel processing of arithmetic operations while CPU executes program; includes trig and exponential functions; jumperable to any pair of I/O ports. Kits (add $15 for assembly):
Without APU chip $155
With 2-MHz APU chip $375
With 4-MHz APU chip $475
BASIC-M (modified BASIC-E, using APU), on CP/M disk $25

MICRO DATA SYSTEMS

MDS-690A SINGLE-BOARD COMPUTER (SI)
6802-MPU board with I/O, RAM, ROM; 6809-compatible. See Computers section. Kit/wired ..... $198/$258

MICRO DIVERSIONS

SCREENSPLITTER (S1)
Video display board software-divisible into up to 50 logically-independent "windows." Displays 40 lines × 86 char; full 128-char ASCII; separate frames, figure-ground, cursor and optional label for each window; windows scroll and format text independently; all characters may be user-defined as winking or reverse. Optional APL, Graphics or Scientific character generators available; addressable to any 8K boundary; additional window-package and text-editor firmware available. Kit/wired ..... $329/$429
Additional APL, graphics or scientific character-generator EPROM $25
Additional window package EPROM (specify address) $25
Text Editor/window package EPROM (specify address) $80

MICRO TECHNOLOGY UNLIMITED

MUSIC SYSTEM (KM)
8-bit, digital/analog-converter-based music system for KIM-1. Plays 4-part harmony with harmonics derived from Fourier synthesis, not squarewaves or pulses. 8-bit DAC, 6-pole low-pass filter, audio amp.
K1002 ..... $35
K-1001-1. Software, on cassette with source listing $13

K-1012 PROM & I/O BOARD (KM)
Combination EPROM and I/O board for KIM-1, VIM, AIM and similar computers. Programs and holds up to 12K of 2708 EPROMS; I/O includes 4

bi-directional ports, 8 control lines, RS-232 serial, modem control signals; 110-4800 baud.
K-1012. Bare board/wired ..... $40/$235

K-1008 VIDEO BOARD (KM)
Alphanumeric and graphics software-generated character set; 53 char x 22 li, graphics 320 (v) x 200 (h); graphics subroutines and patches for Microsoft BASIC available.
K-1008. Bare board/wired ..... $40/$289

K-1016 RAM (KM)
16K dynamic RAM for KIM-1, VIM, AIM and similar computers. Runs at 1 MHz; addressable to any 4K boundary. Requires +8 V and +16 V at 200 mA. Bare board/wired..... $40/$375

THE MICRO WORKS

DIGISECTOR (S3)
Random-access video digitizer for SWTP 6800 and similar computers; stores video signals in computer memory. Resolves 256 × 256 picture scan; 64 levels of gray scale; conversion times as low as 3 µs/pixel; accepts interlaced (NTSC) or non-interlaced (industrial) video input; requires 1 I/O slot; can superimpose cursor on picture. Software supplied digitizes one pixel every other horizontal scan line, fills 16K with 6-bit gray-scale value in under 4 sec, providing 128 × 128 resolution; drives Malibu 160 graphics line printer, commented for interfacing to others. Wired.
DS-68. ..... $170
DS-68R. (Regulated +12V) $180

PROM SYSTEM BOARD (S5)
PROM/RAM combination. 1K 350ns RAM, space for up to 8K 1708 EPROM, both addressable to any 8K boundary; provision to move I/O locations to any unused 1K block in EPROM space, permitting memory expansion to 65K contiguous; +12V regulator optional, for systems using Smoke Signal PS-1 or equivalent power supplies. Wired.
PSB-08. ..... $120
PSB-08R. (Regulated +12V) $125

EPROM PROGRAMMER (S3)
Programs 2708 EPROMs; fits SWTPC 6800 I/O slot. Safety switch and LED indicator for programming voltage; zero-insertion-force socket, extended board for easier PROM insertion/retrieval; +12V regulator optional.
B-08 ..... $100
B-08R. (+12V regulated) $105
U2708. EPROM-burning firmware; specify C000 or FC00 address $30
U2708/1000. KC-standard, 300-baud cassette $10

UNIVERSAL INTERFACE BOARD (S3)
For custom interfaces. Space for 40-pin wire-wrap socket for Motorola 40- or 24-pin interface chips; data and control lines at appropriate edge-connector pins; other bus connections to 16-pin socket pad; includes Molex connector, +5V regulator; space and bussing for up to 35 14-pin ICs. **UIO** ..$25

EXTENDER BOARDS (S3) (S5)
Double-sided extender boards, with bus extensions on bottom, ground plane on top; silkscreened bus pin designations and ground-clip attachment points.
X-50. (SS-50 bus) $30
X-30. (SS-30, I/O bus) $23

MICRONICS

BETTER BUG TRAP (S1)
Debugging board with four hardware breakpoint address registers and a 16-bit clock. Can detect addresses, generate time intervals for real-time clock interval timer, single-step, etc. With 8080A, generates CALL instruction to any memory location when interrupting. Occupies 16 bytes of memory. Functions include master reset, wait on address, interrupt on address, timed interrupt. Compatible with vectored interrupt boards. Bare board/wired ..... $45/$180

MICROPRODUCTS

APPLE II/PR-40 PRINTER INTERFACE (AP)
Interfaces Apple II computer to SWTP PR-40 printer. Plugs into Apple II slot 3; prints one line for each Return command; will list BASIC as screen scrolls; includes cable and cassette software $50

APPLE II EPROM BURNER (AP)
EPROM programmer for 2716 EPROM. Plugs into Apple II; zero-insertion-force EPROM socket; on-board, 25V power supply $90

APPLE II/MFE TAPE INTERFACE (AP)
Interfaces MFE digital tape drive to Apple II; with tape-operating-system software $198

µPMEM

8080 SUPER CPU (S1)
Bare board. For details, see Computers section..... $36

MIDWEST SCIENTIFIC

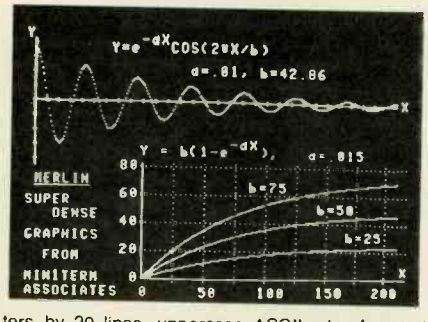
WIRE WRAP CARD (S5)
For SS-50 bus; 44-pin top edge connector, positions for 38 16- or 14-pin wire-wrap sockets; top two rows accept 24- or 40-pin sockets for maximum of 10 large, 18 small sockets; busing for +5V and ground; position for 7805 5V regulator with heat-sink; additional pads for discrete components; includes Molex bus connectors.
WW-1. Kit $25
WWR. Regulator & heat sink $5

Extender Card (S5)
SS-50 extender card, includes female and male Molex connectors.
EXT-1. Kit $25

AUDIO CASSETTE INTERFACE (S3)
For SS-50 I/O (S3) bus. With MSIBUG monitor, permits programs to be saved and loaded on Port 1 without altering Port 0 control-terminal baud rate.
AC-1. Kit/wired ..... $75/$105
MSIBUG Monitor. PROM; for ACIA interfaces addressed $F500 and $F508, monitor RAM $F000-$F07F; MIKBUG compatible.
MT-1. 2708 PROM $60
MT-2. Simlar, but for use in SWTPC 6800 system; RAM at $A000, I/O at $8004 ..... $60

MINITERM ASSOCIATES

MERLIN VIDEO INTERFACE +I/O (S1)
Combination alphanumeric/graphics interface with I/O and ROM facilities. Alphanumerics: 40-characters by 20 lines, uppercase ASCII, plus Inverted video control characters; cursors may be inverted, blanked, or normal; under software control, carriage returns may be displayed or may terminate display line; ASCII and graphics may be mixed. Graphics: Normally software-selectable for sparse (80 × 100) or dense (160 × 100) resolution; super-dense option (320 × 200) can replace sparse mode; all eight bits of each byte are mapped — no interbyte or interline spaces; DMA controller allows display to change with every screen refresh, information on screen not blanked while being modified . I/O: Provides parallel input port with power to run most keyboards; one serial port. ROM: two sockets provided for 1K (2708) PROM or ROM or 2K ROM (firmware available), plus 256-byte RAM for Merlin scratchpad and stack. Monitor/Editor: See under MBI and MEI, below. Interface consists of two, back-to-back mounted boards occupying one Altair-bus slot. MERLIN, as above. Kit/wired ..... $296/$383
M320. Super-dense graphics add-on ..... $39/$54
MCAS/KC-2. 1500-baud Tarbell cassette interface add-on (requires MEIROM). Kit/wired ..... $29/$43



MSEK. Serial I/O expansion kits, expands MERLIN to three parallel inputs, three parallel outputs ..... $45/$75
MC/IO. Combines MCAS and MSEK on one pc board, designed to be housed in keyboard enclosure. Kit/wired ..... $67/$99
MBI. Merlin Basic Intelligence, 2K ROM monitor/editor for Merlin, plus 256-byte RAM. Provides turnkey monitor, cursor control, wraparound scrolling, text editing. Easily interfaced to BASIC or other monitors $40
MEI. Merlin Expanded Intelligence, ROM with cassette (MCAS) routines, extended edit and monitor commands, graphic subroutines $35

ROM/EROM (S1)
8K, 2708 board (also for up to 2K ROM), with power-on start to any 1K address boundary. Kit/wired $89/129

FDI (S1)
Minifloppy Interface kit for up to three drives, with bootstrap ROM. Kit/wired ..... $260/$329

BKPL (S1)
Eight-slot, Altair-bus motherboard $35
BKPL-E. Same, with edge connectors, wired $109
VDRK. Card rack and BKPL-E. Designed for card ejectors $160

MK ENTERPRISES

DTMF TRANSCEIVER (S1)
Interfaces S-100 computer to Touch-Tone phone system, via DAA. Converts Bell System Dual-Tone Multi-frequency (DTMF) signalling to binary and vice versa; when used with interrupt controller (such as IMSAI PIC 8), can perform ring detection and DTMF signalling without CPU looping; allows remote data entry from touch-tone phones; 4-bit input port allows additional data transfer on DTMF detection or servicing up to 8 incoming lines; 4-bit output port for supervision of DAA or other equipment; DAA not provided. Wired $425

MOUNTAIN HARDWARE

100,000 DAY CLOCK (SI)
S-100 clock board; times in 100 µs increments for periods up to 100,000 days (273 years); allows reading of time and programming of time-dependent functions; on-board battery backup. Uses 15 I/O ports for time, plus one I/O port to set interrupt function; user-addressable to any 16 consecutive 8080/Z-80 ports; time set by entering BCD digits through ports; write protect switch prevents accidental clock stop or reset; can interrupt computer at pre-programmed intervals; crystal control, 0.001% accuracy. Can be used with most BASICs: Introl BASIC available with time set, compare, check, display and print commands. Kit/wired ..... $179/$219

INTROL BASIC
Tiny BASIC with added commands for clocks and Introl Remote Control System.
EPROM $100
CUTS cassette or paper tape. $15
CP/M or North Star diskette. $25

AC CONTROLLER (SI) (AP)
For remote switching of Introl remote control system. Available in S-100 and Apple II versions.
Kit/wired ..... $149/$189

PROROM (SI)
7½K EPROM board with programmer.

MULLEN

EXTENDER BOARD (S1)
Raises S-100 boards above others in chassis, for easier in-circuit testing. Includes TTL logic probe indicating low- and high-level logic and pulses on 7-segment LED display; pulse-catcher LED whose brightness corresponds to pulse-stream duty cycle; jumper links in power lines for current measurement and fusing of board under test; edge-connector with all lines labelled; "kluge board" section with holes on 0.1" grid for user circuits.
TB-2. Kit only $35

OPTO-ISOLATOR/RELAY CONTROL BOARD (S1)

Interface board for device control. Has eight reed relays (rated 10VA, 20-200 V) controllable by eight-bit computer command, eight opto-isolators for feedback handshake. I/O port address switch-selectable.

CB-1. Kit only $88

MULTI-TEK

BEFORE BOARDS (S1) (S5)

Prototyping boards for S-100 and all 6800 computers. Supplied without ("X" versions) and with regulated power supply circuit; can be hand-wired or wire-wrapped; will accept flexible cable connectors for piggyback applications; S-100 version supplied without ("X") and with gold-plated connector.

S-100/S-100X ..... $30/$28.50
6800/6800X ..... $24/$22.50

NATIONAL INSTRUMENTS

LSI-11/IEEE-488 INTERFACE (LS/IEE)

Interfaces LSI-11 bus to IEEE-488 bus. Includes 4-meter cable with connector; allows user to connect as many as 14 instruments on a single interface; with software $695

NATIONAL MULTIPLEX

2610(R) "BOOTSTRAP ELIMINATOR" (S1) (S3)

Combination ROM monitor, cassette and serial I/O board. Connects terminal (20 mA, RS-232, or TTL), one or two digital or audio cassette units; all necessary routines in high-speed, EPROMs, including tape start/stop for audio cassette, plus rewind and fast-forward for digital tape units. Includes word-processing, tape-punching and reading routines. Can be used of phase-encoded, Kansas City, MITS, and IMSAI tapes. Wired (specify S-100 or SWTP version) $190

PUC1. Similar, but with 3 serial ports; S-100 only. Wired $235

Z80 MPU (S1) (S5)

Z-80 MPU board, available in S-100 and SS-50 versions. Includes 1K ROM, with monitor, tape read/write, field search, tape recorder start/stop control. Wired $190

8080 MPU (S1)

S-100 version only. Wired $160

NATIONAL SEMICONDUCTOR

BLC-104 (MB)

Combination RAM/PROM and I/O board for SBC Multibus. Combines 8K, 575-ns dynamic RAM (addressable in 4K blocks), 8K PROM sockets, 48 parallel I/O lines, 1 serial port, 1 timer; battery back-up optional; 1-2 wait states. Requires +5 V @ 3.3A, −5 V @ 20 mA, +12 V @ 340 mA, −12 V @ 50 mA. Wired $679

BLC-116. Similar, but with 16K, addressable in one 16K block $936

NEUTRONICS

HEXADIGIT BUS MONITOR (S1)

Hexadecimal readout for S-100 address and data-in buses. Hex readouts in separate box, with five-foot cable; requires +8 V @ 625 mA. Kit/wired ..... $135/$149

NEWTECH

MODEL 6 MUSIC BOARD (S1)

Audio digital-to-analog converter with on-board amplifier, speaker and volume control, plus RCA jack for connection to external audio system. For music, sound effects, morse code, touch-tone synthesis, etc. With BASIC and 8080 assembly-language software. Requires +8 V @ 100-200 mA. Wired $60

MODEL 68 MUSIC BOARD (S3)

Similar to Model 6, but for SWTP-6800 type systems; uses one I/O slot. Supplied with software listings and SWTPC AC-30 compatible cassette ... $60

NORTH STAR

HARDWARE FLOATING-POINT BOARD (S1) (MB)

Hardware arithmetic board performing floating-point add, subtract, multiply and divide with up to 14 digits of precision; approximately 50 times faster than 8080 software or firmware; uses BCD number representation; precision under software control. In versions for S-100 and SBC (Multibus) buses. Includes North Star BASIC modified for hardware calculations; specify whether disk or paper-tape version desired.

FPB-A. S-100 version; requires +8 V @ 1 8 A. Kit/wired ..... $259/$359

FPB-B. SBC version; requires +5 V, regulated, @ 1.8 A ..... $299/$399

Z-80A PROCESSOR BOARD (S1)

Z-80 processor board for S-100 computers with or without front panels. Compatible with Altair and Imsai front panels; auto-jump to any 16-bit address at power-on and reset; with 1K EPROM (2708) space; 8-level vectored interrupt capability; jumper option to add wait state to RAM in computer; available with/without EPROM and supporting parts and sockets.

ZPB-A. Without EPROM option. Kit/wired ..... $199/$259

With EPROM option. Kit/wired ..... $248/$328

ZPB-PROM. Kit to add EPROM option $49

NUCLEONICS PRODUCTS

CRT-1000 VIDEO INTERFACE

16-li × 64-char; accepts TTL parallel ASCII data; has composite video output with selectable pos/neg video and sync; on 3.5" × 5" circuit board, with 20-pin flat ribbon connector; full cursor controls; erase-page, erase-line and erase-to-end-of-line; automatic scrolling; blinking underscore cursor; character width adjustable for different CRT screen widths and scan rates. Requires 5 V @ 350 mA..... $120

CRT-2000. Similar and plug-compatible, but with user-definable character set, foreground and background video, protected video fields..... $150

CRT-3000. Similar to CRT-2000, but with Screen Read..... $160

OBJECTIVE DESIGN

PROGRAMMABLE CHARACTER GENERATOR (S1)

Adds software-created characters to existing video display boards such as VDM-1, Polymorphic VTI, etc. Works with video boards using Motorola 9×7 matrix character-generator ROMs. Board includes parallel keyboard interface, 2-dimensional joystick interface provisions, and 2K onboard character memory; can produce graphic images up to 512 × 256 (not bit-mapping—suggested where basic Image sets are repeated on screen); requires no external system memory or DMA; requires +8 for board, −16 if interfaced to keyboard requiring −12V; list of bus-control signals used is available; specify video display in use when ordering. Kit/wired ..$150/$200

High-speed option (for 4-MHz systems) $16

DATABANK (S1)

PROM programming and storage card with on-board RAM. Holds up to eight 2716 or 2708 PROMs (16K or 8K bytes), plus separate socket for programming; computer can read programmed PROM in place of any other on board, under software control, for testing and verification; on-board static RAM (1K on 2708 boards, 2K on 2716) can be software-substituted for any PROM, to test program patches, or can be independently addressed; 2nd programming socket may be connected to external socket on computer front panel or housed separately; size of address space occupied is switch-selectable; jump-on-reset to lowest-addressed PROM; phantom (bus-line 67) defeats any memory at 0000 during jump.

Without RAM. Kit/wired ..... $200/$225
With 1K RAM. Kit/wired ..... $220/$245
With 2K RAM. Kit/wired ..... $240/$265

DOUBLE-X EXTENDER CARD (S1)

Double-X pattern of interleaved ground and signal lines for reduced noise and crosstalk; 5V regulator for logic probes. Kit/wired ..... $35/$45

CONSOLE INTERFACE (S1)

Special-function interface; includes 8279 programmable keyboard/display interface for switches, keypads, and up to 32 seven-segment displays; 8259 programmable interrupt controller generating interrupts to any location in memory; up to 6K PROM; 256 bytes RAM; real-time clock with selectable interrupt intervals from 100 μsec to 100 ms; power-on jump; optional on-board generation of MWRITE. Available in several configurations, with firmware including interrupt service routines, time-of-year and general timed alarms, console functions, etc. ..$200

PARASITIC

CLOCK FIX KIT

Temperature-compensated, non-overlapping clock for Altair 8800 and 8800a $15

PARATRONICS

MODEL 150 "BUS GRABBER" LOGIC ANALYZER (S1)

One-board logic analyzer for S-100 bus. Automatically monitors address and data busses, MPU status, interrupts and controls signals, performs automatic clock qualification and clock polarity selection; also offers 8 user-defined signals interfacing via optional, plug-in, flat ribbon probe assembly, providing independent 8-channel logic-analyzer functions; triggering, display formatting and operational modes controlled from hand-held pod connected to main pc board by cable; trigger word can be up to 24 bits; analyzer data memory 16 bits by 16 words, can capture over 8 million 16-bit words/sec, for use with future, faster S-100 systems. Data words displayed as ones and zeros on ordinary oscilloscope; connecting cables included; displays signals as series of eight, 8-bit, 16-word truth tables, selectable from control pod. Pod also formats data in hex or octal groupings, stores or updates individual truth tables, chooses post- or pre-trigger data acquisition; trigger-indicator LED on pod and trigger output signal.

Kit/wired ..... $369/$499
8-bit data probe set $10

PERCOM DATA

CI-812 CASSETTE/TERMINAL INTERFACE (SI)

Dual-function interface board for S-100 bus. Cassette interface is KC-standard, with independent record and playback circuits, optional relay kit for programmed control of two recorder/players. Also includes RS-232 terminal interface. Tape data transfer at 30, 60, 120 or 240 bytes/sec; RS-232 @ 300-9600 baud. Kit/wired ..... $100/$130

Remote-Control Kit $15
IC socket kit $15
Test cassette with operating software $5
Operating system firmware (2708) $45

LFD-400 MINI-DISK CONTROLLER (S5)

SS-50 controller board for up to 3 Mini-Floppy drives. (See "Peripherals" section for system details). Wired $325

PICKLES & TROUT

BDPIO PARALLEL I/O BOARD (S1)

Allows interfacing of up to 6 parallel devices with only 1 cable from computer, free use of devices requiring more than one I/O port. Board has 6 bi-directional 8-bit I/O plus 2 8-bit static ports. Bi-directional bus consists of 8 bi-directional data lines, 3 control lines, 3 port number lines, 6 filtered interrupt lines, +8V, ground and one user-definable line; control and port-number lines govern which device can perform I/O to bus, and which port is active. Static ports may be set up as independent input and output or as bi-directional ports, under control of computer or of external device; input strobe sets interrupt latch, patchable to any interrupt line. Instructions available for interfacing to Digital Group Phi-Deck controller, Prolog PROM programmer, or Okidata CP110 printer. Wired, cables extra $165

P&T-488 INTERFACE BOARD (S1) (IEE)

For bi-directional communications between S-100 computer bus and IEEE-488 instrumentation bus. Can function as controller, talker or listener; Includes Bitwiggler tape interface, K.C. compatible; software on K.C. tape included. May be addressed as 4 consecutive I/O ports or memory locations. With 488-compatible cable, Kit/wired .....$250/$325

POLYMORPHIC

I/O IDEABOARD (S1)
Prototyping board for I/O in blocks of four addresses. Requires +8–10 V @ 370 mA, excluding user-added components. Kit $55

CPU (S1)
8080 processor with ½K RAM, vectored interrupt, real-time clock, space for up to 3K ROM (1K ROM monitor available). Accepts inexpensive printer (serial) and cassette interfaces. Kit $215
Printer Interface. Fits above MPU only. RS-232 or 20 mA. Kit/wired .....$65/$80
Cassette Interface. For above MPU only. Kansas City (300 or 600 baud) and PolyPhase (1200, 2400) standards. Kit/wired .....$65/$85

PROCESSOR TECHNOLOGY

CUTS TAPE SYSTEM (S1)
Audio cassette interface, 300 or 1200 baud; includes CUTER tape. Kit/wired .....$149/$189

WWB WIREWRAP PROTOTYPING MODULE (S1)
Kit only $40

EXB EXTENDER BOARD (S1)
Kit only $35

SUBSYSTEM B110 (S1)
Set of module boards, including CUTS tape interface described above, 8KRA RAM, VDM-1 Video Display Module, 3P+S I/O Module, GPM ROM board and Extended Cassette BASIC. (See module board charts for boards other than CUTS).
Kit/wired .....$799/$1095

SUBSYSTEM B190 (S1)
Similar to B110, but with 16KRA memory .....$995/$1195

SUBSYSTEM B350 (S1)
With 32KRA memory .....$1295/$1495

QUAY

Q80FDC FLOPPY-DISK CONTROLLER (S1)
Supports up to four 5¼" or 8" drives; includes general-purpose, programmable, 8-bit TTL parallel I/O port; IBM-3740 format; selectable 128-byte or variable record length; double data buffering; on-board CRC generation and checking. Wired $295

SIGNAL LABORATORIES

AIB ANALOG INPUT BOARD (S1)
Interfaces low-level analog input devices to S-100 computer. Options for programmable gain, low-drift thermal regulation. Provides 8 differential or 16 single-ended input channels, optionally expandable to 16 differential or 32 single-ended lines. Throughput rates to 5K samples/second.; 12-bit A-D conversion; input-fault overload protection. Requires ±18V @ 150 mA, +8V @ 1.2A.
Model 610 AIB $495
Option 01. 16 additional single-ended inputs $100
Option 02. Programmable gain $175
Option 03. Low-drift front end $75

SOLID STATE MUSIC

MUSIC SYNTHESIZER BOARD (S1)
Waveform synthesizer card for S-100 computers; polyphonic capability available through use of multiple cards; frequency software controllable over 9-octave range; volume software-controlled at 15 levels; waveform user-definable in 32 bytes of memory; envelope user-definable; note durations controllable from 64th-note to whole note. High-level music software available. Board is memory-mapped device, addressable from 8000 to FF00; output 1V rms, low-impedance; requires +7 to +9V @ 1.3 A, ±12 to ±18V @ 25 mA.
SB1. Kit $150

4K PROM/RAM BOARD (S1)
Holds up to 4K PROM and static RAM, mixed in 256-byte increments in any pattern. Requires +8V @ 1.5A (4K RAM) to 2.4A (2K PROM & 2K RAM).
MB9. Kit $80

VECTOR JUMP & PROTOTYPING CARD (S1)
DIP-switch selection of vector jump address; will work with systems equipped or not equipped with phantom disable; can be set to jump on Power-on, Reset or both; prototyping area on card for up to 10 16-pin IC's, 3 24-28-pin IC's, 2 spare regulators.
OB-1. Kit $55

SOUTHWEST TECH. PRODUCTS

MP-A 6800 PROCESSOR BOARD (S5)
Includes 6800 MPU, ROM with Mini-Operating System, 128-byte scratch-pad memory, clock, baud rate generator (110-1200 baud), power-up/manual reset circuit. Requires +8 V @ 0.8 A. Bare board/kit .....$15/$110
MP-A2. Similar, but with sockets for up to 8K of 2716 EPROM, on-board DIP switch for easier address assignment. Bare board/kit.....$15/$145

MP-N CALCULATOR INTERFACE (S3)
Hardware arithmetic calculations, to simplify machine-language programs and conserve memory; features Reverse Polish Notation, floating-point or scientific operation (to 8-digit mantissa, 2-digit exponent); four-register stack; memory register; trig functions; base-10 and natural logs; overflow indicator. Bare board/kit.....$10/$47

MP-T INTERRUPT TIMER (S3)
Provides software-selectable interrupts of 1 usec, 10 μsec, 100 μsec, 1 msec, 10 msec, 20 msec, 100 msec, 1 sec, 10 sec, 100 sec, 1 min, 10 min or 1 hour; also includes fully-buffered 8-bit input port with handshaking. Requires +8 V @ 0.3 A, −12 V @ 15 mA. Bare board/kit.....$10/$40

SPACE TIME PRODUCTIONS

MASTER I/O-ROM-RAM BOARD (S1)
Combines serial and parallel I/O plus RAM and ROM, allowing minimal two-board system in conjunction with a CPU board. 1K RAM; 3K ROM; three 16-bit counter/timers, programmable as binary or BCD counters; programmable one-shots, digital delay, pulse or square-wave rate generator, software- or hardware- triggered strobe. Synchronous serial I/O (TTL levels) to 56K baud, software programmable; parallel interface with total of 24 possible I/O lines, programmable as input, output, bidirectional data or handshaking; 2 I/O lines have bit/reset. Bare board/wired .....$48/$369

SPEECH TECHNOLOGY

M188 VOICE GENERATOR (S1) (MB)
Formant speech synthesizer and interface, for generation of speech from vocabulary stored in on-board EPROM, computer memory, or both. On-board sockets and logic for two 2708 or 2716 EPROMs, holding up to 60 words or 35 seconds of speech; supplied with cassette tape of 95 common words, other vocabularies available; 500-ohm audio output @ 0 dBm standard, 0.5W into 8 ohms optional. For S-100 computers, but can be adapted to SBC Multibus. Requires +8V @ 200 mA, +16V @ 12 mA, −16V @ 50 mA. Occupies 4 port addresses, user-selectable. Wired $395

SZERLIP

PROM SETTER (S1)
EPROM programmer board with external programming socket and 3 parallel ports (2 out, 1 in). Programs and reads all 24-pin EPROMs, including 1702A, 2704, 2708, 2716 TI, S5204, 6834; supplied for 1702A and 2704/2708, but can be configured for any combination. Single read/write EPROM socket can be externally mounted for easy accessibility; has write-enable/disable switch. Requires four consecutive I/O port addresses, +8 V @ 0.7 A, ±16 V @ 0.2A. Kit/wired .....$210/$375

RAM'N'ROM (S1)
Holds up to 64K of any 24-pin EPROM (16 sockets); can accept two different EPROM types, in two groups of 8. Has power-on-jump & run for computers with front panel, jump-on-reset and Mwrite logic for computers without. Kit/wired .....$117/$168

TARBELL

1001 CASSETTE INTERFACE (S1)
Saves and reads data on audio cassette machines. Data transfer rates up to 540 bytes per second with high-quality cassette recorder, 187 bytes/sec suggested for medium-quality recorders (both Tarbell format); modifiable for Kansas-City format @ 27 bytes/sec. With Triple-I Phi-Deck, 1000 bytes/sec. @ 10 in/sec. Extra status and control lines available for use with computer-controlled drives such as Phi-Deck, or multiple tape recorders with Ro-Che controller (see Peripherals). Includes soft-ware, room for user-developed circuits. Kit/wired .....$120/$175
8K EMPL. Cassette $15
P.T. Editor. Cassette $5

1011 FLOPPY DISK-INTERFACE (S1)
Interfaces single-density, full-size (8") floppy drives; for up to 4 drives (or 2 double-sided); CP/M-compatible. Includes 32-byte bootstrap ROM with jump-on-reset; ROM switches out of address space once run; uses programmed data transfer (not DMA); connector pins come out to jumper pads, for easy adaptability to different drives; user-circuit area can be used to increase capacity to 8 drives. Bare board/kit/wired .....$40/$190/$265
CP/M Disk $70
CBASIC disk $85

1010 PROTOTYPE BOARD (S1)
Takes up to 33 14-pin ICs, or can mix 40- 18-, 16- and 14-pin ICs; location for 5V regulator; suitable for solder and wire wrap $28

TELESENSORY SYSTEMS

SPEECH SYNTHESIZER MODULE
Converts digital speech data in on-board ROM to analog voice output (external filtering and amplification required). Requires 6-bit parallel address and start signal -15V and -5V power; on 3.10" square board with 22-pin connector; can be made TTL compatible. Available with choice of one 24-word, two 64-word vocabularies; custom vocabularies available on special order.
S2A. With 24-word Calculatory vocabulary $95
S2B. With 64-word "Standard" vocabulary $179
S2C. With 64-word "ASCII" vocabulary $179

CALCULATOR SPEECH SYNTHESIS MODULE
With 24-word Calculator vocabulary only; specify English, German or Arabic. On 4" × 7" circuit board with 16-pin DIP connector, audio filter circuit, 200mW amplifier, volume control, 2" speaker . $150

TELETEK

DAJEN UCRI (S1)
Universal cassette recorder interface. Switch-selectable baud rates from 520 to 41,000 baud (maximum usable typically 5000 baud on cassette, 12,000 baud on 7½ ips tape); switch-selectable Tarbell, Kansas-City or other format. Independent switch selection of transmit and receive data inversion for use with different recorders. Level indicator light. Relay option for independent control of two recorders; independent latched input port for keyboard or other use. Kit/wired ..... $165/$210

DAJEN SYSTEM CENTRAL INTERFACE (S1)
Combines ROM reader/programmer, RAM, serial, parallel and cassette I/O, with reset-jump. Can program 2708 EPROM, read up to 3K; software included in 2K firmware monitor. Has 3 parallel ports, RS-232/20mA/60mA serial port. Cassette I/O compatible with Tarbell; bi-phase recording at programmable speeds from 800 to 100k baud; 2 on-board relays control 2 recorders; status lines can control automatic decks; sync and level indicator LEDs. Firmware monitor includes I/O, EPROM programming, video-board drivers, hex arithmetic, memory examine/move/verify/clear/search, tape verify. With all output connectors. Wired $385

THINKER TOYS

DISK JOCKEY CONTROLLER (S1)
Controller board for full-size, 8" floppy disks. IBM-compatible soft-sectored format, 256K bytes/disk. Can accommodate up to 8 drives; on-board ROM with bootstrap and other functions; 256-byte RAM buffer; board occupies 1K starting at 340:000 octal or E000 hex (other 1K-boundary addresses on special order). Software is initialized to use on-board, memory-mapped serial I/O port, allowing easy use or access to reinitialize to any other port desired. Supplied with DISK/ATE (DOS/Assembler/Text Editor) and BASIC-V. CP/M compatible; patches supplied for those with CP/M, disk available.
Kit $179
Cable for disk drive $20
Additional connectors for multiple drives $15
Software options: see under Peripherals.

KEYED-UP 8080 (S1)
Combination 8080 MPU/front-panel board, with octal keypad and display, two on-board I/O ports (for keyboard), 256-byte RAM and 256-byte ROM. Facilities to start, stop, or step any program; processor remains active after HALT command. Kit $250

VAMP

EXTERMINATOR (S1)
Combination extender/terminator board. Fused power buses; low profile fits inside S-100 cabinets; active termination to reduce noise, crosstalk, overshoot, etc. on bus.
VTE-100-K/-A. Kit wired ..... $50/$75
VTE-100-B. Extender only, with edge connector and fuse clips $23

POLYGRAFIX (S1)
Add-on graphics board for Poly video card (specify whether Rev 1.2, F or H). Stores up to 128 user-generated characters; 512(H) × 128(V) graphics; reverse field and video; piggybacks onto Poly video card. For version 1.2/versions F, H ..... $125/$245
Assembled on Poly video card $525

ACVM-1 VIDEO ADAPTER
For direct video input into TV set. See Peripherals.
RFVM-1 VIDEO MODULATOR. See Peripherals.

VECTOR ELECTRONIC

Microcomputer prototyping boards with bus lines, DIP-spaced holes, and appropriate edge connectors for the following microcomputer systems:

S-100 Boards (S1)
8800V. Power & ground planes for wire-wrap; for 52 16-pin DIPs or equivalent $20
8800V-B. 8800V with sockets and wrap-posts in place and ready to wire, for 2 40-pin, 8 24-pin, 36 16-pin DIPs $90
8801-1. Bare board with edge contacts, for 88 16-pin DIPs, or equivalent in any size DIPs and components $15
8802-1. With 2-hole pads, power & ground buses for 42 16-pin DIPs or equivalent $22
8804. With power and ground planes for wire-wrap; for 70 16-pins or equivalent $22
8801. With 1 pad per hole, plus power & ground buses; for 16-pin DIPs or equivalent $20

SBC MULTIBUS BOARDS (MB)
4608. With 3-hole pads, power & ground buses; for 54 16-pin DIPs or equivalents $45
4608-1. Bare board with edge contacts, for 144 16-pin DIPs or equivalent $34

H11 BOARD (LS)
4607. For Heathkit H11, DEC LSI-11, PDP-8, PDP-11. Bare board with edge contacts; for 89 16-pin DIPs or equivalent $16

VECTOR GRAPHIC

PRECISION ANALOG BOARD (S1)
Contains two analog outputs, eight analog inputs, one control port; 12-bit D/A and A/D conversion for measurement and control of up to eight analog input channels; dipolar and monopolar operation; user bread-board area.
PA. Wired $390

ANALOG INTERFACE BOARD (S1)
For interfacing with potentiometers, joysticks or voltage sources; 8-bit digital port with latch strobe can be used as keyboard input port. Tone pulse generators can be used to produce sounds (450 and 800 Hz) for games or keyboard audio feedback. Four A-to-D inputs. MWRITE logic and power-on jump for computers without front panel: A/D resolution under software control, 16-64 counts for cursor motion, 1024 or more for graph plotting or feedback controls; typical conversion time 480 µsec for 16-count resolution.
AI. Kit/wired ..... $75/$115

HIGH-RESOLUTION GRAPHICS BOARD (S1)
Switch-selectable high-resolution (156H × 240V) and gray-scale (128H × 120V) display modes; 16-level programmable gray scale; uses Vector Graphic 8K static RAM board (not included) as refresh memory; interfaces standard raster-scan monitors; memory available for general use when graphics not in use; with software alpha-numeric character-generator and x-y plotter. Requires +8 V@ 750 mA (typ).
GR. Kit/wired ..... $195/$235

Z-80 BOARD (S1)
Z-80 MPU; 4-MHz clock rate jumper-selectable; jumper-selectable automatic wait state allows 4-MHz operation with slower memory while maintaining 80% or better throughput speed; jumper-selectable MWRITE for systems without front panel; all three Z-80 interrupt modes. Requires +8 V @ 750 mA. Wired $215

8080 CPU BOARD (S1)
8080-MPU board with real-time clock generator and 8-level priority interrupts. Requires +8 V @ 900 mA, +16 V @ 40 mA; −16 V @ 10 mA. Wired $190

WAMECO

WMC 8080A CPU WITH 8-LEVEL INTERRUPT (S1)
8080A MPU board for S-100 bus, with 8-level vector interrupt; interrupt circuitry need not be built up until system has real-time clock board.
CPU-1. Bare board/kit/wired ..... $30/$185/$220

WMC REAL-TIME CLOCK BOARD (S1)
Includes 8-page software source listing and 3-page flowchart for Time-of-Day and Day-of-Week display; addressable to any of 128 port-address pairs; included 16-bit (10-65K µsec) and decade (100 µsec-100 sec) interrupts.
RTC-1. Bare board/kit/wired ..... $30/$199/$229

WWW ENTERPRISES

DYNAMIC RAM
4K-16K dynamic RAM board for homebrew interface. Connects via 4, 14-pin DIP sockets; has bank select; 270-ns access time, 470-ns cycle. Requires +12 V @ 33 mA, +5 V @ 40 mA, −5 V @ 5 mA.
WWW-16KA. Kit/wired ..... $449/$549
4K RAM expansions $80

STATIC RAM
Similar to WWW-16KA, but static; 200-ns access, 300-ns cycle; requires 48 mA at +12 V, other requirements same.
WWW-16KAS. Kit/wired ..... $550/$650
4K RAM expansion $90

XECON MICRO

SMART CASSETTE-I/O CONTROLLER (S1)
Audio cassette interface with on-board RS-232/20-mA serial port. Tape system has control, filing-formatting and search functions in ROM, switch-addressable to any 512-byte memory segment; records modified-KC standard tapes at 1200, 2400, 4800 bits/sec, may be user-programmed for 1200-baud KC compatibility; data interchanges may be performed in either port-addressed or memory-mapped modes (specify port addresses 80-83 or C0-C3 when ordering); optically isolated tape-motor controls. Requires 7-12 V @ 0.8 A, 15-24 V for I/O loop.
MS-CIO-8-COS. Wired, with SMART cassette operating system, PIO address 80-83 ..... $205
MS-CIO-C-COS. Same, but address C0-C3 ..... $205
MS-CIO-8-C. Wired, without OS; addresses 80-83 or C0-C3. jumper-selectable $188

XITAN

ZPU (S1)
Z-80 MPU board with three interrupt modes; includes two clocks, one variable for fine-tunig your system, one crystal-controlled at 2 MHz. Wired $199

SYSTEM MONITOR BOARD 2 (S1)
Includes two serial I/O ports (RS-232/20 mA), 1200/2400-baud audio cassette interface; space for up to 2K RAM (1K provided) and up to 4K 2708/2716 EPROM (one 2708 provided); power-on jump to any memory page boarder; 2K ZAPPLE monitor in ROM, including extension routines and driver routines for VDB video-display board.
SMB2. Wired $395
Interface One. Board with three 25-pin female serial-port connectors on one-inch centers, 26-wire ribbon cable; makes all connections between rear panel and SMB: includes 18" cable, all hardware. $40

ZIATECH

ZT-80 BUS INTERFACE/PROCESSOR (MB/IEE)
Interfaces Multibus computers such as SBC-80 or MDS-800 to IEEE-488 bus; complete controller, talker and listener capability; 1K RAM buffer; 6K bytes/sec transfer. Requires +12 V @ 0.4A, +5 V @ 2.5A, −5 V @ 0.2 A $950

ACCESSORIES

ADVANCED ELECTRONICS DESIGN

101 TRIPLE-OUTPUT POWER SUPPLY
Primarily for floppy-disk subsystems with up to 4 drives. +5 V @ 12 A, −12 V @ 0.7 A, +24 V @ 3.5 A (5.0 A peak, max 2 minutes); other regulated output configurations optional $250

201 TRIPLE OUTPUT POWER SUPPLY
Similar, but for up to 2 drives. +5V @ 5A, −5V @ 0.7 A, +24 V @ 2.8 A (3.5 A peak) $140

BYTE

BYT-8 (S1)
10-slot S-200 chassis with start switch (front panel optional; see Module Boards section), real-time clock, MWRITE logic; power supply delivers +8 V @ 10 A, ±18 V @ 1.5 A each $229

CGRS MICROTECH

AUDIO INTERFACE
Adds audio-cassette mass storage to RS-232 port or terminal extension port. Reads and records Kansas City or Tarbell Bi-Sync tapes. Bare board/kit/wired ..... $10/$30/$50

S-100 CARD RACK (S1)

For rack-mount or table-top use; has room for motherboard and power supply; with end plates, side rails, card guides and mounting hardware. Kit/Assembled ..... $50/$60

COMMODORE/MOS

KIM-4 MOTHERBOARD (KM)
Interfaces KIM-1 with up to six system expansion modules, with all required buffering (motherboard not required to interface KIM-1 with a single expansion board). Includes +5 V, +12 V regulators (external power supply required).
KIM-4 ..... $119

COMPUTERWARE

QM MOTHERBOARD (S1)
14-slot motherboard, including slot for front panel (passively terminated). Wired $120

CROMEMCO

CARD CAGES (S1)
Assembled S-100 card cages, complete with Blitz Bus shielded motherboard, full set of wave-soldered edge-connectors; card guides and card-retaining bar.
CC-8. 8 slots $195
CC-21. 21 slots $395

CURTIS ELECTRO DEVICES

HAM S-100 (S1)
Computerized Morse and Baudot code operating system for ham radio. Receives, decodes, and displays (on user's CRT) Morse or 5-level Baudot TTY at 10-100 or 60-100 wpm. Also serves as keyboard or paddle with CRT display of transmitted text. Contains 7K EPROM with SOL firmware (patchable for other 8080 systems), 1K RAM $700

DIGITAL MICRO SYSTEMS

CRT LOWER-CASE KITS
Add lower-case letters to terminals specified below. Assembled. Takes 15 minutes to install.
ADM3LC. For Lear-Siegler ADM-3 and ADM-3a . $36
SORLC. For SOROC $18

DYMA ENGINEERING

LINE SURGE PROTECTORS
Protect 120-V electronic equipment against power-line surges. 20-A capacity. Available with barrier-strip connections (**#1AC**) 2-pin AC connector and plug (**#2AC**), 3-wire U-ground connector and plug (**#3AC**) $17

ELECTRO-DATA POWER

E.D.P.-188 POWER SUPPLY
Triple-output: +5V dc @ 2.5 A; −5V dc @ 0.3A, +12V dc @ 0.3A, all regulated ±1%. Output ripple 50 mV rms maximum. Current limited +5V output; circuit breaker on ac line. In cabinet, 3½" × 10" W × 7" D $70

E.D.P.-190. Dual-output: +5V dc @ 1.2A; +12V dc @ 100 mA. ±1% regulation, 50 mV max ripple. In cabinet, 3¼" × 5¼" × 6¼" $39

ELECTRONIC CONTROL TECHNOLOGY

ECT-100 CARD CAGE. (S1)
Card cage for S-100 boards, mounts in 19" rack.
ECT-100-F. With 20-slot mother board, connectors and guides. Kit/wired ..... $200/$250
ECT-100. With mother board only. Kit $100

GODBOUT

16-SLOT MOTHERBOARD (S1)
Includes all edge connectors, active termination circuits (see Module Boards); connectors on 0.75" centers, 1.5" spacing on 18th connector for front panel, etc. 8.5" × 16.7" $124

10/11-SLOT MOTHERBOARD (S1)
Same features as 18-slot, but shorter (8.5" × 11"), with 0.75" connector spacing throughout. Can be used as 10-slot extension to existing system, or as 11-slot stand-alone system $90
Bare board, with instructions $30

CPU POWER SUPPLY
Regulated supply: 5V @ 4A with crowbar overvoltage protections; ±12V @ ½A, adjustable (−5V to −10V) negative bias supply @ 10 mA $50

12V 8A SUPPLY
Handles 12A peaks with 50% duty cycle; crowbar overvoltage protection; short protection; current limiting; RF suppression; output adjustable 11-14V. Kit $44.50

INDUSTRIAL MICRO SYSTEMS

DUAL-DRIVE FLOPPY COMPUTER CASE (S1)
12-slot S-100 motherboard and power supply in enclosure with openings for two 800-series Shugart or PerSci 277 floppy drives; 19" rack mount or desk top with wood sides; all plugs and connectors.
61-0070. With wood sides $705
Rack-mount version $655
Less motherboard $565
Less motherboard and power supply $499

MOTHERBOARD (S1)
12-slot motherboard, with AMP 100-pin edge connectors; reset lines terminated; cross grounds between pins; slot and screw connectors for power supply.
C00310. Wired $90

MICRO DATA SYSTEMS

MD-601 MAINFRAME (SI)
Six-slot motherboard, power supply, in aluminum case with redwood and panels, space for two mini-floppy drives.
Kit/wired ..... $139/$179
M-61. Six-slot motherboard. Kit only $20

MICRO TECHNOLOGY UNLIMITED

K-1000 POWER SUPPLY (KM)
Basic KIM-1 power supply, enclosed, terminal-strip output. +5V @ 1.2 A, +12V @ 0.1A regulated; +7.5V @ 0.75A, +16V @ 0.25A, unregulated .. $40

K-1000-2 ADVANCED POWER SUPPLY
For KIM-1 and most other one-board systems. Similar to above, but +5V @ 2A, +12V @ 1A, regulated; +7.5V @ 2.5A, +16V @ .25A, unregulated $74

K-1005 CARD FILE AND MOTHERBOARD (KM)
Holds KIM-1 and up to 4 other Kim-bus compatible boards under it; requires no extra table space ... $68

MIDWEST SCIENTIFIC

HARDHOLES
Protect diskettes from center-hold damage due to improper insertion, clamping-hub slippage, or improper alignment; Mylar; require mounting tool.
HDH-1. Box of 50 Hardholes $12
HTD-1. Hardhole mounting tool $9

COMPUTER SYSTEM CABINET
Walnut-veneer cabinet with slide-out work surface and front doors. Available with two interior partitioning patterns, A and B (B recommended for systems with large CRT, A for systems with small; consult maker for dimensions); overall dimensions 46" H × 47" W $650

MOTHERBOARD (S5)
SS-50, 16-slot motherboard, with connectors; connections for front-panel power, reset, IRQ and NMI; requires MSI Interface Adapter board if decoded-address interface slots desired.
MB-1. Kit/wired ..... $85/$135

INTERFACE ADAPTER BOARD (S3)
SS-50 (S3) interface-card board; eight I/O slots, strappable for 4 or 8 decoded addresses per slot, allowing use of cards with more than one PIA chip; adapter strappable to any desired high-order interface address.
IA-1. Kit/wired ..... $54/$81

MSI CHASSIS & HARDWARE KIT
For MSI motherboard and interface adapter board power supply.
CH-1. Kit $45

POWER SUPPLY
+5V @ 20A, ±15V @ 3A each; can support 6800 system with 56K RAM and/or PROM. All dc circuits individually fused. Power supply tapped for line voltages from 105-125V and 210-250V ac.
PS-1. Kit/wired ..... $724/$105

NO NAME

MAINFRAME (S1)
To accommodate S-100 and other motherboards. With S-100 power supply; fused, switched-accessory power receptacle; fan; line cord; rear panel punched for 6 DB-25 I/O connectors, 3 BNC video/audio connectors; front panel has lighted reset button, keyed power switch: power +8V @ 10A, ±16V @ 3A; dimensions 17½" W × 17⅞" D × 7" H. Assembled $310

CARD CAGE (S1)
For S-100 cards; fits all S-100 motherboards. With 12 sets guides; assembled $39

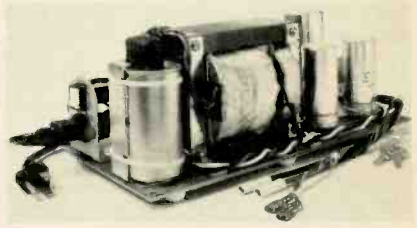
OBJECTIVE DESIGN

CARDFRAME CONSTRUCTION KIT (S1)
Builds 22-slot, S-100 mainframe. Includes pre-punched front and rear panels, support and structural bars, motherboard supports, 10 card guides, chassis plate, optional power supply. Panels include cutouts for switches, power cords, connectors, and motherboard extensions. No motherboard or fan provided, but will accept most popular S-100 motherboards; frame allows addition of front panel, cover and bottom plate (not supplied) $90
With power supply (±16V @ 2A, 110/120/130V in) $155

PARASITIC

CONSTANT-VOLTAGE KIT
Constant-voltage transformer, high-current rectifiers and improved filtering to maintain Altair performance with line voltage swings up to 90-140V. $100

26A POWER SUPPLY KIT
General-purpose power supply with constant-voltage transformer; +9V @ 20 A, ±16V @ 6 A total.



Complete with keyswitch, detachable power cord, fuse holder. Fully insulated, plug-together assembly $210

PENTEC

M68-4 CARD RACK (EX)
Card rack for Motorola EXORciser, Micromodules, and MEK6800D2 microprocessor, and other compatible boards. Rack can accommodate up to 4 boards; power supplied via barrier terminal block on motherboard; four 86-pin edge connectors, card guides provided. Kit/wired ..... $65/$80

E&L PFEIFFER

HEXADAISY CALCULATOR
Circular sliderule for hexadecimal calculations. Calculates relative addresses, twos' complements, hex addition and subtraction; converts decimal to hex and back $4

SMOKE SIGNAL BROADCASTING

PS-1 POWER SUPPLY MODIFICATION KIT. (S5)
For SWTPC 6800. Provides ±16V up to 2A, to power up to 5 fully-loaded Smoke Signal P-38 EPROM boards; also allows SWTPC 6800 8V supply to be increased by 1V, for more adequate regulation with line voltage fluctuations or more than 16K of memory $25

SOUTHWEST TECH. PRODUCTS

MP-B MOTHERBOARD (S3) (S5)
Provides 7 SS-50 slots (for processor, memory, etc.), 8 SS-30 I/O-board slots. Bus may be paralleled onto another MP-B with power supply. Bare

board/kit $30/40
MP-F. Chassis and cover $37.50

MP-P POWER SUPPLY
Supplies all power required for MP-B motherboard with full complement of plug-in boards. Kit $43

SPACE TIME PRODUCTIONS

FAST EPROM ERASER
Parts kit, including bulb, ballast and socket, for ultraviolet EPROM eraser $25

SQUARE 1

FLIPPY-DISK-KIT
Converts most 5¼" mini-floppy diskettes for dual-sided use. Punch and template for holes allowing both sides of disk to be used; only for diskettes whose reverse side is coated or burnished $10

TERMINAL DATA

LINE TESTER KIT
Pc board with 1 male, 1 female RS-232 interface; enables user to check all lines to see which ones are active; probe posts and an LED included.
Kit $39

PROGRAMMABLE LINE AND TERMINAL SIMULATOR
ASCII code generator, for checking terminals, ports and modems; also usable for burning in digital devices after construction. Kit/wired ..... $199/$349

TEXAS INSTRUMENTS

TI PROGRAMMER
Hexadecimal/octal/decimal calculator/converter. Converts numbers in base 8, 10, or 16 to either of the other bases, performs arithmetic in all 3 bases; mode indicator shows base in use; eight-digit capacity. Hex and octal use two's-complement arithmetic, one's-complement key-selectable; logical AND, OR XOR and Shift. Decimal base features signed floating-point arithmetic. Three-key memory stores, recalls or sums to memory contents; parentheses allow operation order to be specified, up to four pending operations. Can handle mixed bases, combined logical and arithmetic operations; constant mode for arithmetic and logical operations. With case, fast-charge batteries & charger $50

THINKER TOYS

WUNDERBUSS MOTHERBOARD (S1)
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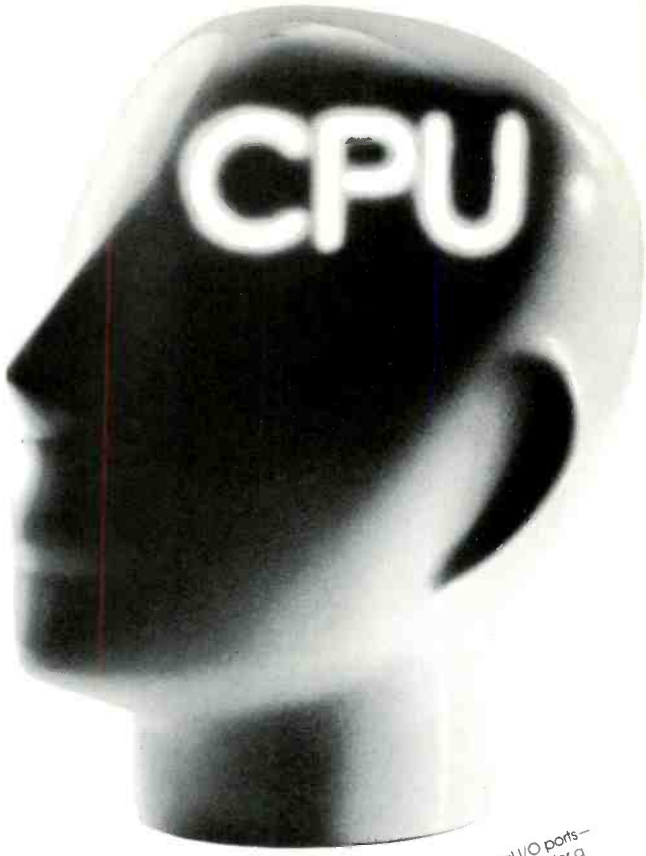

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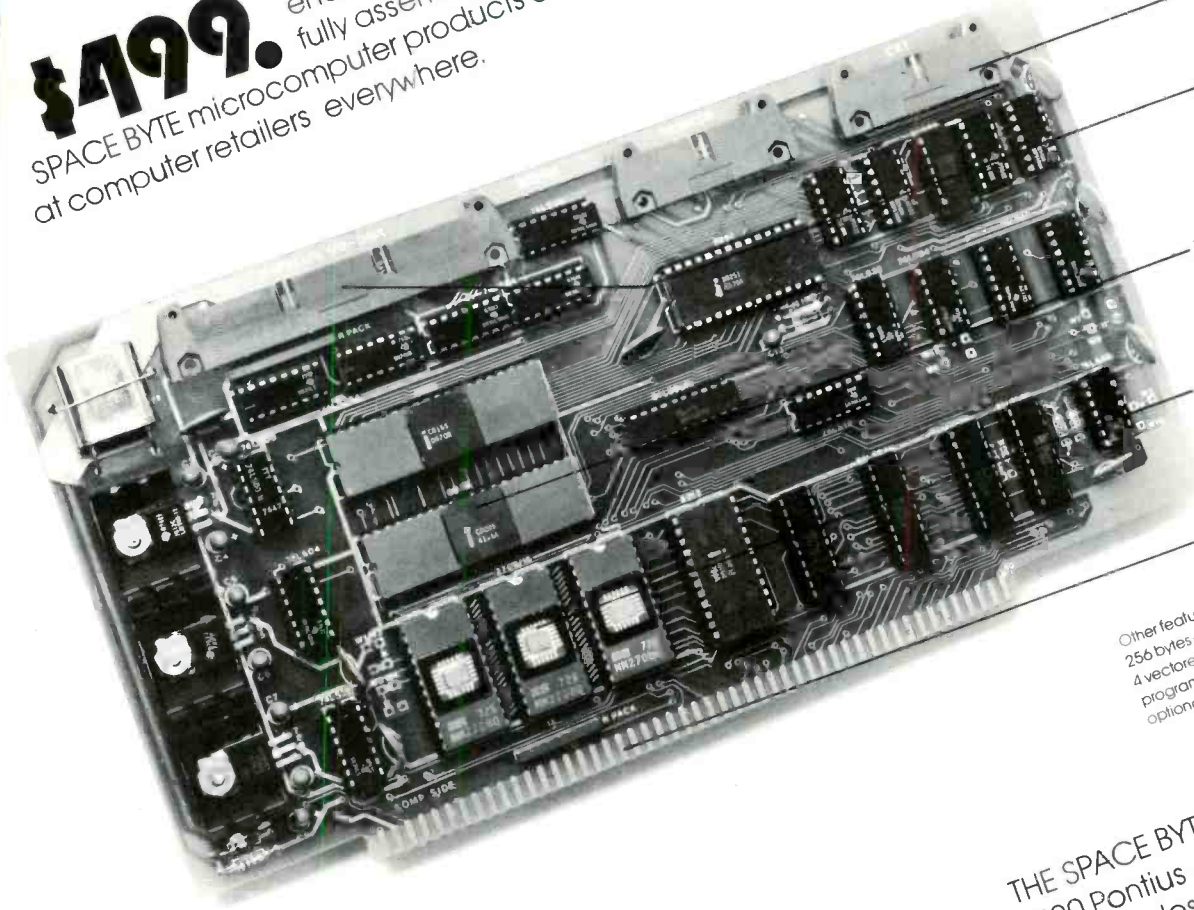

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Texas Residents add Sales Tax $_____
Shipping and handling, $5.00 per unit (USA only)* $_____
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Charge my Master Charge ☐
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