of vector graphics, alphanumerics, and television images. The terminals sell for \$3,900 each.

Ball Type Switches

Edwards Co. is marketing a ball-type switch priced at \$1.80 each. The switch operates when struck from any angle.

Small 16-Bit Minicomputer

A 16-bit minicomputer so small that it can be held in the palm of a hand has been developed for NASA by Teledyne Systems of Northridge, Calif. Only 0.1 in. high and 2.5 in. in diam, it weighs 25 g. The mini has a 47-instruction repertoire and 1,256 words of memory. Constructed on a three-layer ceramic substrate, it can add two 16-bit numbers in about 10 microsec according to the developers. The package contains about 35 integrated-circuit dice interconnected as a hybrid circuit. The unit has 120 edge-mounted terminals and is designed to fit in a planar configuration into a larger hybrid or printed circuit board. It will sell, according to Teledyne, for less than \$1,000 in large quantities and will come in several models. The present model is a parallel-processing microprocessor containing 256 words of RAM and 1,000 words of ROM. Multiplication time is 50 microsec.

ASR-38 Teletype

The RO Model 38 Teletype starts as low as \$937. The KSR Model 38 terminals begin at \$1,209. The ASR-38 terminals go for as low as \$1,452. For about \$200, any of them can be fitted with a built-in factory-tested modem.

Speed: 100 words/min is standard. Much faster speed is available. The Model 38 interfaces with the Teletype 4210 magnetic tape data terminal. It is also plug-to-plug compatible with the Model 33.

Teletype Corp.
Dept. 89N
5555 Touhy Ave.
Skokie, Ill. 60076

Inexpensive 16-Bit Minicomputer

Computer Automation has taken its Naked Mini/LSI, put it on a 15 x 16 in. printed circuit board, and priced it at \$990 with 4K memory (in quantities of 200).

16-Bit Microprocessor

National Semiconductor is claiming the first 16-bit microprocessor on a single card. Designated the IMP-16C, the system consists of a 16-bit microprocessor, clock system, I/O bus drivers, and 256 words of read/write memory on an 8.5 x 11 in. printed circuit card. The system is built from National's family of GPC/P (general purpose controlled/processor) LSI functional blocks. These building blocks are expandable for 4-, 8-, 12-, or 16-bit solutions, thus providing a

flexible alternative to solutions now presented by hardwired, fixed systems. IMP-16C can also be programmed. It uses a standard set of 42 instructions and can address up to 65,000 words of memory.

The microprocessor section consists of a register and arithmetic-logic unit (RALU) and a control and read-only memory (CROM). The RALU section has seven general-purpose registers and an arithmetic-logic unit. The logic can process a 4-bit slice of the total 16-bit functions. Four RALUs complete the 16-bit processing. The CROM stores the microprogram and the necessary control logic for the RALUs. It can implement the 42-microinstruction set.

The IMP-16C can interface with Teletype and control panels with software. Price: \$1,380 from National Semiconductor.

Notes

Ten-channel event recorder for long-term experiments*

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In operant experiments, it is desirable to obtain a graphic record of response performance. This permits equipment function to be checked rapidly and the development of progressive changes in response pattern to be followed. Although the cumulative recorder is the traditional choice for providing this information, a 10-station experiment concerning the self-administration of drugs by primates performing on a 24-h multiple schedule for several years produced more cumulative records than could be inspected. A more compact display was required for monitoring the experiments. A drum-type recorder that records up to 40 days of response from 10 stations simultaneously was devised.

CONSTRUCTION

As shown in Fig. 1, the recorder consists of 10 waxed paper, cold stylus event recorders mounted above a single drum that rotates once each 24 h. A carriage, consisting of a threaded rod driven by a one-revolution/day (RPD) motor and a bed made of an aluminum rod, transports each event pen a sufficient distance along the axis of the drum so that each day's response record lies directly adjacent to the previous day's record.

The recorder drum consists of a 9-in. Plexiglas cylinder with ¼-in.-thick Plexiglas ends held in place

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Fig. 1. A 10-channel drum recorder suitable for recording response information continuously for periods of 40 days.

with screws. Two Flexframe feet are used to attach the drum securely to the 40-in.-long Flexframe rod used as a drive shaft. The drum is supported by two self-aligning ball bearings and drive at 1 RPD by a synchronous

timing motor connected through a flexible tuning knob shaft.

The frame of the recorder was fabricated of two 9 x 12 in. aluminum plates, separated by four Flexframe rods mounted at the corners of the plates. A fifth rod is used as a bed to support the event pens above the surface of the recording paper.

The event pen carriage was fabricated from a 4-in. piece of 1/4-20 threaded rod mounted in 1/4-in. self-aligning ball bearings and driven by a 1-RPD motor.

Construction of the event recording pens is shown in detail in Fig. 2. The solenoid and stylus were obtained from a Simpson 10-channel event recorder and are obtainable as replacement parts. A C. H. Stoelting signal magnet with stylus serves as well with less modification required. A sheet metal bracket was fabricated, as shown in Fig. 2, to function as a bearing for one end of the stylus armature and to provide a lateral drive from the carriage screw. A threaded insert attached to the bracket by two jam nuts provides the lateral drive from the carriage. A glassware spring stretched between the threaded carriage and the stylus end of the recording pen allows the unit to move freely along the carriage while adjusting to variations in screw and drum contours.

Conventional Simpson recording paper is mounted on the drum and held in place with small pieces of masking tape. The cold stylus waxed paper record was selected for use because of its low maintenance, low cost, and freedom from inking problems. The paper is available with a variety of coordinates, making it possible to match indicated time with that obtained with the recorder.

Conventional timing motors are available in a wide range of speeds, permitting a drum rotation rate that exactly matches the period of the experimental cycle.

OPERATION

Figure 3 is a representative graph of nearly 90 days of

Fig. 2. Detail of the event pen and bracket used to provide carriage travel.

Fig. 3. A continuous record of the drug self-administration and free operant response made by a monkey for a period of 90 days.

responding obtained with one channel.

The dependent variable is the distribution of responses in time. Identifying legends attached to the left of the graph permits ready comparison of saline and drug effects. Drugs were identified by code number as part of a blind control condition.

It is apparent that the graph presented yields information about response distributions that would not be evident from daily response totals and that could not be conveniently obtained by most other methods of data presentation.

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An inexpensive, low-frequency function generator*

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In research on visual tracking, it is sometimes necessary to present a target that moves with varying velocities in a complex and erratic fashion (e.g., Steinbach, 1969). Complex analog equipment can provide the necessary voltages (Young, 1962, for example, used the sum of four sinusoids in his technique), but the simple technique described below is adequate for many studies and provides a function generator that produces repeatable, slowly varying voltages in any waveform the investigator chooses.

The apparatus is schematically illustrated in Fig. 1. It requires a light-dependent resistor (LDR, silicon, or cadmium sulfide cell)¹ with a mask over the LDR that has a narrow slit cut in it. A cardboard disk with the opaque function in polar coordinates cut on it is rotated by a motor (not shown in the figure).² A dc source of illumination is also required. The items are arranged so that the amount of light falling on the LDR is determined by the opening in the narrow slit which is not occluded by the opaque portion of the disk. The

LDR requires a separate dc source (a 6-V battery is usually sufficient); the amount of light falling on the LDR causes its resistance to be altered proportionally, and the potential changes can be read across the leads of the LDR.

The maximum height and depth of the cutout function are determined by the maximum diameter of the photosensitive surface of the LDR. The masking slit should be of the same length. It is usually necessary to experiment somewhat to find an orientation of the LDR under the slit that produces a response linear with respect to the amount of light passing through the slit. In my application, the generated potential changes were displayed as a moving spot on an oscilloscope that had the horizontal sweep disabled, and this provided the target to be tracked.

If an irregular waveform is used, cycle time or repetition rate will be determined by the rpm of the motor. The motor used rotated at 0.6 rpm; thus, it was 100 sec before the function repeated. The waveform was sufficiently irregular, however, so that the S was unaware of repeating cycles even after several minutes of observation. The top illustration in Fig. 2 shows the waveform resulting from the irregularly cut cardboard disk to the left of the function. It is possible to use any repeatable waveform (sine, square, triangle, sawtooth,

Fig. 1. Exploded view of the low-frequency function generator components.

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