ETI for Electronics & Computing Enthusiasts

$1.95 MM70924

# Electronics Today

INTERNATIONAL

May 1982

## Super Dice
PROJECT

Krypton cubes

## Faster Than Light Travel

D.I.Y. Time warp

## Optical Disc Records

Digital sound

## AF Signal Generator
PROJECT

Ride the waves

## LED Level Meter
PROJECT

A no-needle V.U.


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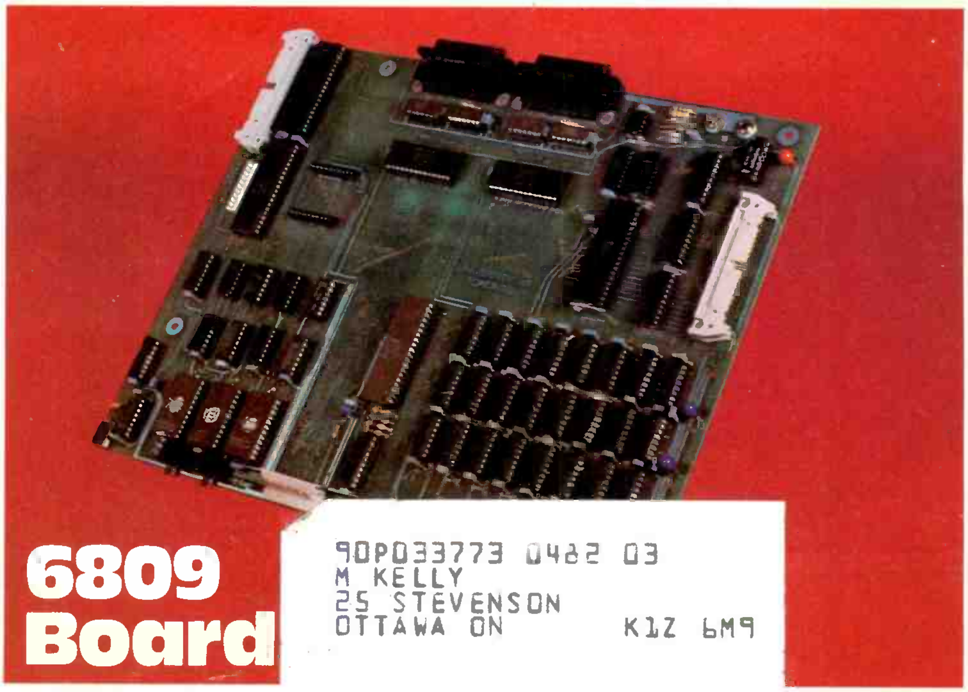


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OTTAWA ON K1Z 6M9

# What you should know about the Multiflex Z80A computer

**Excelltronix**
Components & Computing Inc.

**MULTIFLEX** is a young, fast-growing Canadian computer company. Most people have only just heard of us within the past year, because previous to that we were involved in intensive, low-profile research and development.

**THE Z80A SYSTEM** was developed over a two-year period. The company's intent was to produce a computer suitable for both hobbyists and industry, capable of functioning as a stand-alone trainer yet infinitely expandable. That goal has been attained, with the added benefit of a very low price.

**STAND-ALONE FEATURES** Selected for maximum usefulness and lowest cost, include the following:

**Separate motherboard and CPU card,** which communicate over the industry-standard S-100 bus. The motherboard can accommodate up to four S-100 cards.

**Space on the CPU card** for up to 4K of RAM and up to 16K of EPROM. The RAM is organized as two blocks of 2K bytes each, (200 nS 2114 devices are used) which can be located within any 2K block in the address-space by hardware jumpers. An 8K or 16K block size may be selected for the EPROMs and this, too, may be located at any address. 2708 and 2716 devices may be used exclusively or in combinations.

**A resident 3.5K Monitor** which facilitates machine-language program entry, execution and debugging, and controls all input/output hardware on the motherboard. The Monitor is in two 2716 EPROMs which may be removed and re-used if the user wishes to implement a more powerful operating system.

**A hex keyboard,** fourteen Monitor function keys, and two unassigned keys for user routines.

**A six-digit hex LED display** organized as a four-digit address field and a two-digit data field.

**An interface** to a conventional cassette recorder, which sends and receives data at 2000 bits per second with exceptional reliability. The Monitor includes a special routine which simplifies precise calibration of the recorder.

**An EPROM programmer** for 2708, 2716, 2732 and 2532 devices. The contents of any block of system memory may be written out to EPROM, and programmed EPROMs may also be read into RAM through the programming socket for duplication. Many industrial buyers have used Multiflex Z80A systems just to download data from larger computers, to be programmed into EPROMs.

**A parallel interface** based on the 8255 PPI chip. Twenty-four I/O lines are available, which can be programmed in several configurations.

**$369.** in kit form.

**$449.** Assembled & tested.

RS232 OPTION $25

**Read the independent review of this product in ETI May 1981.**

**EXTRA 2K OF RAM FREE THIS MONTH ONLY**

**Each Multiflex Kit will be serviced fast and for free**

*(Provided that the construction is reasonable)*

**An optional RS-232C serial interface,** already wired on the motherboard. The components for this may be purchased and installed at any time, allowing communication with a modem, printer, or other device using the RS-232C standard. Eight jumper-selectable baud rates are available, from 110 to 9600 baud.

**A 40-chip wire-wrap area** on the motherboard for custom hardware development or modifications. The wire-wrap plane is centrally located for easy access to bus signals and all I/O hardware.

**Available now (GOOD STOCK)**

**MULTIFLEX S100 64K MEMORY BOARD WITH REFRESH**
**USING THE 8202**
**INCLUDING 16K OF RAM (4116-200 ns)**

**SPECIAL**

**$295.00 KIT $379.00 ASS + T**

**MULTIFLEX S100 64K ECONORAM**
**USING 4164 (has no internal refresh and uses the Z80 refresh.)**

**SPECIAL**

**$169.00 KIT $250.00 ASS + T**

***THIS MONTH ONLY***

***SOON TO BE RELEASED BY MULTIFLEX***

**S100 IEEE COMPATIBLE CARDS**
at unbelievably low prices

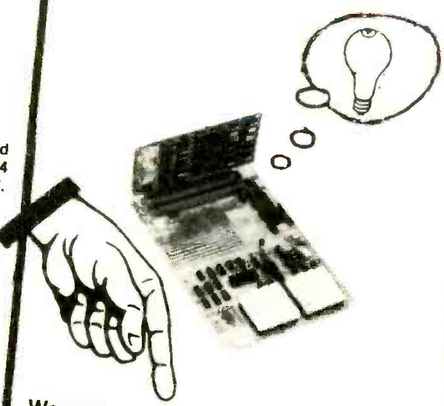
**CPU CARD**
Using Z80 A or B (6 MHz). 64K of RAM on board (4164). Serial port & parallel port 24, I/O lines. 4 Sockets for Eproms (2716, 2732, 2764) or 6116 RAM.

**MEMORY CARD**
256K of RAM (4164) with internal and external refresh

**FLOPPY CONTROLLER CARD**
Which can handle up to four 8", or 5¼" DS, DD drives and also has a provision for DMA

**SPECTACULAR VIDEO BOARD**

**COMPUTING CONTEST**



**We are computerizing our store and your suggestions could win you a prize! See page 28 for details**

***FOR ORDERING INFORMATION SEE OPPOSITE PAGE.***

master charge

CHARGEX

***If we run out of stock on any of these items at the time of your order, our superfast service will rush the items to you as soon as humanly possible.***

*Circle No. 7 on Reader Service Card.*

Circle no. 5 on Reader Service Card.

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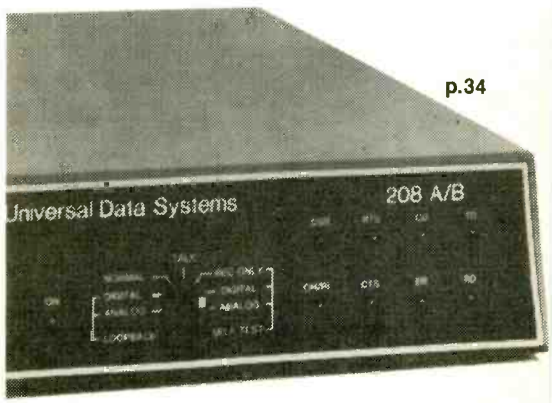
# Electronics Today INTERNATIONAL

## Features



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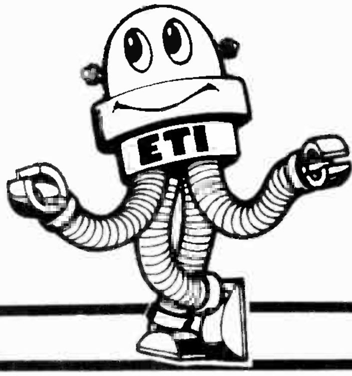


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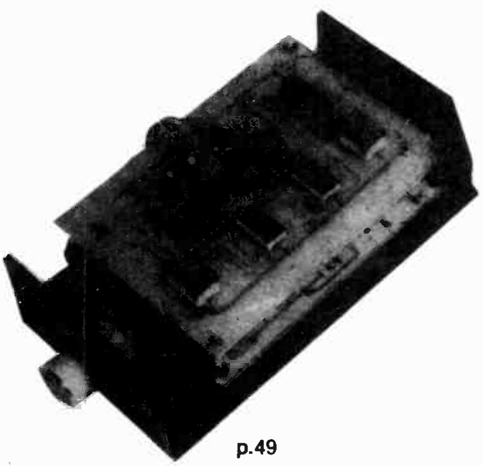
ISSN 0703-8984

# Projects




*Our Cover:*Since its discovery in the thirteen century, the Holy Shroud of Turin has been an object of interest of both theologians and men of science. Does it actually bear an image of the face of Christ? A look at the most recent investigations on page 13.



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# Columns, News and Information



## ADVERTISERS' INDEX



**Editorial Queries**
Written queries can only be answered when accompanied by a self-addressed, stamped envelope. These must relate to recent articles and not involve the staff in any research. Mark such letters ETI-Query. We cannot answer telephone queries.

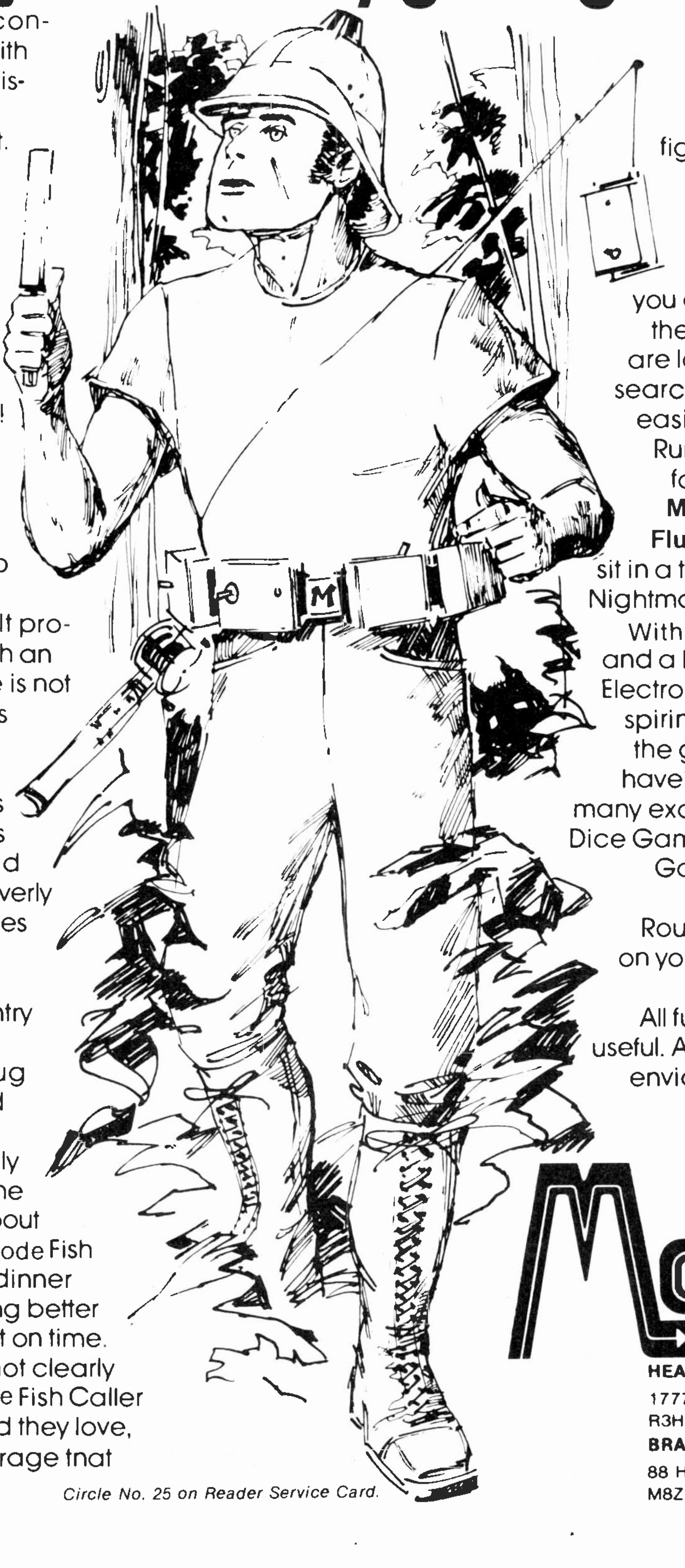
**Binders**
Binders made especially for ETI are available for $8.00 including postage and handling. Ontario residents please add provincial sales tax.

**Sell ETI and ETI Special Publications**
ETI is available for resale by component stores. We can offer a good discount when the minimum order of 15 copies is placed. Readers having trouble in obtaining the magazine could ask their local electronics store to stock the magazine.

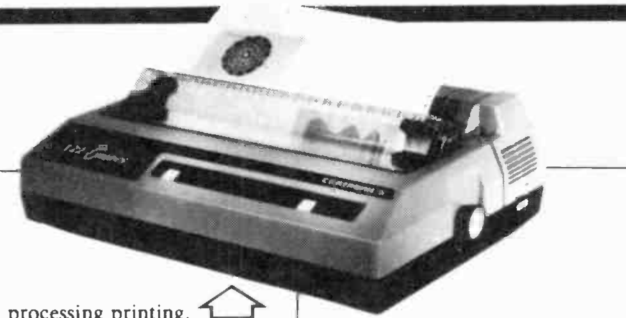
**Component Notation and Units**
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier: thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100nF, 5600pF is 5n6. Other examples are 5.6pF = 5p6 and 0.5pF = 0p5.
Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is the same, 4.7kohms is 4k7, 100ohms is 100R and 5.6ohms is 5R6.

**PCB Suppliers**
ETI magazine does NOT supply PCBs or kits but we do issue manufacturing permits for companies to manufacture boards and kits to our designs. Contact the following companies when ordering boards.
Please note we do not keep track of what is available from who so please don't contact us for information on PCBs and kits. Similarly do not ask PCB suppliers for help with projects.

K.S.K. Associates, P.O. Box 54, Morriston, Ont. N0B 2C0.
B&R Electronics, P.O. Box 6326F, Hamilton, Ont., L9C 6L9.
Wentworth Electronics, R.R.No.1, Waterdown,Ont., L0R 2H0.
Danocinths Inc., P.O. Box 261, Westland MI 48185, USA.
Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5V 2A5.
A-1 Electronics, 5062 Dundas Street W., Islington, Ont., M9A 1B9.
Beyer & Martin Electronic Ltd., 2 Jodi Ave., Unit C, Downsview, Ontario M3N 1H1.
Spectrum Electronics, Box 4166, Stn 'D', Hamilton, Ontario L8V 4L5.
Dacor Limited, P.O. Box 683, Station Q, Toronto, M4T 2N5.



# News



## Meter

Heath Company has introduced a low-priced portable digital multimeter. The IM-2260 measures voltages from one millivolt to 1000 Volts DC (or 750 Volts AC), with current measurement from one milliamp to 10 Amps. It can measure resistance from one ohm to 20 megohms. A special diode test function can check forward and reverse condition of diodes and other semiconductors.

State-of-the-art LSI (large scale integration) measuring circuitry is used in the IM-2260 to provide high-stability readings and

automatic polarity indication. Pushbutton switching adds extra convenience for users of the IM-2260 and built-in references are provided to help ensure accurate calibration. A large 3½-digit LED (light-emiting diode) display shows the values of all measurements.

Input protection is provided for all functions of the IM-2260. Voltage measurement circuitry is protected from signals up to 1000 volts. Most of the IM-2260's current measurement functions are protected by diode and fuse circuits. The IM-2260's resistance measurement circuitry is protected from up to 350 Volts. Fully isolated circuitry allows floating measurements up to 500 Volts (peak) from earth ground.

Measuring just 3" H x 8.5" W x 11" D (7.62 x 21.59 x 27.94 cm), the digital multimeter weighs less than three pounds (exluding batteries), and can draw operating power from several different sources: six 1.5 VDC carbon-zinc, alkaline or rechargeable nickel-cadmium "C" cells (not included) or 120 VAC, 60 Hz power with the optional Heath PS-2404 battery eliminator. A battery test circuit allows a direct check of battery condition. A built-in circuit recharges nickel-cadmium batteries.

The IM-2260 portable digital multimeter is mail order priced at $199.95. The optional PS-2404 battery eliminator is priced at $11.95. An assembled version of the IM-2260 digital multimeter is also available at $349.95 and like the IM-2260 is available from Heathkit Electronic Centres in Vancouver, Calgary, Edmonton, Winnipeg, Ottawa, Mississauga and Montreal.

## Printer

Centronics Canada Inc. has introduced the Model 122 graphics dot matrix printer, a heavy-duty 120 CPS desk-top printer which is ideally-suited for both data processing and business processing applications. It is a very cost effective printer for the small business systems, communications systems, and personal computer users who desire more speed, reliability, and/or features than are available on today's low-cost mini computer printers. At a suggested list price of $1635., the Model 122 offers many unique features not available on competitive products.

The Model 122 graphics printer provides all the standard features expected of an industrial grade, 132 column data processing printer, coupled with standard pin addressable graphics for business processing or design graphics applications. The user can select not only standard alpha numeric printing and pin addressable graphics, but also has the choice of six-pin or eight-pin graphics. This unique flexibility makes the 122 software compatible with the Centronics Model 739, giving the user a broad base of readily available software packages to perform applications, such as trend analysis, business graphics, pie charts, bar codes, CAD/CAM draft plots, as well as data processing printing.

Standard features of the Model 122 graphics include: 120 CPS bidirectional/logic seeking printing in monospaced alpha numeric mode, unidirectional/logic seeking printing in graphics mode, six or eight pin graphics, selectable forms length (from 3½" to 15½" in ½" increments), selectable lines per inch (6, 9 or 18 LPI), "clean hands" ribbon cassette, and seven resident international character sets.

For more information, contact Centronics Canada, telephone (416) 447-8591.

## Free Money

The Ernest C. Manning Awards Foundation is searching for an innovative Canadian who may be eligible for a $75,000 cash award.

The Foundation was established two years ago to promote the discovery, recognition, encouragement and rewarding of innovative people in Canada. It hopes to act as a positive force in Canada, encouraging Canadian innovators to develop their ideas within Canada, rather than taking them abroad.

Since its establishment, the Foundation has been involved in fund-raising activities to support the awards program, and has now collected more than $1,750,000 from private and corporate contributors across the country.

Now, the Foundation is set to grant its first annual $75,000 award. To accomplish this, it is inviting nominations from all Canadians. Those nominations will be examined by a selection committee, and the award recipient will be honoured at an awards dinner in Calgary in September of this year.

While there are no set categories for the award, the selection committee will pay particular attention to innovative ideas which are of benefit to a broad spectrum of Canadians. Foundation trustees have expressed a desire to receive significant numbers of nominations from the fields of the biological sciences, the physical sciences and engineering, the social sciences, business, labour, law and government and public policy.

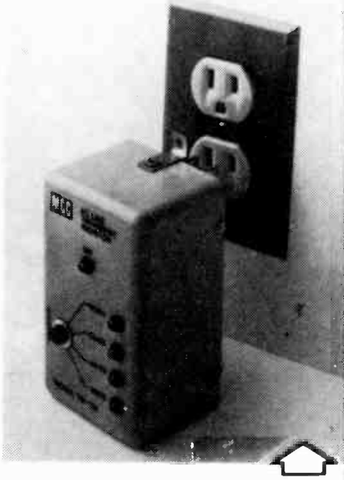
The deadline for nominations for the 1982 award is May 31. Nomination forms may be obtained by writing to: The Ernest C. Manning Awards Foundation, P.O. Box 2276, Main Post Office, Calgary, Alberta, T2P 2M6.

## Spelling Checker

Microproof dictionary software is now available on five CP/M formats: Osborne, Apple, Superbrain, Omikron, and the standard IBM 8" formatted disks.

Microproof checks word processed documents for spelling errors using a 50,000 word dictionary. The dictionary is extremely compressed and occupies only a third of a double density 5" disk. Additional words can easily be added to the dictionary. An optional correction feature is available that allows corrections to be made within the text without returning to the word processing program.

CP/M Microproof retails for $149.00 (also available for TRS-80 and Apple II at $69.50). The optional correction feature can be added for $60. for more information, write Cornucopia Software, 1625 Beverly Place, Berkeley CA 94707.



## Plug-in Monitor

Computers, word processors, electronic cash registers, and other microprocessor and microcomputer-based equipment, are extremely susceptible to damage from irregularities in AC line power known as "transients" and "surges". These irregularities are caused by lightning, or by large electric motors in elevators or heavy machinery using the same main power line, or even by nearby electric typewriters, copying machines or fluorescent lights.

The most common deleterious effects of these irregularities are loss of data or garbled information, and if any sensitive electronic device suffers consistently from these problems, the new Monitor produced by MCG Electronics, Inc., of Deer Park, NY, will determine whether the AC line power contains transients and surges that could cause them.

The Monitor is simply plugged into a standard 120 VAC outlet and left in place for a period of time. A green LED indicates that it is operating. If any surge or transient occurs in the power line of at least 200 V magnitude and 1/2 microsecond duration, the first of the four red LEDs on the face of the Monitor lights up and stays lighted. The other three red LEDs indicate that voltage in the line has reached 400 V, 600 V, or 800 V or more. A memory feature retains the transient data for 24 hours so that if the Monitor is accidentally unplugged, any LEDs that have been lit will go out, but will go on again when it is plugged back in. The LEDs can be turned off and the Monitor reset at any time simply by pushing the "reset" button.

According to the manufacturer, the Monitor is of greatest value in facilities using a large number of microprocessor-based devices, particularly if a large amount of electrical equipment is also used or if electrical equipment is operating nearby. The Monitor can then be moved from outlet to outlet to determine which, if any, are safe, which require protection, and how much protection each requires. It can also determine whether a newly installed machine will cause damage before it has a chance to do so.

The price of the MCG Electronics Power Line Monitor is $159. For more information, contact MCG Electronics Corp., 160 Brook Ave., Deer Park, N.Y. 11729.

## Graphics

Graphics Interface '82, the most comprehensive computer graphics event in Canada, is being held May 17 to 21, 1982 at the Constellation Hotel, Toronto, Ontario. Tutorials on topics of vital interest to computer professionals will be presented on May 17th and 18th. Graphics Interface '82 is co-sponsored by the National Computer Graphics Association of Canada (N.C.G.A.) and the Canadian Man-Computer Communications Society (C.M.C.C.S.) with support from the I.E.E.E. Computer Society, the Canadian Image Processing and Pattern Recognition Society and other professional societies.

For more information on the Conference, please contact Graphics Interface '82, 961 Eglinton Avenue East, Suite 200, Toronto, Ontario M4G 4B5, telephone (416) 424-4758/(416) 424-3482.

## Electrons Are Waves!

A basic experiment on the wave nature of electrons an experiment that has eluded physicists for fifty years has been accomplished at the IBM Research Laboratory in Zurich, Switzerland.

The experiment involves the 'tunneling' of electrons through a thin region of empty space, a vacuum, which they could not penetrate if they were the small, hard particles envisioned in classical physics.

The modern view of particles such as electrons, called quantum mechanics, was formulated in the late 1920s. Quantum mechanics treat such particles as having the properties of both particles and waves. As waves, when they encounter a barrier such as a vacuum they don't just bounce off, but penetrate a short distance into the barrier.

If the barrier is thin enough, some part of the wave penetrates it and appears on the other side as an electric current. This is called tunneling.

In addition to its scientific interest, electron tunneling in solids is the basis of a number of high-performance electronic devices such as the tunnel diode.

The Zurich experiments have, for the first time, unequivocally shown tunneling through a vacuum between two electrodes, one a needle point and the other a flat metal sample. Tunneling through a vacuum is difficult to observe because it occurs only over very small distances, a few angstroms (an atomic diameter is typically about three angstroms). The slightest vibration can ruin such an experiment.

## Phase-locked Loop

The XR-2213, a high stability phase locked loop system for tone detection and frequency synthesis, has been introduced by Exar Integrated Systems, Inc. The XR-2213 was designed for use in telecommunications equipment, such as dial tone detectors.

As a tone decoder, the XR-2213 can be externally adjusted for any tone in its range (0.01 Hz to 300 kHz). As a frequency synthesizer, the XR-2213 generates extremely stable frequencies. From one stable reference frequency such as a crystal, the XR-2213 can generate frequencies in much higher ranges. The XR-2213 features a wide supply voltage range of 4.5V to 15V.

The XR-2213 consists of a VCO that is highly stable with temperature, input preamplifier, phase detector, quadrature phase detector and high gain voltage comparator. The input preamplifier allows an input signal range of 2.0 mV to 3.0 V RMS, while the VCO and voltage comparator both provide Q and not Q outputs for greater flexibility and reduced external circuitry. All loop parameters are independently and externally adjustable.

For more information, contact EXAR Integrated Systems, Inc., 750 Palomar Ave., P.O. Box 62229, Sunnyvale, Ca., 94088.

## Fiber Optic Connector

Switchcraft, Inc. has announced what it calls a "breakthrough in low fiber optic connector attenuation" — 0.3 dB typical with 0.6 dB max. value.

The new Switchcraft connectors provide assurance of the lowest attenuation capability available at this time, and this contributes to the fiber optic systems' overall transmission effeciency. Switchcraft *Fiber-Conn* fiber optic connectors are specially designed for easy assembly and maintenance; terminate to standard cables; are self-compensating and self-extracting, and provide data links up to 50 meters. Longer links are possible on special order.

The new connector package offers options of customer assembly or individual connector components or custom assemblies supplied by Switchcraft. It also includes a customized tool with instructions to aid technical personnel in assembling the connectors to cables. Switchcraft *Fiber-Conn* components include connectors, couplers and receptacles. When used with standard fiber optic cables, a wide variety of connection configurations with low attenuation are possible. Connectors mate with couplers and receptacles; receptacles may be panel or chassis-mounted.

Inside the receptacle is a provision for mounting a semiconductor light source or detector. The unique Switchcraft coupler has an inner compensating spacer which automatically adjusts mating gap to .001 inch (2.54 mm). Precise control of gap and tolerance permits low, repeatable attenuation values.

Switchcraft Inc. is represented in Canada by Atlas Electronics Limited, 50 Wingold Avenue, Toronto, Ontario, with branch offices in Montreal, Winnipeg, Edmonton, and Vancouver.

## Microcomputer Sales Boom

Sales of microcomputers will top $250 million in Canada during 1982, a 250% increase over 1981. Rese figures are reported in a recently published study done by Evans Research Corporation, a Toronto Company.

Other figures of interest are that there are now 200 computer stores in Canada, 47 of them Radio Shack Computer Stores. 60% of microcomputer sales are to small businesses, the remaining 40% being purchased by hobbyists, education and large business.

## 'Scope

Hameg has announced a general-purpose oscilloscope, HM705, with a variety of operating modes and trigger facilities designed for both laboratory and field service. A maximum Y sensitivity of 2mV/cm at full bandwidth shows the performance of the vertical amplifiers. The HM705 triggers even complex signals beyond 100MHz. Two non-synchronous signals, or a composite signal with a non-synchronous component, and also aperiodic events can likewise be triggered. Single-shot operation is also possible. The wide sweep range from 5 ns/cm (including x10 magnification) to 2.5 s/cm gives excellent resolution. Additionally, it is possible to expand short signal periods by a factor of 1000 using the sweep delay. Several LED's facilitate easy handling and help prevent incorrect setting. The 14kV CRT with rectangular screen and internal graticule ensures an extremely bright and well-defined display.

These features and others make the HM705 an instrument of great flexibility in all fields of communications, consumer and industrial electronics.

For more information, contact BCS Electronics Ltd., 980 Alness St., Unit 35, Downsview, Ont., M3J 2S2, telephone (416) 661-5585.

# TEK 2213/15

## INSTRUMENT SPECIFICATIONS

### PRODUCT SPECIFICATIONS

### VERTICAL DEFLECTION
(2 Identical Channels)

**Bandwidth* and Rise Time** - (at all deflection factors from 50 Ω terminated source). * Measured at - 3 dB.

| 0° C to +40° C | +40° C to +50° C |
|---|---|
| Dc to 60 MHz, 20 mV/div to 10 V/div, 5.8 ns reduced to 50 MHz for 2 mV to 10 mV/div, 7 ns | 50 MHz, 7 ns |

**Deflection Factor at BW** - 2 mV/div to 10 V/div ±3% (+20° c to +30° C) or ±4% (0° C to +50° C). 1-2-5 sequence. Uncalibrated, continuously variable between steps to at least 25 V/div.

**Vertical Display Modes** - CH1; CH2; CH2 ADD (normal and inverted), alternate, chopped - approx 250 kHz rate, electronically switched.

**CMRR** - Common-mode rejection ratio at least 10:1 at 10 MHz for common mode signals of 6 divisions or less.

**Input R and C** - 1 MΩ ±2% paralleled by approx 30 pF.

**Max Input Voltage**
Dc coupled 400 V (dc + peak ac)
800 V (p-p ac at 1 kHz or less)
Ac coupled 400 V (dc + peak ac)
800 V (p-p ac at 1 kHz or less)

**Delay Line** - Permits viewing leading edge of displayed waveform.

### HORIZONTAL DEFLECTION

**Time Base A** - (Both 2213 and 2215) — 0.05 μs/div to 0.5 s/div (1-2-5 sequence). 10X mag extends max sweep rate to 5 ns/div.

**Time Base B** - (2215 only) — 0.05 μs/div to 50 ms/div (1-2-5 sequence). 10X mag extends max sweep rate to 5 ns/div.

**Variable Time Control** - Time Base A (both 2213 and 2215) provides continuously variable uncalibrated sweep rates between steps to at least 1.25 s/div.

**Time Base A (both 2213 and 2215) and B (2215 only) Accuracy, center 8 divisions** -

| | +20° C to +30° C | 0° C to +50° C |
|---|---|---|
| Unmagnified | ±3% | ±4% |
| Magnified | ±5% | ±6% |

**Horizontal Display Modes (2213)** - A, A intensified after delay, delayed.

**Horizontal Display Modes (2215)** - A, alternate (A intensified by B and B), B. Electronic switching between intensified and delayed sweep.

### 2213 SWEEP DELAY

**Delay Times** - Less than 0.5 μs, 10 μs, and 0.2 ms.

**Multiplier** - Increases delay time by 20 to 1 or more.

**Jitter** - 5000 to 1 (0.02%) of maximum available delay time.

### 2215 SWEEP DELAY

**Delay Times** - Continuously variable by means of a 10 to 1 vernier control. Delayed (B) portion is intensified on the main (A) trace.

**Delay Position Range** - Less than 0.5 to more than 10 divisions.

**Delay Dial Accuracy** - ±1.5% of full scale.

**A/B Sweep Separation** - Control permits main and delayed sweep to be separated by at least 3.5 divisions.

**Jitter** - 10,000 to 1 (0.01%) of maximum available delay time.

### TRIGGERING

**2213 and 2215 A Time Base**

**Trigger Modes** - Normal (sweep runs when triggered), automatic (sweep runs in the absence of a triggering signal and triggers automatically for signals down to 20 Hz), and tv field (with slope set for negative going transitions, and trigger level adjusted close to blanking level, sweep starts at first line of video; use NORMAL for tv line display). LED indicates when sweep is triggered.

**A Trigger Holdoff** - Adjustable control permits a stable presentation of repetitive complex waveforms.

**Sensitivity** - Auto and Normal Internal: Below 5 MHz, signal must be at least 0.4 divisions amplitude; requirements increase above 5 MHz; at 60 MHz, signal must be at least 1.5 divisions amplitude.

Auto and Normal External: Up to 5 MHz, trigger signal must be at least 50 mV p-p; requirements increase up to 60 MHz, where signal must be at least 250 mV p-p.

TV Field: Composite video must be at least 2 divisions amplitude.

**Level and Slope (NORM Mode)** - Internal: Trigger level can be adjusted over the range of amplitudes displayed on the CRT. External, dc coupled: level can be adjusted over a range of at least ±2 V, or 4 V peak-to-peak. External, dc coupled and attenuated (÷ 10): level can be adjusted over a range of at least ±20 V, or 40 V peak-to-peak.

**External Inputs** - R and C approx 1 MΩ paralleled by approx 30 pF. 400 v (dc + peak ac) or 800 Vac peak-to peak at 1 kHz or less.

**2215 Delayed (B) Timebase**

**Level and Slope** - Separate slope and level controls for triggering B sweep.

**Sensitivity** - Up to 5 MHz, signal must be at least 0.4 divisions in vertical amplitude; requirements increase up to 60 MHz, where signal must be at least 2 divisions in amplitude.

### X-Y OPERATION

**Full Sensitivity X-Y (CH1 Horiz, CH2 Vert)** - 2 mV/div to 10 V/div, accurate ±5%. Bandwidth is dc to at least 2 MHz. Phase difference between amplifiers is 3° or less from dc to 50 kHz.

### DISPLAY

**CRT** - 8 x 10 cm display. Horizontal and vertical center lines further marked in 0.2 cm increments. P31 phosphor standard. 10 kV accelerating potential, mesh grid, halo suppressed.

**Graticule** - Internal, non-parallax, not illuminated.

**Beam Finder** - Compresses trace to within graticule area for ease in locating an off-screen signal. A pre-set intensity level provides a constant brightness.

**Z-Axis Input** - Dc coupled, positive-going signal decreases intensity; 5 V p-p signal causes noticeable modulation at normal intensity; dc to 5 MHz.

### ENVIRONMENTAL CAPABILITIES

**Ambient Temperature** -
Operating: 0° C to +50° C.
Nonoperating: -55° C to +75° C

**Altitude** - Operating: to 15,000 ft; max allowable ambient temperature decreased by 1° C/1000 ft from 5000 to 15,000 ft. Nonoperating: to 50,000 ft.

**Vibration** - Operating: Test samples were subjected to sinusoidal vibration in the X, Y, and Z axis with the frequency varied from 10 Hz to 55 Hz to 10 Hz in one minute sweeps for a duration of 15 minutes per axis and a dwell of 10 minutes at 55 Hz. Total displacement was 0.015 inch peak-to-peak (2.4 Gs at 55 Hz).

**Shock** - Operating and nonoperating: Test samples were subjected to 3 shocks, both directions along each axis for a total of 18 shocks. Peak accelerations of each half-sine shock was 30 Gs.

**Humidity** - Operating and non-operating: Test samples were subjected to 5 cycles (120 hours) of humidity testing.

### OTHER CHARACTERISTICS

**Probe Adjust Signal** -
Square wave, 0.5 V ±20%, 1 kHz ±20%.

**Power Requirements** - 90 to 250 V, 48 to 62 Hz without range switching, 50 watts max at 115 V and 60 Hz.

**Cabinet Dimensions** -
Height: 137 mm (5.4 in) with feet and handle.
Width: 327 mm (12.9 in) without handle; 360 mm (14.2 in) with handle.
Depth: 445 mm (17.5 in) with front cover; 440 mm (17.3 in) without front cover; 511 mm (20.1 in) with handle extended.
Weights: 7.6 kg (16.8 lb) with cover, accessories, and pouch; 6.1 kg (13.5 lb) without cover, accessories, and pouch; 8.2 kg (18 lb) domestic shipping weight.

### INCLUDED ACCESSORIES

Two P6120 10X voltage probe packages with two IC grabber probe accessories (013-0190-00).

### ORDERING INFORMATION

**2213** Dc to 60 MHz dual trace, single time base oscilloscope with delayed sweep.

**2215** Dc to 60 MHz dual trace, delayed alternate time base oscilloscope.

**Power Cords** -
Standard: 110 Vac North American plug
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Option A2: United Kingdom Power Plus (240 V).
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Option A4: 240 V North American Plug.

### OPTIONAL ACCESSORIES

Cover and accessory pouch (020-0672-00); viewing hood (016-0566-00); C-5C Opt 04 scope camera, Model 200C SCOPE-MOBILE® cart; Rack Adaptor Kit 016-0466-00.

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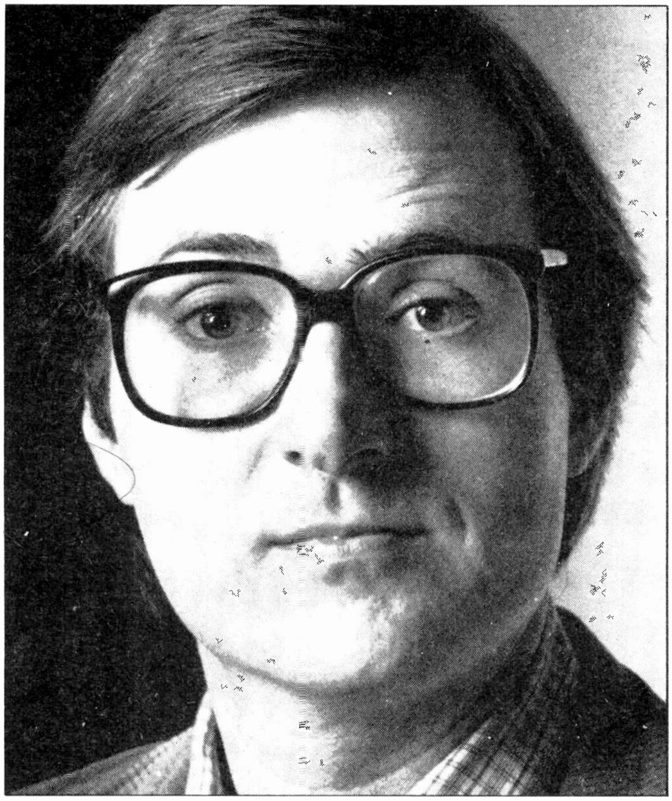
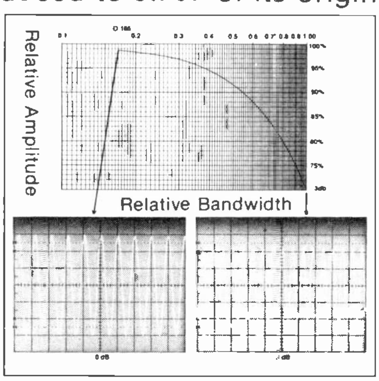


# Why do I need a 60 MHz scope? Won't any 10 MHz scope do?

Remember that the bandwidth specification of an oscilloscope represents the bandwidth at which the voltage amplitude of a sine wave is reduced to 0.707 of its original voltage.




10 MHz sine wave measured on a 60 MHz scope.

The same 10 MHz sine wave as measured on a 10 MHz scope.

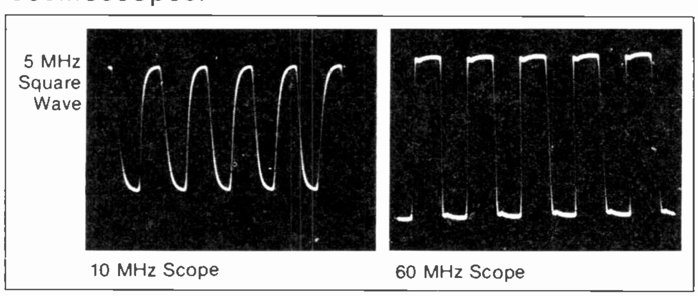
**Bandwidth is the frequency at which a scope can display a sine wave with a 30% reduction in signal amplitude with respect to a known standard.**

This means that if you try to make an amplitude measurement of a 1 volt, 10 MHz sine wave on a 10 MHz oscilloscope, what you will actually measure is 0.7 volts. This amounts to an error of 30%. Most scopes are capable of making voltage amplitude measurements with a typical accuracy of 3%, but only if the bandwidth of the signal being measured is about 1/5 or less the bandwidth of the scope. With a 10 MHz scope, you can observe and measure 2 MHz sine waves with confidence. With a 60 MHz scope you can make accurate amplitude measurements on 12 MHz sine waves.

Also remember that only sine waves still look like sine waves after passing through a low pass filter (like the amplifiers of an oscilloscope.) Any other wave shape will be altered to look like a sine wave. A 10 MHz square wave, viewed on a 10 MHz oscilloscope will look like a sine wave.

This is because a square wave, or any pulse for that matter, has much higher frequency components than just its fundamental frequency. These high frequency components go into making the high speed transition, or pulse edge. As the speed of the square wave approaches the speed of the oscilloscopes amplifier circuits, this edge transition time becomes a significant portion of the period of the signal, until eventually, the square wave is rounded off to look like a sine wave.

This last point is particularly important when working on digital electronic circuits, where edge to edge timing measurements can be critical. Todays microprocessor clock rates are pushing 5 MHz, and the trend is towards ever greater speeds. To get an accurate representation of the signals with todays speeds, you need a scope with at least a 35 MHz to a 45 MHz bandwidth. The speed of digital circuits a few years from now will demand 60 MHz oscilloscopes.

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# Shroud of Turin

**Since its mysterious appearance in the fourteenth century, the piece of linen cloth with the strange image of a crucified man, now known as the Holy Shroud of Turin, has elicited awe, disbelief, scepticism, and scientific curiousity. Its history and its authenticity are, as one scientific punster put it, "shrouded in mystery". This article fills in some background on the Shroud, including its known and conjectured history and the conclusions—or lack of them—of scientific investigations up to the latest scientific enquiry of 1978.**

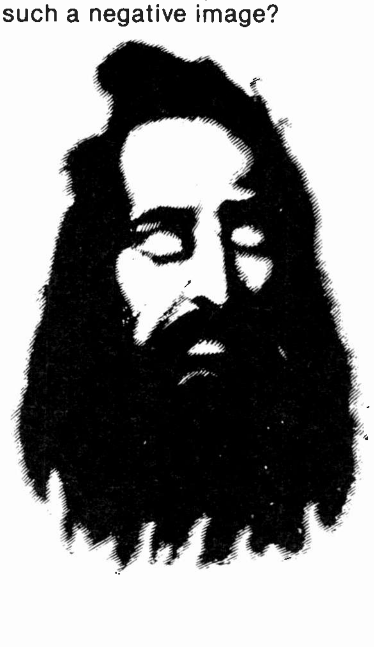
THE HOLY SHROUD of Turin is kept, well wrapped in silk, asbestos and lead, in the Royal Chapel of Turin's Cathedral of St. John the Baptist, which has been its home since 1578. Officially the property of the House of Savoy, former rulers of Italy, the Shroud has for centuries been equally jealously guarded by the Catholic Church, who have seldom allowed it to be viewed by the general public and have consistently shown resistance to scientific examination which might prove, once and for all, whether the Shroud is at least authentically from the time of Christ, or whether it could be the work of a mediaeval forger. Even on its first appearance in the West in the fourteenth century there were doubters of its authenticity, notably Bishop Henry of Pitiers around the middle of the century, and some years later the bishop of Troyes, Pierre d'Arcis, both of who tried to stop the exposition of the Shroud on the grounds that it was not genuine.

This cloth that has caused so much controversy is a piece of linen a little over 14 feet long and about a yard wide — in excellent condition considering its supposed age — which bears on it an image, formed by some unknown means, of a crucified man. The man appears to have been laid on his back on the cloth, which was then folded over his head to cover his front, since there is a complete image of both the front and back of the body.

The man of the image was about 181 cm (5 ft.,11 in.) — tall for his supposed time, not impossibly so — with a powerful and well-proportioned physique. A leading ethnologist has described him as "of a physical type found in modern times among Sephardi Jews and noble Arabs", and his age has been estimated as between 30 and 45. There is a good deal of evidence that this man was a crucifixion victim, and there are also traces of what could be taken to be blood spilled due to the Crown of Thorns, the scourging, etc. that Christ is said to have undergone.

## Scientific Investigation

True scientific investigation of the Shroud really only started in 1898, when Secondo Pia used the new science of photography to take pictures of the Shroud — and discovered that the image was a negative one. Instead of the masklike, ghostly appearance of the Shroud, the man stood out on photographic negatives as a positive, lifelike image — especially the face. This discovery alone makes the likelihood of the Shroud's being an artist's forgery much more remote; it would be practically impossible for any artist to reproduce tones that are the reverse of all he has learnt to depict in nature, especially without the photographic means of checking his work. Besides, who would want to produce artificially such a negative image?



Medical men have also shown a good deal of interest in the Shroud. They claim that the anatomical data of the image would be far beyond the capabilities of any fourteenth century artist, judging from what contemporary works show us of the prevailing knowledge of anatomy. They also deduced from experiment that a crucifixion victim would have to be nailed through the wrists, as is the man of the Shroud, since the palm of the hand would not be strong enough to bear the weight of the body. Subsequent discovery of a crucified man proved them to be right — but would a mediaeval forger have known this, considering that all contemporary portrayals of the Crucifixion show nails through the hands?

Angles of blood flow also indicate crucifixion, and markings on the forehead and in the side would correspond exactly with wounds Christ is said to have received.

In tests done before 1978, no trace of pigments has been discovered, as would be expected if the Shroud were the work of an artist. As well, it has been discovered that whatever caused the image has not penetrated right through the fibre of the linen, nor has it encrusted between the fibres. This would also seem to rule out paint, or any kind of 'wet' process of image-formation.

Analysis has been made of the weaving of the linen to try and trace its origins. Whilst the style — a three-to-one herringbone twill — is unusual in linen, it is by no means unique, and could certainly come from first-century Palestine. While the linen was being examined, minute traces of cotton were also found, suggesting that the linen had been woven on equipment also used for the weaving of cotton. By analysing the species of cotton, scientists determined that it originated from the Middle Eastern area. Whilst a forger might have gone to the length of obtaining a piece of linen from this precise area, it is one more piece of evidence pointing towards the authenticity of the Shroud's provenance.

Up till 1978 scientists had been unable to identify any actual blood on the Shroud; it has been conjectured tha either the age of the cloth or the fire and water damage it sustained in the sixteenth century might account for this, but since there is in any case no sign of penetration of any liquid into the cloth, it is arguable that scientists might perhaps not expect to find traces of actual blood.

The Shroud was also subjected to pollen-testing by means of removing surface particles from it on pieces of sticky tape. Dr. Max Frei of Switzerland in this way determined four predominant areas where the Shroud had been in its history: near to the Dead Sea in Palestine; in the area of the Anatolian steppe; Istanbul; and Northern Europe. The latter corresponds to our knowledge of the Shroud's history, but the other areas could offer vital clues to its earlier existence.

One important test that has not yet been carried out is carbon dating, which could tell us the age of the cloth to within ±100 years. This has until recently been resisted by the Church as it would have necessitated large areas of the cloth being destroyed, but now that carbon dating techniques have advanced, minute threads are enough to enable a dating, and the Church has at last given permission for this to take place.

In recent research using image-intensifying and other equipment associated with the American space project, scientists have come to the conclusion that the image must have been created at a distance by some form of emanation, rather than by contact. This was borne out when, using an Interpretation Systems VP-8 Image Analyser, the image was shown to contain perfect three-dimension information. An ordinary two-dimensional picture or photograph does not contain enough information relating to distance and proportions to be immediately translateable into a meaningful 3-D image. The fact that the Shroud image does must add considerably to the likelihood of its not having been the work of an artist.

**The Shroud's History — Known and Conjectured**

The Shroud appeared in Western Europe in the mid-1350s as the property of a chivalrous but poor French knight, Geoffrey de Charny. How it came into his possession has never been explained, but he (or more probably his widow Jeanne de Vergy) was responsible for its first exposition. It passed from him to his son, also Geoffrey, and then to his granddaughter, Margaret, who finally entrusted it to the keeping of the House of Savoy in 1453. The Shroud was damaged by fire and by the water used to douse it in 1532, and although the triangular patches so evident on all photographs were necessary to repair the cloth after this, the image itself received little damage.

The prior history of the Shroud is unclear. There is a legend, substantiated by some ancient writings, of King Abgar V of Edessa (a prosperous town beyond the borders of the Roman Empire) having corresponded with Christ and later, after Christ's death, having been presented by a disciple, Thaddeus, with some kind of holy or miraculous image of Christ's face. When some years later a king who was hostile to Christianity succeeded to the throne, this 'image' was hidden in a bricked-up niche in one of Edessa's city gates, where it remained, hermetically sealed and beautifully preserved, until around the year 525.

By the time of its rediscovery Christianity was well established in both eastern and western Europe, and the image was immediately revered and worshipped as being an image of Christ 'not made by hands'. It was accredited with miraculous protective powers, and many copies were made of it. The strange thing about the image, which came to be called the Mandylion, was that in many details it resembles exactly the face on the Shroud.

There is no account anywhere in the Gospels of what Christ looked like, and until about the sixth century there had been no tradition or consensus of opinion about this in art. However, around the sixth century likenesses of Christ which correspond in too many details for coincidence to the image on the Shroud start to appear in both Byzantine and western art. They date from the discovery of the Mandylion, supposedly an image 'not made by hands', which would therefore be regarded as the definitive true image of Christ, but they are also identical to the image of the Shroud. Wilson draws the obvious conclusion: the Mandylion and the Shroud are one and the same.

His conjecture is further substantiated by the fact that the Mandylion disappeared from Constantinople (where its home had been since 944) during the sack of the city by the Crusaders in 1204, and has never been rediscovered since. Wilson speculates that the Mandylion/Shroud could have fallen into the hands of the Knights Templar, a religious and chivalrous orgainisation which was finally quashed by Philip the Fair of France. The Templars were reputed to have strange religious and initiation ceremonies which included the worship of a 'head' — an image of some kind. This of course laid them open to the charge of heresy, and Philip delivered them not unthankfully to the Inquisition wilst pocketing their considerable wealth.

The treasury of the Templars had been at Acre, on the eastern Mediterranean coast (close to the Gospel areas); from there it had moved to Cyprus and thence to Paris, but the 'image' or 'head' they were said to worship was never found. Descriptions of it, however, make it sound distinctly like the image on the present-day shroud: it was said to be blurry, pale, indistinct, and many of the features, e.g., the forked beard, correspond exactly.

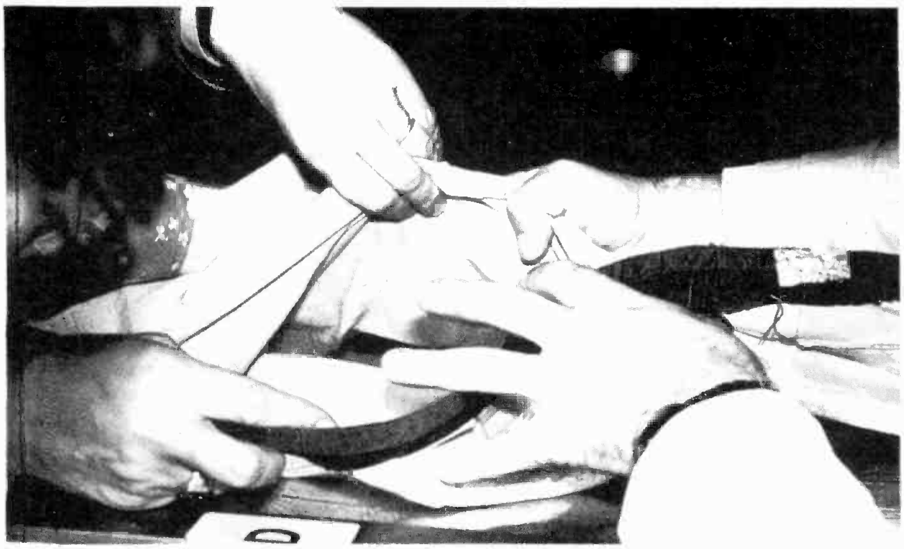
In 1314 the Templars' Master of Normandy, one Geoffrey de Charnay, was burnt at the stake in Paris; some 40 years later the shroud as we know it turned up in the possession of Geoffrey de Charny. It does not seem unreasonable to conjecture some kind family relationship — the spelling of the name was irrelevant in those days — whereby Geoffrey de Charny came into possesson of the Shroud. It would also explain his family's reluctance to explain where the Shroud came from; de Charny would not wish to be accused of heresy as a Templar.

Whilst this conjectural history of the Shroud is pretty convincing, it must be emphasised that it works from the premise that the Shroud is genuine. If one wishes to look at it another way, the theory also gives us a fair amount of evidence to suppose that the Shroud could be a copy of the Mandylion. . . if the scientific evidence didn't seem to be against the Shroud's having been the work of an artist.

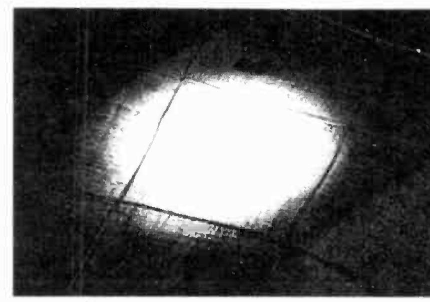
# Images of the Shroud

(Left to right) Dr. Ray Rogers, Dr. John Jackson (American scientific team) and Professor Giovanni Riggi (Turin, Italy) take their first glimpse of the underside of the Shroud as Professor Luigi Gonella (representing the Archbishop of Turin) looks on. © *1978 Barrie M. Schwortz*

Reflected light close-up of #3 bloodstain on the forehead of the frontal image, with a 6 cm grid placed over that area of the Shroud for size reference. © *1978 Barrie M. Schwortz*

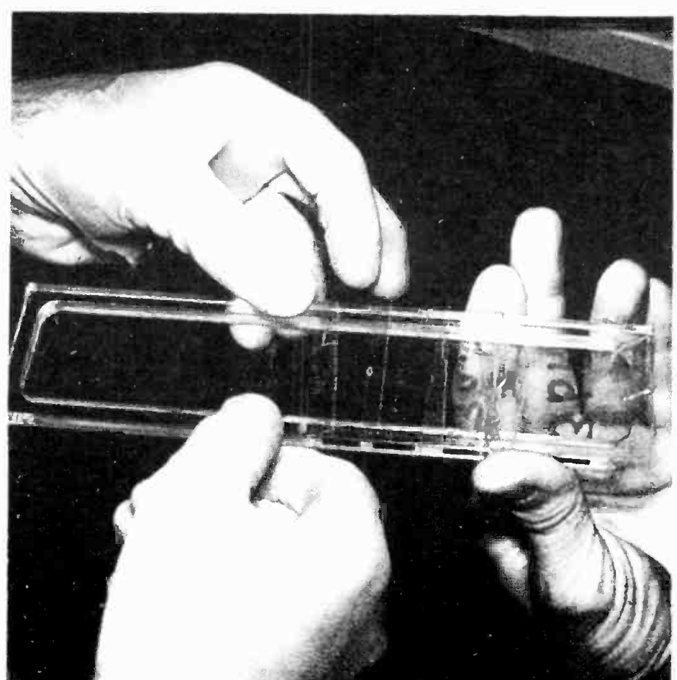


Scientists eagerly examine the underside of the Shroud, seen for the first time in 400 years. This is the first photograph taken of the underside of the Shroud. © *1978 Barrie M. Schwortz*



#3 bloodstain of the frontal image of the Shroud viewed with transmitted light. This is the first photograph of the Shroud of Turin with transmitted light, showing the comparative density of a bloodstained area versus image area. © *1978 Barrie M. Schwortz*

(Left to right) Chemist Ray Rogers (American scientific team) looks on as Swiss criminologist Dr. Max Frei takes a tape sample of the Shroud. Rogers took 36 tape samples for the American team. © *1978 Barrie M. Schwortz*

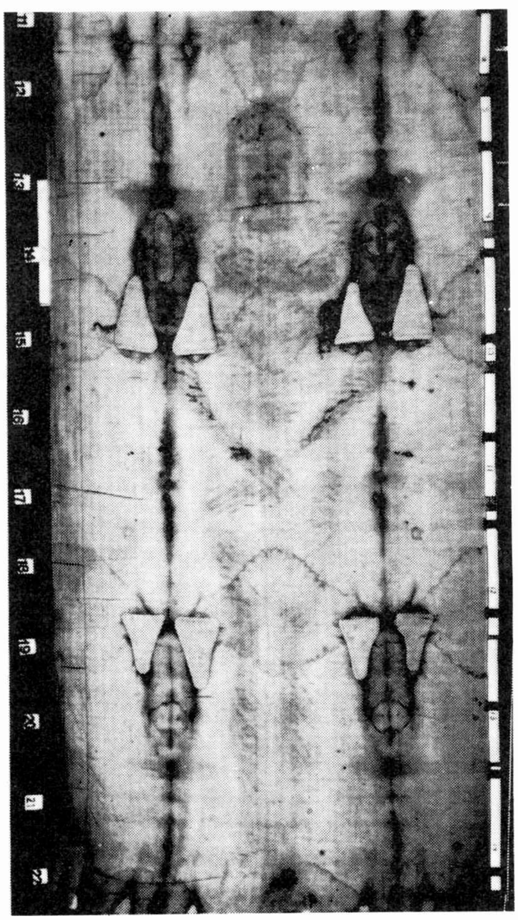


Tape samples taken from the surface of the Shroud are placed on specially sterilised glass plates. © *1978 Barrie M. Schwortz*

The Shroud is removed from the backing board, which it had been fastened to for public display, by two of the Poor Clare nuns who are responsible for care of the Shroud. In rear pictured left to right: Gabriele Porratti (Italian scientific team) and Don Devan (American scientific team). © 1978 Barrie M. Schwortz

# Images of the Shroud

When the right arm is positioned as it would have been during the crucifixion the blood flows are clearly seen to be vertical. Note the wound in the wrist, presumably from being nailed to the cross, *not* through the hand as traditionally depicted. © 1978 Barrie M. Schwortz



Photographs of the frontal image on the Shroud taken with reflected light. This is how the Shroud appears under normal viewing conditions.
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## Question of Authenticity

When talking of the Shroud's authenticity, it must be emphasised that we are talking about whether or not it originates from the first century A.D., and whether or not the image was 'made by hands'. Science will never be able to prove or disprove conclusively whether it was Christ's body that caused the image to be formed or not; that must be left to the speculation of religion.

There are, however, many scientific findings which indicate that the Shroud is not a fourteenth century artistic forgery: the lack of pigments found, the absence of any penetration of the fibres or the spaces between fibres, the consistency of the weaving and the cotton particles with the Middle Eastern area around the first century, the anatomical evidence of the crucifixion and the pollen samples from Middle Eastern areas, notably around the Dead Sea, as well as from Constantinople and Europe. These pollen samples also substantiate Wilson's theory that the Shroud spent some time in Edessa, which is in the region of the Anatolian steppe.

There is also the question of the means of image formation, the aspect of the Shroud which scientists study with the most interest; even if it was man-made, we still have no idea of the process.

## Pollen samples

In the 1973 tests sticky tape was pressed on the Shroud to remove dust and any other particles which adhered to it. It was found that pollen grains were present not only from plants found in France and Italy, but also from those found in Palestine and in saline regions such as the Dead Sea. This may give some general indication that the Shroud had at one time been in the region of Palestine, but it cannot prove this, since pollen can be carried very long distances by various means (birds, winds, etc).

## Three dimensions

In 1977 two scientists of the US Air Force Academy, John P. Jackson and Eric J. Jumper, reported that they had found that the density (or darkness) or the image varies directly with the distance that the corresponding part of the body would have been from the Shroud which covered it. Microdensitometer measurements have been correlated with the estimated body-cloth distance and these suggest that the image contains three-dimensional information. The darkest parts of the image, such as the nose, would have been closest to the Shroud.

Jumper and Jackson felt that the image must therefore have been formed at a distance and not by close contact. They carried out measurements on the cloth-to-body distances using a man of similar build in a similar pose with the aid of stereometric photography. Their photographs were processed with a complex image analyser instrument which had been designed to convert variation of image intensity into distance. They found that the Shroud contains three-dimensional information and used a computer to reconstruct a three-dimensional model of the image. This clearly showed that the image of the Shroud is quite unlike any normal photographic image. The smallest feature of the image which can be resolved is 5mm.

## STURP

It was largely through the interest created by the three-dimensional image work in the USA that a team of 32 specialist US scientists was formed who sought and obtained permission to carry out by far the most thorough scientific investigation ever made on the Shroud.

Some of the scientists call themselves 'sindologists', this name being derived from the Italian word 'sindone' (shroud). They are a largely self-appointed, independent, non-profit group of scientists and assistants and do not work under the auspices of any other body. The name STURP (Shroud of Turin Research Project Incorporated) has been adopted by this group. Previous investigators have been mainly selected by the Archbishop of Turin.

STURP's scientific proposals were submitted to the Archbishop of Turin (keeper of the Shroud) and to Centro Internazionale di Sindonologia in September 1977, and to Umberto II, a former King of Italy and the legal owner of the Shroud; all gave their approval.

## Scientific Work

The work of the scientists included looking for fluorescence under X-ray and ultraviolet irradiation. X-ray fluorescence provides data on the elements present in various parts of the Shroud. In the X-radiography work, low-energy X-rays were passed through the Shroud and were detected by an X-ray film placed at the back of the Shroud. The films were manually processed in a nearby darkroom and were given a preliminary visual examination so that any necessary changes could be made in the exposure of the subsequent films.

In the visible region an extensive series of photographs was made with red, green and blue filters for colour separation so that colour mosaics of the whole surface of the cloth could be built up at reductions of 5.6:1 and 22:1. The importance of this visual light photographic work becomes obvious if one remembers that the computer work on the image, including three dimensional image work, was carried out with photographs made in 1931. The filters were chosen by Sam Pellicori, a physicist employed at the Hughes Aircraft Company's Santa Barbara Research Centre, California, so as to bring out the slight colour differences between various parts of the Shroud. The images underwent further processing by computer programs developed at the Jet Propulsion Laboratory's Image Processing Laboratory for Planetary Studies, which have been especially designed to bring out every possible piece of detail in the images returned by spacecraft from distant planets. The raw images returned by such spacecraft often shown little contrast, rather like the Shroud. Over 500 photographs were taken at various wavelengths.

In other work ultraviolet transmitting filters were used for contrast enhancement. Another series of photographs was taken in which the visible spectrum was divided into 10mm intervals by a series of filters. the Shroud was also examined in infrared radiation to ascertain if any new features became visible, since chemicals containing certain groups of atoms may be identified in this region. Infrared thermographic techniques were employed, since together with micro-Raman spectra these are considered to be the most likely methods for identifying blood components and certain types of burial substances mentioned in the Scriptures.

Minute particles of fibre, pollen, dust, etc. were removed by means of specially prepared adhesive tapes and also by means of a suction device. In the case of the tape, both

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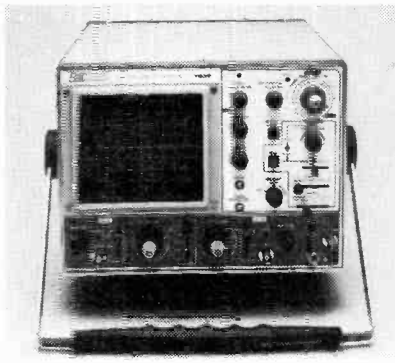
Five ranges of time-base delay from 1nS to 100mS highlight this new instrument. The delayed-sweep capability of the 1530 is a major advantage in the evaluation of digital pulse trains and other complex waveforms. Complex signals can be expanded by as much as 1000 times for examination of signal components and troublesome "glitches." The absolute minimum magnification is 5 times at frequencies to 30MHz. The delayed-sweep feature is also useful in the measurement of rise and fall times of pulse signals.

For highest display accuracy, the 1530 offers a variable hold-off function. This ensures triggering at the first pulse of a multi-pulse signal, preventing improper waveform display. The 1530 can also display two signals that are unrelated in frequency by alternately triggering on both the channel A and B signals.



Other convenient features include a FIX mode to eliminate trigger level adjustments, differential input capability, single sweep operation, selectable triggering filters and a built-in video sync separator.

If you're looking for the kind of features and performance found in the 1530, but without delayed-sweep capability, B&K-PRECISION offers the 35MHz model 1535. While costing somewhat less than the delayed-sweep model, the 1535 is a high-performance instrument that doesn't sacrifice performance.

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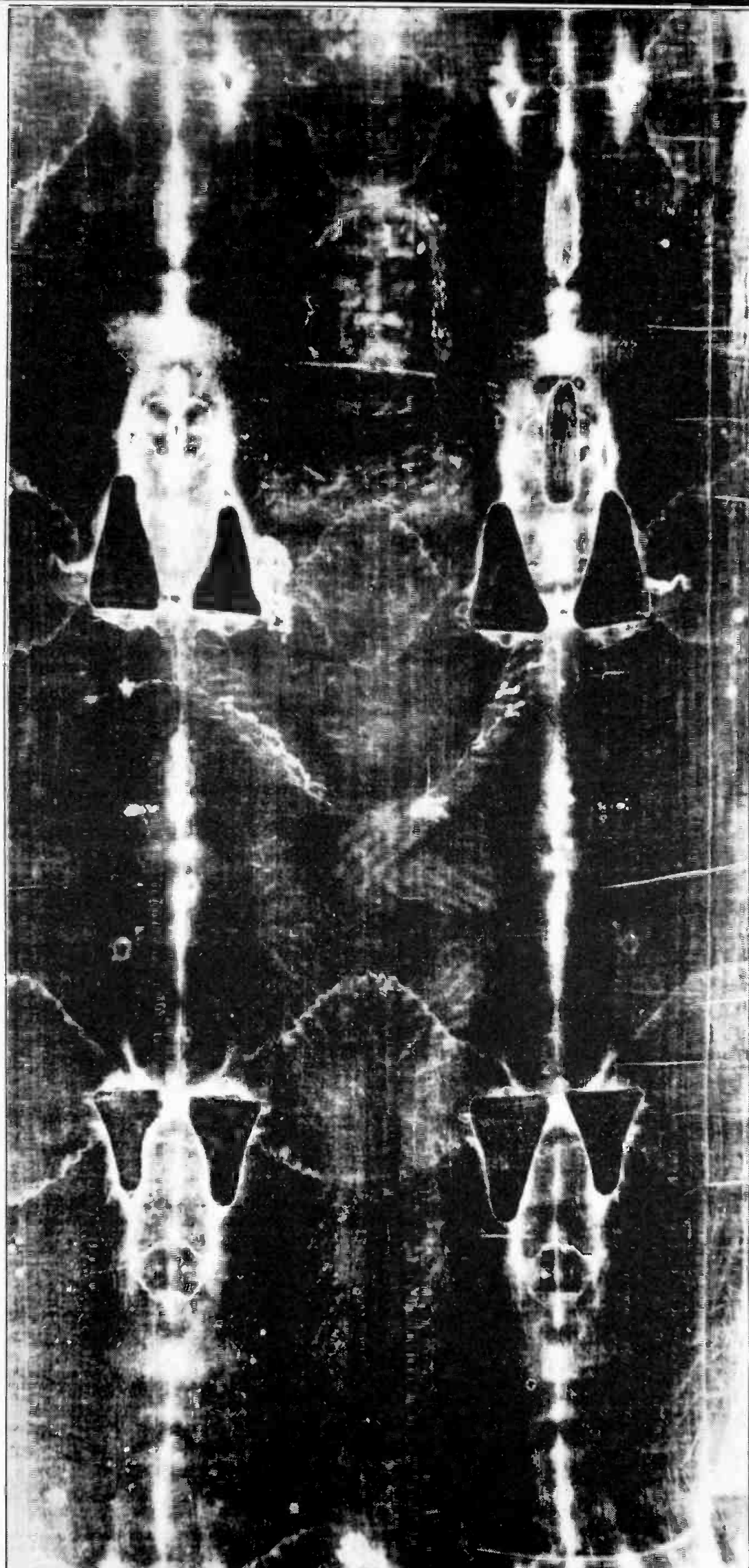


## How Was The Image Formed?

As stated, this question arouses the main curiosity of scientists; what force could possibly have caused the formation of this negative, three-dimensional image? The word 'force' is used purposely, since it seems more and more apparent from modern research that the image was not caused by direct bodily contact with the Shroud. Attempts at reproducing this 'contact' process with bodily oils, unguents, etc., have failed to produce anything looking remotely like the image on the Shroud. The lack of penetration of the 'blood' or the image into the fibres supports this, as does the three-dimensional information carried by the image.

A more promising suggestion is that the image is some kind of scorch, the colour being the sepia of the first stage of the oxidisation process before actual burning. A cloth placed over a heated brass ornament produced an image far more like that of the Shroud than any other experiment yet tried, and spectroscopic laboratory analysis bears this theory out.

What, however, could have caused a dead body to produce a radiance or force sufficient to scorch cloth, acting in so controlled a manner and over so short a period that it dissolved and fused blood flows onto the cloth as well as creating the perfect impression of the body, yet without actually burning the cloth? Some kind of very swift thermonuclear flash, acting in an upward and downward direction with no diffusion, is the answer that has leapt to the minds of many scientists, though they are no nearer to explaining how this could be possible than they were before. However, as experience at Hiroshima has shown, such powerful blasts can cause prints of shadows cast by the light of the blast to be imprinted on buildings, etc. There are even photographs to prove this.

So although scientists now have better access to investigation of the Shroud than ever before, none of their work has yet been conclusive. Research has indicated that the Shroud is unlikely to be an artist's forgery, yet scientists still cannot explain how the image got onto the linen, either naturally or by the hand of man. For this reason the results of the analysis of the scientific tests are eagerly awaited to provide more evidence to help unravel the mystery of the Holy Shroud of Turin.

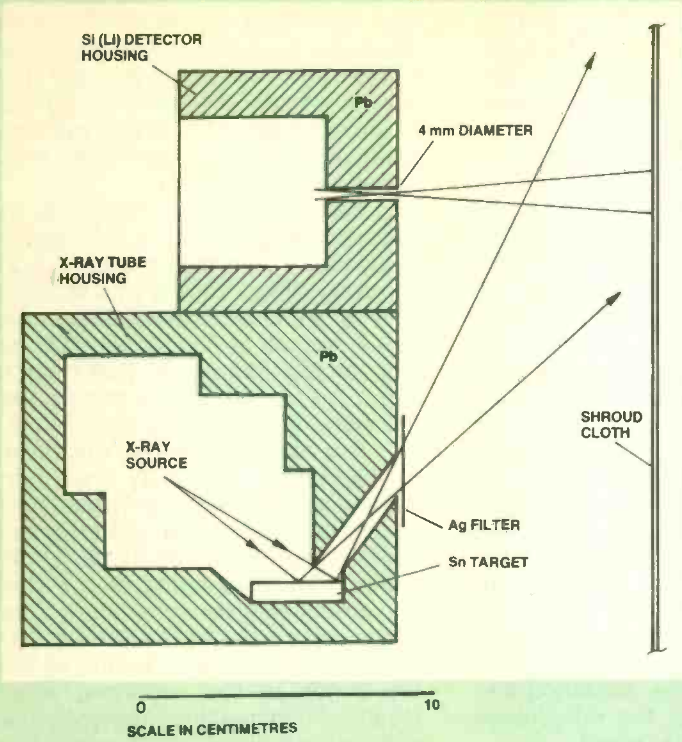



*Figure 1.* The apparatus used for the X-ray work.

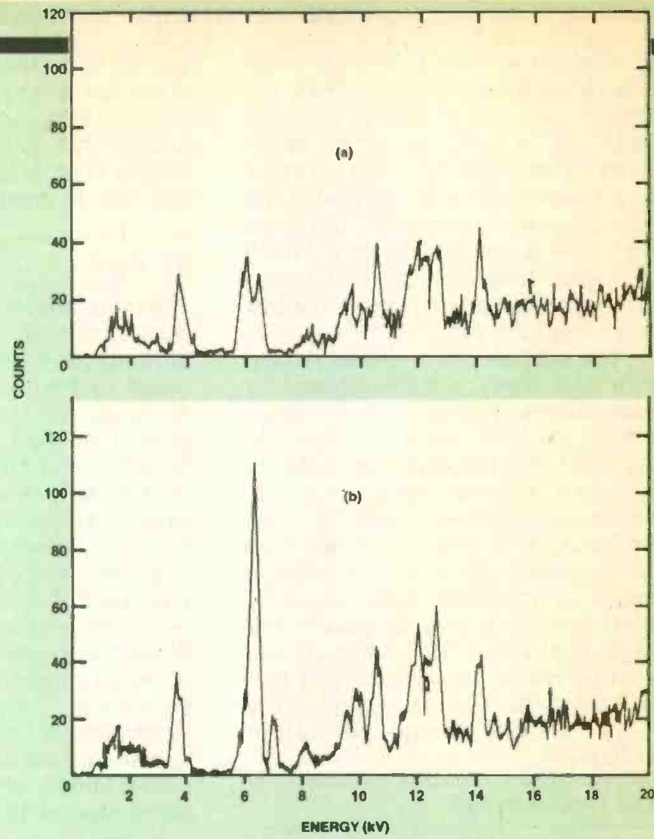
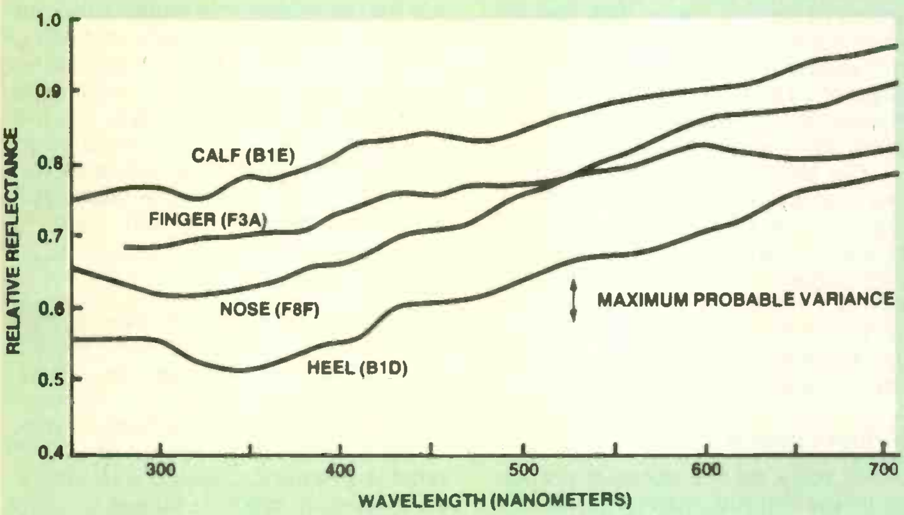



*Figure 2.* (a) X-ray fluorescence spectrum; (b) similar spectrum taken over the side wound 'blood' region. Note the higher peak at 6.4 keV.

# Images of the Shroud



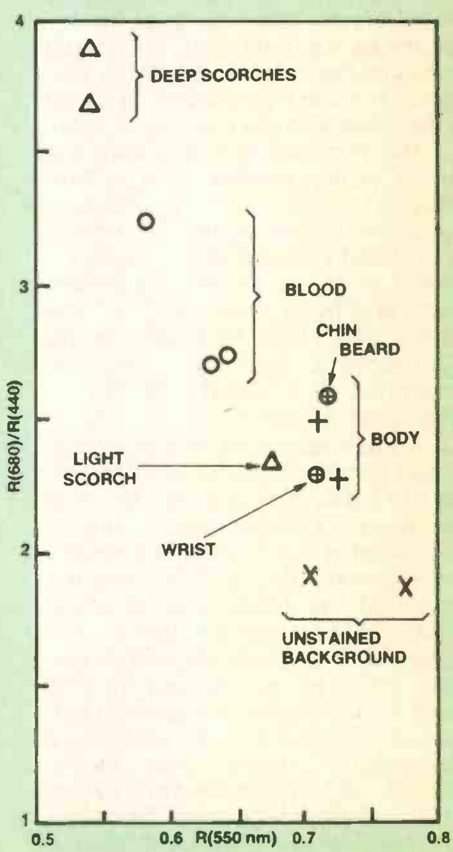




*Figure 4.* Spectral differences of various details on the Shroud are intensified by taking the ratio of widely separated reflectances and normalising to the absolute R at 550 nm. Notice the grouping by stain type, and that the darker the feature is, the redder it is. The body image points 'Beard' and 'Wrist' contain minute traces of blood.

the adhesive and the tape were made of pure hydrocarbons so that the Shroud was not contaminated; indeed, the scientists wore white gloves when handling the Shroud. The adhesive tape was applied to the Shroud with a specially designed roller; after it had been removed each tape was attached to a labelled microscope slide and placed in a box which was later sealed.

The particles of material removed on the tapes were examined by visual microscopy and by the micro-Raman method. Further work on these particles involved electron spin resonance, electron microscopy, ion microprobe techniques and the scanning electron microscope. It is hoped that scanning electron microscope images at magnifications of up to 10,000 times will provide data of the image depth and sharpness at different points on the Shroud and this may help us to produce a satisfactory theory of the image formation mechanism.

## X-ray Fluorescence

The main aim of the X-ray fluorescence experiment was to estimate the variations in the concentration of the elements in different areas of the Shroud containing 'blood' stains, other parts of the image, the background cloth, the scorch areas and the patches. Elements with atomic numbers exceeding 16 could be detected with the equipment used.

The fluorescent X-rays from the Shroud were detected by a silicon (lithium) semiconductor detector shielded with lead so that an area of 1.3 $cm^2$ of the Shroud surface was examined at any one time. The pulses from the detector were amplified and fed to a pulse-height-analyser having 512 channels. Each spectrum was transferred to a digital cassette for subsequent analysis.

A prominent peak due to iron at 6.4 keV (with a smaller peak at 7.0 keV due to its K-beta X-rays) was found in the 'blood' stained regions and a much smaller iron peak in other areas of the Shroud (Fig. 2). This does not prove that the 'blood' stained areas contain blood, since a material such as jeweller's rouge ($Fe_2O_3$) could have been used as an image-colouring agent. A quantitative comparison between whole blood, rouge stains and the Shroud results was made. Calcium and Strontium were found, but the workers suggested that these may have arisen from dust carried from the marble and limestone regions of northern Italy. The absence of heavier atoms, as far as could be detected with the equipment used, indicates that pigments or dyes containing such elements could be present only in small amounts.

## UV Work

The ultraviolet-visible reflectance and fluorescence spectra from the Shroud have been investigated in detail by the husband-and-wife team of Roger and Marion Gilbert, who state that their measurements were performed as an aid to later analysis of the substances making up the various stains on the cloth and to a possible determination of the manufacturing techniques of the cloth. They took fluorescence and absolute reflectance spectra on areas of the Shroud not containing markings for possible comparison with other cloth samples. They also recorded fluorescence and relative reflectance spectra of the image, scorched and bloodstained areas, the reflectance being relative to clear areas.

The relative spectral reflectance of four areas of the Shroud image is shown in Fig. 3 and the spectral fluorescence of four similar areas in Fig. 4. It can be seen that the lower the reflectance of an area, the lower the fluorescence. At lower fluorescence levels, the peak moves towards longer wavelengths.

These workers noted that the image (without magnification) seems to have the same sepia colouring as the lightest of scorch marks and that the image colour does not seem to come from a particular matter. The image is extremely faint under backlighting, whereas the bloodstains then stand out as dark reddish-brown spots.

The body image areas seem to have the same spectral reflectance properties as those of the scorched areas together with similar fluorescence characteristics. The stains seem to quench the fluorescence of the cloth and to exhibit a low-level fluorescence of their own in the 600-700 nm region.

## Further Spectral Work

Further work on the spectral properties of the Shroud, mainly in the visible region, has been described in a paper by S.F. Pellicori. His results using a 'quick look' spectrometer are shown in Fig. 5; this spectrometer used a continuously variable interference filter wheel to provide a bandwidth of 17 nm, a silicon photodiode detector being employed. The reflectance curves of Fig. 5 are normalised to unity at 700 nm, the absorption increasing as the wavelength decreases. The changes in slope of the bloodstains makes a comparison with human blood more definitive.

Pellicori has also compared the reflectance spectrum of the Shroud bloodstains with that of four-day-old labratory blood which, in one case, was baked. The corresponding bands in the regions of 550 nm and 625 nm have enable him to say that there is sufficient correlation to decide that the material on the Shroud is blood.

The relative spectral responses of substances that may once have been in contact with the Shroud have been examined before and after baking in air for five hours at 150°C; the baking simulates aging of the cloth and produces a colour similar to that of the clear areas of the Shroud. This colour is due to the formation of double bonds in the cellulose, which results in increasing absorption at shorter wavelengths. Experiments have shown that an invisible deposit of perspiration plus skin oils becomes visible on baking and displays a spectrum closely resembling the Shroud body image. It was concluded that a likely cause of the body image is cellulose degradation stimulated by natural substances on the Shroud or burial preparations from the body. It has also been shown that iron (III) oxide (rouge) is not wholly responsible for the 'bloodstains' nor for the image; this oxide is too red to produce the body image and has a different reflectance curve. Many people have remarked about the decrease in image contrast as the observer comes nearer to the Shroud and this is partly attributable to the increased contribution of scattered light into the cone of vision.

## Infrared Studies

Infrared reflectance spectroscopy of the Shroud was undertaken in the 3-5 um and the 8 - 14 um bands, where readily available detectors coincide with atmospheric transmission windows. A black-body source at 980°C provided radiation, which was focused by sodium chloride lenses to form a 20 mm diameter spot on the Shroud, which was 400 mm away, thus producing an equilibrium temperature of 59°C. The reflected radiation was detected with a mercury-cadmium-telluride detector about 2m from the Shroud (Fig. 6). The radiation was

# Images of the Shroud

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*Figure 5.* Shroud background linen and modern linen artificially aged by baking. Reflectance of iron oxide to be compared with body image (Figure 7). If $Fe_2O_3$ were present ir a high enough concentration to make up a visible image, its reflectance curve would be quite different from the Shroud's image.

*Figure 6.* Comparison between Shroud blood spectrum and laboratory blood artificially aged by baking.

*Figure 7.* Laboratory simulations of body image spectral reflectance characteristics produced by accelerated aging, and Shroud body image included for comparison. $P_1$ and $P_3$ are skin oil plus perspiration.

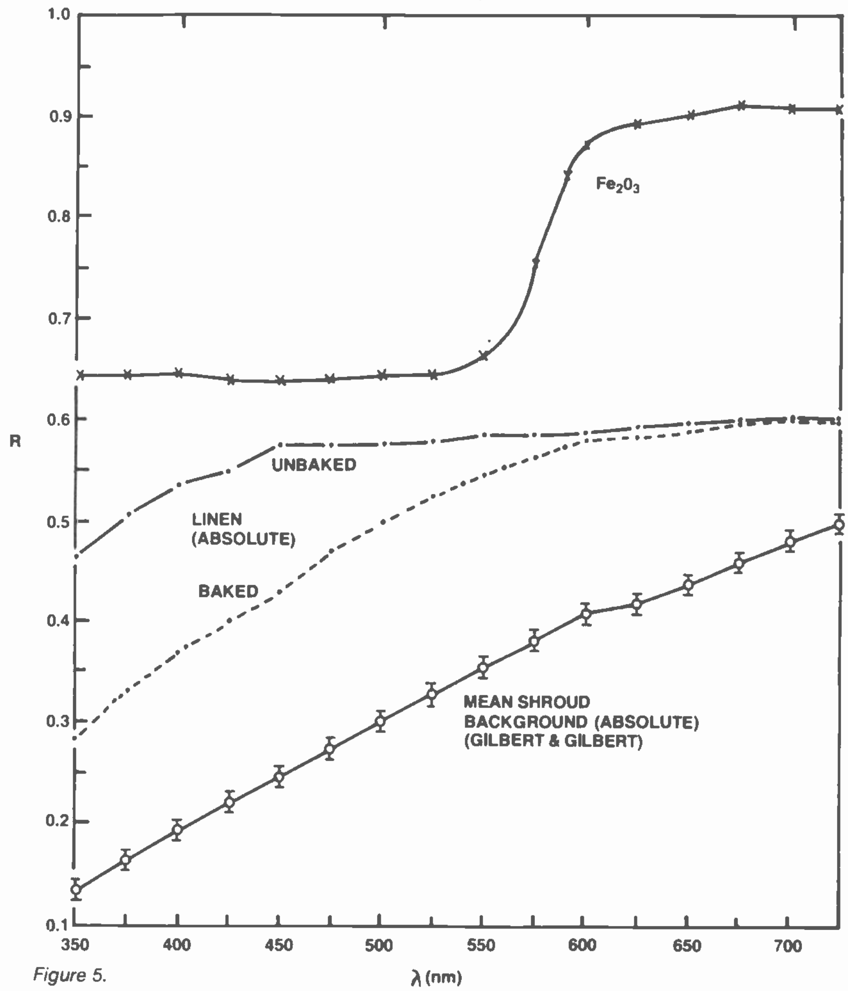



*Figure 5.*

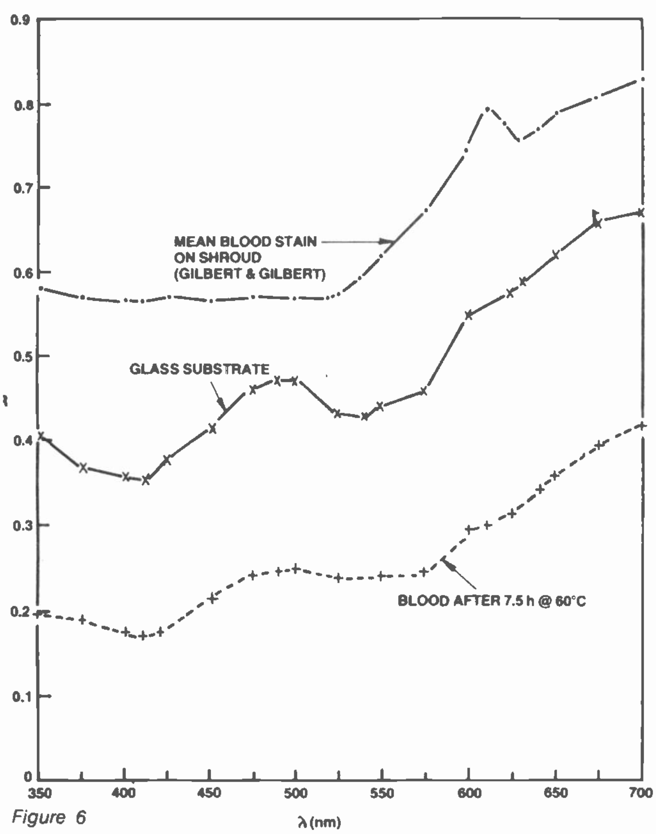



*Figure 6*

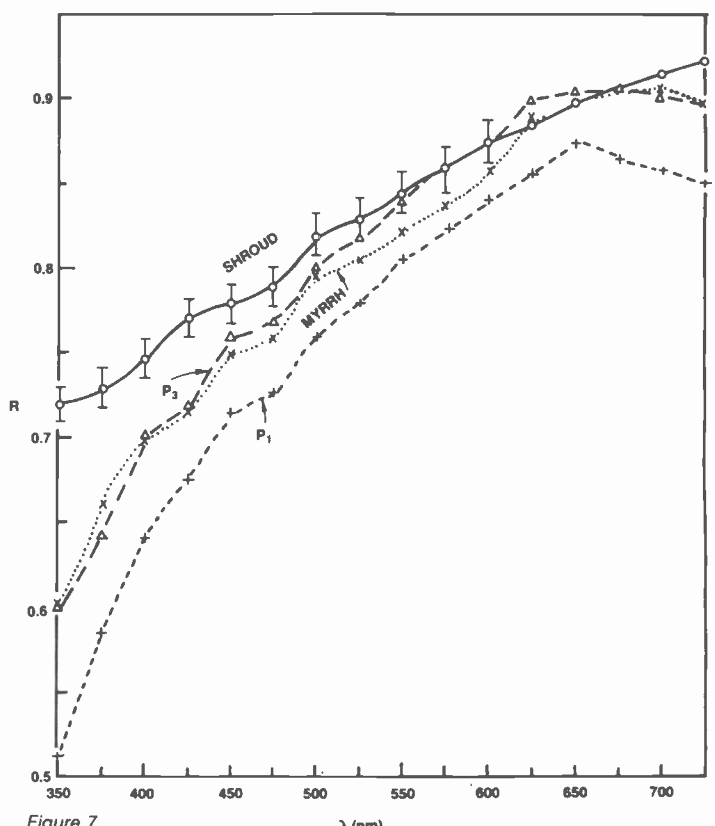


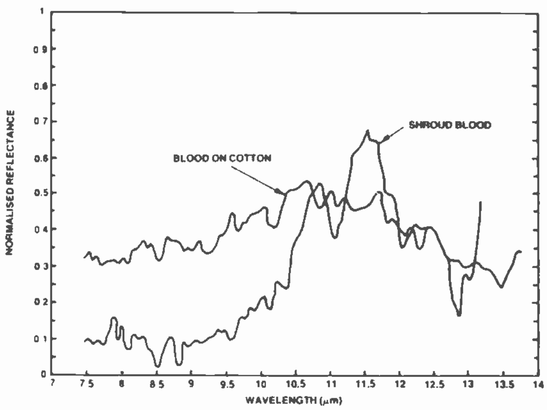

*Figure 7.*

chopped at 500 Hz and the reflected signal processed with a synchronous amplifier to provide background rejection.

The spectral similarities of most of the features observed rendered the results somewhat inconclusive. The Shroud bloodstained areas showed different spectra from known bloodstains both in the shorter (Fig. 7) and longer wavelength (Fig. 8) bands. It has been suggested that these differences are due to surface effects rather than the chemical composition of the materials.

The infrared image was found to be approximately a reversed image of that seen in visible light, the linen background appearing black and the bloodstains bright, with the scorch and image areas of intermediate brightness. The authors felt that the thermographic imaging results are consistent with their expectations.

*Figure 8.* **Normalised spectral reflectance of blood-on-cotton and Shroud blood in the 8 to 14 $\mu m$ infrared band.**



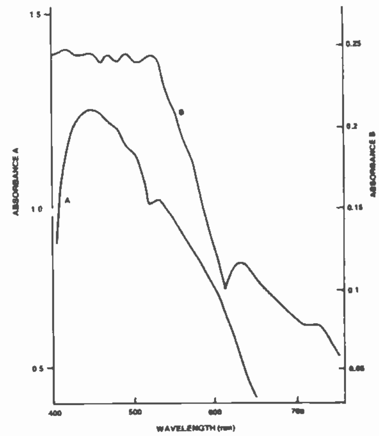




*Figure 9.* **(a) Transmission spectrum of a brownish-red stained fibril from a blood area of the Shroud. (b) Transmission spectrum obtained by transformation of the reflection spectrum of the blood areas of the Shroud.**

## Blood on Tapes

J.H. Heller and A.D. Adler have described their work with a single 25 mm x 75 mm specimen of adhesive tape which had been pressed on one of the bloodstained areas of the Shroud and which has enabled them to identify the presence of blood by spectroscopic and chemical tests. Under microscopic examination at 1000X magnification, some hundreds of linen fibrils were found, less than twelve possible bloodstained fibrils, a single brownish-red translucent crystal and other debris of the centuries.

These workers stained an old specimen of linen with one-year-old blood and took samples of this using adhesive tape. Microscopic examination showed crystals and fibrils similar in appearance to those from the Shroud sample. Both the Shroud fibrils and the simulated fibrils were examined by micro-spectrophotometry at visible wavelengths (Fig. 9). There is no specific spectrum for blood, since much depends on its exact chemical state and on its state of aggregation, but all of the fibrils showed intense absorption in the 400-450 nm band, indicating a porphyrinic substance. The Shroud fibrils would be expected to show the spectrum of a fully oxidised denatured methaemoglobin and the results indicated this type of spectrum, although the high degree of scattering from the samples rendered the bandshape features less distinct and produced peak shifts. Thus the identification with blood was less positive than desired when this measurement alone is considered.

## Conclusions

Recent scientific work on the Shroud seems to have established fairly conclusively that the bloodstains do originate from real blood, provided that the evidence of the various workers is considered as a whole. It also seems almost certain that the Shroud was once draped over the body of a man who had undergone not only the tortures of crucifixion, but who had also received other wounds very similar to those of Jesus Christ as described in the Gospels (the side wound, the crown of thorns and the beating).

The conclusions on the mechanism of image formation seem less definite. The suggestion of Pellicori that the image was formed by perspiration and oils accelerating the normal degradation and darkening of the cellulose of the cloth seems to be the most promising. It is supported by laboratory evidence in which darkening of cellulose cloths was speeded by baking; body oils, sweat and olive oil (the latter is found in myrrh and aloes used in the burial oils of ancient Palestine) were used in these experiments. The images formed in some hours and had some characteristics of the Shroud image when viewed microscopically.

Pellicori's hypothesis suggests the Shroud image was formed by skin contact. Some say this could not explain the three-dimensional effect, but Pellicori feels we do not yet have enough understanding of the image transfer mechanism to answer this point. Not all scientists agree with Pellicori's suggestions. Early suggestions that the body image is light singeing of the cloth with a hot statue seem to be refuted by ultraviolet fluorescence studies, which show that the body image has a different fluorescence from the fire-scorched regions. As regards the work of McCrone (mentioned earlier), the STURP team made extensive tests to detect pigments or their binding agents, using microchemical techniques down to levels of under 1 microgram. None were found and the traces of iron oxide revealed were not only invisible to the naked eye, but equally distributed throughout the image and non-image areas. How could they produce the image, in spite of McCrone's views?

The very detailed tests on the Shroud have given no indication that it could have been a fake; indeed, they indicate the opposite view. Although it might have been possible to prove the Shroud a fake, it seems science can never prove it is genuine, nor whom it covered, although no other suggestion than that it was the body of Jesus Christ seems to have been made. Science's main concern, however, is with 'how?' and not with 'whom?'.

# PULLING THE PLUG

# Electric Heads

Heads are useful, let's face it, and you're darn lucky to have one. If yours were to become unbolted, fall off in the subway, be stolen by wandering Bedouins, be repossessed by the finance company or find itself otherwise indisposed, you'd probably feel very bad. Quite understandable, too. There are a lot of things that are very difficult to get done without a head. Oh, there are the everyday tasks of eating, breathing, hearing, seeing, smelling, picking your teeth and throwing dandruff to the wind, but that's just a tiny fraction of what heads are actually good for. For instance, imagine trying to do chin-ups without this useful appendage. You wouldn't know when to stop, and you might very well injure your neck stump.

Headless people are discriminated against by society. They have trouble getting jobs as anything other than coffin fillers and party amusements, and people tend to shun them when they walk down the street. They are frequently classified as being dead, or, at best, mortally wounded, and, as such, are deprived of many of their civil rights, just as if they were actually dead. Many of the headless are even turned away by the very service organizations that were set up to aid the utterly senseless members of our society: even the nurses at special training classes for the hard of hearing tend to shriek and get unpleasant if someone even slightly headless enters the room.

Thus it is that we applaud this new application of technology specifically for the headless, the partially headless, the moderately witless and the Conservative party of Ontario. A complete line of electronic heads, this new innovation will allow any individual formerly suffering from headlessness to re-enter society and be accepted as being no different than any other individual with skin by Mattel. These heads feature micro-processor controlled eyes, ears, lips and eyebrows, and a full four bit archetecture to drive the brain software. Speech synthesis using the latest chips from Texas Instruments allows the user to utter any one of 256 words, permitting a headless individual to carry on a perfectly normal conversation in BASIC. Each eye is equipped with a Reticon 256 x 256 element image sensor, availing full simulated vision of any object, providing it's graph paper or a checker board. The heads come in six popular colours; blue, green, purple, orange, harvest gold and fluorescent silver pinstripes.

Custom heads are also available, and there's a wide range of options which can be added to any head at a nominal charge, including a cigar lighter, LED flasher, nostril lamps, a fog horn and steam jets in the ears.

For more information, please contact *Electric Heads Ltd.*, 40992 Fiberglass Crescent, Tar Pits, Alberta. Ask about their quantity discount for schizophrenics.

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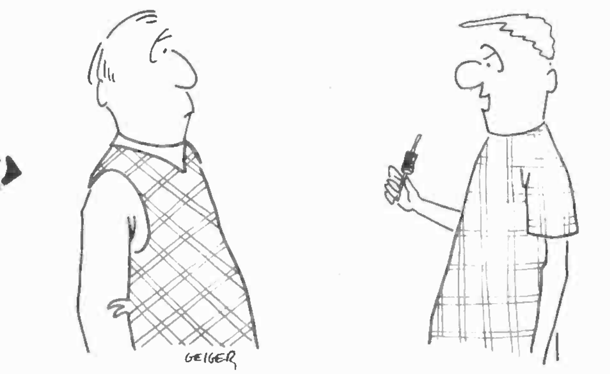


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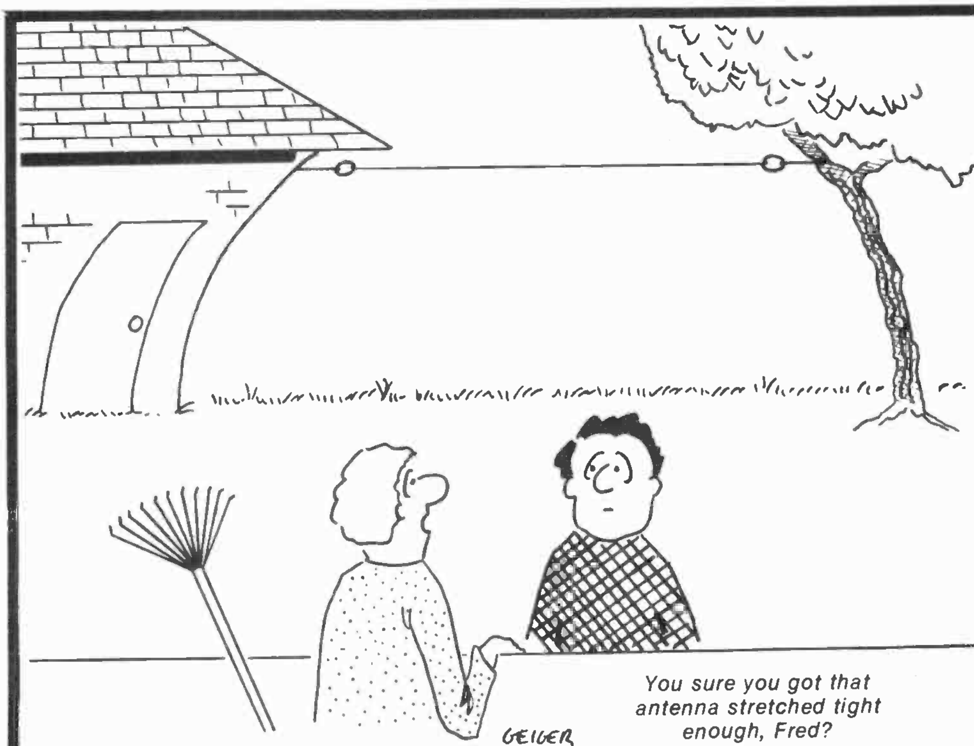
# Electronics

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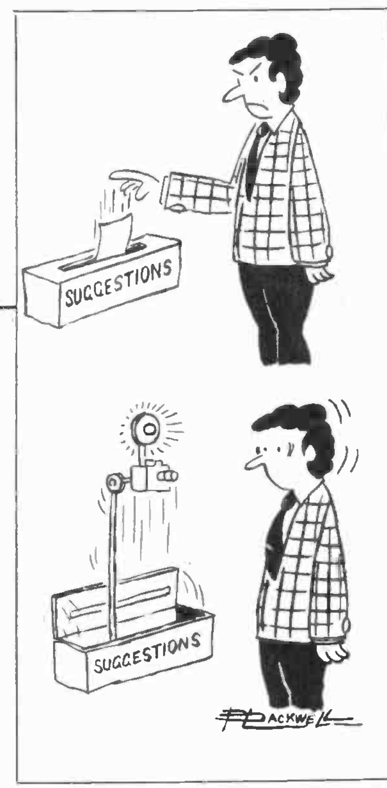


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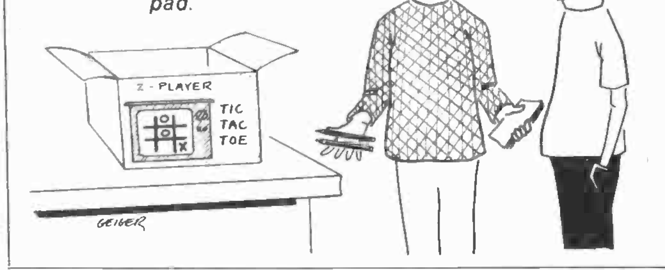



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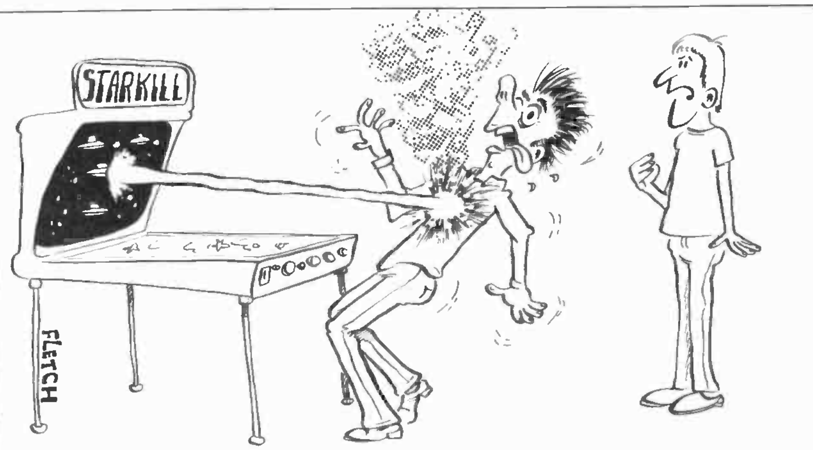



*That'll teach you not to use foriegn coins.*

# Contest

**A new computer system and a contest. View the future, become enlightened and, most important, win stuff.**

JUST BEFORE GOING TO PRESS, which is usually when most things get done around here, we found out about another new computer system. The Multiflex from Exceltronix is due to be augmented shortly by a second system, provisionally dubbed the Multiflex S100-2. Cheaper than a PDP-11 and a better paperweight than a Sinclair, the new Multiflex will represent some heavy continuing state-of-the-art, with fresh new designs all around. However, its proposed applications are even niftier still. Read on.

## The System

As of this writing, the system is pretty well through the development stage, and, In fact, the initial hardware is already beginning to stagger to its feet. The actual availability, for those with a thirst for silicon and fiberglass, is slated for the end of the summer. The basic price for the initial system in kit form will be in the area of a thousand dollars.

The CPU is based on the familiar Z80 processor, although the intent is to make the works happy at up to 6MHz with the Z80B. The CPU board holds 64K of RAM and 4 2716 or 2732 EPROMs, which can be mixed with 2016 static RAM chips, as well. The CPU card has two serial ports, which can support terminals, and twenty four I/O lines.

Mass storage Is provided by a floppy board based on the Western Digital disk controller chip. It will run with either 5¼ or 8 Inch disks, and can deal with double sided double density formats. The floppy disk board supports an optional plug in piggy back DMA board as well.

The memory card holds 256K of RAM per board, which is really dense, considering that, even a few years ago, an S100 board held about 8K. There is on-board provision for internal refresh, although, with the Multiflex CPU this isn't required.

The video board Is only needed if you don't want to use a terminal. It has an 80 X 24 character screen, and, in fact, can itself be used as a stand alone terminal.

## Applications

What they're really hopping around about down there at Exceltronix is the application they've dreamed up to use their new toys. It will involve two of the new computers, three twenty megabyte hard drives, and is expected to be on line by August. It's neat.

First off, one of the machines will handle the store's inventory. It will have two terminals, and a complete list of what's in stock and how many of each item are available. You, the poor beknighted soul searching all over town for a left handed output transistor, will not have to shoot down a low flying salesman, but will be able to query the system directly, and enter your list of parts, however silly it may be, into a terminal. The machine will tell you what's to be had. . . you can get into substitutions on the spot, if you like. . . and a shopping list will be printed out, where upon one of the blue eyed leaping gnomes behind the counter will get the bits. The machine will keep track of what's in stock, what's in need of re-ordering, and so on.

Now it gets trendy. If you have any sort of a computer and a modem more sophisticated than a transistor radio and two Dixie cups, you'll be able to phone the computer and order stuff. The system will talk to anything that it can make believe is a dumb terminal at 300 baud. Payment can be by any of the major (unexpired) credit cards by leaving the appropriate numbers and ritual symbols with the computer. You should avoid sending cash through the phone lines.

The second system will be a user service network, and will use one Multiflex and two twenty megabyte drives. The first disk will be a read-only deal; it will behave like a message board, and the rest of the civilized world will be able to call it, see a menu of what's on it, and then call up individual files at will. It will contain freebee software and messages of use to computer owners.

The second disk will be user writable. It will be cleaned periodically, and files deleted at the cleaning staff's discretion. The system will be useable by computer owners for mass storage. . . not terribly secure mass storage, of course. . . and also for communication. Messages can be left on it, and Multiflex users will be able to dump programs onto it along with questions they might have of the Exceltronix staff. Thus, instead of calling from Yellowknife at three in the afternoon and being put on hold for five minutes 'til someone can be found to answer one's question (does the power switch *have* to be on to make the computer work?), a message can be dumped onto the disk, at 2:00 AM when the rates are low if you like, and a reply called up at a later, equally flexible time.

The system will be free for anyone, with any system, who wants to use it. For anyone without a system, Exceltronix also plans to offer a real cheap, $190.00, home terminal.

## Contest!

The contest works like this. Send in your suggestions for the new Multiflex S100-2. They can relate to anything you think should be incorporated into the system, from game paddles to cybernetic intelligence, just so long as it's somewhat possible and doesn't require interplanetary travel for the parts. Everyone who sends in a suggestion will receive a voucher funny-money thing worth five percent off on anything purchased at Exeltronix, valid until the end of June 1982. The fifty best ideas will be selected, and credit for them announced to the world on the message board disk. All the ideas will be heaved into a hat, or possibly a touque, this being the great white North, and a winner drawn. This lucky soul will become the enchanted posessor of a Multiflex Logic State Analyser kit, which no digital experimenter can afford to be without.

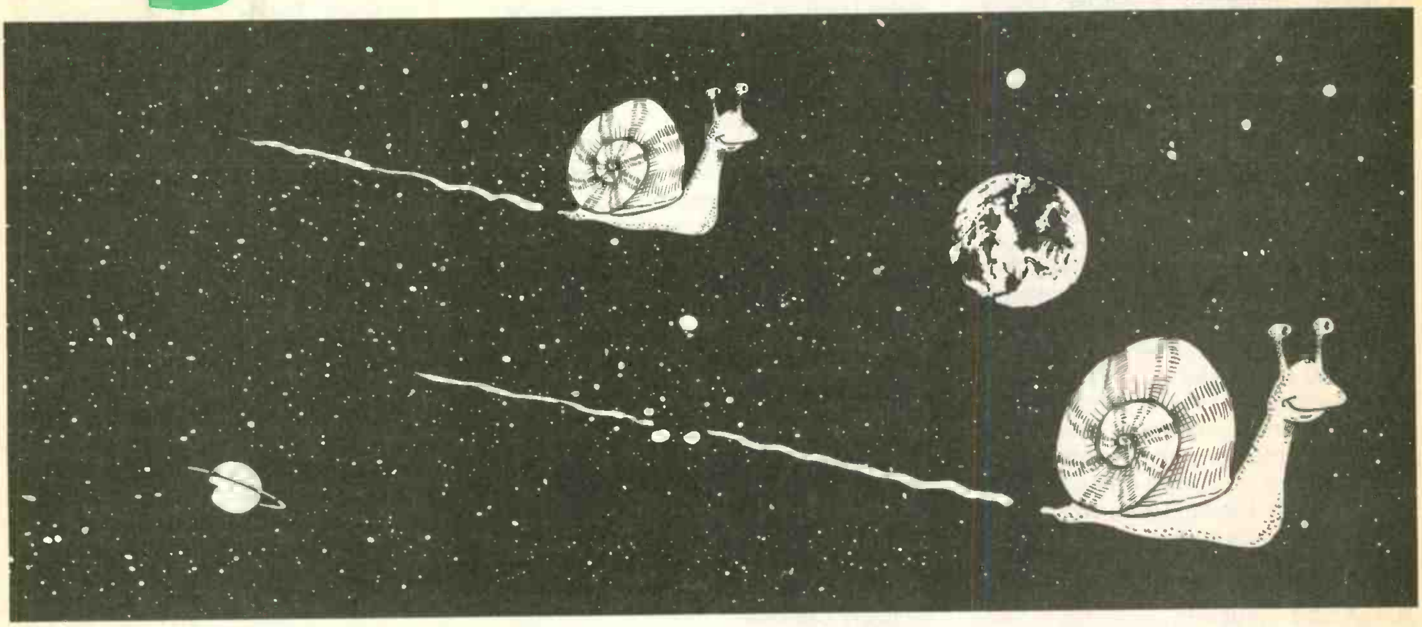
Do not send us your ideas. Send them to:

**Multiflex Contest**
**319 College Street**
**Toronto, Ontario**
**M5T 1S2**

Fine print: All entries become the property of Exeltronix, and none can be returned. The contest is open to anyone except employees of Exeltronix, Electronics Today International magazine and associated companies, except where prohibited by law. The prize must be accepted as awarded, and the decisions of the judges are final.

# Faster Than Light Travel





**Captain Kirk used it, the Nostromo needed it, and the Empire couldn't exist without it. But A.S. Lipson, light-sabre in one hand and phaser in the other, lays waste to the plots of countless space operas.**

ONE OF THE MOST popular themes chosen by science fiction writers is that of the galactic empire. The scene is thus; centuries in the future, man has spread out through the galaxy, colonising planets in other star systems, and has built up an empire, simultaneously solving the problem of overpopulation on Earth. But the stars are all an awfully long way away, even the relatively close ones. If a light year is the distance light travels in a year (and light travels at about 299,793,000 metres per second, or, if you prefer, 186,000 miles per second — fast enough to circle the equator seven and half times in one second!), even the nearest star is nearly four and a half light years away. The distances from us to the 10 nearest stars are given in Table 1.

As you can see, the stars seem uncomfortably far away. If we start to consider stars at the far side of the galaxy, we find that we are talking about distances of the order of 80,000 light years! The problem with such unimaginably great distances, of course, is that travelling them takes rather a long time. If we are to colonise the stars, then either we need to develop some means of travelling faster than light, or our astronauts are going to get either very bored or very dead on the way to wherever they're going.

## Conversation Stopper

Even supposing that we could overcome the problem of boredom, there would still be a communication problem. Supposing you wish to talk to old Aunt Ethel at Alpha Centauri (say); once you've said 'hello' over the radio, it's another 4.4 years before Aunt Ethel will hear you, because radio signals travel at the same speed as light, and Alpha Centauri is 4.4 light years away. It takes the same time for the reply to get back. All in all, it takes nearly nine years to get a reply, even from the nearest star systems! This is clearly no way to run a conversation. The same problem also operates with any interstellar communication. Radio, light, or anything slower, just isn't fast enough for the sort of communication needed for our new galactic civilization. Unfortunately, we don't have anything faster.

So what's the big problem? We can just let the wizards get on with it, and they can invent us a faster-than-

**TABLE 1**

| Star | Distance In Light Years |
|---|---|
| Proxima Centauri | 4.3 |
| Alpha Centauri (A and B) | 4.4 |
| Barnard's star | 5.9 |
| Wolf 359 | 7.6 |
| HD 95735 | 8.1 |
| Sirius (A and B) | 8.6 |
| UV Ceti (A and B) | 8.9 |
| Ross 154 | 9.5 |
| Ross 248 | 10.3 |
| Epsilon Eridani | 10.8 |

light drive!

### Speed Limit

There is, of course, a slight snag (nothing's ever that easy). In 1905, a gentleman by the name of Albert Einstein published a paper laying down the foundations of what is now known as *special relativity*. Among the many interesting results of special relativity is the following; it is impossible to accelerate any body to the speed of light, let alone beyond. You can get close; in big particle accelerators, electrons have been made to more at more than 99.99% of light velocity, but never quite 100%. This obviously creates a slight problem with our ideas about interstellar travel, and unfortunately, there is now relatively (oh, dear) little doubt that that Einstein's results are correct. They are among the most thoroughly tested conclusions in the history of physics, and so far no-one has been able to fault them. There have been one or two occasions when people thought that they'd proved Einstein wrong, but it always turned out that they had mucked up their experiments, or misinterpreted their readings. So far Einstein seems quite safe.

While destroying most of our hopes of an FTL drive, relativity also provided us with a partial solution to our problems. You remember that one of the reasons we wanted a faster-than-light drive in the first place was to reduce the length of time that our travellers would have to spend on the journey, and hence reduce not only the boredom of such voyages, but also the amount of food needed (not forgetting little things like oxygen, as well). Well, we may not need a faster-than-light drive after all! Because according to relativity theory, when you travel at high velocities, time starts to do funny things. Measured by an observer on Earth, time on a fast-travelling spaceship appears to have slowed down. (A more detailed treatment of this is really the province of another article, so we won't go into it very thoroughly.) If someone was to set off in a spaceship for Alpha Centauri, for instance, at a reasonably high acceleration, although to us on Earth it would appear that the journey took many years, to the astronauts it would seem that significantly less time had elapsed. In the course of a lifetime, in fact, such a traveller could reach many quite distant stars, accelerating at only 1g or so (1g is the acceleration requried to simulate Earth's gravitational pull within the ship), and, indeed, return.

So where's the snag this time? Well, although the astronaut's time scale slowed down, Earth's didn't, and though he may be only 40 years older (say) at the end of his voyage, the astronaut is liable to find himself returning to an Earth which has aged by literally thousands of years! There are obvious problems with attempting to build a galactic empire like this . . . I mean, how'd you like to go off, spend 40 years of your life investigating likely star systems for colonizing, and then find when you come back that all your family and friends have been dead for a thousand years?

### Space Origami

Let's get back to the original problem, that of finding either FTL travel, or FTL communications. As we have seen, FTL travel, at least, seems to be pretty well forbidden by relativity, and the closest we can get to it seems to be fairly useless (Murphy's law rules), since timescales on Earth, if not for the astronauts, tend to get unfortunately long. Is there no other way of achieving FTL?

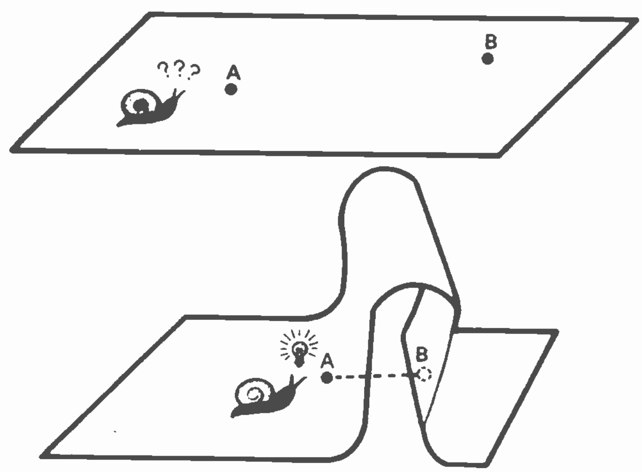



**Fig. 1 The snail bends the paper to bring the two dots closer together thus shortening the distance it must travel.**

The most immediate answer stems from science fiction. When science fiction writers first found out about Einstein's results, they realised that this was doing in their galactic empires, so they invented something called hyperspace. The basic idea of hyperspace is that you 'bend' ordinary space around in four dimensions (or so we are told), and bring the two places you want to travel between very close together. Then you take a short cut across the middle . . . No . . . I can see I'm not explaining this very well . . . Imagine a flat piece of paper, with two dots on it, a metre or so apart. There is a snail at one of the dots, and it wants to get to the other dot as quickly as possible. Let us say that the fastest this snail can move is a metre every hour. It obviously will take it an hour to get to the other dot. Now imagine that the snail is extremely brilliant and is able, somehow, to bend the paper sheet so that the two dots lie just next to each other (see Fig. 1). Then the snail will be able to get from one dot to the other in far less time. Now imagine doing this with three dimensional space, instead of a two dimensional sheet of paper, and you can see how there could be 'shorter-than-short cuts' outside of space. The theory of hyperspace, however, has a small snag (surprise!); nobody's made it work yet. So far it remains only a rather ingenious way round relativity for science fiction writers. (Mind you, if anybody out there has any bright ideas, there's probably a Nobel prize in it for the first person to make hyperspace work practically . . .)

### Faster Than Photons

There seems to be just one hope left for FTL. You will remember we said that nothing, according to relativity, can be accelerated past the speed of light. Well, there may be a loophole; in 1967 it was pointed out by one



*Continued on page 86*

# CMOS Circuits

**Certain elementary safety precautions must be taken when handling CMOS ICs or designing CMOS circuits. Ray Marston explains all.**

Early CMOS ICs earned a reputation for being easily damaged by static electricity, either when being handled or when being soldered into circuit boards, etc. Subsequently, manufacturers tried to overcome this 'fragility' problem by providing the ICs with extensive built-in input and output protection on each gate in each package. These protection networks do a fairly satisfactory job, but provide the design engineer with a few extra problems when designing CMOS circuits. This month, we will take an in-depth look at the subject.

## CMOS Protection Networks

CMOS ICs are, by definition, Metal-Oxide Semiconductor devices, in which the input signal is applied to the near-infinite impedance (about $10^{12}$ ohms) of the metal-oxide gate. Typically, the gate oxide has a breakdown voltage of about 80V: if a gate oxide break-down does occur, the resultant damage to the device is catastrophic and irreversible. To protect the CMOS against excessive input voltages (particularly arising from static energy), all modern CMOS ICs are provided with extensive built-in protection on all inputs and outputs.

Fig. 1 shows the standard protection network that is used on the vast majority of B-series CMOS device.

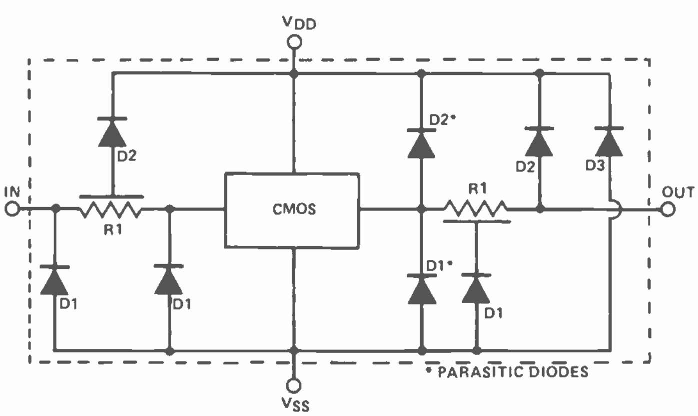



**Fig. 1 These are the standard electrostatic-discharge protection networks used on most B-series CMOS ICs. The two diodes associated with the resistors are distributed across the entire resistance, as shown.**

Here, all diodes marked as 'D1' are used to prevent the input or output from swinging more than 600 mV below the $V_{SS}$ (0V) rail, and all diodes marked as 'D2' are used to prevent the input or output from swinging more than 600 mV above the $V_{DD}$ (supply positive) rail. D3 is intended to prevent the $V_{DD}$ terminal from swinging negative to

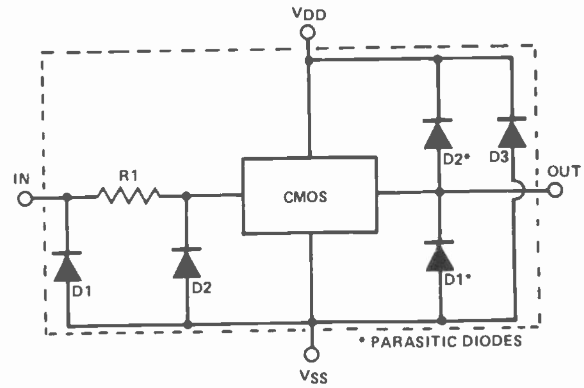



**Fig. 2 This protection network is used on the 4049B and 4050B hex buffers. Note that the input is free to swing above the positive supply ($V_{VV}$) rail.**

the $V_{SS}$ pin (electrostatically) when the device is being handled.

There are a couple of minor exception sto the standard version of the protection network. One of these is the type used on the 4049B and 4050B series of hex buffer/converters which, as shown in Fig. 2, have their inputs free to swing well above the $V_{DD}$ rail. These particular ICs are specifically intended for use in logic-level conversion applications, in which (for example) the input may come from a 12V CMOS network but the output and the IC supply rail are matched to a 5V TTL network.

Another exception is the 4066B type of transmission gate or bilateral switch, and its equivalents. These devices comprise a bilateral electronic switch and a switch-control network. In these circuits, all switch-control networks have the type of input protection shown in Fig. 1, but the switches themselves have the simple protection network shown in Fig. 3.

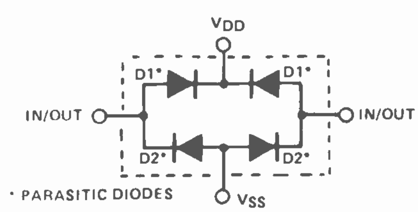



**Fig. 3 The 4066B quad bilateral switch has standard B-series protection on its gate control input terminals, but has this simplified form of protection on its 'switch' elements.**

Note in Figs. 1-3 that all diodes marked with asterisks are 'parasitic' devices, which just happen to occur fortuitously as an inherent part of the CMOS manufacturing process, while all other diodes are specifically designed into the circuits. Also note that the networks are intended only to give protection against 'normal' electrostatic discharge voltages. When the networds are subjected to ordinary DC signals, the diodes are liable to burn out if their forward currents exceed 10 mA or so, thereby causing possible catastrophic damage to the IC substrate.

Major CMOS manufacturers such as RCA reckon that an electrostatically charged human body can be approximated by the circuit of Fig. 4, in which the 'body'

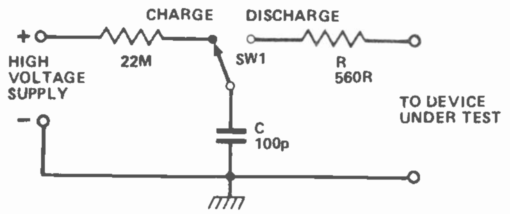



**Fig. 4 Manufacturers use this equivalent-body discharge network when evaluating the capabilities of their CMOS protection networks.**

has an effective capacitance of 100pF and a source resistance of 560R. The manufacturers have caried out extensive tests with this model by charging the 'body' to various voltages and then discharging it (via the 560R series resistor) into different terminal combinations (input, output, $V_{SS}$, $V_{DD}$) of CMOS devices to establish worst-case capability figures for the three types of electrostatic-discharge protection networks. It should be noted in these tests that the 560R series resistor acts as a current-limiting voltage dropper, so the voltage actually reaching the CMOS device is far lower than the initial electrostatic voltage.

The results of the manufacturer's protection capability tests are shown in Fig. 5. As you can see, the

| PROTECTION NETWORK | WORST – CASE CAPABILITY |
|---|---|
| STANDARD B–SERIES | 4 kV |
| 4049B AND 4050B | 1 kV TO 2 kV |
| 4066B BILATERAL SWITCH | < 800 V |

**Fig. 5 These are the worst-cast capabilities of the three different CMOS protection networks, when tested with the network of Fig. 4.**

standard protection network can withstand a 4kV electrostatic discharge. A quick calculation shows, however, that this represents a peak protection-diode current of several amps, yet we've already seen that these diodes can withstand DC currents of only 10 mA or so. Puzzled?

## Up The Junction

Just about the only way of destroying a diode is to literally vaporize its junction, and this can only be done by applying an adequate amount of power for sufficient time for the melting process to take place. Since a junction must inevitably be formed on a substrate, which has a finite mass, all junctions inevitably have a certain amount of thermal inertia and are, in fact, destroyed by energy overloads (power-time product), rather than by simple power overloads.

Consequently, it is quite normal to find that a diode rated at 1A, for example, can, in fact, withstand brief current surges up to several hundred amps. Similarly, CMOS protection diodes, which have very low DC current ratings (10 mA), can withstand very high levels of surge current (several amps), provided that the surge current duration is very brief. Fig. 6 shows the typical surge current capabilities of these protection diodes. Remembering that the 100p — 560R 'human body' equivalent circuit has a time constant of a mere 56 nS, it no longer comes as a surprise to note that these diodes can withstand several amps of peak current from a 4 kV discharge!

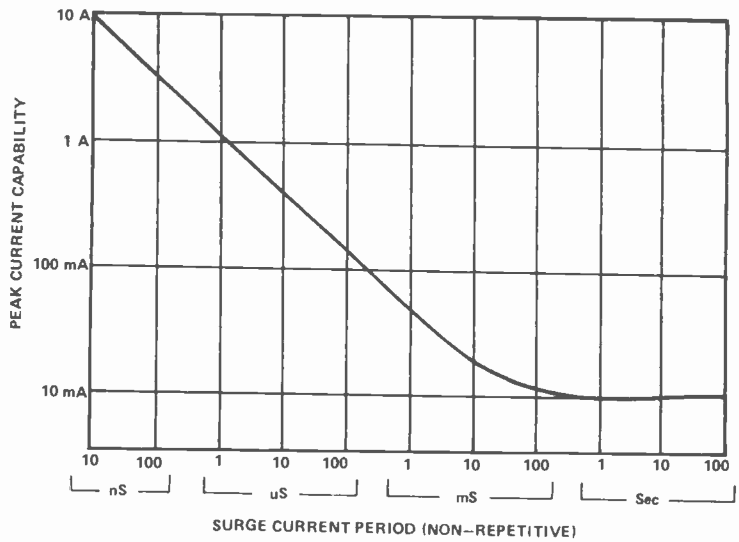



**Fig. 6 Typical surge-current capabilities of CMOS protection diodes.**

## CMOS Circuit Design

By now you will have gathered that you can effectively destroy a CMOS device by simply blowing one or more of its 'protective' diodes with a DC current as low as 10 mA. Consequently, when designing CMOS circuits, precautions must be taken to ensure that excessive diode current cannot flow in the CMOS chips.

CMOS ICs can be 'blown' by excessive signals applied to either the input or the output terminals. If several CMOS stages are cascaded, empirical experience shows that a front-end blow will usually destroy only a single device (because low energy levels are normally involved), but a rear-end (output) 'blow' will often have a ripple effect (because high energy levels are involved) and cause the destruction of all ICs in the chain.

The most common cause of front-end 'blow, and its cure, are illustrated in Fig. 7. Here, a capacitor is connected directly bectween the IC gate and the 0V line: when SW1 is closed, the capacitor charges up via R1 and eventually attains the full positive supply potential. When SW1 is opened (to switch the circuit off), C1 tries to discharge via D2, the 'upper' input protection diode of the gate.

In the Fig. 7a circuit, the only discharge path for C1 is via D2 and the IC's supply terminals; consequently the discharge currents will be quite low and the IC will probably suffer no damage. In Fig. 7b, on the other hand, a 100R resistor is connected across the supply terminals, so C1 will try to discharge to ground via D2 and R2, and the resulting 90 mA peak current will almost certainly result in the destruction of the chip. In practice, R2 may well take the form of various resistors and semiconductor devices distributed throughout the total circuit.

Fig. 7c shows the cure for the Fig. 7b design problem, a 10k resistor wired in series with the gate to limit the C1 discharge currents to a safe value. Whenever you design CMOS circuits and have to connect a capacitor between a gate and the 0V rail, always make sure that the capacitor discharge current is limited to a safe value, either by a series gate resistor or by some other factor.

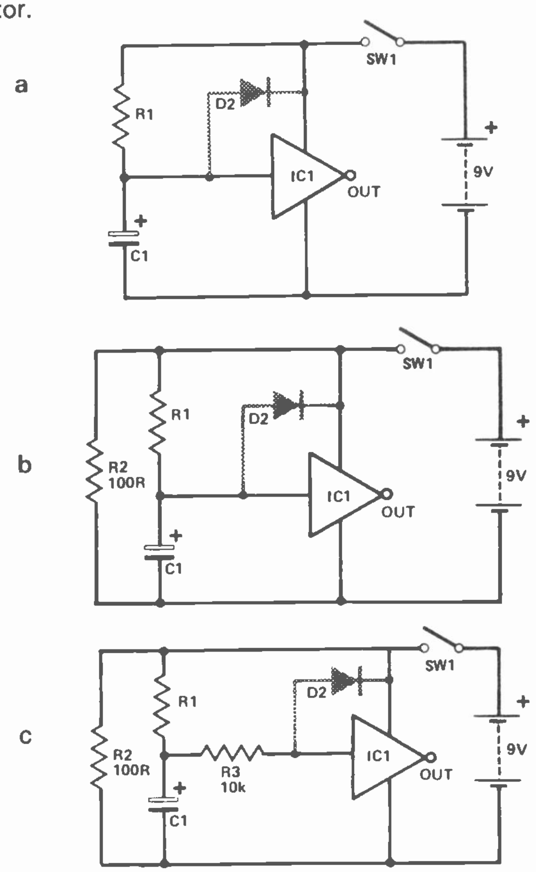
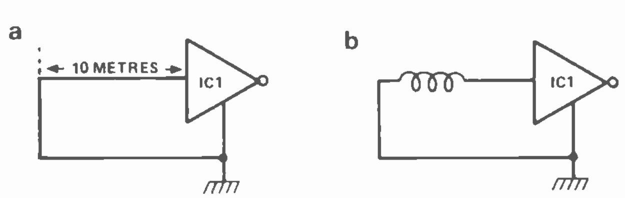



**Fig. 7 Circuits (a) and (c) are safe, but circuit (b) will almost certainly cause a front-end 'blow'. See text for explanation.**

Fig. 8 illustrates another possible cause of front-end 'blowing', and its cure. In Fig. 8a, it seems that the IC's input is safely grounded by the 10m of input cable (in practice, this cable may go to a low impedance sensor, etc), but in actual fact (Fig. 8b) this cable will inevitably be inductive and can easily pick up unwanted radiation and possibly feed destructive signals to the IC input. Figure 8c shows that the circuit can be rendered safe with a simple filter (R1-C1) and a series gate resistor (R2).



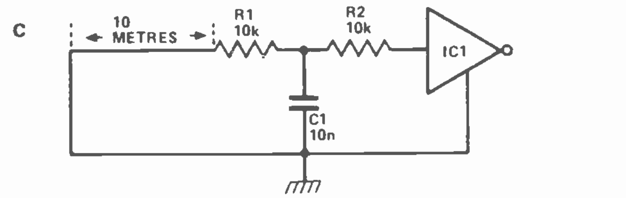




**Fig. 8 Long input cables, as in (a), can be equivalent to an inductor (b), and present another front-end blowing hazard. The cure is simple (c).**

## Back-end Blowing

The most common cause of back-end blowing is unexpected back-EMFs (from inductive loads) reaching the CMOS output by breaking through from power-driving circuitry.

Inductive loads, such as relays, can generate surprisingly large back EMFs as their fields collapse at switch-off, as can be proved by conecting a relay in the 'buzzer' mode shown in Fig. 9. Typically, a 12V relay will generate a back-EMF of about 300V! If you ever use CMOS to switch a relay or other highly inductive load using a transistor driver, always protect the transistor with a pair of 1N4001 diodes connected as shown in Fig. 10A. If you want to be really safe, you can use another pair of similarly-connected diodes to directly protect the output of the CMOS stage, as shown in Fig. 10b.

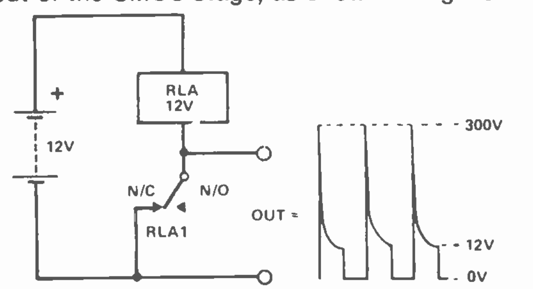



**Fig. 9 This 'buzzer' circuit can be used to check the magnitude of the back-EMF from a relay. 300 V is typical!**

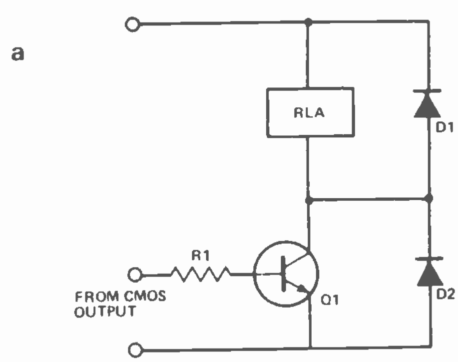
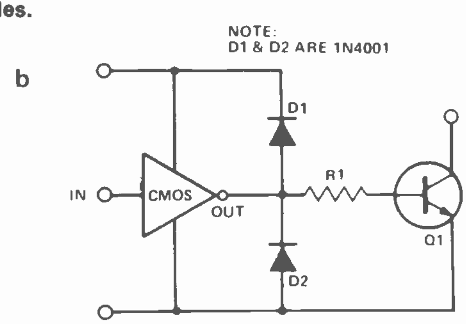
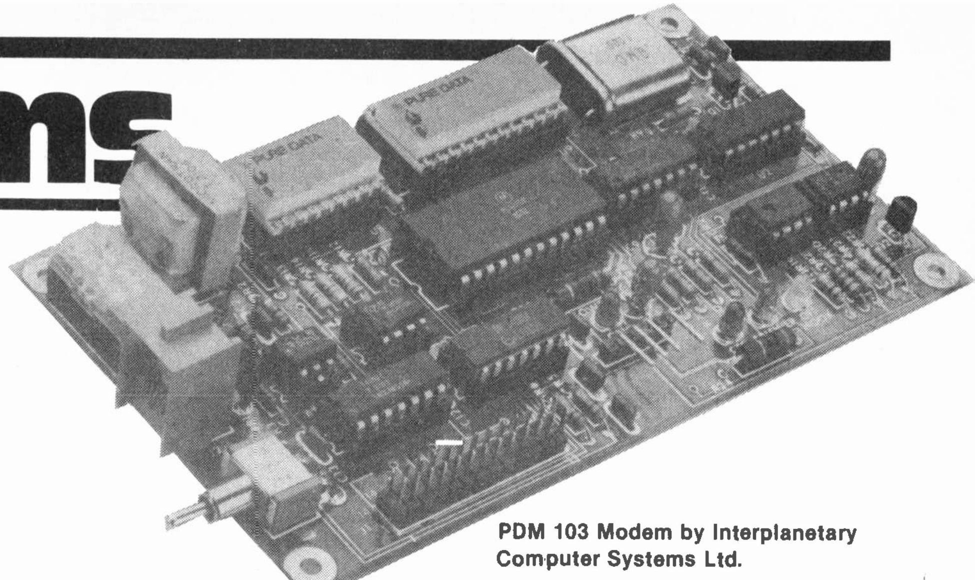



**Fig. 10 (a) a transistor relay-driver can be protected with a pair of diodes.**



# Modems



PDM 103 Modem by Interplanetary Computer Systems Ltd.

**The danger in giving your computer a modem is that it might start ordering pizzas. Data by phone, by Robert Traub.**

TELEPHONE MODEMS have become very popular over the past few years with the increased number of microcomputers now in homes. Modems come in a variety of styles and vary greatly in cost and functions. These units are fast becoming common place with the home microcomputerist. Covered here is some basic information to help those starting in this area to understand their modem.

## Tone Control

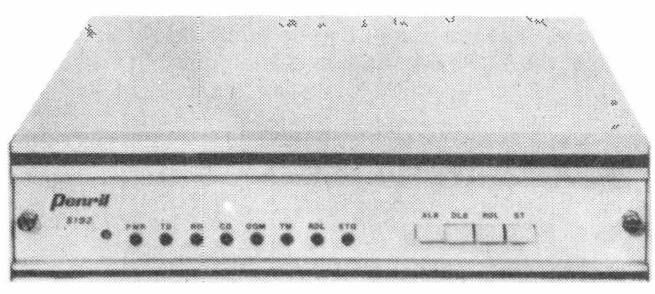
The word "Modem" is a contraction of the two words; *MOdulator* and *DEModulator*. The term modulator means "to vary the amplitude, frequency, or phase of a carrier wave for the transmission of intelligence". In the case of the telephone modem it is frequency variations that occur. The demodulator is simply a circuit that will receive a modulated signal, and separate it into its component parts for use. There are many types of modems, each for a different purpose and each with an associated cost, but for this discussion we will be referring to the Bell 103A type. With the telephone modem, there are two set of signals used, each having two different tones. These tones are sent over the telephone lines and detected at the far end. The two sets of tones that are used are (1) the originate tones and (2) the answer tones.

The two sets of tones or frequency pairs are designated as F1 and F2. F1 is the lower frequency pair and F2 is the higher frequency pair. The originate only type of modem transmits F1 and receives F2, while the answer only modem transmits F2 and receives F1. Another way of saying this is that a modem in the originate mode will be transmitting F1 and receiving F2, and when in the answer mode, will be transmitting F2 and receiving F1. These tone pairs are broken down to their individual tones, and each tone has a designation; one is called *mark* mark and the other is called *space*. With the originate only modem, one transmitted tone is designated as F1M for mark, and has a frequency of 1270Hz. The other transmitted tone is designated as F1S for space, and has a frequency of 1070Hz. Note that the difference between these two frequencies is 200Hz (1270-1070 = 200), thus having a shift of 200Hz. With the answer only modem, or answer mode, one transmitted tone is designated as F2M for the mark and has a frequency of 2225Hz. The other transmitted tone is designated as F2S for space and has a frequency of 2025Hz. See chart 1. Again, the difference or shift between these two frequencies is 200Hz.

The 103A class of modems are designed for use over switching lines. These are the standard telephone lines found in residences. This type of modem is low speed, usually 110 or 300 baud. (The higher speed modems require either a conditioned line or a dedicated line; both of these line types are available at increased cost to the user.) The 103A is asynchronous and can operate in either half duplex or full duplex. In the half duplex mode, the modem can receive or transmit tones, but not both at the same time, while in full duplex mode the modem can both receive and transmit tones at the same time. Another operating characteristic of this modem is that it uses frequency shift keying (FSK). With frequency shift keying, one tone is sent out as the carrier tone, say mark, and when the system is keyed by the data bits, it will shift this tone down by 200Hz to send the space tone. This shifting of tones is dependent on the data bits that are being sent at the time; when the data bit is a "1" the mark tone is sent, and when the data bit is a "0" the space tone is sent. Note that the amplitude of the signal does not vary with FSK; only frequency of the tone is changed. There are, of course, different 103A types of modems available on the market and some offer originate/answer as well as switching and ring detectors, while others may be originate only or answer only and offer no special features. With originate only modems, the user must originate the call and with answer only modems someone else must answer. The ring indicator feature will turn on a light when a ring signal is detected by the originating modem.

## RS232 Blues

The interface used is the standard serial RS232C. As RS232C is a universal type of interface designed

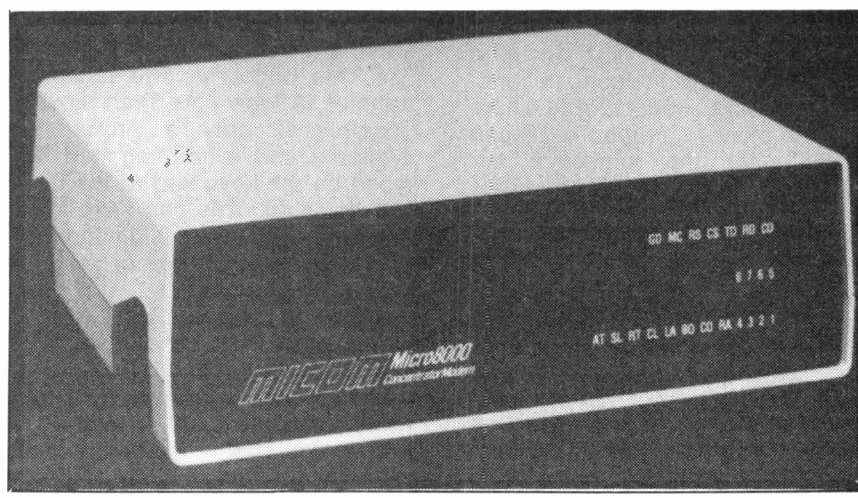


for use with many different types of peripheral equipment such as printers and crt terminals, a general coverage will be presented here. This type of interface is defined under the CCITT V.24 standard for low speed communications. The interface has an operating range of 0 to 20,000 bps (bits per second) synchronous and asynchronous. With asynchronous data transmission and reception, the data includes a start bit and one or two stop bits in order to maintain proper communications. The 8 bit serial ASCII word, for instance, would have a start bit at the beginning, followed by the 8 bits of data, followed by two stop bits that indicate the end of that data byte. Therefore, in this case, 11 bits would be sent through the line for each character. See Fig. 1. This is the most common form of serial communications used with microcomputers. This standard allows for a great flexability in the selection of printers and modems as well as other peripheral equipment.

With the RS232C standard there are two types of connectors, both with 25 pins. First there is the Data Terminal Equipment (DTE) and second there is the Data Communications Equipment (DCE) connector. The male connector is the DTE and the female connector is the DCE. The DCE uses the connector designated as DB-25S, and the DTE equipment uses the connector designated as DB-25P. Some examples of DCE equipment are computers and modems while DTE equipment would include terminals, printers and most other peripheral equipment. Therefore, always connect a DTE to a DCE. The length of interconnecting cable for this standard has been limited to 50 feet, but longer lengths could be used if special precautions are observed. The RS232C voltage specifies a bi-polar voltage; this will vary between plus 25 volts maximum and minus 25 volts maximum, with the area between plus 3 volts and minus 3 volts regarded as the transition region or the "undefined" signal region.

The RS232C specifies that the pins on the connectors be lettered (double letters) and that each group of letters be given a specific function; this insures compatability between equipment of different manufacture and is defined as follows:

AA PIN 1 — Protective Ground. This is the common physical ground between interconnecting equipment.




AB Pin 7 — Signal Ground/Common Return. This is the ground strap for the actual signal carrying circuit, and not the physical equipment ground.

BA Pin 2 — Transmitted Data. This is data that is sent to the DCE.

BB Pin 3 — Received Data. This is data received from the DCE.

CA Pin 4 — Request To Send. This is a control signal sent to the DCE.

CB Pin 5 — Clear To Send. This is a control signal sent from the DCE.

CC Pin 6 — Data Set Ready. This is a control signal sent from the DCE.

CD Pin 20 — Data Terminal Ready. This is a control signal sent to the DCE.

CE Pin 22 — Ring Indicator. This is a control signal sent from the DCE.

CF Pin 8 — Received Line Signal Detector. This is a control signal sent from the DCE.

CG Pin 21 — Signal Quality Detector. This is a control signal sent from the DCE.

CH Pin 23 — Data signal Rate Selector (DTE). This is a control signal sent to the DCE.

CI Pin 23 — Data Signal Rate Selector (DCE). This is a control signal sent from the DCE.

DA Pin 24 — Transmitter Signal Element Timing (DTE). This is a timing signal sent to the DCE.

DB Pin 15 — Transmitter Signal Element Timing (DCE). This is a timing signal sent from the DCE.

DD Pin 17 — Receiver Signal Element Timing. This is a timing signal sent from the DCE.

SBA Pin 14 — Secondary Transmitted Data. This is a data signal sent from the DCE.

SBB Pin 16 — Secondary Received Data. This is a data signal sent to the DCE.

SCA Pin 19 — Secondary Request To Send. This is a control signal sent to the DCE.

SCB Pin 13 — Secondary Clear To Send. This is a control signal sent from the DCE.

SCF Pin 12 — Secondary Received Line Signal Detector. This is a control signal sent from the DCE.

The other pins are not assigned, but may be used for other controls if needed.

The signal levels for the RS232CC are defined as:

DATA — Binary State (-3 to -25) is "1" or *mark*.

DATA — Binary State (+3 to +25) is "0" or *space*.

Control Circuits — (-3 to -25) is *off*.

Control Circuits — (+3 to +25) is *on*.

Some of the more common control signals include Data Set Ready. This line, when plus or "on", indicates that the modem is connected to the telephone line and is in the data mode. Another is the Clear To Send; when this pin is plus or "on", it tells the originating modem that it has established contact and transmission can begin. Which control lines are used will depend on the particular printer or modem installation.

The voltage levels for the RS232C were given as between plus 25 volts and minus 25 volts. It should be noted that these are the *maximum* voltage levels allowed, and lower voltages such as plus 15 and minus 15 volts are common with this standard. Another point that requires attention is the fact that both modems and microcomputers are of the *DCE* type. Therefore, in order to hook these two similar pieces of equipment together with the RS232C line, the wires on pins *2 and 3* must be reversed on one end (not both). Both are DCE types, and are not intended, by the standard, to be connected together.

## More Numbers

In 1977 a new standard designated RS449 was introduced. This standard uses a 37 pin connector and a 9 pin connector. The 37 pin connector is used in place of the 25 pin connector of the RS232C for normal interchange of data and the 9 pin connector is introduced for use with secondary channels. With this standard cable length can extend to 200 feet for low speed (300 baud). All of the electrical characteristics have been revised and both balanced and unbalanced circuits are supported.

The 103A type of modem can be either direct hookup to the line or acoustically coupled. With acoustic coupled modems the telephone handset is placed in a rubber cradle. There is a mouth piece (microphone) placed directly under the handset's ear piece, and of course an ear-piece (speaker) placed directly under the handset's mouth piece. This will establish a communications link between the telephone handset (line) and the modem. This type of interface is not the best as external noises can interfere with the transmission and volume levels are not always adequate for reliable data transfer. A direct coupled modem is almost always better, and its use is recommended.

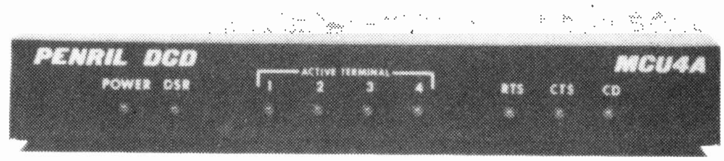
The purpose of the modem then is to take the digital bi-polar signal from the microcomputer or printer and convert it to two different analogue signals (tones) for transmission over the analogue telephone lines. Conversely, it takes the analogue signals present at the telephone and convert these tones to bi-polar digital code for the microcomputer (or printer).

With the bigger computer installations, modems are used at the remote end to drive a printer of some type. This is very common where leased equipment and computer time is required by a company or organization. In more recent years, with the advent of microcomputers, the modems are finding their way into direct connection with the microcomputer itself (this is the reason for the reversal of pins 3 and 4). With this type of interconnection, the user can have the benefit of a program with a "buffer" to work either into or out of. A buffer will allow the user, in the case of transmission, to type in all of the message, edit it, and send it out at a constant rate of speed. Also, the user may load the buffer with data from either a disk system or cassette system and have large amounts of data transmitted at one time, without the need to type it all at the time of transmission. In the case of receiving, the buffer will allow the user to take in at one timer a complete transmission, and have it stored on either a diskette or cassette for later use. This, of course, offers more data transfer in less time than would be possible if only a printer were available and everything had to be typed on the keyboard at the time of transmission. This can save a great deal of money if one is paying for the use of computer time or telephone time.

The microcomputer buffer and all of the associated operating functions are the responsibility of the microcomputer's software. There are many different types of modem programs available and not all offer the required features for complete two way communications. Software that is well designed can look after almost every need that would arise when working with modems. Some of the features that would be desired are the ability of the software to save the buffer contents on either the disk system or the cassette system, the ability to see on the local console all data that is transmitted out over the modem, and conversely to see all incoming data on the console. The software should have some way to handle control characters to insure that they do not interfere with the communications link. The software should also be able to detect and notify of any loss of signal. There are other features that can be added, even auto-dialing, but they are not required by any means.

Some other types of modems available at additional cost are;

- *Bell 201C* which requires leased lines but can use switched lines as back-up. The common speed for this model is 2400 bps.
- *Bell 303,* for use over leased lines only and is designed for high speed, wideband data such as computer-to-computer communications. Typical baud rates with this type are from 18.75 K bps to 460.8 K bps.
- *Bell 801A & 801C*, where 801A is an automatic calling unit that can originate calls through standard rotary dial facilities, and 801C is an automatic calling unit that can originate calls through touch tone facilities.




## Hanging Up

Modems are fast becoming one of the most popular accessory items available for the home microcomputerist. This information will be of value to anyone who is interested in starting up or who wishes to learn more about the unit they already have.

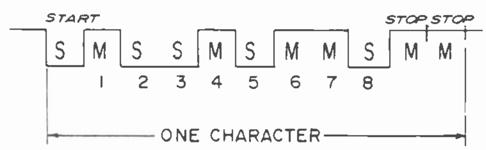



FIG. 1.

Figure shows one full character taking 11 bits total.

Chart showing tone pairs for originate and answer modes.

| MODE | TRANSMIT TONES | | RECEIVE TONES | |
|---|---|---|---|---|
| ORIGINATE | F1 SPACE F1S 1070HZ | F1 MARK F1M 1270HZ | F2 SPACE F2S 2025HZ | F2 MARK F2M 2225HZ |
| ANSWER | F2 SPACE F2S 2025HZ | F2 MARK F2M 2225HZ | F1 SPACE F1S 1070HZ | F1 MARK F1M 1270HZ |

CHART 1.

# ETI SPECIALS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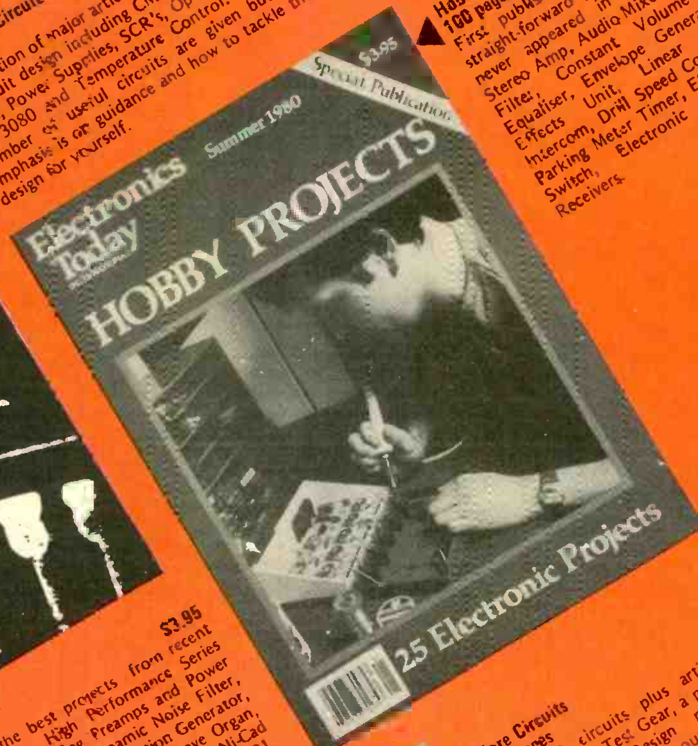


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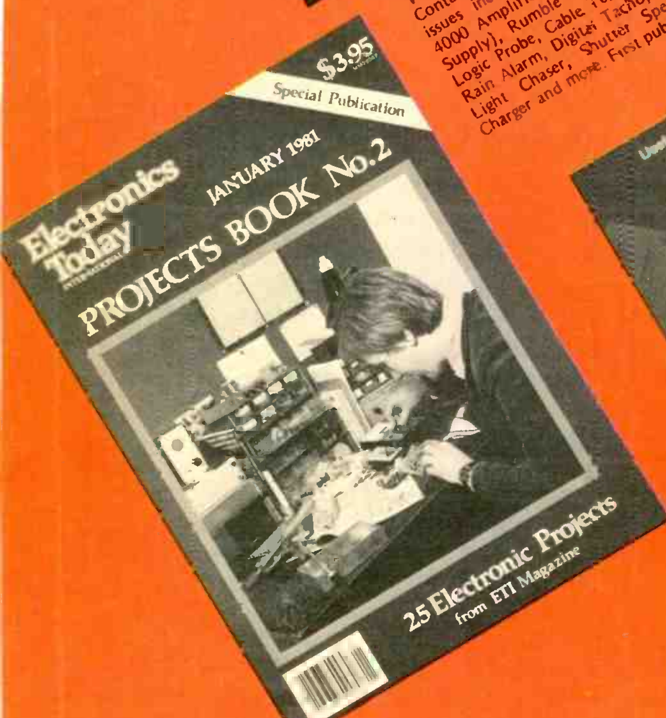


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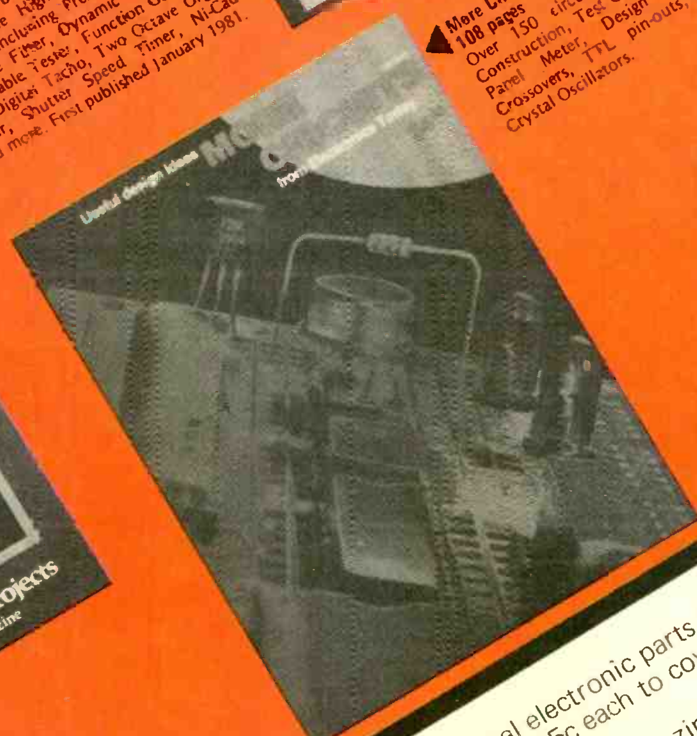

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# Drones

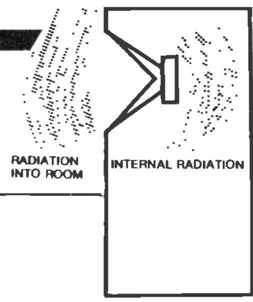



Fig. 1. Air suspension

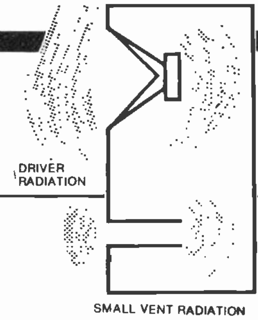



Fig. 2. Bass reflex

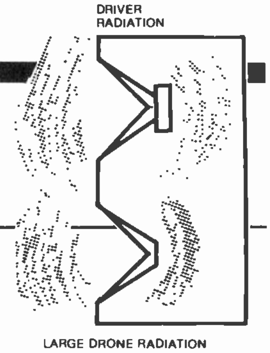



Fig. 3. Passive radiator

**Drone speakers were once regarded as only those used to play Anne Murray. Now they've become more sophisticated, as Wally Parsons explains.**

PROBABLY NO ASPECT of audio is as cluttered with misconceptions, misunderstanding, myths, fairy tales, black magic, and plain wishful thinking as the operation of loudspeakers. In their efforts to do something clever and provide some material for those otherwise unemployable souls who write advertising copy, many manufacturers are guilty of compounding the confusing by issuing advertising statements which are often impossible and even idiotic.

Ironically, the one speaker type to have suffered the least misunderstanding is the passive radiator, or, to use its more droll title, the drone cone. The reason for the lack of misunderstanding seems to be that hardly anyone even pretends to understand it. This is shown by the relatively small number of such speakers on the market.

The purpose in this article is to shine some light on the operation and virtues of this marvelous device, while, along the way, dropping some insights into loudspeaker operation in general.

### Backwaves, The Poor Unwanted Orphans

From the outset, it should be understood that the passive radiator is really a variation on another system, the bass reflex, rather than a distinct system in itself. Our investigation must, therefore, begin with a look at this, the most misunderstood acoustic principle to walk the face of the earth.

The problem lies in the fact that the loudspeaker (the round object with its magnet and cone, mounted in some kind of enclosure, and henceforth referred to as "the driver") is a cantankerous beast which, in its perversity, insists on radiating sound from both sides of its diaphragm. Now, this wouldn't be too bad, in fact, it might even be a blessing, were it not for the fact that the two fields are out of phase. Therefore, drivers are mounted on baffles of infinite size, or in closed boxes to prevent front and rear waves from meeting and bringing about the end of the universe, or some other calamity such as stamping each other "Cancelled".

Since truly infinite baffles are rather impractical, closed boxes are the rule. When a driver is mounted in one wall of such a box, the rear wave is trapped inside and must be dissipated, which usually means converting it into heat. In a small box the trapped air also results in a pressure and rarefaction cycle which oppose cone movement, and has the effect of reducing the compliance of the driver. The result is an increase in resonant frequency, and an increase in the bass cut-off frequency. For reasons beyond our present scope, the only way to minimize the bass loss is either to use a large box and/or accept a loss of efficiency.

Bit of a Hobson's Choice, what?

### Letting The Air Out

Some daring individuals have indulged in the practice of drilling a hole in the box "to let the air out" and reduce internal pressure changes.

While such a hole, or vent will 'let the air out", it doesn't automatically happen in a very useful way.

A box with a vent in one wall forms a Helmholtz resonator, in which the air in the vent acts as an acoustic mass which resonates with the compliance of the air inside the box. By adjusting the box size, vent size and depth it is possible to control the resonant frequency of the resonator as well as its Q so that it interacts with these same characteristics of the driver in such a way that an extended response characteristic is synthesized.

The performance of the bass reflex can be outstanding, but even with the number of degrees of freedom in design, so many factors are interdependent as to introduce undesireable trade-offs.

For example, frequently a design may dictate a relatively small vent with a long duct behind it to increase vent depth. This works fine, but because of the small size of the vent, we have a narrow column of air moving at high velocity. This result in large energy losses due to friction with the duct wall and viscous losses within the air itself.

We could use a vent around the same size as the driver, but this would require either a large box, with a low compliance driver, or a long enough duct which would act like a tuned pipe. Besides, with a large short vent there is danger that the back wave above the tuned frequency of the system would leak around the vent causing cancellation at various frequencies.

### Condition of Passivity

Earlier it was stated that the air in a vent acts as an acoustical mass which resonates with the compliance of the air trapped in the box. There is no reason why we have to use air. All sorts of other things have mass. For example, a loudspeaker cone has mass. If a driver, minus the motor (or you can leave the motor there if you like), which consists of the magnet and voice coil, were installed in place of the vent, its mass would resonate with the compliance of the air trapped within the box, just as a bass reflex.

"But", you say, "if it does exactly the same thing, why go to the expense of installing another piece of equipment when it costs nothing to cut a hole in a box?" Right you are, George. But we have gained something for our money.

The most important gain is the fact that we can alter the characteristics of the passive radiator, which we have installed, more or less independently of the physical characteristics, that is the dimensions, of the box.

Suppose, for example, that a particular bass reflex design used a 12 inch driver and the largest practical vent area was 10 sq. in. Say it's a high compliance low resonance driver and we wish to tune the box to around 30 Hz. Depending on the size of the box, the vent may require a duct some 7 or 8 inches long. As a result of frictional and viscous losses the output of such a vent at resonance would probably be considerably below that of the driver, whereas we would like to be substantially equal. If we replace the vent with a passive radiator of 12 inches diameter we would have a radiating area of about 78 sq in. requiring negligible depth. Such a large diaphragn would operate at low velocity with only suspension losses to contend with, resulting in much higher output.

## Theory of Operation

Most treatments of such speakers get very involved in equivalent electrical impedance circuits such as Fig. 4, and talk about resonant circuit meshes, accompanied by endless equations full of Greek alphabet soup. These are great for design work if you know how the things operate, but how, actually *do* they work? What are the mechanics? Or, as someone recently asked, how come when one diaphragm moves out the other doesn't move in, with the two motions cancelling?

To get a handle on this problem, take another look at Fig. 3. To simplify matters, assume that both the driver and passive radiators are 12 inch units. Let's assume further that the passive radiator is actually a driver identical with the regular driver, only the voice coil isn't attached to anything, while the regular driver is connected to an amplifier.

If there's a stereo salesman you don't like, one neat way to drive him into a state of ulcers is to walk into the store, pick out the first passive radiator speaker you see and push in on either the driver or the drone. Whichever one you push, watch the other one move out. Let go and watch the one you pushed pop back out while the other one moves in. Try it on the other unit and watch the same think happen. Push in on one unit while restraining the other. Feel the force. Watch the salesman turn blue.

Now repeat the experiment, this time using an amplifier connected to the driver, and a signal of only a few Hertz. Same thing happens, right? This isn't helping the guy who asked me why it doesn't happen, is it.

Okay, let's repeat the experiment using a signal of around 100 Hz, with level high enough to allow us to observe cone movement. Hello, looky here, the passive radiator is truly passive, not moving (this assumes a system with real extended bass).

At very low frequencies, movement of the driver cone simply displaces internal air, causing an opposite movement of the drone. Any external air motion is cancelled, resulting in no sound. However, at the higher frequency the passive radiator's mass is such that it couldn't start moving fast enough to vibrate. The driven cone moved inward, compressing the trapped air. This compressed air tried to move the passive radiator, but before the latter could get going, the driven cone moved outward, causing a reduction of internal air pressure.

Thus, the passive radiator contributes nothing to the acoustic output, and the system behaves like a closed box.

But, at some frequency between these two there is a transition from negative output to zero, and this occurs at the frequency at which the mass of the passive diaphragm resonates with the combined compliance of its suspension and that of the enclosed air. At that frequency, if the driven cone moves in it will compress the internal air, which in turn will force the passive diaphragm outward. However, because of the diaphragm mass there will be a delay in its movement, so that by the time it starts to move outward, the driven cone will have also begun to move outward. Then, of course, the reduced internal air pressure will cause it to move inward again, but delayed so that the driven cone is also moving in at the same time.

The two diaphragms are in phase and their outputs now add.

Several other things also happen. For one thing, with the two radiators close together, the pressure and rarefaction cycles of one tends to load the other. This is the mutual radiation impedance, and improves the loading on each unit, increasing acoustical power output and lowering distortion while increasing the acoustical damping. For this reason, the output is more than the sum of the two units, and, in our example, may easily be equivalent to that of an 18 inch signal driver in a larger enclosure. This mutual radiation impedance occurs when any two diaphragms are close together provided the diaphragms are small with respect to the wavelength radiated, and provided both diaphragms are of substatially the same area. It doesn't matter whether the diaphragm be a cone, or the air at the front of a vent. Obviously, it doesn't occur when a 78 sq in cone is mated to a 10 sq in vent.

Another desireable effect is increased output from the diaphragm because of its negligible friction losses, compared with a small vent. Also missing is the "chuffing" sounds often occurring with small vents due to the combination of high friction and high air velocity.

## Impedance

Fig. 5 shows the familiar impedance curve of a driver in free air and the same driver in a bass reflex enclosure whose box is tuned to the driver's free air resonance. This same curve also occurs with a passive radiator system under the same tuning conditions.

Why?

Let's go back to Fig. 3. At resonance the driven cone moves more freely than at other frequencies. Its tendency to want to vibrate on its own causes it to generate a back EMF which opposes the driving signal. In other words, it behaves like a higher impedance. However, when driver and drone are both at resonance, the drone increases internal pressure, and reduces it in step with driver motion. This tends to reduce freedom of cone motion and damps the resonance. This reduces the back EMF and cancells the impedance rise. It should be noted that the driver also damps the resonance of the drone in the same way.

Above resonance the passive radiator behaves more like a rigid wall. Consequently, the driver behaves as if it were an air suspension system. Since such a system has a system resonance higher than the free air resonance of the driver, this appears as the upper impedance peak on the curve.

How about the lower peak.

Below resonance the two diaphragms are effectively coupled together by the air within the box. As a result, one voice coil is now moving two diaphragms. In fact, the mass of the passive radiator is now added to the mass of the driven cone, resulting in a lower natural resonant frequency. This appears as the lower peak.

*Continued on page 86*

# AF Signal Generator


**Our latest do-it-yourself test gear project is a simple-to-build signal generator with many features found on expensive designs.**

THERE IS NO doubt; if you dabble in electronics much and build more than just the odd project, then test gear of all descriptions is a must. Furthermore, if the project is in the audio category, then somewhere along the line you will need an audio source.

Of course, using a bit of ingenuity, the clever ETI reader might use the auxiliary output of a stereo system as a signal, but there are disadvantages with such a method: neither the amplitude (size) nor the frequency (pitch) of the signal can be accurately specified. What you really need is a signal generator like this project, providing a selection of waveforms (sine, triangular or square) with fully variable amplitudes with the added facility of a controllable DC bias to the output signal. All this is achieved with only a two-IC circuit which operates from two 9V batteries.

## Construction

There is nothing critical in the construction of this project if you use our design of printed circuit board. Everything is quite straightforward. Solder in resistors first, followed by capacitors and IC sockets and finally insert the two ICs.

Following the connection diagram in Fig. 2 you should now connect the switches, potentiometers, battery clips and output sockets and test out the project before insertion into its case. Set all presets and pots to midposition and switch on. By connecting the output to a suitable amplifier (e.g., your stereo system), adjust the output to a suitable level using the amplitude control, RV6.

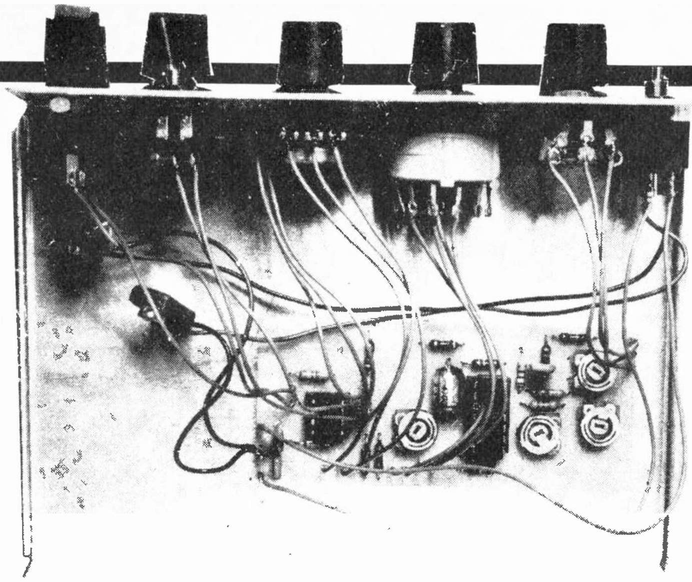
Now, turn SW1 to 'sine' and open SW3 (i.e., switch off the DC bias). Adjustment of RV4 and RV5 should remove any distortion and a perfectly

**PARTS LIST**

| | |
|---|---|
| **Resistors (All ¼ W, 5%)** | |
| R1 | 18k |
| R2,7,9 | 10k |
| R3,4 | 4k7 |
| R5 | 10M |
| R6,8 | 15k |
| R10,13,14 | 47k |
| **Potentiometers** | |
| RV1,3 | 1k0 miniature horizontal preset |
| RV2 | 10k linear potentiometer |
| RV4,5 | 100k miniature horizontal preset |
| RV6 | 100k logarithmic potentiometer |
| **Capacitors** | |
| C1,3,4 | 100n ceramic |
| C2 | 4n7 mica |
| **Semiconductors** | |
| IC1 | 8038 waveform generator |
| IC2 | 741 operational amplifier |
| **Miscellaneous** | |
| SW1 | single-pole, three-way rotary switch |
| SW2 | double-pole, single-throw toggle switch |
| SW3 | single-pole, single-throw toggle switch |
| Case to suit | |
| Battery clips and batteries | |
| Knobs, output sockets, IC sockets | |

'clean' note should be heard. Turn the frequency control RV2 fully anti-clockwise to its lowest frequency setting and adjust RV1 until the lowest note possible from the generator is heard. One further adjustment can be made with RV3 if you have an oscilloscope; varying the preset will alter the duty cycle (best observed on square wave) which should be 50%; i.e., high for half the wavelength and low for the other half. If you don't have the use of a 'scope leave this preset at midposition and the adjustment won't be far out.

Finally the project can be housed in a suitable case.



## HOW IT WORKS

Integrated circuit IC1 is a special purpose device, capable of generating sine, triangle or square waveforms (or derivations of these), to a high accuracy. The frequency of the waveforms is primarily defined by the charge and discharge rate of capacitor C2. This capacitor should be, ideally, a type whose value is very stable with temperature, e.g., a mica type, although others are usable, with lower accuracy.

The charge rate of the capacitor is also a function of the value of resistor R3. Likewise R4 controls the discharge rate. For a symmetrical waveform R3 and R4 should be of equal value. Preset RV3 allows adjustment of these two resistors to ensure that the charge rate of the capacitor exactly equals the discharge rate and so the waveform is symmetrical.

The voltage at pin 8 of the integrated circuit also controls the frequency of the generated waveform (over a 1000:1 range). Thus, by sweeping the control voltage on this pin between Vcc and (⅔ Vcc + 2V) i.e., 5 to 9 V, the frequency of the waveform varies from 20 Hz to 20 kHz. The control voltage is derived from potential divider RV1,2 and R1.

Presents RV4 and 5 allow sine wave distortion to be minimised to only 0.5%, and this is best achieved by listening to the sine wave and adjusting the two presets until distortion is no longer audible.

The outputs of this integrated circuit are found at pins 2 (sine), 3 (triangular) and 9 (square). Switch SW1 selects one of the wave shapes and connects it to the amplifier circuit of IC2, via RV6, the amplitude control. The amplifier is configured as a mixer, although in its simplest mode (i.e., with SW3 open) the IC is just an inverting amplifier, whose output is centred symmetrically about 0V. However, with SW3 closed, a DC bias voltage is mixed with the waveform and the output can be moved up or down in voltage, still having the same AC amplitude.

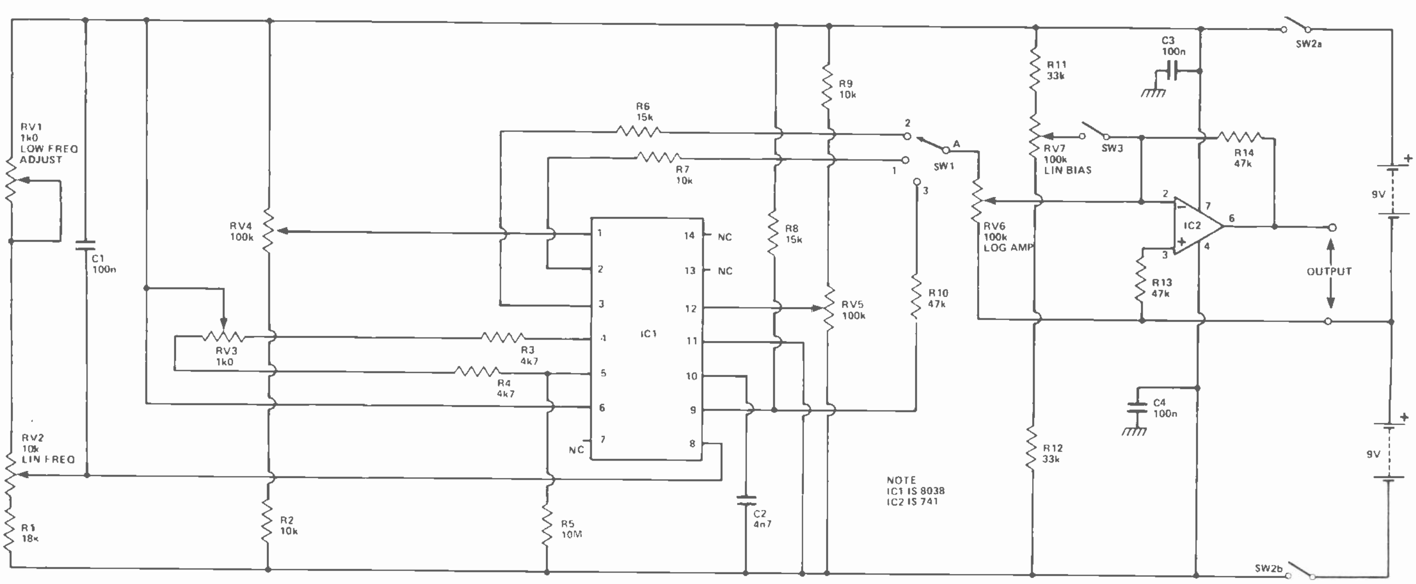



**Fig. 1 The Audio Signal Generator circuit diagram.**

*Continued on page 78*

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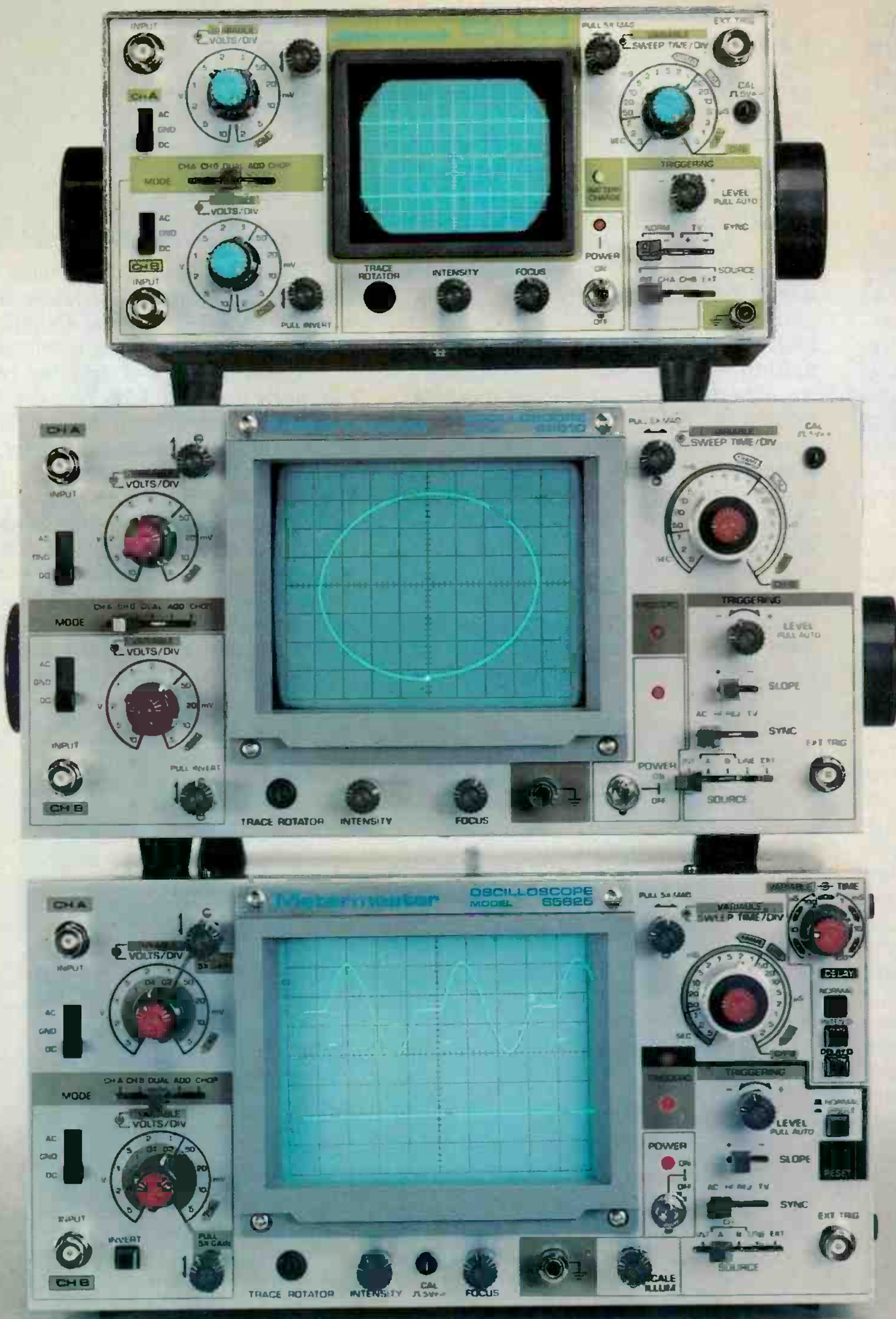

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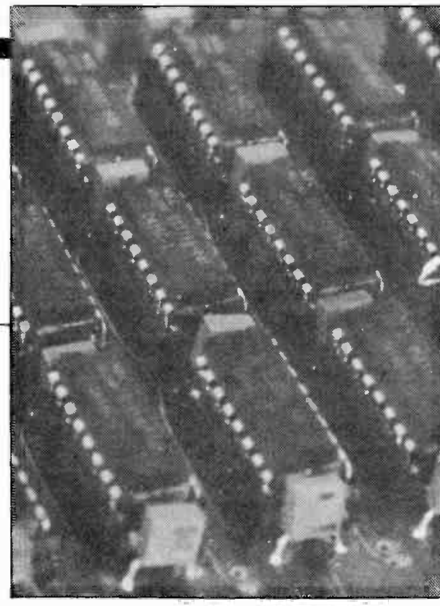
*Circle No. 11 on Reader Service Card.*

# 6809 Board Review



**It's got 48K of RAM, an RS-232C interface, an on board monitor, a mnemonic assembler and it's green. Everything you could want in a computer if you don't like BASIC, by Steve Rimmer.**

The University of Toronto computer, or the 6809 board, is the second non-dedicated microprocessor system to be developed by Exceltronix Components and Computing. Like the first, the Multiflex (ETI May 1980), it represents the state of the art quite well. It has been the object of a lot of attention, both in its hardware design and its supporting software, and the whole works is heavily neat. Plus, it's green.

Greenness counts.

Before we get into the technicals and nit pickings, it might be worth a few inches of type to explain just what this thing does, in regards to what more familiar systems are up to. When you turn on a PET, for example, the screen comes on and is very friendly with you. It talks to you in a moderately English language, and even a partial orangutan can get something going on a PET (or an Apple, TRS-80, etc). This is because these systems use what is called *higher level languages*. They have extensive on board software which interprets English commands into the dialect that the computer likes to talk in, called *machine language*.

However, higher level languages are somewhat slow, and restricted in what they can do. They also require lots of memory to hold their programs, memory which might otherwise be useful for the actual running of the program. Thus, there is most assuredly a place for machines which do not have languages, but require the programmer to work directly in machine language. This is what the 6809 board is. . . er, sort of.

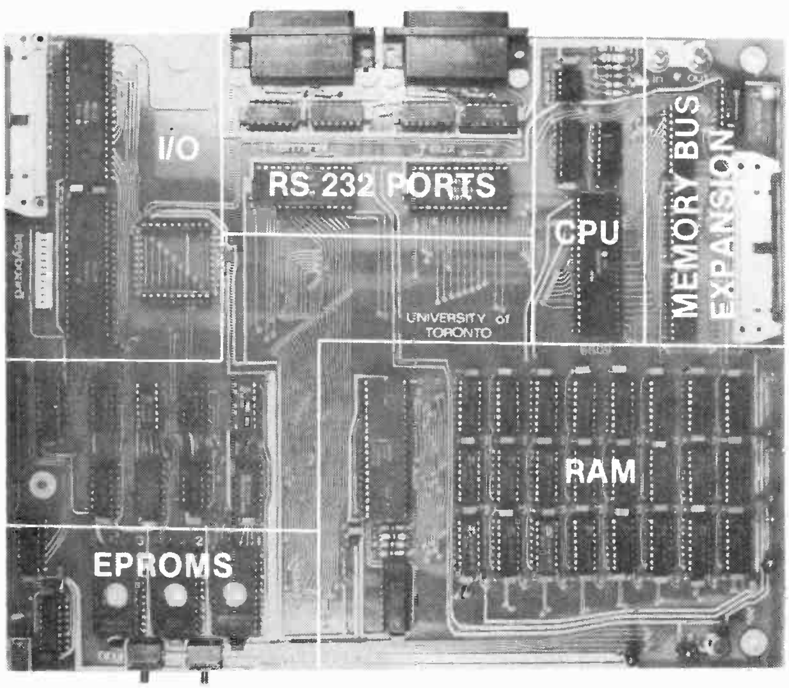
### The 'Puts (In, Out and Otherwise)

The U of T board was, as you might have guessed, originally designed for use by computer students at the U of T. However, you don't have to be going there to have your space expanded by one of them, and, if you've checked out the current tuition fee schedule, you'll probably agree you'd be better off if you weren't. However, because this thing was built for classroom situations, where in the kids can become unruly. . . maniacal. . . if things cease to work, the documentation is superb, and there is quite a lot of it that will lead a total beginner into the awe inspiring world of 6809 programming.

The computer occupies a single board a little larger than this magazine. It has space for 48K of RAM, and, at the moment, chips to fill it are included in the purchase price of the computer. There are two RS-232C ports, which are used to connect the machine to a terminal and an optional printer or modem. A terminal is essential, as the board does not have any kind of video interface of its own. It can, however, be used with a hex keyboard and a four digit LED display, although why anyone would want to is a bit elusive. Exceltronix can, of course, supply a terminal.

The processor is, as may be apparent by now, the Motorola 6809, examples of which are found in the Radio Shack *Colour Computer* and the Apple auxilary processor card. This is a good chip to do ML programming on, and, if you've tried breaking into this area with an 8080 or Z80 based system, the 6809 will be a much more pleasant trip. The instruction set is similar to that of the 6502, which is quite straightforward.

The board also features a buf-



fered bus expansion connector, a cassette interface and three on board EPROM sockets. Two 6522 VIAs are in there, too, of which one is available as an I/O port. The non-maskable interupt line is connected to a push button switch to stop runaway programs, and a second switch, the reset, does a cold start for when you're fed up and want to punish your present program by trashing it.

Lamentably, the overall greenness of the board is interrupted by the chips and other paraphenalia.

The board, with documentation and a smile from the salesperson is $495.00 in kit form, or $649.00 assembled. In addition, you'll need the afforementioned terminal and a +5, +12 and −12 volt power supply.

## Plugging In

The required terminal configuration is 9600 baud, full duplex, 8 bit characters, one stop bit and no parity. As none of our terminals happened to be set up this way, we used the terminal program on our TRS-80 Model II, which allows the configuration to be specified in software. After clearing away the detritus and flotsam of the computer room, the board was plugged in and fired up. It immediately smiled and said, quixotically,

#

which, as it turns out, was exactly what it should have done. This is the prompt, and it indicates that you are in the monitor. As it turns out, and as we shall peruse shortly, one could also be in the "Teach". You thought Teach was just a dead pirate, didn't you? Arrrgh, Billy!

If you are unfamiliar with monitors, a brief explaination might be in order as to what they can do. Skip over this bit if you are an MIT graduate.

Each byte of an ML program is an instruction or some data. Thus, to get a program into RAM all ye gots ta do is stick numbers into addresses. This could be done, as it was done on the very early microcomputers, with a raft of toggle switches and a row of LEDs. This is unutterably tedious, though, and to be avoided. Hence, most systems in the present world of ultra-sophisticated technology use what are called *monitors*, more or less extensive blocks of software that handle the doing of programs.

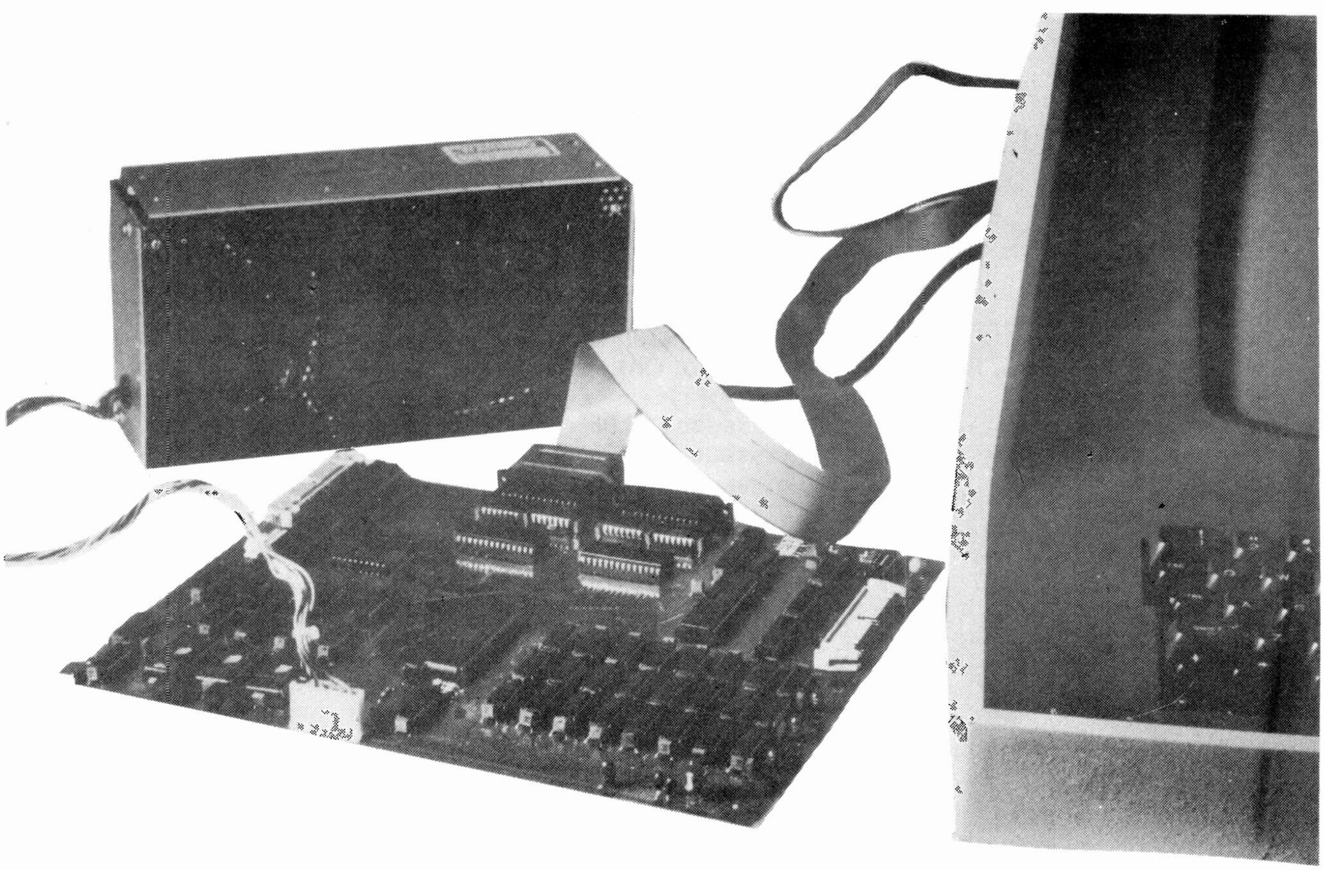
A monitor lets you enter bytes, and see what's in a range of RAM. It lets you execute a program beginning at a specific address, and examine the contents of the CPU's registers afterwards to see what happened. In addition, the more sophisticated monitors have features like single step execution, which lets you go through your program to see what's happening with each instruction, block transfers, to shift a whole range of RAM contents to somewhere else, insert and delete (which are really functions of the block transfer) and a breakpoint table, which allows the insertion of effective BRK instructions in the program to permit checking out single sections for debugging. The monitor may also handle the tape interface.

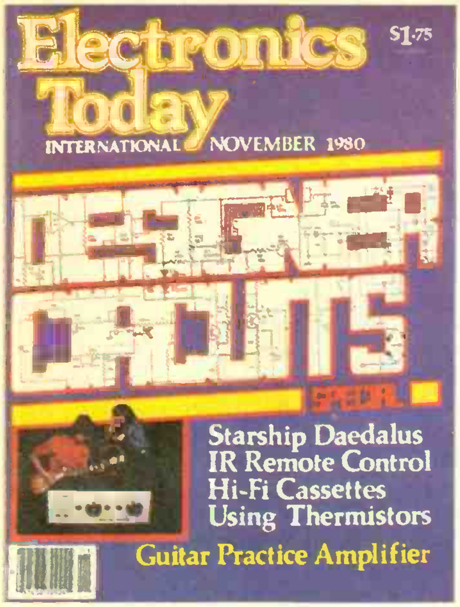
The monitor provided for the U of T board is very sophisticated (it drinks its tea with its little finger sticking out), and is much more powerful than most of the monitors available for higher level machines when they're to be used to do machine language programming.

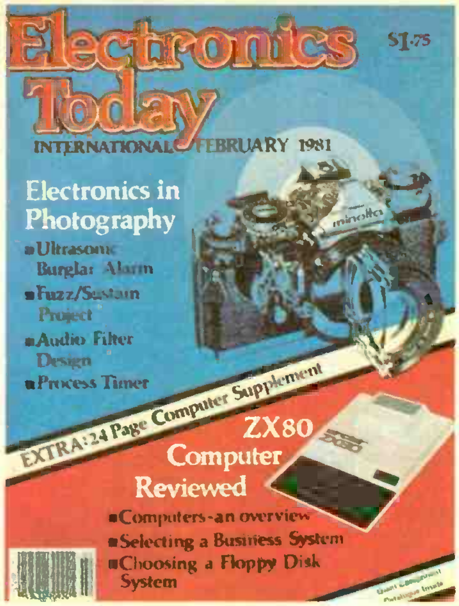
The monitor functions are as follows;

- *M.* #M AAAA CC (NN) Looks at and

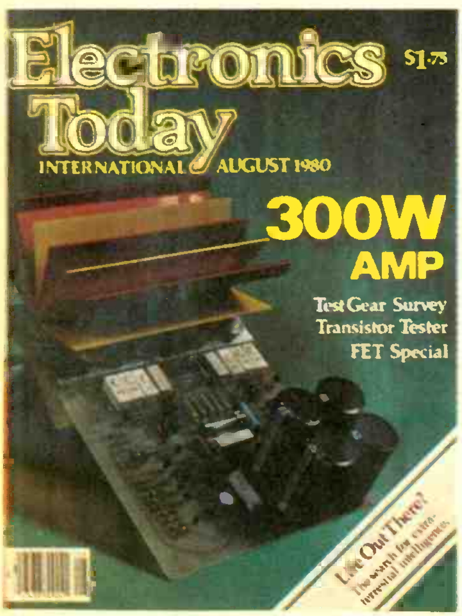
Continued on page 47







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Continued from page 45

optionally changes memory. AAAA is an address, CC is its contents, returned by the monitor, and NN, if entered by the dude with the terminal, will replace CC in RAM. The M instruction permits stepping either forwards or backwards through sequential RAM locations.

- *L.* #L Loads data from the RS232C port into RAM. Not remarkably exciting, but useful if you're sending a lot of stuff over from somewhere else.

- *O.* #O AAAA BBBB takes all the data from location AAAA to location BBBB and sends it out through the cassette interface for eventual preservation on oxide.

- *I.* #I loads a program from the cassette interface.

- *V.* #V AAAA BBBB X is a memory test, which checks the operation of the RAM from AAAA to BBBB.

- *D.* #D AAAA BBBB displays a region of RAM on the terminal screen. . . a splendidly useful feature.

- *G.* #G AAAA executes the program beginning at location AAAA.

- *S.* #S AAAA single steps through a program, beginning with location AAAA.

- *C.* #C continues single stepping after a break.

- *P.* #P continues running after a break.

- *R.* #R n CC DD examines and optionally changes the register contents.

- *B.* #B is a sophisticated breakpoint routine.

The monitor uses page zero for its own variables, plus locations CFD4 to CFD7.

In using the monitor, nothing cropped up that was unusual, and everything did what it said it was going to. The whole works was, on the average, about as good as any monitor I've encountered to date. . . plus, of course, it's on a board that's green.

**Return of Arrgh, Billy**

The monitor command we haven't looked at is "T", which jumps the machine out of the monitor, and into something called the *Teach*. This is an assembler/editor, which is a different way of handling machine code. Assemblers will be familiar to users of the Acorn ATOM.

When you look up the instructions for the 6809 in a programming handbook, you'll find that they are designated by three letter mnemonics, like AND, BEQ, RTS, etc. These don't mean anything more to the machine than would BASIC text without an interperter, but the Teach software can deal with them. It engulfs a string of these mnemonics, and *assembles* from this text a machine language program. At the same time, the text remains untouched. Thus, the ML program can be run, and, if it bombs, the reason can be gleaned from the ashes and changes made to the text, which can then be re-assembled. This provides the user with most of the advantages of machine language programming, and many of the niceties of a higher level language. There are, in fact, higher level languages that work this way, too.

The text entering facility of the Teach supports English labels, and calculates relative branches. This means, for example, that if you wanted to have a program that looped, you would just say;

```
---
---
LABEL ADC #1
---
---
CMPA #20
BNE LABEL
---
```

There are no relative branch instructions to figure, and it's not even necessary to know the location of one's subroutines. All very nice.

It probably wouldn't be too hot an idea to dig into the Teach in its completeness here, as it's a moderately complex language, and we are limited to 80 or so pages. In addition, the folks in the ad department insist on having some of it for their own capitalistic ends. However, here is the basic library of Teach commands. . . real brief.

- A. Assemble the code as specified by text in the text buffer. The text buffer is anywhere where text is. Clever, this.

- AT. Like A, but with a listing.

- AP. Once again, like A, but with a listing sent to the printer.

- E. Jump into the editing mode.

- FIX. This command does some pointer/character manipulations to help recover text if the ML code tramples on it.

- INIT. Effectively starts over, with a blank text buffer. FIX will kill an INIT.

- J. Jump to a specified address.

- M. Go back to the monitor.

- MEM. Lists the memory pointers.

- P. Print a file on the printer.

- R. Read text from the cassette.

- T. Print a file on the terminal.

- TERM. Set up the system for the type of terminal being used. The ones available on ours were Hazeltine, DEC VT-100, DEC VT-52, Volker Craig VC404, Lear Siegler ADM-3A and Televideo 950. The user can also specify a terminal structure.

- W. Write a file to the cassette.

Using the Teach was a lot easier than using a monitor, and crashes weren't as catastrophic. It's much harder to use than the monitor if you don't read the instructions all the way through, but this is probably to be expected. Assemblers are the ideal way for someone who's never done any machine language programming to get into it, and this assembler is quite nice.

**Plus, it's Green**

What more can be said?.

Now, having read all of the above stuff, you are probably asking yourself one of two questions, specifically "Do I want to go out, make $495.00 in a hurry by selling squirrel pelts to fly fisherman, zip on down and buy one?" or, alternately, "Why is it green?" To the second question, I can only say, "Hey, man, like, that's how it is, y'know."

More on the first, though. There are several reasons for buying a one board, low level type computer. First off, it's the way to learn about pro-

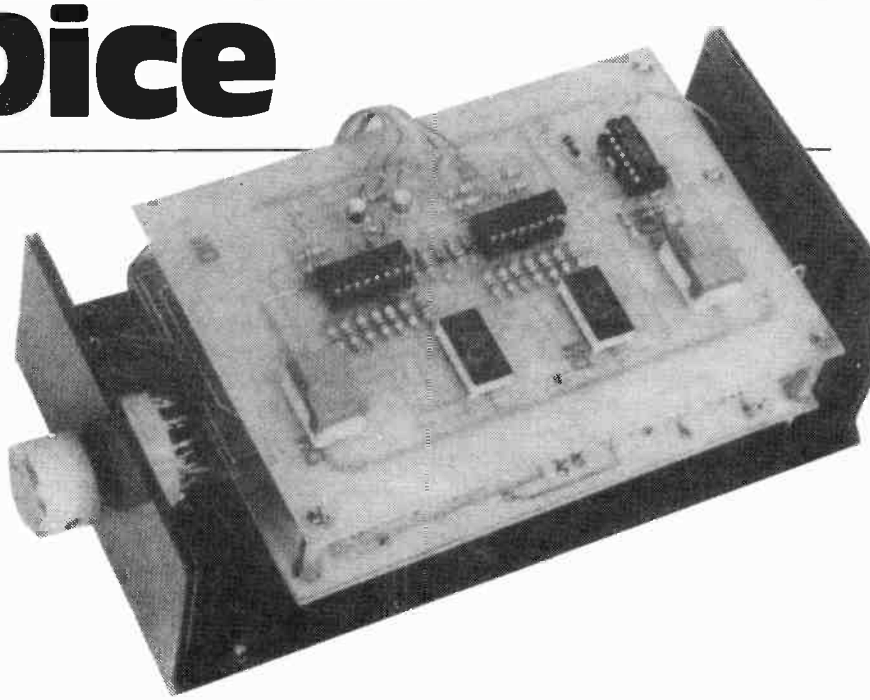
Continued on page 78

*Circle No.13 on Reader Service Card.*



*Circle No.14 on Reader Service Card.*

# Super Dice



**The ultimate electronic dice project, this unit gives a digital readout in terms of a single die, the sum of two dice , and dice or cards.**

IF YOU ARE INTO LONG games of chance and/or skill, such as fantasy- or war-games, in which vast quantities of random numbers are selected by rolling dice or pulling cards, you'll be fully aware of the disadvantages of the conventional dice and card systems. Both systems are time-consuming and tedious to use, errors can be made in adding the die numbers, and disputes about numbers can arise if the dice or cards are replayed before they've been seen by all other players.

The ETI Superdice project is designed to overcome all these problems. It's a digital readout unit that, at the touch of a button, generates an output to represent a random number of a single die (1-6), or the correctly weighted sum of two dice (2-12), special dice or cards with ranges of 0-9, 1-20, 1-36 or (with slight circuit modifications) any other number range that you care to choose. The circuit is battery-powered and has all sorts of neat features, such as leading-zero suppression and time-controlled auto-blanking to conserve power, and spin blanking and number recall to enhance the game action and avoid play disputes.

In use, the number range is first selected by SW1 and a random number in that range is then called up by pressing SPIN button PB1: the display blanks while PB1 is pressed, but displays the selected number as soon as PB1 is released. If PB1 is not used again by the end of a 5s (approximately) period, the display automatically blanks again, to conserve power. If any dispute arises concerning the last number that was displayed, it can be re-displayed by pressing RECALL button PB2.

The most important feature of our Superdice project is its ability to display the equivalent of the sum of two independently generated die numbers, with correctly weighted odds in all cases. The probability of generating these 2-12 numbers is shown below:

| | | |
|---|---|---|
| 2 : 1 in 36 | 6 : 1 in 7.2 | 10 : 1 in 12 |
| 3 : 1 in 18 | 7 : 1 in 6 | 11 : 1 in 18 |
| 4 : 1 in 12 | 8 : 1 in 7.2 | 12 : 1 in 36 |
| 5 : 1 in 9 | 9 : 1 in 9 | |

In our circuit, we generate these numbers by using two independently-clocked 1-6 random-number generators and then adding their total before feeding the resulting number to the display ststem: hence the apparent complexity of our circuit.

## Construction

The Superdice project is constructed on a pair of stacked PCBs. The two seven-segment LED displays and the SPIN and RECALL buttons are mounted, together with IC11, IC12, IC13 and associated components, on the upper PCB, which is a simple single-sided board. All of the remaining circuitry (IC1 to IC10) except SW1 and SW2 is mounted on the lower PCB, which is a double-sided affair and uses a large number of Veropins for the through-board connections.

The actual construction of the unit should present few problems. If you are not capable of producing the PCBs yourself (the double-sided one may be a problem), you can buy ready-etched boards for this project (see the list of PCB suppliers on the contents page).

Start the construction by building the single-sided display board. You can test the completed board by simply connecting it to a 6V supply, pressing PB1 and checking that the units indicator displays a '0' and the tens display is blanked once PB1 is released, that the display auto-blanks after roughly 5s, and that the display can be recalled using PB2.

Next, proceed with the construction on the double-sided PCB, taking special care to ensure that the two sides are joined at all the indicated points by Veropins pushed through the board and soldered on both sides of the tracks. When construction is complete, fit the ICs into place in their sockets in numerical sequence, starting with IC1 and ending with IC10.

At this stage you can temporarily interconnect the two PCBs and the two ganged halves of RANGE switch SW1, and then give the unit a full functional check. Check that the unit gives the ranges already described in the introduction. Carry out a long check on the 2-12 (dice) range and ensure, by recording the results of a couple of hundred 'spins', that the odds approximately tally with the list already given, with '7' being the most probable result of a spin and a '2' or '12' the least likely.

Finally, you can complete the construction by bolting the two PCBs together using suitable spacers and fitting the assembly into a suitable case, together with SW1 and SW2 and the battery pack. On our proto-

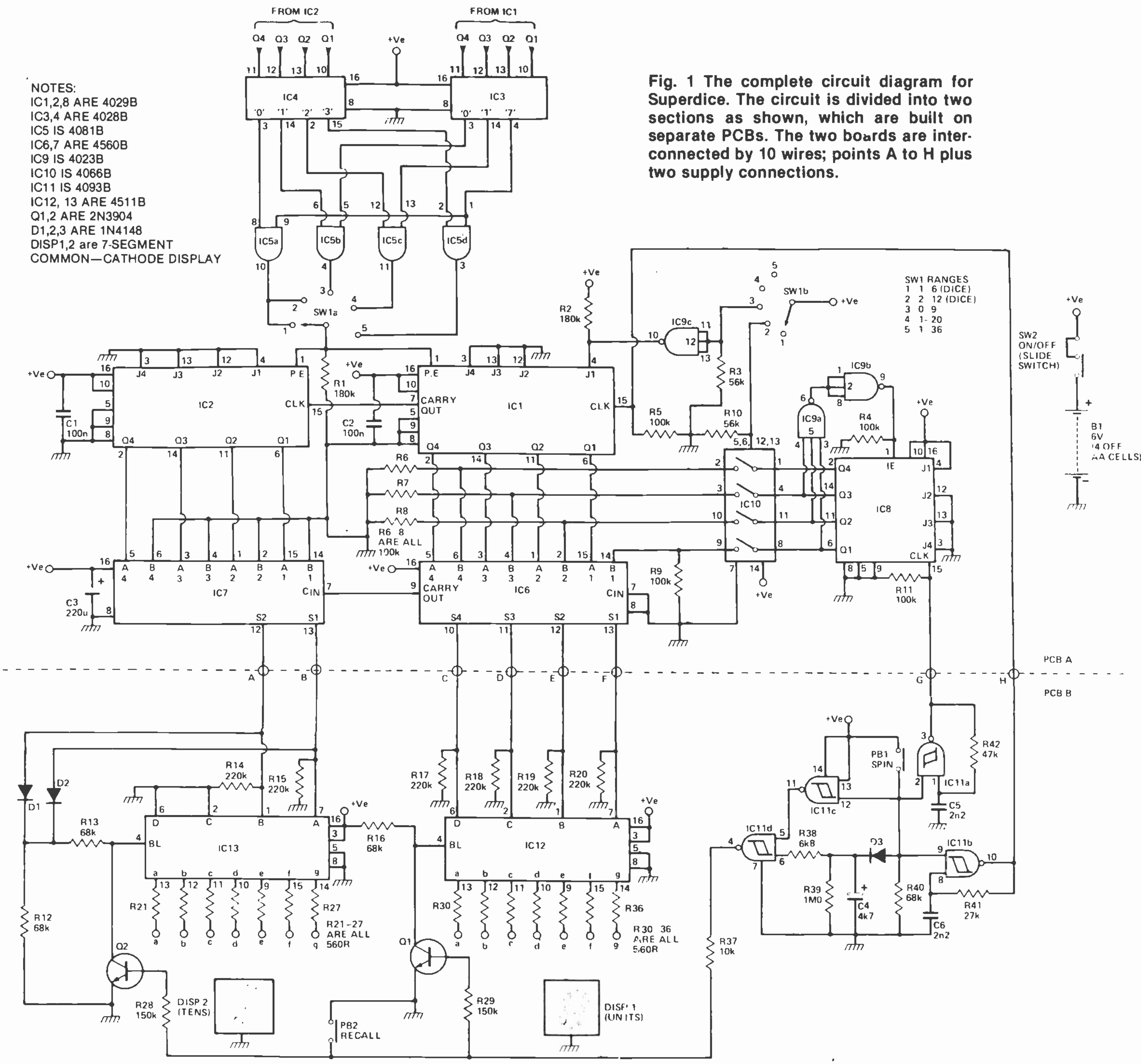



**Fig. 1 The complete circuit diagram for Superdice. The circuit is divided into two sections as shown, which are built on separate PCBs. The two boards are interconnected by 10 wires; points A to H plus two supply connections.**

type we used 30 mm spacers to fix the assembly to the case bottom and give adequate clearance for the battery, and 22 mm spacers between the PCBs to give the correct height to the upper board so that PB1 and PB2 pass through holes cut in the case top.

## Odd Odds

The 'spin' ranges of this project can easily be altered to give ranges other than those already described, provided that the range starts with a 0 or 1 and ends with a value below 99, and is required to represent a single die or card. On these ranges, SW1b must not be connected to IC10. The procedure for selecting a range is as follows.

The low end of the range (0 or 1) is determined by SW1b. The presence of a connection between SW1b and the input of IC9c causes the range to start with a '0'; no connection causes the range to start with a '1'.

The top end of the range is determined by ANDing the decoded outputs of IC4 and IC3 with one of the IC5 gates so that they feed appropriate reset or preset-enable pulses to IC1-IC2. The decoded outputs of IC4-IC3 must have a value that is equal to the desired highest number plus one. Thus, to give a top range of 64, the decoded '6' of IC4 must be ANDed with the decoded '5' of IC3. The decoder connections of IC3 and IC4 are as follows'

| | | |
|---|---|---|
| '0' = pin 3 | '4' = pin 1 | '8' = 9 |
| '1' = pin 14 | '5' = pin 6 | '9' = 5 |
| '2' = pin 2 | '6' = pin 7 | |
| '3' = pin 15 | '7' = pin 4 | |

*Circle No.2 on Reader Service Card.*

## HOW IT WORKS

The basic operating principle of the circuit is fairly simple. Whenever SPIN button PB1 is pressed, two restricted-range BCD counters (IC1-IC2 and IC8) are independently clocked (by gated astables IC11b and IC11a respectively) at a fast rate for the duration of the PB1 closure. Since the clock rates are high, it is not possible to predict the number of clock pulses that will be fed to the counters during the period of the manual switch closure, so the resulting generated BCD numbers are 'random'.

When the unit is used in the dice (2-12) mode, these counters are both set to the 1-6 counting mode and their outputs are summed (via the closed 'switches' of IC10) in BCD-adders IC6-IC7. The results of the additions are presented to seven-segment displays DISP1 and 2 via drivers IC12 and IC13, thereby ensuring that the displayed numbers are correctly weighted. On all other ranges, the output of the IC8 counter is effectively disabled by the open-circuit switches of IC10, and the output of the IC1-IC2 counter is added to zero before being fed to the display system; in these cases, the IC1-IC2 counter range may be 1-6, 0-9, 1-20 or 1-36, depending on the setting of SW1.

The display circuitry features leading-zero suppression, spin blanking and time-controlled auto-blanking, and has a manual RECALL facility. The operation of these facilities can easily be understood. Display-drivers IC12 and IC13 are supplied with a blanking facility (BL, pin 4), the action being such that the displays are enabled only when a logic 1 (high) bias is applied to pin 4. In our circuit, the blanking signal of IC13 is obtained from the leading BCD inputs (pins 1 and 7) of the chip via diode OR gate D1-D2 and can only be present when the BCD number is other than zero; the circuit thus has leading-zero suppression.

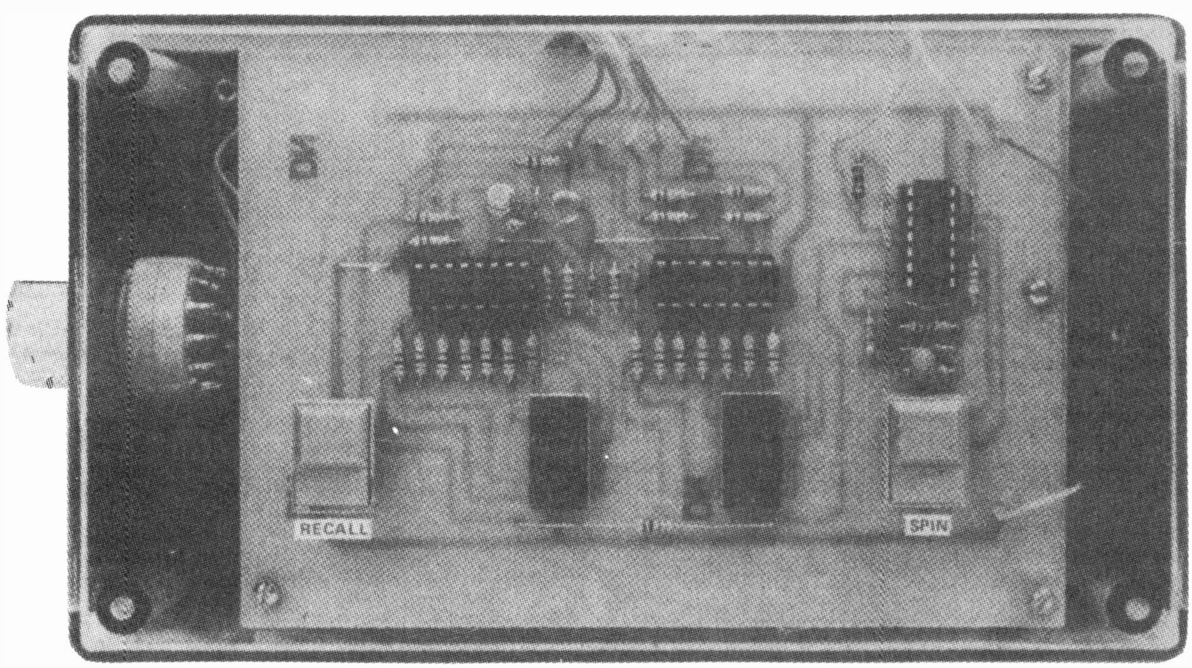
The displays of IC12 and IC13 can be blanked by driving Q1-Q2 on, or enabled by turning Q1-Q2 off: thus, a blanked number can be recalled by closing RECALL switch PB2 which turns Q1-Q2 off. IC11c-IC11d are used to generate the spin-blanking and time-controlled auto-blanking signal. When PB1 is closed, C4 charges via D3, applying a high signal to one side of IC11d, but the output of IC11c goes low, applying a low signal to the other side of IC11d. Consequently, the output of IC11d goes high and turns Q1-Q2 on, blanking the display for the duration of the PB1 closure. When PB1 is released, the output of IC11c goes high and feeds a high signal to one side of IC11d, while the other side of IC11d is held temporarily high by the charge of C4; IC11d output goes low, turning Q1-Q2 off and enabling the display. After a delay of about 5s, however, the C4 voltage decays to such a level that the output of IC11d switches high and drives Q1-Q2 on, thereby giving time-controlled auto-blanking.

The only parts of the circuit that require further explantion are the BCD counter stages (IC1-IC2 and IC8). These are 4029B presettable up/down counters, wired in the BCD up mode in our circuit. A feature of these chips is that they have four BCD jam inputs (j1 to j4), and the jam code can be loaded into the counter by feeding a logic 1 signal to the pin 1 preset enable (PE) terminal of the IC. This feature makes it possible to reset the counter to any desired number (rather than simply to zero) at the end of each count cycle.

A jam code of 0001 is wired to IC8. IC9a-IC9b detect the arrival of each '7' state on the BCD output and activate the PE terminal, so that the circuit repeatedly counts from 1 to 6.

Similarly, on the IC1-IC2 counter, a jam code of 0000 0000 or 0000 0001 (depending on the setting of SW1b) is wired to the circuit. BCD-to-decimal decoders IC3 and IC4 and AND gates IC5a-IC5d are used to detect the desired reset count states (7,7,10,21 or 37) of the counters and active the PE terminals of IC1-IC2 at appropriate times, to give the five ranges of 1-6, 2-12, 0-9, 1-20 and 1-36.

Note that the use of IC3-IC4 for decoding (rather than the use of dedicated logic decoders) enables the user to easily change the PE values (a simple re-wiring job) to give any desired count range up to 98.




**The dice within.**

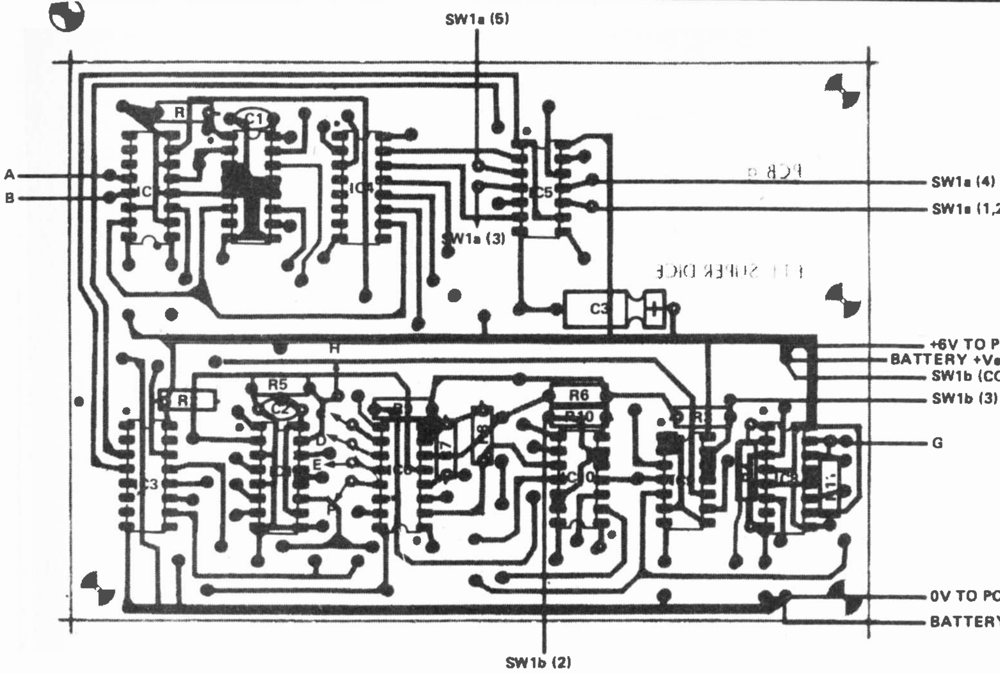



Fig. 2 Component overlay for PCB a of the Superdice. This is the double-sided board, although only the 'component side' tracks are shown. The right-hand side of R2 isn't floating; it solders to the topside track. The two sides of the board must be connected by Veropins (soldered both sides) where indicated by black dots.

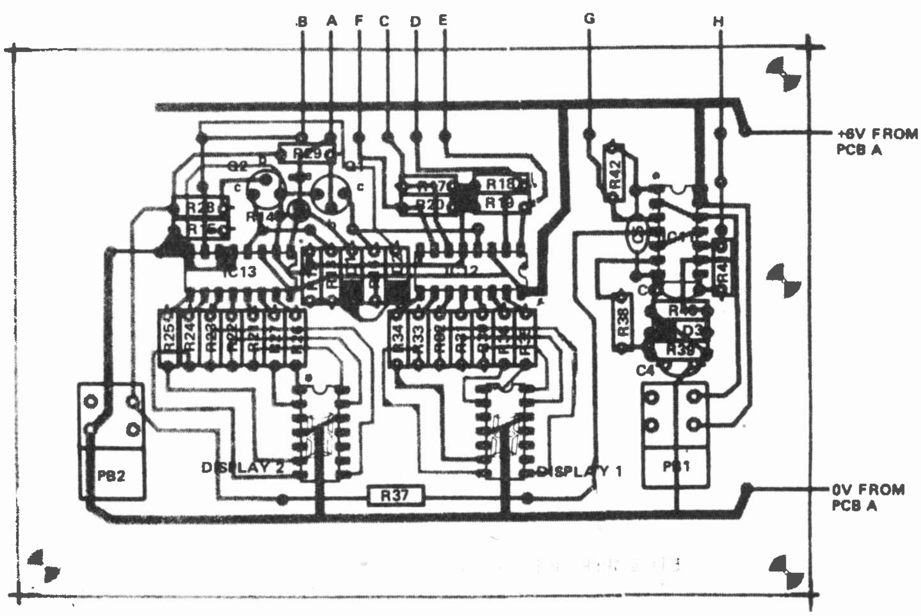



Fig. 3 Component overlay for the single-sided display board. Make sure you get the right size displays to fit the foil pattern.

If you liked this project, please circle Reader Service Card number 55. If you didn't, circle number 56.

## PARTS LIST

**Resistors (all ¼ W, 5%)**

| | |
|---|---|
| R1,2 | 180k |
| R3,10 | 56k |
| R4,5,6,7, 8,9,11 | 100k |
| R12,13,16,20 | 68k |
| R14,15, 17,18,19,20 | 220k |
| R21-27,30-36 | 560R |
| R28,29 | 150k |
| R37 | 10k |
| R38 | 6k8 |
| R39 | 1M0 |
| R41 | 27k |
| R42 | 47k |

**Capacitors**

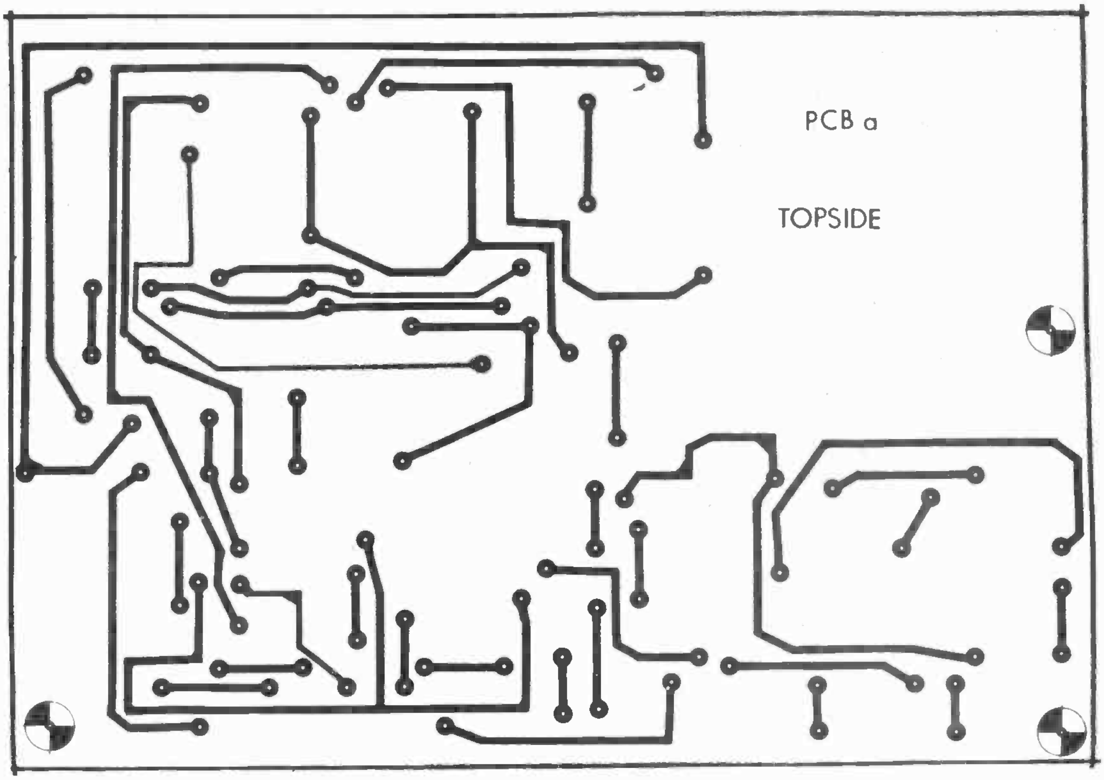
| | |
|---|---|
| C1,2 | 100n ceramic |
| C3 | 220u 16V axial electrolytic |
| C4 | 4u7 35V tantalum |
| C5,6 | 2n2 ceramic |

**Semiconductors**

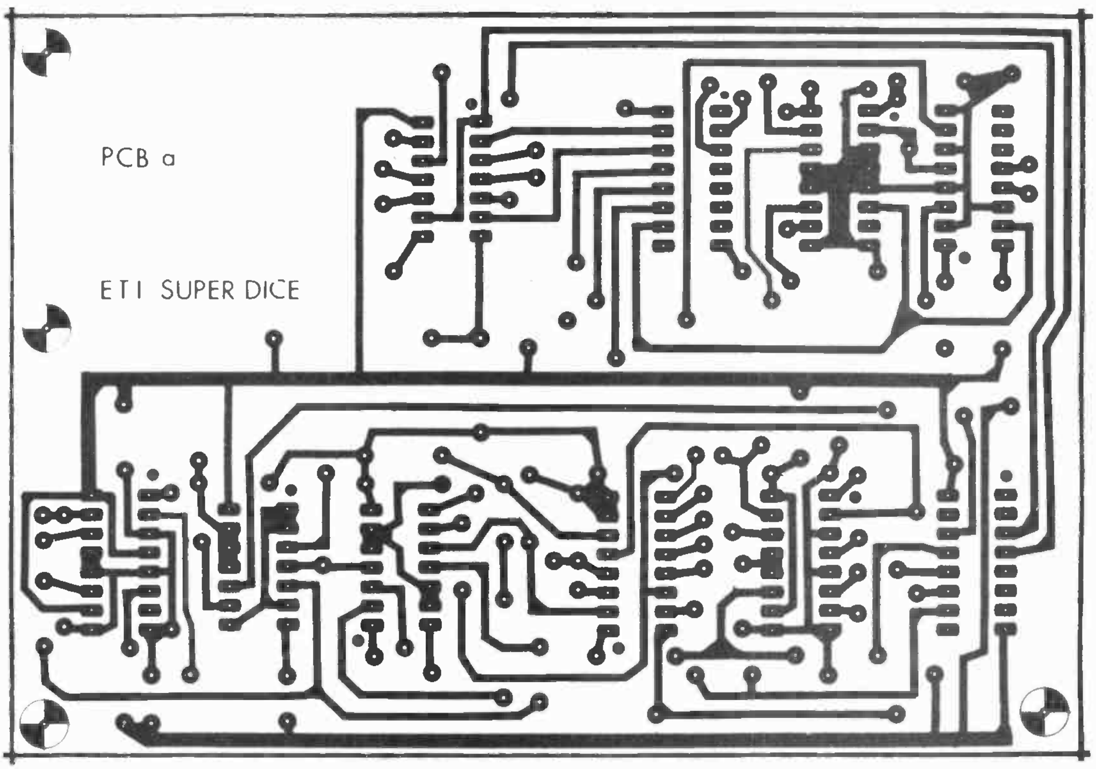
| | |
|---|---|
| IC1,2,8 | 4029B |
| IC3,4 | 4028B |
| IC5 | 4081B |
| IC6,7 | 4560B |
| IC9 | 4023B |
| IC10 | 4066B |
| IC11 | 4093B |
| IC12,13 | 4511B |
| Q1,2 | 2N3904 |
| D1-3 | 1N4148 |
| DISP1,2 | seven-segment common cathode display, 0.3" character |

**Miscellaneous**

| | |
|---|---|
| SW1 | two-pole five-way rotary switch |
| SW2 | SPDT slide switch |
| PB1,2 | push-buttons |
| B1 | four batteries |
| Case PCB. | |




The two foil patterns for the double-sided Superdice board.




*Continued on page 79*

# Optical Disc Records

If you liked this article, please circle Reader Service Card number 49. If you didn't, circle number 50.

**The new technology of the digital disc 'played' by a laser pick-up with no direct surface contact at all may signal the eventual demise of the conventional record and turntable system. So says Alan Concannon**

GRANDFATHER most probably used a freshly sharpened silver of bamboo each time he played his record on the gramophone. Then progress introduced the scratchy stainless steel needles, the ones which were supposed to be thrown away after each playing of the old 78s. With the fifties came the plastic record with the microgroove and the sapphire stylus, then finally the diamond stylus. But the eighties, due to research carried out by Philips Industries and other manufacturers, will see the introduction of the laser beam stylus, which for numerous reasons will quickly categorise all its predecessors as museum pieces.

Existing hi-fi records and turntables are adversely affected by worn sapphires and diamonds, dust, scratches and many other surface defects. Also, to combat the bogey of scratch, audio engineers have tried to devise equalisation circuits which allowed treble notes to be recorded over normal level and played back at reduced volume. This makes the surface noise, which is in the same tonal range, more difficult to hear. But with static, dust and other pollutants gathering around the stylus, the battle to keep the sound pure is one of constant vigilance.

## The New Record Player

The only really new technology in the future turntable system will be the records, which will become digital discs, and the stylus or means of taking the recording from the disc to the amplifier. The new laser pick-up stylus, at least for consumer-standard record players, will work with existing amplifiers and speakers, so initially the turntable will be the only hi-fi component to be replaced.

On consumer record players the Philips compact disc (just 115 mm diameter with 60 minutes' playing time) spins on a turntable, but there the similarity ends. Sound reproduction is vastly superior due to the sound information being stored on the disc digitally and read out optically.

Playing the disc is based on the principle of light diffraction, which means that pre-recorded information can be extracted without mechanical contact. The information is stored on the disc in the form of a helical track of microscopic pits, the pick-up head being an optical device using a miniature aluminium gallium arsenide laser. The light reflected back from the metallic layer on the disc contains all the signal information in digital form to reproduce the original recording.

The laser in the pick-up produced today is estimated to last 2000 hours. The proposed units, which Philips originally expected to be on the market during 1980, are no bigger than today's cassette players. The units will provide an output signal for playback through any standard stereo amplifier.

The disc is recorded on one side only and is covered by a metallic layer beneath a transparent protective coating. It is both light in weight and durable, and because the information is not stored on the surface of the disc it is secure against dust, dirt, scratches and general wear. With the disc only 115 mm in diameter, storage creates no problem. Operating the player is described as simplicity itself; you select the play, stop, automatic or search mode, and it responds to your requests.

## Commercial Disc

The new optical disc recorder was based on the technology used in the video disc system for home entertainment, but Philips' designers had a few problems to overcome. They had to develop an inexpensive disc recorder of digital information, which had to have direct read-after-write capability and be able to record in any ordinary enclosure, i.e., not the usual dust-free protected room.

They concluded that an optical disc recording by laser was the answer, and produced a disc that can record as much digital data as 25 magnetic tapes operating at 6250 bits per inch. Due to its protective cover, no processing of the disc is required and its shelf life of ten years is assured with a tellurium-based film.

The system is also error-free, the optical system being designed to check the recorded data instantly and to re-record at once any part of the disc where irregularities appear. This process was developed experimentally for the Phillips DRAW (Direct Read After Write) information system. The DRAW system records information on a 300 mm disc with 40 000 tracks per side or 1.0 x $10_{10}$ bits per side.

## The Optical Disc

A variety of materials was considered for the disc substrate and its protection. After taking into account thickness uniformity, strength, optical properties and cost, polymethylmethacrylate (PMMA, or Plexiglass) was selected as the primary disc material.

A tellurium-based film was chosen for the recording medium, consideration being given to reproducibility, storage, resolution and sensitivity. The sensitivity of tellurium is sufficient to allow at least 10M bit/second recording with less than 8 mW incident at the film surface. Accelerated aging tests on the tellurium-based film indicated a shelf life of ten years at normal room temperatures.

Protection from scratches, dust, and sticky fingers, etc, is provided by a transparent cover over the disc, this system being known as the Philips *Air Sandwich* (see Fig. 1). The sandwich consists of two discs, each coated with a tellurium layer and separated by ring spacers at the inner and outer radii. The tellurium is placed on to the disc during the assembly process in a clean, dust-free room prior to the protective cover being applied.

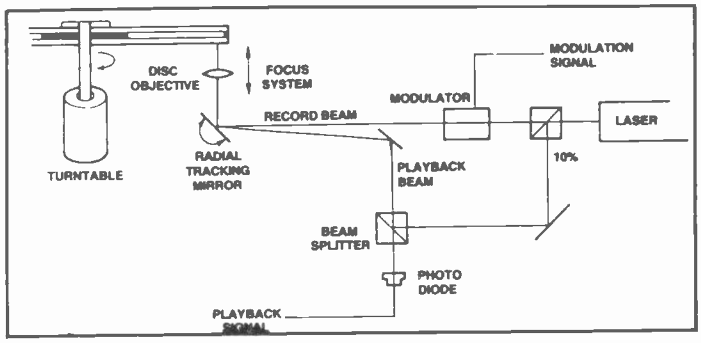
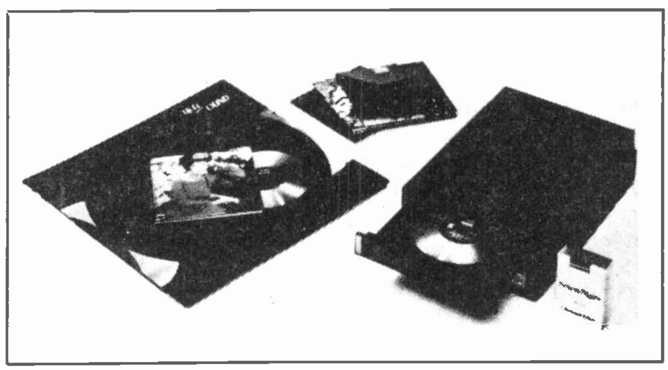



Fig. 2 Optical system for the commercial-standard disc recorder.

with the information signal by a light modulator. The read beam passes through two mirrors and a beam splitter, so arranged that the record and read beams are recombined at the objective. The objective focuses the beams on to the information layer inside the disc, the focused power mediate correction of errors possible; should any difference occur between the record and read signals they are detected and re-recorded.

Warping of the disc can cause vertical excursion of the information surface by as much as 1mm. Any misfocus is sensed optically, and the



The Sony/Philips laser-read disc system.

## The Optical System

In the optical system, (see Fig. 2) the light output from the laser is split into two beams: 90% for recording and 10% for reading or reproducing what is on the record.

The recording beam is encoded

available for recording at the disc's surface being 12 mW.

Since the read beam is slighty off centre to the optical recording axis, the playback spot trails the recording spot by a few microns. This means that the recorded pit is read shortly after writing, making im-

error is minimised by a servo-mechanism focusing system.

A radial tracking mirror is used to follow the recording tracks during playback. The read spot must follow the tracks to within 0.1 x $10^{-6}$m. Since disc eccentricity on remounting can be as large as 50 x $10^{-6}$m, the radial mirror must be controlled to reduce this error to within the 0.1 um limits. Mistracking is sensed optically, and the signal controls the radial mirror to reduce the error.

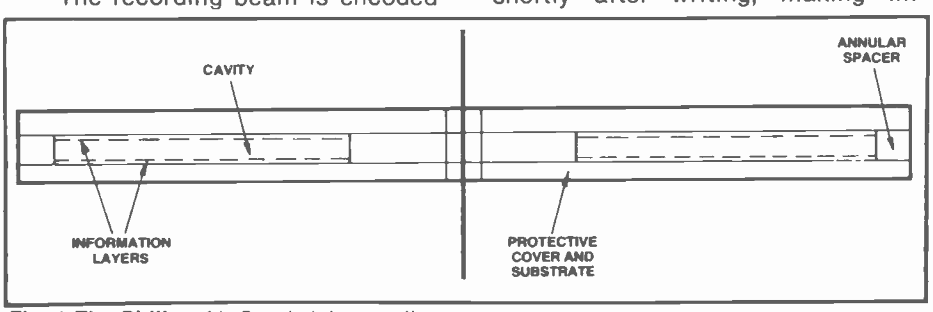



**Fig. 1 The Philips *Air Sandwich*** or a disc protective system. (Not to scale.)

## Comparison with Magnetic Tapes

When a comparison is made between the best commercially available magnetic storage devices and the optical disc system the results are interesting (see Table 1). Using the optical disc, the cost per bit of information stored is considerably cheaper, storage life is greater, access time is reduced, and the hardware cost for information stored lowered. Magnetic tapes' main advantage is that it can be erased and re-recorded, while the laser optical disc system is permanent and would not be suitable for this type of application.

Briefly, then, the laser optical disc's main advantages are low cost, efficient storage and improved archival properties. The volumetric storage efficiency of the optical disc is also better; approximately one hundred times better than that of magnetic tape's 6250 bits per inch.

The packing density of magnetic recording (see Fig. 3) has an ultimate limit somewhere below $10^8$ bits per in$^2$, whereas optical recording on metal films has now progressed to this level, and densities above $10^9$ bits per in$^2$ are expected as a result of current research.

The consumer video disc system maps roughly six bits of information on each pit on the disc. The recording format chosen for the digital disc conservatively assigns only one bit to a recorded pit. The present research and development is aimed at increasing the storage capacity of the disc to about $10^{11}$ bits. Endeavours will be made to produce smaller pits, smaller track spacing, more efficient data encoding and an increase in the number of encoded bits per recorded pit.

Amplifiers and speakers have reached a stage where it is difficult to improve on them in any great degree. But for any class of consumer, in the home or on the air, the record and turntable system has until now been a major weakness. With the advent of the laser optical system, tomorrow should bring a near-perfect and highly durable system to satisfy even the most fastidious music lover.

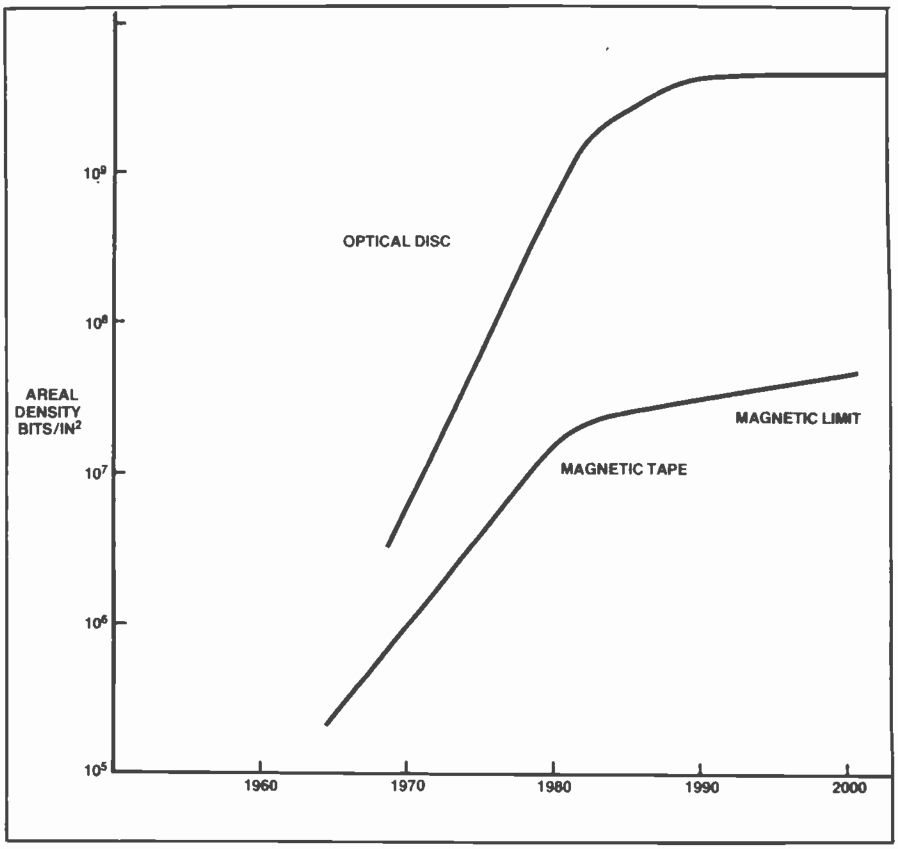
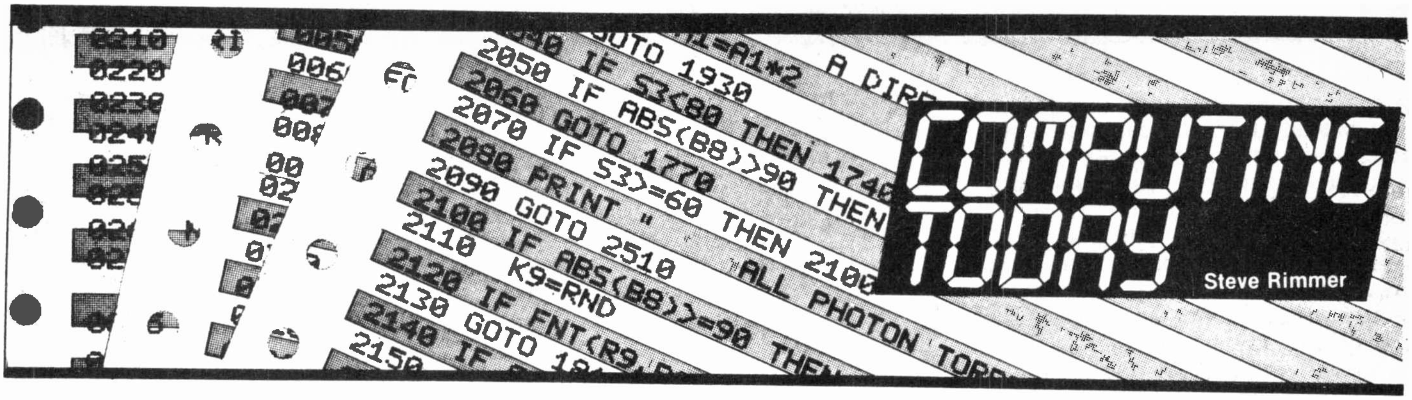



Fig. 3 Graph showing areal recording density for the optical disc compared to magnetic tape.

## Commercial units only

| Device | Media cost per bit in cents | Archival life in years | Access time in ms | User capacity Mbytes | Hardware cost in US dollars |
|---|---|---|---|---|---|
| 6250 bits/in tape IBM 3420-8 | $2.2 \times 10^{-6}$ | 1-2 | 45 000 | 91 | $28 440 |
| IBM 3850 System | $5 \times 10^{-5}$ | 1-2 | 16 000 | 462 500 | $2 400 000 |
| Philips Optical Disc | $5 \times 10^{-8}$ | Up to ten years | 100-500 | 2500 | $10 000 |
| Philips Juke Box | $5 \times 10^{-9}$ | Up to ten years | 3000 | $25 \times 10^6$ | $200 000 |
| Philips Optical Disc Pack | $1.5 \times 10^{-8}$ | Up to ten years | 50-100 | 125 000 | $200 000 |

Table 1. Characteristics of magnetic tape and optical discs.




WORD PROCESSING. . . sort of has a ring to it. A neat image, this, and rather a la 1984. I've always envisioned a word processor as a thing with a crank and a slot in the top to stuff words into. Or, I suppose, it could be an electric one, with a motor and a speed selector. Grinds, purees, minces, blends, slices and dices any words up to eight syslables in length. . . no more tears, no more syntax burns or paper cuts. Just send $29.95 before midnight tonight...

Writing a word processor for your computer is by no means a simple undertaking. However, it isn't impossible, and you might be up for having at it as an excercise in writing extensive programs. It will be worthwhile checking out the various systems around, and deciding on which features you want to incorporate into your particular package. This will also provide you with an ideal base from which to give up and go out and buy one.

This month, we're going to look at the bowing and headscrapings of a word processing pprogram written for the Acorn *ATOM*. Basically, it's just a text entry module which does some screen control and jams characters into RAM. However, it will serve to illustrate what's happening in this, the most rudimentary part of the software. Thereupon, it becomes your problem

## ATOM bomb

First off, the bulk of the software pretty well has to be in machine language, because BASIC is (a) too slow, and (b), too large. The ATOM is good this way, having a first rate assembler which I've grown to cherish. The program, however, is in normal 6502 code, and, except for a few peculiarities of the ROM routines of the ATOM, will go fine on any other system (PET, Apple, OSI, etc) using this processor.

The initial bit of information required to write one of these things is knowing where the cursor control registers are, and how they work. I'm fairly proud of myself for figuring these out for the ATOM, since no one, not even the chaps at Torch Computers, seemed to know about them. I shall now impart this priceless wisdom unto you.

The ATOM's screen consists of two pages of RAM, specifically pages 128 and 129. The page number in which the cursor lives is stored in memory location 223 decimal, in page zero. In other words, if the cursor's in the top half (16 lines) of the screen, this byte will be 128; otherwise, yes, you've guessed it, 129. Heavy.

Location 222 narrows things down a mite. It is the line number times thirty two. In other words, ?222/32 will give you a number from 0 to 15 representing the line the cursor is on. Location 224 is how many spaces over the cursor is, or its horizontal position (0 to 31).

Now, you were to go

*A = ?222 + ?224 + (256x?223)*

"A" would be the actual RAM location of the cursor at the time of executing the statement. Inutterably weird, yet reasonable to a degree.

### program 1

```
>
>L.
 10 REM Acorn Atom Text Entry Module
 20 CLEAR4;CLEAR0
 30 P.$21
 40 DIM NN(8);DIM MM(8);DIM LL(12),P(-1);[
 50:MM0 LDX @0
 60:MM1 LDA @127;JSR #FFF4;INX;CPX #80;BNE MM1
 70 LDX @0;JSR #FFED
 80:MM2 LDA #8F,X;JSR #FFF4;INX;CPX #80;BNE MM2
 90 LDX @0;STX #80
100 RTS
110:MM3 CMP @127;BNE MM4
120 TAX;LDA #82;SBC @1;STA #82;TXA;BCC MM6
130 CLC;DEC #83;LDX #83;CPX @130;BPL MM6
140 LDX @130;STX #83;JMP MM6
150:MM4 TAX;LDA #82;ADC @1;BCC MM5
160 CLC;INC #83
170:MM5 STA #82;TXA;LDY @0;STA (#82),Y
180:MM6 RTS
190:NN1 JSR NN2;INC #85;JSR NN2;RTS
200:NN2 LDY @0
210:NN3 LDA (#84),Y;CMP @13;BNE NN4
220 LDA @32
230:NN4 JSR #FFF4;CPY @255;BEQ NN5
240 INY;JMP NN3
250:NN5 RTS
260:LL0 LDA @12;JSR #FFF4;LDX @0;STX #80;STX #82
270 LDX @130;STX #83
280:LL1 JSR #FFE3;CMP @27;BNE LL2;RTS
290:LL2 JSR MM3;CMP @13;BNE LL3
300 JSR #FFED;LDX @0;STX #80 JMP LL1
310:LL3 CMP @127;BNE LL4;LDX 224;CPX @0;BEQ LL1
320:LL4 CMP @32;BNE LL5
330 LDX @0;STX #80;JMP LL7
340:LL5 CMP @127;BNE LL6
350 DEC #80;JMP LL7
360:LL6 INC #80;LDX #80;STA #8E,X
370:LL7 LDX #80;CPX @25;BNE LL8
380 LDX @0;STX #80
390:LL8 LDX 224;CPX @31;BNE LL9
400 CMP @32;BEQ LL9
410 JSR MM0;JMP LL1
420:LL9 CMP @5;BEQ NN0
430 JSR #FFF4;JMP LL1
440:NN0 RTS
450:NN6 JSR #FFE3;STA #81;RTS
460 ]
470 P.$6
480 LINK LL0
490 ?#84=0;?#85=130
500 P.$12;LINK NN1
510 END
```

The function of the text entry module is to let you type in characters, display the resulting words on the screen and simultaniously store these very characters in memory somewhere. Since the ATOM has about 7K of RAM tied up for its graphics memory, unused in a word processing trip, I've used this space to store the entered characters. The CLEAR 4;CLEAR 0 statement at the beginning of the program is a convenient way of emptying this space in a hurry.

One of the niceties of word processors is automatic line ending. In other words, you never have to type a carriage return, except to end a paragraph. Whenever you exceed the number of characters allowable on a line, the machine just tranfers the word you are in the midst of typing onto the next line and keeps on going. Rather civilized.

There are several ways of doing this, but it's useful to see that the easiest entails processing the text as words instead of characters. The obvious method is to transfer the incomplete word character by character down to the next line, but this is a bit complex, as it means a lot of scrounging around in the screen RAM. A better way is to create a word buffer, which,in this example, lives at locations #8F through #A0, and an index for it, which is at #80. Now, as characters are typed, they are, of course, printed, but also stuck in the buffer at the location determined by (#8F + the contents of the index). Whenever a space, character 32, is entered, the index is reset to zero. Since the buffer is, effectively, only as big as the index says it is, there's no worry about having to erase its old contents when this happens. The buffer always holds the word being entered.

Usually, the buffer contents are ignored. However, when the end of a line (indicated by the contents of location 224) is reached, a routine is called to automatically change lines. First off, it prints as many delete characters ($127's) as there are characters in the buffer, thus erasing the part of the word that's up on the old line. Then it calls the ROM subroutine at #FFED, which prints a carriage return followed by a line feed. Then it dumps the buffer out onto the beginning of the new line and carries on as it was. Complicated, I know, but it does work.

It's important that attention be given to the buffer should a delete be typed from the keyboard, too, as the index will want decrementing.

## RAMmed In

The screen memory can only hold two pages of text, or a maximum of 512 characters, which isn't much good unless you're composing matchbooks. Therefore, the text is also stored in the text RAM, (the graphics memory). Note that this precludes the use of the Acorn Soft VDU package with this thing, as this package provides lower case letters by plotting them in high resolution graphics, which would wipe out the text.

Locations #82 and#83 hold the upper text memory pointer. This is the address of the next free byte in graphics memory after the string of characters. It gets incremented every time a character is put in memory, and decremented every time a delete is struck. It serves as the address for the deposition of the next character. Unlike the screen arrangement, the text is not stored in lines, but in a long 7K block of undifferentiated characters. The automatic line return does not stick carriage returns in the text memory, so reading the characters back onto the screen in properly ended lines would require an automatic ending routine much like the character entry one.

The pointer is stored, as are all addresses outside of zero page, as a two byte number, giving, in effect, a sixteen bit address capacity. The first byte is the location in the page, and the second the specific page in question. Therefore, the first location in the screen RAM, which is 32768, would have 0 in its address bit location, and 128 in its page location. ($32768 \div 256 = 128$). The text memory starts on page 130.

There are two other routines in this particular block of ML code which are not called by the text entry module, but are included for use if you decide to expand this into a more complete text handling program. The first is the replay. It takes the page number it finds in page zero location #84 and dumps it and the next adjecent page onto the screen. However, it does so without any automatic line ending, so the position of the characters on the screen corresponds with those in memory (?#81-128) pages up. Thus, it's easy to write a routine which prints a character on the screen and subsequently sticks it in memory this number of bytes further up to facilitate editing.

The second routine is the character getter, which is just a jump to the keyboard scan in ROM, followed by an STA instruction to put the resulting character into location #81, to be retrieved by another routine. It's particularly useful for working with a BASIC driver, as ATOM BASIC has no GET statement.

## program 2

```
RUN
 40 2E82
 50 2E82 A2 00     :MM0 LDX @0
 60 2E84 A9 7F     :MM1 LDA @127
 60 2E86 20 F4 FF JSR #FFF4
 60 2E89 E8        INX
 60 2E8A E4 80     CPX #80
 60 2E8C D0 F6     BNE MM1
 70 2E8E A2 00      LDX @0
 70 2E90 20 ED FF JSR #FFED
 80 2E93 B5 8F     :MM2 LDA #8F,X
 80 2F95 20 F4 FF JSR #FFF4
 80 2E98 E8        INX
 80 2E99 E4 80     CPX #80
 80 2E9B D0 F6     BNE MM2
 90 2E9D A2 00      LDX @0
 90 2E9F 86 80     STX #80
100 2EA1 60         RTS
110 2EA2 C9 7F     :MM3 CMP @127
110 2EA4 D0 1A     BNE MM4
120 2EA6 AA         TAX
120 2EA7 A5 82     LDA #82
120 2EA9 E9 01     SBC @1
120 2EAB 85 82     STA #82
120 2EAD 8A        TXA
120 2EAE 90 21     BCC MM6
130 2EB0 18         CLC
130 2EB1 C6 83     DEC #83
130 2EB3 A6 83     LDX #83
130 2EB5 E0 82     CPX @130
130 2EB7 10 18     BPL MM6
140 2EB9 A2 82      LDX @130
140 2EBB 86 83     STX #83
140 2EBD 4C D1 2E JMP MM6
150 2EC0 AA        :MM4 TAX
150 2EC1 A5 82     LDA #82
150 2EC3 69 01     ADC @1
150 2EC5 90 03     BCC MM5
160 2EC7 18         CLC
160 2EC8 E6 83     INC #83
170 2ECA 85 82     :MM5 STA #82
170 2ECC 8A        TXA
170 2ECD A0 00     LDY @0
170 2ECF 91 82     STA (#82),Y
180 2ED1 60        :MM6 RTS
190 2ED2 20 DB 2E :NN1 JSR NN2
190 2ED5 E6 85     INC #85
190 2ED7 20 DB 2E JSR NN2
190 2EDA 60        RTS
200 2EDB A0 00     :NN2 LDY @0
210 2EDD B1 84     :NN3 LDA (#84),Y
210 2EDF C9 0D     CMP @13
210 2EE1 D0 02     BNE NN4
220 2EE3 A9 20      LDA @32
230 2EE5 20 F4 FF :NN4 JSR #FFF4
230 2EE8 C0 FF     CPY @255
230 2EEA F0 04     BEQ NN5
240 2EEC C8         INY
240 2EED 4C DD 2E JMP NN3
250 2EF0 60        :NN5 RTS
260 2EF1 A9 0C     :LL0 LDA @12
260 2EF3 20 F4 FF JSR #FFF4
260 2EF6 A2 00     LDX @0
260 2EF8 86 80     STX #80
260 2EFA 86 82     STX #82
270 2EFC A2 82      LDX @130
270 2EFE 86 83     STX #83
280 2F00 20 E3 FF :LL1 JSR #FFE3
280 2F03 C9 1B     CMP @27
280 2F05 D0 01     BNE LL2
280 2F07 60        RTS
290 2F08 20 A2 2E :LL2 JSR MM3
290 2F0B C9 0D     CMP @13
290 2F0D D0 07     BNE LL3
300 2F0F 20 ED FF  JSR #FFED
300 2F12 A2 00     LDX @0
300 2F14 86 80     STX #80 JMP LL1
310 2F16 C9 7F     :LL3 CMP @127
310 2F18 D0 06     BNE LL4
310 2F1A A6 E0     LDX 224
310 2F1C E0 00     CPX @0
310 2F1E F0 E0     BEQ LL1
320 2F20 C9 20     :LL4 CMP @32
320 2F22 D0 07     BNE LL5
330 2F24 A2 00      LDX @0
330 2F26 86 80     STX #80
330 2F28 4C 3A 2F JMP LL7
340 2F2B C9 7F     :LL5 CMP @127
340 2F2D D0 05     BNE LL6
350 2F2F C6 80      DEC #80
350 2F31 4C 3A 2F JMP LL7
360 2F34 E6 80     :LL6 INC #80
360 2F36 A6 80     LDX #80
360 2F38 95 8E     STA #8E,X
370 2F3A A6 80     :LL7 LDX #80
370 2F3C E0 19     CPX @25
370 2F3E D0 04     BNE LL8
380 2F40 A2 00      LDX @0
380 2F42 86 80     STX #80
390 2F44 A6 E0     :LL8 LDX 224
390 2F46 E0 1F     CPX @31
390 2F48 D0 0A     BNE LL9
400 2F4A C9 20      CMP @32
400 2F4C F0 06     BEQ LL9
410 2F4E 20 82 2E  JSR MM0
410 2F51 4C 00 2F JMP LL1
420 2F54 C9 05     :LL9 CMP @5
420 2F56 F0 06     BEQ NN0
430 2F58 20 F4 FF  JSR #FFF4
430 2F5B 4C 00 2F JMP LL1
440 2F5E 60        :NN0 RTS
450 2F5F 20 E3 FF :NN6 JSR #FFE3
450 2F62 85 81     STA #81
450 2F64 60        RTS
```

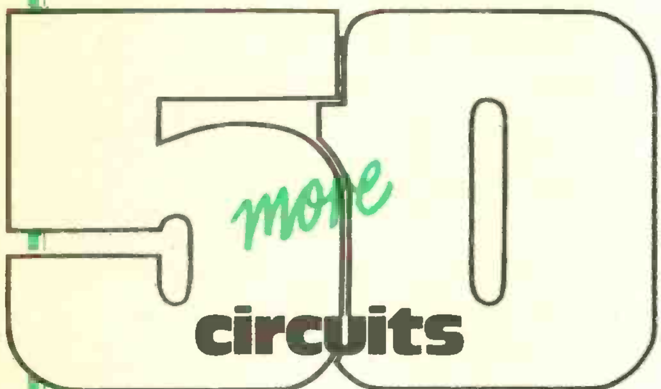
### Send Us Stuff!!!

**Yes, we know you've got a program you've just been slaving away over that will revolutionize the field of random toenail generation, and we don't really want it. Anything else, though, will be gladly considered for publication. We pay a veritable king's ransom for material we use. . . a cut rate, bargain basement king, albeit. Send your stuff to Computing Today at this address by mail or carrier gnu.**

# next month

## Leptons

You think these are a kind of soup, don't you? No, actually, what we have here is another theoretical particle. More fun than quarks, slower than tachyons and less irritating than a meson in your eye.




## 50 More Circuits

If you liked the fifty circuits we ran in February, you'll like these even more, as they run from fifty one to over a hundred (101, actually), and hence have larger numbers.


## Heath Computer Review:

Decidedly not for the Space Invaders set, this powerful little brute is well suited for the descerming home computer owner as well as for business applications.

## Series 5000 Phono Pre-amp

The next part in our Series 5000 pre-amp, this circuit will gracefully caress the signals from your cartridge, passing them tenderly upon their way to ultimately rock the floor.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- *The secret life of Heinrich Hertz!*

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*At the time of going to press, the articles mentioned are in an advanced stage of preparation. However, circumstances may result in changes to the final contents of the magazine.*

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**BP72: A MICROPROCESSOR PRIMER $7.70**
**E.A. PARR, B.Sc., C.Eng., M.I.E.E.**
A newcomer to electronics tends to be overwhelmed when first confronted with articles or books on microprocessors In an attempt to give a painless approach to computing, this small book will start by designing a simple computer and because of its simplicity and logical structure, the language is hopefully easy to learn and understand. In this way, such ideas as Relative Addressing, Index Registers etc. will be developed and it is hoped that these will be seen as logical progressions rather than arbitrary things to be accepted but not understood.

**BEGINNERS GUIDE TO MICROPROCESSORS**
**TAB No.995 $10.45**
If you aren't sure exactly what a microprocessor is, then this is the book for you. The book takes the beginner from the basic theories and history of these essential devices, right up to some real world hardware applications

**HOW TO BUILD YOUR OWN WORKING MICROCOMPUTER**
**TAB No.1200 $16.45**
An excellent reference or how-to manual on building your own microcomputer All aspects of hardware and software are developed as well as many practical circuits

**BP78: PRACTICAL COMPUTER EXPERIMENTS $7.30**
**E.A. PARR, B.Sc., C.Eng., M.I.E.E.**
Curiously most published material on the microprocessor tends to be of two sorts, the first treats the microprocessor as a black box and deals at length with programming and using the "beast". The second type of book deals with the social impact. None of these books deal with the background to the chip, and this is a shame as the basic ideas are both interesting and simple.
This book aims to fill in the background to the microprocessor by constructing typical computer circuits in discrete logic and it is hoped that this will form a useful introduction to devices such as adders, memories, etc as well as a general source book of logic circuits

**HANDBOOK OF MICROPROCESSOR APPLICATIONS**
**TAB No.1203 $14.45**
Highly recommended reading for those who are interested in microprocessors as a means of accomplishing a specific task The author discusses two individual microprocessors, the 1802 and the 6800, and how they can be put to use in real world applications

**MICROPROCESSOR/MICROPROGRAMMING HANDBOOK**
**TAB No.785 $14.45**
A comprehensive guide to microprocessor hardware and programming Techniques discussed include subroutines, handling interrupts and program loops

**DIGITAL INTERFACING WITH AN ANALOG WORLD**
**TAB No.1070 $14.45**
You've bought a computer, but now you can't make it do anything useful. This book will tell you how to convert real world quantities such as temperature, pressure, force and so on into binary representation

**MICROPROCESSOR INTERFACING HANDBOOK: A/D & D/A**
**TAB No.1271 $14.45**
A useful handbook for computerists interested in using their machines in linear applications. Topics discussed include voltage references, op-amps for data conversion, analogue switching and multiplexing and more.

**COMPUTER TECHNICIAN'S HANDBOOK**
**TAB No.554 $17.45**
Whether you're looking for a career, or you are a service technician, computer repair is an opportunity you should be looking at. The author covers all aspects of digital and computer electronics as well as the mathematical and logical concepts involved.

**THE ESSENTIAL COMPUTER DICTIONARY AND SPELLER**
**AB011 $9.45**
A must for anyone just starting out in the field of computing, be they a businessman, hobbyist or budding computerist. The book presents and defines over 15 000 computer terms and acronyms and makes for great browsing.

**HOW TO TROUBLESHOOT AND REPAIR MICROCOMPUTERS**
**AB013 $10.45**
Learn how to find the cause of a problem or malfunction in the central or peripheral unit of any microcomputer and then repair it. The tips and techniques in this guide can be applied to any equipment that uses the microprocessor as the primary control element.

**TROUBLESHOOTING MICROPROCESSORS AND DIGITAL LOGIC**
**TAB No.1183 $13.45**
The influence of digital techniques on commercial and home equipment is enormous and increasing yearly. This book discusses digital theory and looks at how to service Video Cassette Recorders, microprocessors and more.

**HOW TO DEBUG YOUR PERSONAL COMPUTER**
**AB012 $10.45**
When you feel like reaching for a sledge hammer to reduce your computer to fiberglass and epoxy dust, don't. Reach for this book instead and learn all about program bug tracking, recognition and elimination techniques

**THE COMPLETE HANDBOOK OF ROBOTICS**
**TAB No.1071 $13.45**
All the information you need to build a walking, talking mechanical friend appears in this book. Your robot can take many forms and various options — light, sound, and proximity sensors — are covered in depth.

**HOW TO BUILD YOUR OWN SELF PROGRAMMING ROBOT**
**TAB No.1241 $13.45**
A practical guide on how to build a robot capable of learning how to adapt to a changing enviroment. The creature developed in the book, Rodney, is fully self programming, can develop theories to deal with situations and apply those theories in future circumstances

**BUILD YOUR OWN WORKING ROBOT**
**TAB No.841 $11.45**
Contains complete plans — mechanical, schematics, logic diagrams and wiring diagrams — for building Buster. There are two phases involved: first Buster is leash led, dependent on his creator for guidance; the second phase makes Buster more independent and able to get out of tough situations.

## COMPUTERS
(SOFTWARE)

**BEGINNER'S GUIDE TO COMPUTER PROGRAMMING**
**TAB No.574 $16.45**
Computer programming is an increasingly attractive field to the individual, however many people still overlook it as a career The material in this book has been developed in a logical sequence, from the basic steps to machine language.

**BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES $8.25**
**S. DALY**
This book is based on the author's own experience in learning BASIC and in helping others, mostly beginners, to program and understand the language. Also included are a program library containing various programs, that the author has actually written and run These are for biorhythms, plotting a graph of Y against X, standard deviation, regression, generating a musical note sequence and a card game. The book is complemented by a number of appendices which include test questions and answers on each chapter and a glossary.

**THE BASIC COOKBOOK.**
**TAB No.1055 $9.45**
BASIC is a surprisingly powerful language . if you understand it completely This book picks up where most manufacturers' documentation gives up With it, any computer owner can develop programs to make the most out of his or her machine

**PET BASIC — TRAINING YOUR PET COMPUTER**
**AB014 $16.45**
Officially approved by Commodore, this is the ideal reference book for long time PET owners or novices In an easy to read and humorous style, this book describes techniques and experiments, all designed to provide a strong understanding of this versatile machine

**PROGRAMMING IN BASIC FOR PERSONAL COMPUTERS**
**AB015 $10.45**
This book emphasizes the sort of analytical thinking that lets you use a specific tool — the BASIC language — to transform your own ideas into workable programs The text is designed to help you to intelligently analyse and design a wide diversity of useful and interesting programs.

**COMPUTER PROGRAMS IN BASIC**
**AB001 $14.45**
A catalogue of over 1 600 fully indexed BASIC computer programs with applications in Business, Math, Games and more. This book lists available software, what it does, where to get it, and how to adapt it to your machine

**PET GAMES AND RECREATION**
**AB002 $12.45**
A variety of interesting games designed to amuse and educate Games include such names as Capture, Tic Tac Toe, Watchperson, Motie, Sinners, Martian Hunt and more.

**BRAIN TICKLERS**
**AB005 $8.00**
If the usual games such as Bug Stomp and Invaders From the Time Warp are starting to pale, then this is the book for you The authors have put together dozens of stimulating puzzles to show you just how challenging computing can be

**PASCAL**
**TAB No.1205 $16.45**
Aimed specifically at TRS-80 users, this book discusses how to load, use and write PASCAL programs. Graphic techniques are discussed and numerous programs are presented

**PASCAL PROGRAMMING FOR THE APPLE**
**AB008 $16.45**
A great book to upgrade your programming skills to the UCSD Pascal as implemented on the Apple II. Statements and techniques are discussed and there are many practical and ready to run programs.

**APPLE MACHINE LANGUAGE PROGRAMMING**
**AB009 $16.45**
The best way to learn machine language programming the Apple II in no time at all The book combines colour, graphics, and sound generation together with clear cut demonstrations to help the user learn quickly and effectively

**Z80 USERS MANUAL**
**AB010 $14.45**
The Z80 MPU can be found in many machines and is generally acknowledged to be one of the most powerful 8 bit chips around This book provides an excellent 'right hand' for anyone involved in the application of this popular processor

**HOW TO PROGRAM YOUR PROGRAMMABLE CALCULATOR**
**AB006 $10.45**
Calculator programming, by its very nature, often is an obstacle to effective use This book endeavours to show how to use a programmable calculator to its full capabilities. The TI 57 and the HP 33E calculators are discussed although the principles extend to similar models.

**BP33: ELECTRONIC CALCULATOR USERS HANDBOOK $4.25**
**M.H. BABANI, B.Sc.(Eng.)**
An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators Presents formulae, data, methods of calculation, conversion factors, etc, with the calculator user especially in mind, often illustrated with simple examples. Includes the way to calculate using only a simple four function calculator Trigonometric Functions (Sin, Cos, Tan). Hyperbolic Functions (Sinh, Cosh, Tanh) Logarithms, Square Roots and Powers

## PROJECTS

**BP48: ELECTRONIC PROJECTS FOR BEGINNERS $5.90**
**F.G. RAYER, T.Eng.(CEI), Assoc.IERE**
Another book written by the very experienced author — Mr F.G Rayer — and in it the newcomer to electronics, will find a wide range of easily made projects Also, there are a considerable number of actual component and wiring layouts, to aid the beginner
Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron
Also, many of the later projects can be built along the lines as those in the 'No Soldering' section so this may considerably increase the scope of projects which the newcomer can build and use.

**221: 28 TESTED TRANSISTOR PROJECTS $5.50**
**R.TORRENS**
Mr Richard Torrens is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book The projects themselves can be split down into simpler building blocks, which are shown separated by boxes in the circuits for ease of description, and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own

**BP49: POPULAR ELECTRONIC PROJECTS $6.25**
**R.A. PENFOLD**
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors The projects selected cover a very wide range and are divided into four basic types. Radio Projects, Audio Projects, Household Projects and Test Equipment

**EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONIC PROJECTS**
**AB007 $9.45**
An ideal sourcebook of Solids State circuits and techniques with many practical circuits. Also included are many useful types of experimenter gear

**BP71: ELECTRONIC HOUSEHOLD PROJECTS $7.70**
**R. A. PENFOLD**
Some of the most useful and popular electronic construction projects are those that can be used in or around the home The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms

**BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS $8.10**
**R.A. PENFOLD**
Projects, fifteen in all, which use a 12V supply are the basis of this book Included are projects on Windscreen Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, Depth Warning and Shaver Inverter.

**BP69: ELECTRONIC GAMES $7.55**
**R.A. PENFOLD**
In this book Mr R A Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits

**BP95: MODEL RAILWAY PROJECTS $8.10**
Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered include controllers, signals and sound effects striboard layouts are provided for each project

ETI BOOKS

# PROJECTS
(CONTINUED)

**BP76: POWER SUPPLY PROJECTS $7.30**
**R.A. PENFOLD**
Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop The designs provided are all low voltage types for semiconductor circuits

There are other types of power supply and a number of these are dealt with in the final chapter, including a cassette power supply. Ni-Cad battery charger, voltage step up circuit and a simple inverter

**BP84: DIGITAL IC PROJECTS $8.10**
**F.G. RAYER, T.Eng.(CEI),Assoc.IERE**
This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome An ideal book for both beginner and more advanced enthusiast alike

**BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS $7.55**
**F.G. RAYER, T.Eng.(CEI), Assoc. IERE**
Numeral indicating devices have come very much to the forefront in recent years and will, undoubtedly, find increasing applications in all sorts of equipment With present day integrated circuits, it is easy to count, divide and display numerically the electrical pulses obtained from a great range of driver circuits

In this book many applications and projects using various types of numeral displays, popular counter and driver IC's etc are considered

**213: ELECTRONIC CIRCUITS FOR MODEL RAILWAYS $4.50**
**M.H. BABANI, B.Sc.(Eng.)**
The reader is given constructional details of how to build a simple model train controller, controller with simulated inertia and a high power controller A signal system and lighting for model trains is discussed as is the suppression of RF interference from model railways The construction of an electronic steam whistle and a model train chuffer is also covered

**BP73: REMOTE CONTROL PROJECTS $8.60**
**OWEN BISHOP**
This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. Not only are radio control systems considered but also infra-red, visible light and ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc

# CIRCUITS

**BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1 $8.25**
**R.A. PENFOLD**
Another book by the very popular author, Mr. R A. Penfold, who has designed and developed a large number of various circuits These are grouped under the following general headings; Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits

**THE GIANT HANDBOOK OF ELECTRONIC CIRCUITS**
**TAB No.1300 $24.45**
About as twice as thick as the Webster's dictionary, and having many more circuit diagrams, this book is ideal for any experimenter who wants to keep amused for several centuries. If there isn't a circuit for it in here, you should have no difficulty convincing yourself you don't really want to build it

**BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS $5.50**
**F.G. RAYER, T.Eng.(CEI),Assoc.IERE**
Field effect transistors (FETs), find application in a wide variety of circuits The projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home

This book contains something of particular interest for every class of enthusiast — short wave listener, radio amateur, experimenter or audio devotee

**BP87: SIMPLE L.E.D. CIRCUITS $5.90**
**R.N. SOAR**
Since it first appeared in 1977, Mr R N Soar's book has proved very popular The author has developed a further range of circuits and these are included in Book 2 Projects include a Transistor Tester, Various Voltage Regulators, Testers and so on

**BP42: 50 SIMPLE L.E.D. CIRCUITS $3.55**
**R.N. SOAR**
The author of this book, Mr R N. Soar, has compiled 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components — the Light Emitting Diode (L E.D ) A useful book for the library of both beginner and more advanced enthusiast alike

**BP82: ELECTRONIC PROJECTS USING SOLAR CELLS $8.10**
**OWEN BISHOP**
The book contains simple circuits, almost all of which operate at low voltage and low currents, making them suitable for being powered by a small array of silicon cells. The projects cover a wide range from a bicyle speedometer to a novelty 'Duck Shoot'; a number of power supply circuits are included

**BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS $5.50**
**F.G.RAYER, T.Eng.(CEI),Assoc.IERE**
Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of applications in electronics today This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct In most of the circuits there is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs

**BP44: IC 555 PROJECTS $7.55**
**E.A. PARR, B.Sc.,C.Eng., M.I.E.E.**
Every so often a device appears that is so useful that one wonders how life went on before without it The 555 timer is such a device Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers

**BP24: 50 PROJECTS USING IC741 $4.25**
**RUDI & UWE REDMER**
This book, originally published in Germany by TOPP, has achieved phenomenal sales on the Continent and Babani decided, in view of the fact that the integrated circuit used in this book is inexpensive to buy, to make this unique book available to the English speaking reader Translated from the original German with copious notes, data and circuitry, a "must" for everyone whatever their interest in electronics

**BP83: VMOS PROJECTS**
**R.A. PENFOLD**
Although modern bipolar power transistors give excellent results in a wide range of applications, they are not without their drawbacks or limitations This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with in the chapter on audio circuits A number of varied and interesting projects are covered under the main headings of Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits

**BP65: SINGLE IC PROJECTS $6.55**
**R.A.PENFOLD**
There is now a vast range of ICs available to the amateur market, the majority of which are not necessarily designed for use in a single application and can offer unlimited possibilities All the projects contained in this book are simple to construct and are based on a single IC A few projects employ one or two transistors in addition to an IC but in most cases the IC is the only active device used

**BP 50: IC LM3900 PROJECTS $5.90**
**H.KYBETT,B.Sc., C.Eng.**
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.

Simple basic working circuits are used to introduce this IC. The LM3900 can do much more than is shown here, this is just an introduction. Imagination is the only limitation with this useful and versatile device. But first the reader must know the basics and that is what this book is all about

**223: 50 PROJECTS USING IC CA3130 $5.50**
**R.A.PENFOLD**
In this book, the author has designed and developed a number of interesting and useful projects which are divided into five general categories: I — Audio Projects II — R F. Projects III — Test Equipment IV — Household Projects V — Miscellaneous Projects

**224: 50 CMOS IC PROJECTS $4.25**
**R.A. PENFOLD**
CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC

Mr. R A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories. I — Multivibrators II — Amplifiers and Oscillators III — Trigger Devices IV — Special Devices.

**THE ACTIVE FILTER HANDBOOK**
**TAB No.1133 $11.45**
Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the ideal reference for active filter design. The book introduces filters and their uses also presents many practical circuits including a graphic equalizer, computer tape interface and more

**DIGITAL ICS — HOW THEY WORK AND HOW TO USE THEM**
**AB004 $10.45**
An excellent primer on the fundamentals of digital electronics. This book discusses the nature of gates and related concepts and also deals with the problems inherent to practical digital circuits.

**MASTER HANDBOOK OF 1001 PRACTICAL CIRCUITS**
**TAB No.800 $20.45**
**MASTER HANDBOOK OF 1001 MORE PRACTICAL CIRCUITS**
**TAB No.804 $19.45**
Here are transistor and IC circuits for just about any application you might have. An ideal source book for the engineer, technician or hobbyist Circuits are classified according to function, and all sections appear in alphabetical order

**THE MASTER IC COOKBOOK**
**TAB No.1199 $16.45**
If you've ever tried to find specs for a so called 'standard' chip, then you'll apppreciate this book. C L. Hallmark has compiled specs and pinouts for most types of ICs that you'd ever want to use

**ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS**
**AB016 $10.45**
This practical handbook enables you to take advantage of the vast range of applications made possible by integrated circuits The book tells how, in step by step fashion, to select components and how to combine them into functional electronic systems. If you want to stop being a "cookbook hobbyist", then this is the book for you

# AUDIO

**BP90: AUDIO PROJECTS $8.1**
**F.G. RAYER**
Covers in detail the construction of a wide range of audio projects. The text has been divided into preamplifiers and mixers, power amplifiers, tone controls and matching and miscellaneous projects

**HOW TO DESIGN, BUILD, AND TEST COMPLETE SPEAKER SYSTEMS.**
**TAB No.1064 $13.45**
By far the greatest savings in assembling an audio system can be realized from the construction of speakers. This book contains information to build a variety of speakers as well as instructions on how to design your own

**205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES $3.55**
**B.B. BABANI**
This book gives data for building most types of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams for every construction showing the dimensions necessary.

**BP35: HANDBOOK OF IC AUDIO PRE-AMPLIFIER AND POWER AMPLIFIER CONSTRUCTION $5.50**
**F.G.RAYER, T.Eng.(CEI),Assoc.IERE**
This book is divided into three parts: Part I, understanding audio IC's, Part II, Preamplifiers, Mixers and Tone Controls, Part III Power Amplifiers and Supplies. Includes practical constructional details of pure IC and Hybrid IC and Transistor designs from about 250mW to 100W output.

**BP47: MOBILE DISCOTHEQUE HANDBOOK $5.90**
**COLIN CARSON**
The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Many people have wasted a "small fortune" on poor, unnecessary or badly matched apparatus

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco" gear.

**HOW TO BUILD A SMALL BUDGET RECORDING STUDIO FROM SCRATCH. . .**
**TAB No.1166 $16.45**
The author, F Alton Everest, has gotten studios together several times, and presents twelve complete, tested designs for a wide variety of applications If all you own is a mono cassette recorder, you don't need this book. If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.

**BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING $5.50**
**M.K. BERRY**
Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator

This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of equipment. It then describes how the sounds are generated and how these may be recorded to build up the final composition.

**BP74: ELECTRONIC MUSIC PROJECTS $7.70**
**R.A. PENFOLD**
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser-Units, Tremelo Generator etc

**P81: ELECTRONIC SYNTHESISER PROJECTS $7.30**
**M.K. BERRY**
One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effects generator Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

**ELECTRONIC MUSIC SYNTHESIZERS**
**TAB No.1167 $10.45**
If you're fascinated by the potential of electronics in the field of music, then this is the book for you Included is data on synthesizers in general as well as particular models There is also a chapter on the various accessories that are available.

**See the order form on page 25**

ETI BOOKS

# TEST EQUIPMENT

**BP75: ELECTRONIC TEST EQUIPMENT CONSTRUCTION** **$7.30**
**F.G. RAYER, T.Eng. (CEI), Assoc. IERE**
This book covers in detail the construction of a wide range of test equipment for both the Electronics Hobbyists and Radio Amateur. Included are projects ranging from an FET Amplified Voltmeter and Resistance Bridge to a Field Strength Indicator and Heterodyne Frequency Meter. Not only can the home constructor enjoy building the equipment but the finished projects can also be usefully utilised in the furtherance of his hobby.

**99 TEST EQUIPMENT PROJECTS YOU CAN BUILD**
**TAB No.805** **$14.45**
An excellent source book for the hobbyist who wants to build up his work bench inexpensively. There are circuits to measure just about any electrical quantity. The variety is endless and includes just about anything you could wish for!

**HOW TO GET THE MOST OUT OF LOW COST TEST EQUIPMENT**
**AB017** **$9.45**
Whether you want to get your vintage 1960 'TestRite'signal generator working, or you've got something to measure with nothing to measure it with, this is the book for you. The author discusses how to maximize the usefulness of cheap tést gear, how to upgrade old equipment, and effective test set ups.

**THE POWER SUPPLY HANDBOOK**
**TAB No.806** **$16.45**
A complete one stop reference for hobbyists and engineers. Contains high and low voltage power supplies of every conceivable type as well mobile and portable units.

**BP70: TRANSISTOR RADIO FAULT-FINDING CHART** **$2.40**
**CHAS. E. MILLER**
Across the top of the chart will be found four rectangles containing brief descriptions of various faults, vis· — sound weak but undistorted; set dead, sound low or distorted and background noises. One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared.

**ELECTRONIC TROUBLESHOOTING HANDBOOK**
**AB019** **$9.45**
This workbench guide can show you how to pinpoint circuit troubles in minutes, how to test anything electronic, and how to get the most out of low cost test equipment. You can use any and all of the time-saving shortcuts to rapidly locate and repair all types of electronic equipment malfunctions.

**COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS**
**AB018** **$9.45**
A complete guide on how to read and understand schematic diagrams. The book teaches how to recognize basic circuits and identify component functions. Useful for technicians and hobbyists who want to avoid a lot of headscratching.

# RADIO AND COMMUNICATIONS

**BP79: RADIO CONTROL FOR BEGINNERS** **$7.30**
**F.G. RAYER, T.Eng.(CEI),Assoc.IERE.**
The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency and power of transmission. This is followed by a "block" explanation of how control-device and transmitter operate and receiver and actuator(s) produce motion in a model.

Details are then given of actual solid state transmitting equipment which the reader can build. Plain and loaded aerials are then discussed and so is the field-strength meter to help with proper setting up.

The radio receiving equipment is then dealt with which includes a simple receiver and also a crystal controlled superhet. The book ends with the electro-mechanical means of obtaining movement of the controls of the model.

**BP91: AN INTRODUCTION TO RADIO DXing** **$8.10**
This book is divided into two main sections one to amateur band reception, the other to broadcast bands. Advice is given to suitable equipment and techniques. A number of related constructional projects are described.

**No. 215: Shortwave Circuits & Gear For Experimenters & Radio Hams** **$3.70**
Covers constructional details of a number of projects for the shortwave enthusiast and radio "Ham". Included are an add-in crystal filter, adding an "S" meter in your receiver; crystal locked H.F. Receiver, AM tuner using phase locked loop; coverter for 2MHz, 40 to 800 MHz RF amplifier, Aerials for the 52, 144MHz bands, Solid State Crystal Frequency Calibrator, etc.

**BP46: RADIO CIRCUITS USING IC's** **$5.90**
**J.B. DANCE, M.Sc.**
This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. The chapter on amplitude modulated (a m ) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f m.) receivers will appeal to those who desire high fidelity reception.

# REFERENCE

**THE BEGINNER'S HANDBOOK OF ELECTRONICS**
**AB003** **$9.45**
An excellent textbook for those interested in the fundamentals of Electronics. This book covers all major aspects of power supplies, amplifiers, oscillators, radio, television and more.

**ELEMENTS OF ELECTRONICS — An on-going series**
**F.A. WILSON, C.G.I.A., C.Eng.,**
**BP62: BOOK 1. The Simple Electronic Circuit and Components** **$8.95**
**BP63: BOOK 2. Alternating Current Theory** **$8.95**
**BP64: BOOK 3. Semiconductor Technology** **$8.95**
**BP77: BOOK 4. Microprocessing Systems And Circuits** **$12.30**
**BP89: BOOK 5. Communication** **$12.30**
The aim of this series of books can be stated quite simply — it is to provide an inexpensive introduction to modern electronics so that the reader will start on the right road by thoroughly understanding the fundamental principles involved.

Although written especially for readers with no more than ordinary arithmetical skills, the use of mathematics is not avoided, and all the mathematics required is taught as the reader progresses.

Each book is a complete treatise of a particular branch of the subject and, therefore, can be used on its own with one proviso, that the later books do not duplicate material from their predecessors, thus a working knowledge of the subjects covered by the earlier books is assumed.

BOOK 1· This book contains all the fundamental theory necessary to lead to a full understanding of the simple electronic circuit and its main components.

BOOK 2 This book continues with alternating current theory without which there can be no comprehension of speech, music, radio, television or even the electricity utilities.

BOOK 3· Follows on semiconductor technology, leading up to transistors and integrated circuits.

BOOK 4 A complete description of the internal workings of microprocessor.

BOOK 5: A book covering the whole communication scene.

**BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE** **$12.25**
**ADRIAN MICHAELS**
This book will help the reader to find possible substitutes for a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer selection of modern transistors. Also shown are the material type, polarity, manufacturer and use. The Equivalents are sub-divided into European, American and Japanese. The products of over 100 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. Fantastic value for the amount of information it contains.

**BP1: FIRST BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES** **$2.80**
**B.B. BABANI**
This guide covers many thousands of transistors showing possible alternatives and equivalents. Covers transistors made in Great Britain, USA, Japan, Germany, France, Europe, Hong Kong, and includes types produced by more than 120 different manufacturers.

**BP14: SECOND BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES** **$4.80**
**B.B. BABANI**
The "First Book of Transistor Equivalents" has had to be reprinted 15 times. The "Second Book" produced in the same style as the first book, in no way duplicates any of the data presented in it. The "Second Book" contains only additional material and the two books complement each other and make available some of the most complete and extensive information in this field. The interchangeability data covers semiconductors manufactured in Great Britain, USA, Germany, France, Poland, Italy, East Germany, Belgium, Austria, Netherlands and many other countries.

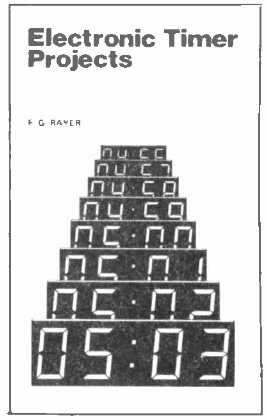
**TOWER'S INTERNATIONAL OP-AMP LINEAR IC SELECTOR**
**TAB No.1216** **$13.45**
This book contains a wealth of useful data on over 5 000 Op-amps and linear ICs — both pinouts and essential characteristics. A comprehensive series of appendices contain information on specs, manufacturers, case outlines and so on.

**CMOS DATABOOK**
**TAB No.984** **$14.45**
There are several books around with this title, but most are just collections of manufacturers' data sheets. This one, by Bill Hunter, explains all the intricacies of this useful family of logic devices. the missing link in getting your own designs working properly. Highly recommended to anyone working with digital circuits.

**BP68: CHOOSING AND USING YOUR HI-FI** **$7.25**
**MAURICE L. JAY**
The main aim of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of hi-fi equipment now on the market.

Help is given to the reader in understanding the equipment he is interested in buying and the author also gives his own opinion of the minimum standards and specifications one should look for. The book also offers helpful advice on how to use your hi-fi properly so as to realise its potential. A Glossary of terms is also included.

See the order form on page 25




# Book Of The Month

Timer Projects..........................BP93..........................$5.50

Simple timers, complicated timers, analogue and digital timers, timers with LEDs, buzzers, Nixies. . . you should be really up to your clavical in timers if you get this book. There are timers here for simple applications, like getting your eggs right, and ones to turn things on and off unattended. There is also consideration given to clocks, which are timers of a sort, and delays circuits, such as windshield wiper "mist" circuits. Time yourself silly with this this emminently useful tome.

This book has circuits for both the beginner who's just into it for a few minutes, and the serious experimenter who wants to devote whole eons to timers. Many of the projects will find uses around the home, and, of course, can be adapted to many other purposes limited only by your imagination. . . and how much time you've got to play with the transistors.

# Into Linear ICs Part 5

**More 555 circuits: Ian Sinclair investigates some unusual uses for this ubiguitous chip.**



LET'S GO A BIT FURTHER along this 'test-instrument' line of thought. Fig. 9 shows a 555 circuit which generates a squarewave signal with no input needed. This is achieved by making the timer self-triggering, so that the trigger input on pin 2 has to be connected to the threshold pin, pin 6. The action goes something like this. Imagine that the unit has just been switched on, so that the voltage at pins 6 and 7 is low. Since the voltage on pin 2 must also be low, the unit will trigger, and pin 7 will be open-circuited. This now allows the voltage at pin 7 to rise, so that C2 will start to charge through R3 and RV1 — meantime the output voltage on pin 3 has gone high. When the voltage on pin 6 reaches two thirds of the supply voltage, the timer circuits switch over, so that pin 7 (and also pin 2) is grounded, but the voltage at pin 6 is still at about two thirds of the supply voltage. The output voltage at pin 3 is now low again. C2 now discharges through RV1 and R3, because pin 7 is internally grounded, until the trigger voltage of one third of V+ is reached. When this voltage is reached, the effect on pin 2 is to start another cycle, with the output going high again and C2 charging once more. Providing that the value of RV1 + R3 is much greater than that of R2, the output wave has a good square shape. If R2 is too large in comparison, the high part of the output wave, known as the mark, lasts longer than the low part, the space.

That's a basic form of circuit — let's see what we can use it for. Since the squarewave at the output can be at an audio frequency, and since the 200 mA current capability of the 555 is quite enough to drive a small loudspeaker, the 555 can be used in a number of alarm circuits. A burglar alarm basic circuit is shown in Fig. 10, using a loudspeaker of 4 ohms to 16 ohms resistance; Fig. 10(b) shows how a 60 to 80 ohm loudspeaker can be used in a simple circuit.

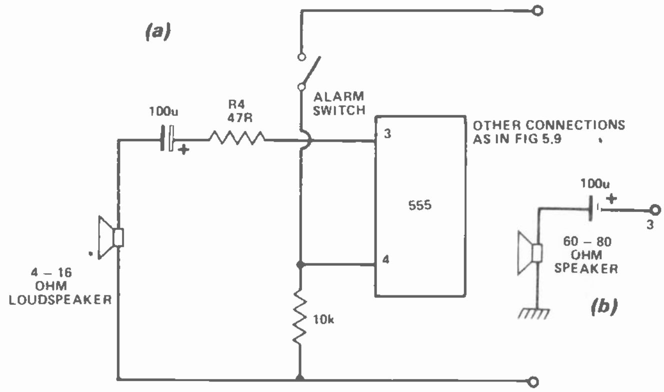



**Fig. 10 Using the square-wave generator (a) to drive a loudspeaker when an alarm switch is pressed. The connection (b) for a high resistance speaker are also shown.**

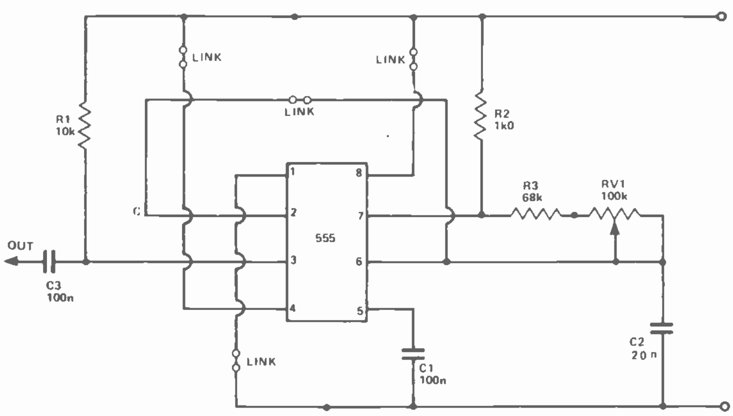



**Fig. 9 The square-wave generator.**

## Sine Wave

The circuit itself is simple, using the 555 connected as a square-wave oscillator with an output to the loudspeaker. R4 is used to limit the amount of current which can flow, in case the current capability of the 555 is exceeded. The alarm is sounded by SW1 being closed — this switch can be a window contact, a door-mat switch or any of the many types of swich sold for this purpose by security specialists.

We're not limited to outputs from mechanical switches. Fig. 11 shows a freezer-alarm circuit which is a development of the circuit of Fig. 9 and which also uses the 555 as an oscillator driving a loudspeaker. The temperature sensing device is a thermistor which is located inside the freezer, using the special sticky tape which is sold for sealing freezer bags — ordinary tape cracks at low temperatures. The thermistor need not be near the alarm circuit, and can be connected by fine-gauge wires which can be laid over the freezer sealing rubbers without causing any damage. RV1 is used to adjust the amount of resistance which is connected in series with the thermistor, so that Q1 is just biased off. A rise in the temperature will cause Q2 to switch on. With Q2 on, the voltage at pin 4 of the 555 is raised enough to allow the 555 to start oscillating — any voltage above

0.7V which can pass a current of 0.1 mA is enough to release the reset action. The 555 oscillates, and the alarm sounds. RV1 should be set so that the alarm will NOT sound every time the lid is raised, but will sound if the lid is kept open for more than a few minutes.

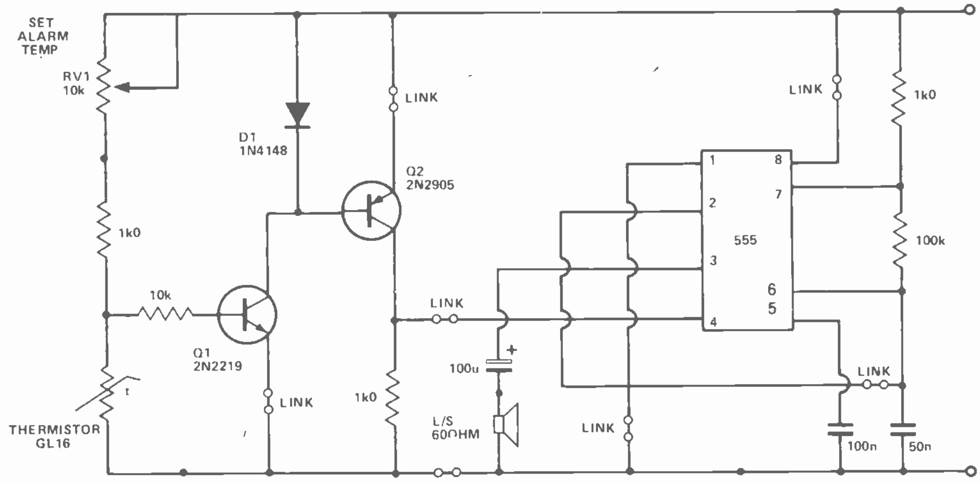



Fig. 11 Using a 555 as the oscillator in a freezer-alarm.

## Over To You

All change again, this time to a circuit which can be used for controlling the speed of small motors (are you listening, model train and slot-car fans?). The type of control which is used is called mark-space control, and it's a great improvement over the simple variable resistor which is so often used as a speed control for small motors. In a rectangular wave (Fig. 12) the mark time is the time for which the voltage is high, and the space time is the time for which the voltage is low. A large mark-space ratio means that the output voltage is high for most of the time of one cycle; a small mark-space ratio means that the voltage is low for most of the time of a cycle. A 1:1 mark-space ratio means a square wave, whose average voltage is equal to half of the peak voltage. If we apply a voltage which has fixed amplitude but variable mark-space ratio to a small electric motor, the speed of the motor will depend on the mark-space ratio and very smooth control of speed can be achieved, without the loss of torque which is the problem when a variable resistance is used as a controller.

The circuit of Fig. 12 shows the mark-space generator. Motors which take less than 200 mA stalled (not moving) current at 12 V can be operated directed from the output of the 555 timer, but most model locomotive motors nowadays need rather more current, so that a simple add-on power booster, using a 2N3055 (as in Fig 13) is useful. The variation of the mark-to-space ratio is carried out by using the oscillator circuit of Fig. 9 with the addition of two diodes. While C2 is charging, D1 conducts so that the charging current comes through R1 and the portion of RV1 which is between point A and the top end of the potentiometer. When the circuit switches over, with pin 7 internally grounded, D1 is cut off, and C2 discharges through D2, R2 and the other part of the potentiometer RV1 between point B and the tap. Since the total resistance of R1, R2 and RV1 is constant the frequency of the output is steady, but the ratio of charge-to-discharge times can be varied greatly by adjusting RV1. With the values shown, the ratio can be varied between about 1:100 and 100:1, so that an excellent control range can be obtained.

Note that this circuit is useful only if the supply to the circuit is DC, and reasonably smoothed. Most model-motor supplies are simply full-wave rectified, with no smoothing, so that a 5 000 μF capacitor, rated at 36 V should be added to make the circuit more effective — but check that this does not cause the output voltage to rise above the rated 16 V for the 555. If it does, use the modifications shown in Fig. 14.

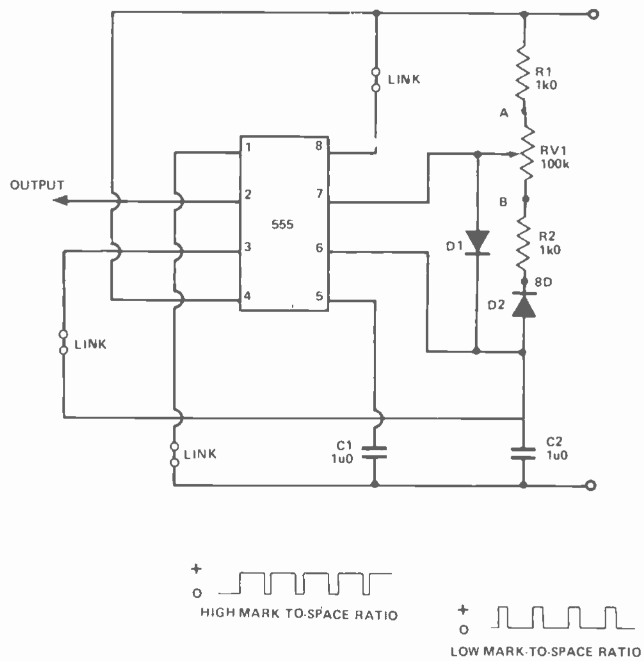



Fig. 12 The motor-speed controller circuit. Full speed corresponds to a large mark-to-space ratio, and currents greater than 0.2A can be provided by using a power-booster.

## Odd and Ends

Now for the odds-and-ends section. Fig. 15 shows a circuit for a car or motor-bike rev counter. Old fashioned mechanical rev counters needed a mechanical drive, but the modern electronic type need only electrical connections, and can be used with any conventional ignition

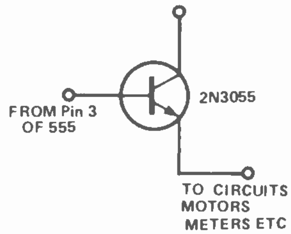



**Fig. 13 A power-booster stage for the motor-speed controller.**

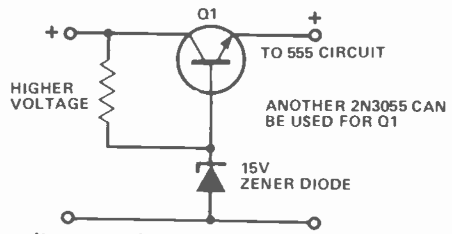



**Fig. 14 A voltage regulator to prevent the supply to the 555 rising above 16V.**

system which uses contact points. The circuit operates on the sudden rise of voltage across the points each time they open to create the spark. For a single cylinder engine, there is either one spark per revolution (two-stroke) or one spark every second revolution (four-stroke), and for multi-cylinder engines, this number is multiplied by the number of cylinders which are fired from the same contact-breaker. For a four-cylinder engine running at 3 000 rpm, for example, there will be two sparks per revolution, 6,000 sparks per minute, 100 per second. Each time the points separate, Q1 and Q2 will turn on, causing the collector of Q2 to go momentarily to a low voltage. This, in turn, triggers the 555, sincle pin 2 of the 555 is connected to the collector of Q2 through C2. Once the 555 is triggered, C4 starts to charge, and the output voltage goes high. The values of R4 and C4 are chosen so that the output will remain high for one two-hundredth of a second, so that if the rate of the input pulses is 200 per second, the output from the 555 will stay high — the 555 is being triggered again just at the end of each delay. This rate of 200

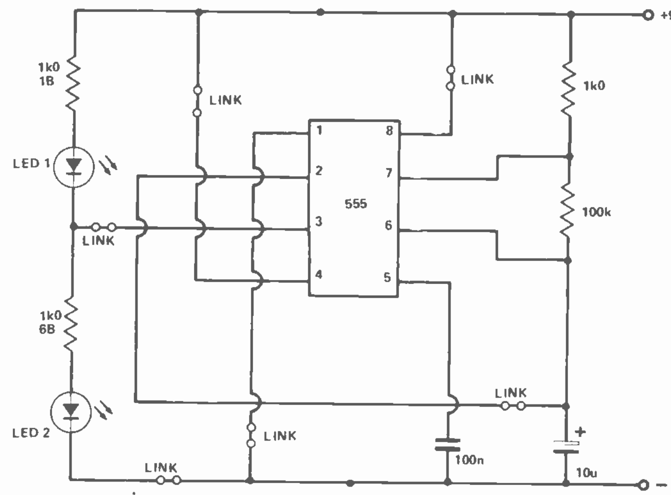



**Fig. 16 The 555 tester circuit.**

pulses per second corresponds to 6 000 RPM for a four-cylinder four-stroke, and RV1 can be adjusted so that the meter M reads full scale at this pulse rate. This calibration need not be done from an engine — incidentally, it can just as easily be carried out using a 200 Hz signal generator. Another method is to calibrate using 60 Hz from a small transformer, and adjust the meter to read 1666 RPM with this input.

If the engine speed is less than 6 000 RPM, the 555 has time to finish its output wave before it is triggered again, so that the meter reading is rather less than at full speed. The meter reading is proportional to the average voltage at the output of the 555, and that is, in turn, proportional to the speed of the engine to which the circuit is attached.

We'll finish with a little one — you can word out for yourselves how it works. It's for testing 555s, and it makes use of the oscillator circuit. When a working 555 is inserted, the LEDs will flash alternatively. If both LEDs light or if only one lights, the 555 is faulty. If neither of the LEDs lights the battery is flat!

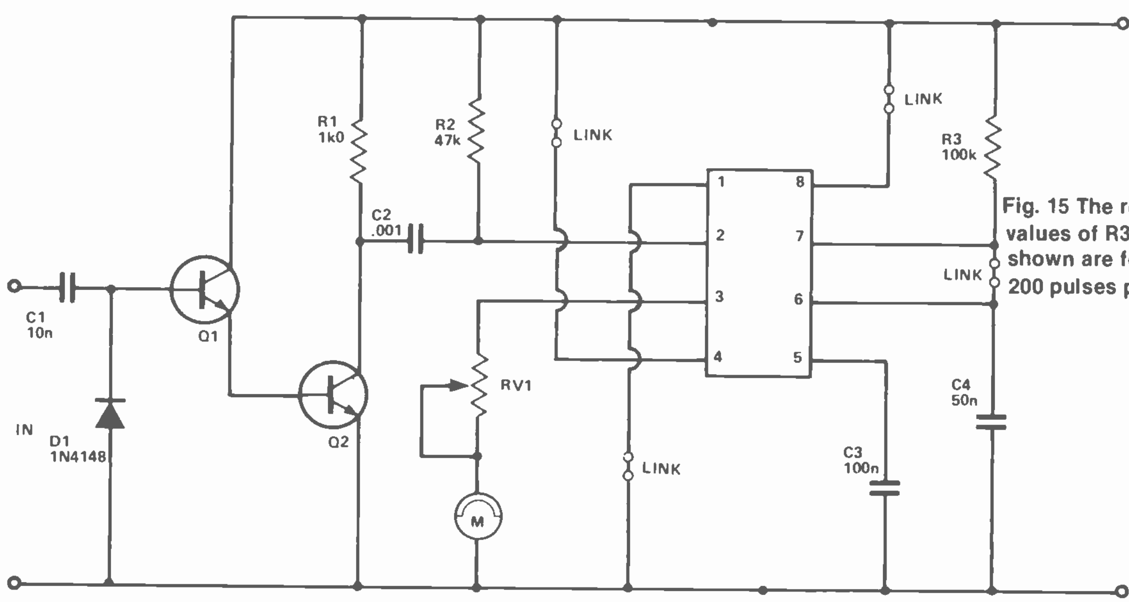



**Fig. 15 The rev-counter circuit—the values of R3 and C4 which are shown are for full-scale reading on 200 pulses per second.**

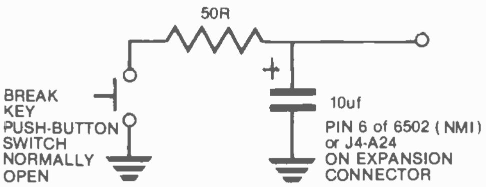
# Computer Bits

### 6502 Break Key
Yin H. Pun

This is an effective 'break' key for a 6502 based microcomputer such as PET or Apple. It uses the NMI (non-maskable interrupt) pin of the 6502 and the circuit simply contains a capacitor, a resistor and a push button.

One may ask why one needs such a key since the PET already has a 'RUN-STOP' key to break programs. The 'RUN-STOP' is okay for stoping programs written in BASIC, but it cannot stop programs written in machine language. This is where the NMI break key finds itself useful.

Here is the circuit: (for PET)



(PULL-UP RESISTOR IS ALREADY THERE)

The capacitor debounces the push-button as it is pressed. When the 6502 senses a falling edge on the NMI pin, the 6502 will service the NMI routine. On the PET, the 6502 will perform an indirect jump to location indicated in addresses 0094 and 0095 hex. The PET will restart the BASIC operating system if these locations were not changed by the user, that is, the PET will print a 'READY' on the screen whenever the 'break' key is pressed. Now you can break into a running machine language program such as SPACE INVADERS or BREAKOUT. Some programs may still be 'running' after you've pressed the 'break' key but nevertheless, you get your cursor back, so POKE 144,85:POKE145,228 to bring the IRQ routine back to normal.

With this 50¢ addition to your 6502 based microcomputer, you can break into all the machine language programs you want, thereby saving your sanity if your M.L. program goes into an endless loop!

### One-Stroke Keywords
Barry Dexter

Owners of the OSI Superboard II computer can reduce the work of entering BASIC lines with one-key entry of keywords. The program which follows gives you this function plus automatic line numbering when selected. It changes the vector to "Input" so we can intercept the flow of characters from the keyboard and alter what goes on into BASIC.

Do a Cold Start, then enter Listing 1 through the Monitor. Double check your entry since even one wrong byte can cause all kinds of grief. Now go to the starting address-$0222 - and press "G". The "O.K." message should appear—if it doesn't, do a Cold Start and find your error before trying again.

In operation pressing the Control key together with any other key will cause a keyword to appear. The locations of the words are shown in Table 1. Put narrow strips of masking tape on each key and print the words on with a ball-point pen.

To start automatic line numbering press the "Rub-Out" key, then enter a line number and statement followed by a Return. A number 10 greater than you entered will appear, ready for your next statement. To stop Auto-line press "Rub-Out". (Always turn off Auto-line before a RUN). The increment between lines can be changed by POKE 225,X where X is from 1 to 255.

Listing 2 will generate an Auto-load tape of the routine in Listing 1. Whenever you wish to load this tape set the Monitor address to some high value such as $0999, start the recorder and press "L".

```
              TABLE 1.
KEYS ARE PROGRAMMED AS FOLLOWS
CONTROL KEY & LETTER OR CHR:
A    FOR
B    NEXT
C    DATA
D    INPUT
E    DIM
F    READ
G    LET
H    GOTO
I    RUN
J    IF
K    RESTORE
L    GOSUB
N    REM
O    STOP
P    ON
Q    NULL
R    WAIT
S    LOAD
T    SAVE
U    DEF
V    POKE
W    PRINT
X    CONT
Y    LIST
Z    CLEAR

.    SIN
-    COS
/    TAN
,    EXP

0    ATN
1    PEEK
2    LEN
3    STR$
4    VAL
5    ASC
6    CHR$
7    LEFT$
8    RIGHT$
9    MID$
: - RETURN
CARRIAGE RETURN - PRINT
LINE FEED  -  SAVE
LINE FEED ALONE-IF
ESCAPE KEY ALONE - THEN
SHIFT KEY & CAR.RETURN - TO
```

```
     LISTING 2.
5 REM ****AUTOLOAD TAPE MAKER
7 POKE 517,0: REM  SAVE NOT NEEDED
10 PT = 61440:TP = PT + 1
20 DATA .,0,2,2,2,/,. 0,2,2,2,G
25 FOR X = 1 TO 2E3: NEXT : REM  PUT BLANK LEADER ON TAPE
30 GOSUB 400
50 FOR X = 546 TO 724:A =  PEEK (X)
60 GOSUB 100
70 B = 13: GOSUB 300
80 NEXT
90 GOSUB 400: END
100 B =  INT (A / 16):C = A - B * 16
110 GOSUB 200:B = C
200 B = B + 48: IF B > 57 THEN B = B + 7
300 WAIT PT,2
310 POKE TP,B
320 PRINT  TAB( 6) CHR$ (B)
330 RETURN
400 FOR X = 1 TO 6: READ A$
410 B =  ASC (A$): GOSUB 300: NEXT : RETURN
500 REM  OMITTING LINE 320 WILL SPEED UP PROGRAM
```

```
    LISTING 1.
CHANGE 'INPUT' VECTOR & SET FLAGS
0222 A9 3C    LDA IMM
0224 8D 18 02 STA ABS
0227 A9 02    LDA IMM
0229 8D 19 02 STA ABS
022C A9 00    LDA IMM
022E A2 03    LDX IMM
0230 95 E2    STA ZPX
0232 CA       DEX IMP
0233 10 FB    BPL REL GOTO 0230
0235 A9 0A    LDA IMM
0237 85 E1    STA ZER
0239 4C 00 00 JMP ABS GOTO 0000

DECIDE WHICH LOOP TO FOLLOW
023C 2C 03 02 BIT ABS
023F 10 03    BPL REL GOTO 0244
0241 4C BF FF JMP ABS GOTO FFBF
0244 86 F4    STX ZER
0246 84 F5    STY ZER
0248 A6 E3    LDX ZER
024A D0 79    BNE REL GOTO 02C5
024C A4 E4    LDY ZER
024E D0 4D    BNE REL GOTO 029D
0250 A6 E2    LDX ZER
0252 F0 06    BEQ REL GOTO 025A
0254 A5 E5    LDA ZER
0256 C9 0D    CMP IMM
0258 F0 51    BEQ REL GOTO 02AB
025A A2 30    LDX IMM
025C 88       DEY IMP
025D D0 FD    BNE REL GOTO 025C
025F CA       DEX IMP
0260 D0 FA    BNE REL GOTO 025C

FETCH CHARACTER FROM KEYBOARD
0262 20 ED FE JSR ABS SUB- FEED
0265 85 E5    STA ZER
0267 C9 7F    CMP IMM
0269 D0 08    BNE REL GOTO 0273
026B A5 E2    LDA ZER
026D 49 FF    EOR IMM
026F 85 E2    STA ZER
0271 A9 0D    LDA IMM
0273 C9 0D    CMP IMM
0275 F0 12    BEQ REL GOTO 0289
0277 C9 1B    CMP IMM
0279 D0 02    BNE REL GOTO 027D
027B A9 D6    LDA IMM
027D C9 FA    CMP IMM
027F D0 02    BNE REL GOTO 0283
0281 A9 0D    LDA IMM
0283 30 09    BMI REL GOTO 028E
0285 C9 20    CMP IMM
0287 30 08    BMI REL GOTO 0291
0289 A4 F5    LDY ZER
028B A6 F4    LDX ZER
028D 60       RTS IMP

LOOK UP A KEYWORD IN ROM
028E 38       SEC IMP
028F E9 B6    SBC IMM
0291 AA       TAX IMP
0292 CA       DEX IMP
0293 F0 08    BEQ REL GOTO 029D
0295 C8       INY IMP
0296 B9 86 A0 LDA ABY
0299 10 FA    BPL REL GOTO 0295
029B 30 F5    BMI REL GOTO 0292
029D C8       INY IMP
029E 84 E4    STY ZER
02A0 B9 86 A0 LDA ABY
02A3 10 04    BPL REL GOTO 02A9
02A5 29 7F    AND IMM
02A7 86 E4    STX ZER
02A9 10 DE    BPL REL GOTO 0289

GENERATE A LINE NUMBER
02AB 18       CLC IMP
02AC A5 11    LDA ZER
02AE 65 E1    ADC ZER
02B0 90 02    BCC REL GOTO 02B4
02B2 E6 12    INC ZER
02B4 85 AE    STA ZER
02B6 A5 12    LDA ZER
02B8 85 AD    STA ZER
02BA A2 90    LDX IMM
02BC 38       SEC IMP
02BD 20 E8 B7 JSR ABS SUB- B7E8
02C0 20 6E B9 JSR ABS SUB- B96E
02C3 A2 00    LDX IMM
02C5 E8       INX IMP
02C6 E6 E3    INC ZER
02C8 BD FF 00 LDA ABX
02CB 85 E5    STA ZER
02CD D0 BA    BNE REL GOTO 0289
02CF 85 E3    STA ZER
02D1 A9 20    LDA IMM
02D3 D0 B4    BNE REL GOTO 0289
```



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Arrr, Billy... Have Ye Ever Been Te Sea?

No, I suppose not... well, better off fer ya, I suppose. Nothin' out there but salt 'n' spray, pirates 'n' ol' Davy Jones's locker. Naw, Ye wouldn't a' liked it one bit. Ye'd get cold, 'n' wet, Ye're not even dressed fer the sea, Billy, me Boy... If'n ye wants te be livin' the life o' a pirate, ye gots to get yerself some cloths, Lad. Like an ETI T-shirt, fer example. Ay, that's what all the swashbucklers 're wearin these days. Nice sky blue, so's 'is Majesty's Gunners can't sees yer against the sky. Made of fine polyester so's it'll dry real quick if'n ye gets dunked in the icy North Atlantic. Gets yerself a T-shirt, Billy in small, medium or large Send.$5.50 each plus PST in Ontario. to:

ETI T-shirts
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(Yes Captain Highliner)

# LED Level Meter

PROJECT

**The LED level meter described here, is ideal for any application requiring a wide dynamic range level display. Naturally, two are required for stereo applications.**

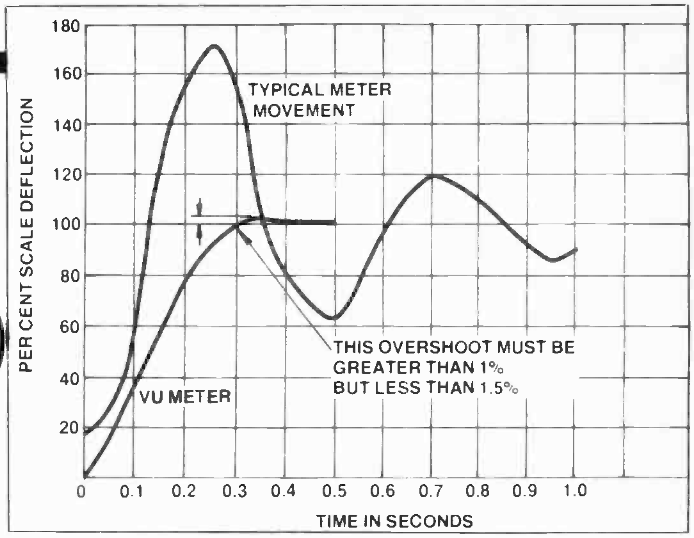
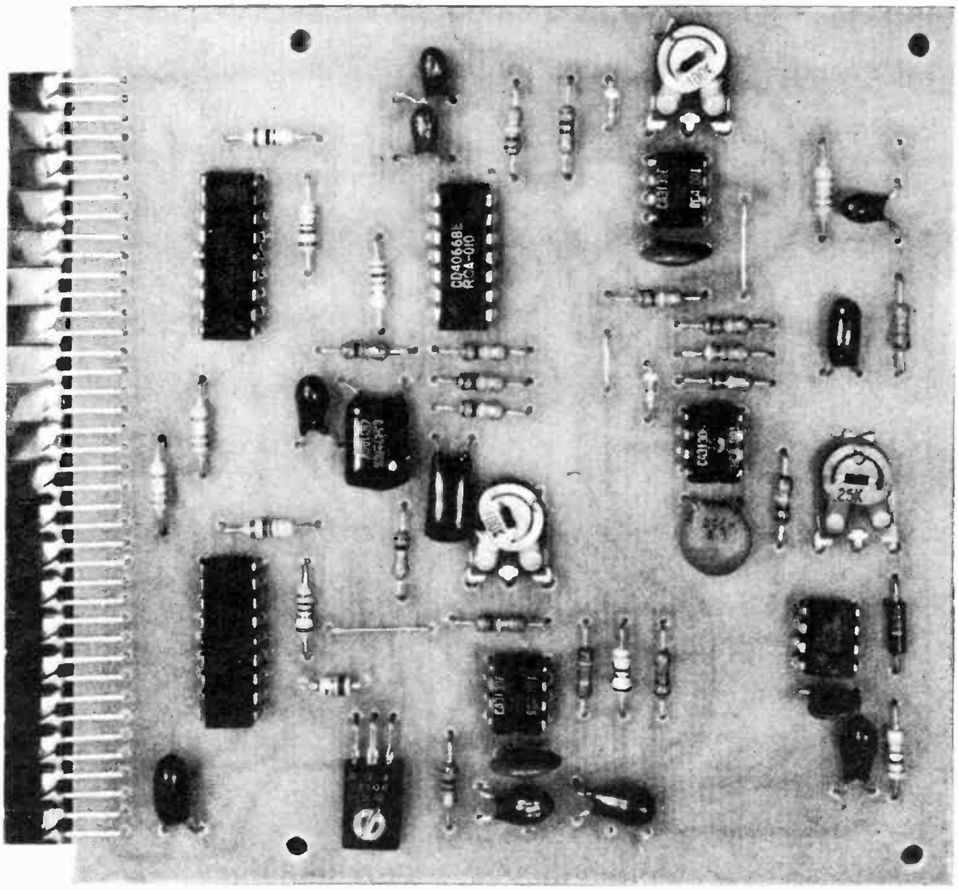



**Fig. 1 'Ballistics' of a VU meter compared to conventional moving-coil meter.**

THE ETI LED LEVEL meter overcomes a number of the drawbacks inherent in mechanical VU meters by replacing the meter movement with a row of light emitting diodes driven by a pair of dB LED display drivers. Twenty LEDs are used, with 3 dB between each LED, so the total dynamic range displayed is 60 dB. The circuit monitors both the true peak and the average signal level and displays both simultaneously. The difference between the peak and the average voltages of a sinewave is around 3 dB, so with a sinewave applied consecutive LEDs will light. With music applied however, the difference between the two LEDs will be substantially greater, depending on the transient nature of the signal applied.

Fig. 2 shows a complete circuit diagram for the LED level display. The input is fed first to a prescaling amplifier formed by an LM301 op-amp, IC1, and the associated passive components. This stage has adjustable gain, set by the preset RV1 that allows the 0 dB point to be set to the desired reference voltage. This will be covered in greater depth later, in the setting up procedure. The output of the prescaling stage is connected to the input of a full wave rectifier formed by IC2 and its associated components. The output of the full wave rectifier is fed to an averaging filter formed by R9 and C6, and to a peak follower formed by IC3 and associated components. The peak follower has a rapid attack/slow decay characteristic so that it responds quickly to any transients but decays slowly so the transient can be seen easily on the display. The outputs from the peak follower and the averaging filter are connected to the inputs of two CMOS analogue switches.

The outputs of these switches are connected together and go to the input of the LED display. Two more CMOS switches are used to form a square wave oscillator. This oscillator has out of phase outputs used to drive the signal-carrying analogue switches alternately off and on at a relatively high frequency. When the switch connected to the output of the averaging filter is on, the average signal voltage is connected to the input of the LED display. This switch is subsequently turned off by the oscillator and the other analogue switch turned on, connecting the output of the peak follower to the LED display. So, only one of the two LEDs is on at any ins-




**Full-size reproduction of the completed project. Note the components are laid flat to permit close stacking of two boards for a stereo display.**

tant, but the rapid switching speed between them and the persistence of vision make them both appear to be on.

Input signals to the LED display portion of the circuit are fed simultaneously to the LM3915 driving the upper 30 dB display and via a voltage amplifier to the lower 30 dB display.

The resistors R26 and R27 set the reference voltage of IC7 at 3.1 V and 30 dB below this voltage is

$$\frac{-30}{20} = \log\frac{x}{3.1}\text{, or } 98\text{ mV.}$$

Now, the top LED driven by IC6 must correspond to this voltage, so the required gain around IC5 is 5.34/98 mV or 54.6. The values of the resistors R19 and R18 set this gain at (180 + 33 + 3.9)/3.9 or around 56 which is a good enough approximation, amounting to an error of less than 0.5 dB.

Internally, the LM3915 consists of a string of comparators; each one compares the input signal to a reference voltage it derives from a ten-way potential divider (see Fig. 3). The accuracy of the LM3915 is determined by these internal resistors and is therefore very good. To ensure the display is accurate over the entire 60 dB range it is only necessary to ensure that the changeover from one LM3915 to the other is accurate. Resistors R18, R19, R22, R24, R26, and R27 have been

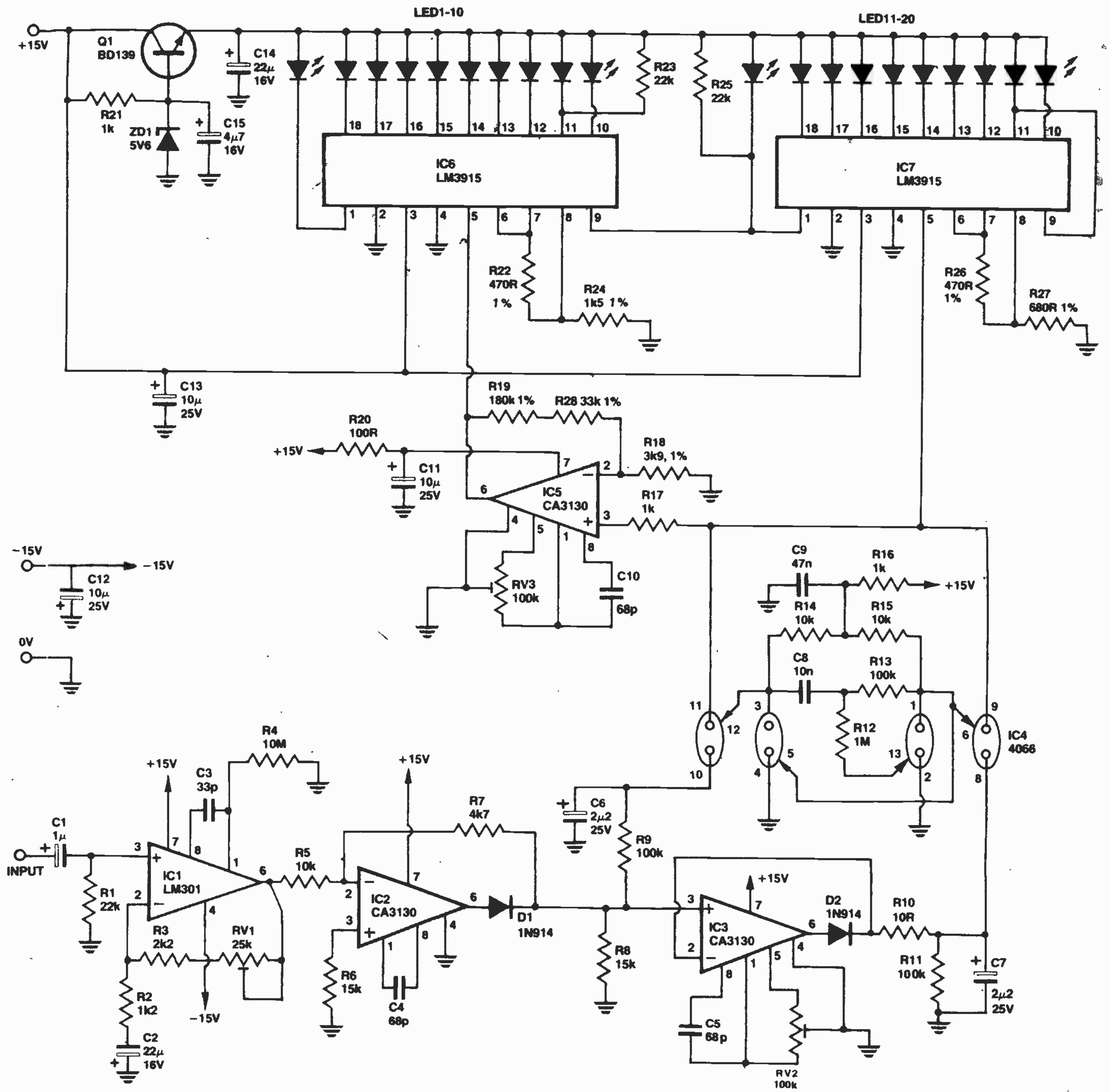



Fig. 2 Circuit diagram of the LED Level meter.

specified as 1% tolerance types for this reason.

Transistor Q1 forms a simple voltage regulator delivering 5V to the LEDs. This decreases the power dissipation in the LM3915s. The current consumption from the positive rail is around 100 mA while the negative rail needs only several milliamps. If the display is to be used from an existing power supply in a preamplifier for example, care should be taken to ensure that the relatively high positive rail current does not upset the preamplifier performance.

## Construction

Start construction by mounting the LEDs. This is by far the most difficult part of the project. The LEDs must be inserted evenly and with equal heights, and this is not easy. Furthermore, the LEDs must be inserted the right way around. The longer of the leads represents the anode of the LED. Check the orientation of each LED against the overlay, before soldering.

Now all the other components can be mounted. The order of mounting is not really important although it is good general practice to solder the passive components first (resistors and capacitors). And then solder the ICs and transistors. The presets are mounted against the circuit board and this is best done by bending their leads at right angles first, and then soldering. Similarly, many of the larger capacitors may have to be folded against the board. Be careful with the orientation of all polarised components, such as transistor Q1 and the electrolytic and tantalum capacitors. Tantalum capacitators are very intolerant of reverse biasing.

## Setting Up Proceedure

Once all the components have been mounted on the pc board and checked, the unit can be switched on. Ensure that the power supply you are using has sufficient current capability for the positive rail and that it is correctly connected to the supply points on the circit board. If the input is touched with a finger two LEDs should light and move up the display. If all is well the dc offsets can now be adjusted. The preset RV2 adjusts the dc offset of the peak follower. This will be adjusted to equal the dc level of the average filter, i.e. that from the output of the full wave rectifier. The overall dc offset can be nulled by

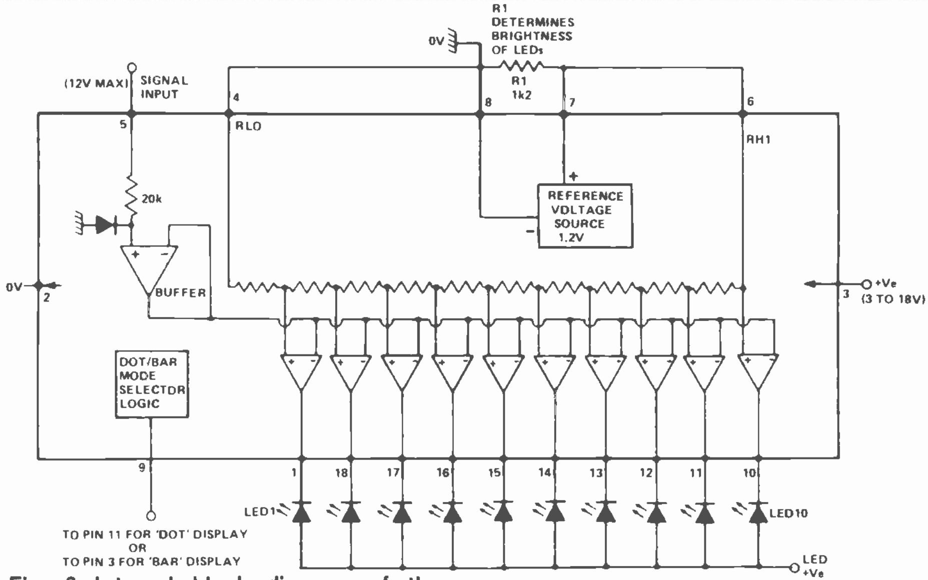
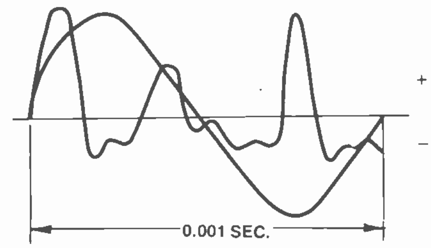



**Fig. 3 Internal block diagram of the LM3915.**

PEAK FACTOR 10-15 dB GREATER THAN SINE WAVE




**A typical 'music' signal may have a completely different peak-to-average ratio compared to a sinewave, and the peaks are often not symmetrical in amplitude about the zero axis. The duration of peaks may be as short as 50 microseconds.**

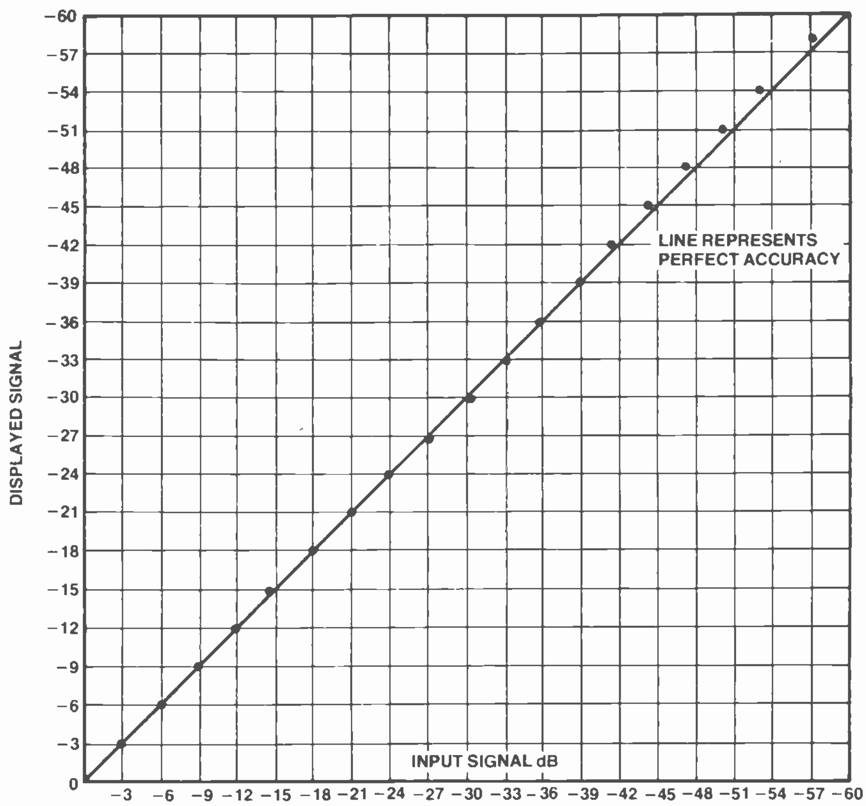
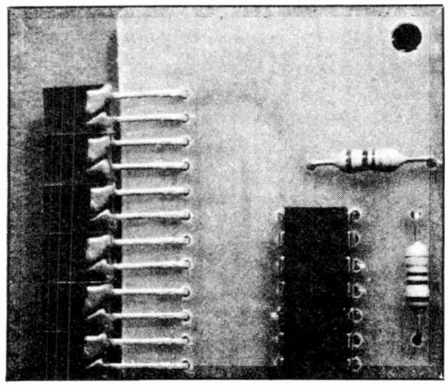



**Fig. 4 Accuracy of the ETI LED level meter display (dots) compared to 'perfect accuracy' (line).**

RV3.

First connect the input of the LED level meter to ground on the board. This ensures that no signal voltage will be present when the adjustments are made. Now turn both RV2 and RV3 fully clockwise; both LEDs should run off the bottom of the display. Turn RV3 slowly counterclockwise until the second LED from the bottom has just turned on. If RV2 is now turned counterclockwise also, a second LED will light on the display. This is the peak level LED. Adjust RV2 to superimpose this LED onto the second bottom LED. Now adjust RV3, turning it clockwise again until the LED has just run off the bottom of the display.

The final stage in the setting up procedure is to align the meter for the appropriate 0 dB level. Preset RV1 varies the gain of the prescaling amplifier stage formed by IC1. Adjustment of this preset will vary the input voltage required to light the top LED between 260 mV and 2.5 V. If your application requries 0 dB to be a higher voltage than 2.2 V, use a potential divider at the input to decrease the input signal voltage. If more gain is required increasing the value of the preset from 25k to 100k will decrease the necessary input voltage to around 70 mV, which should be sufficient for most applications.



**Close-up of the pc board showing orientation of the LEDs. IC7 at lower right.**

## HOW IT WORKS

The input stage consists of a variable gain amplifier formed by IC1 and its associated components. This is a conventional IC amplifier circuit in which the gain is determined by the values of the components RV1, R3 and R2. Specifically:

$$A_V = \frac{R2 + R3 + RV1}{R2}$$

So the bigger the value set on RV1, the greater the gain. Capacitor C2 has the effect of decreasing this gain for very low frequencies, or dc, decreasing the dc offset on the output.

The second stage is the full wave rectifier or 'absolute value generator'. As mentioned in the text, most fully wave rectifiers requrie more than a single op-amp, so this stage will be of use in any application requiring a full wave rectifier with minimum component count. For negative-going signals the stage functions as an inverting amplifier with a gain of 0.5. This is determined by the values of R5 and R7. when the input signal goes positive the output is driven hard against its negative supply voltage, which in this case is 0 V. So the output stage is turned off, and has a relatively high output impedance. In this state the resistors R5, R7 and R8 form a potential divider and connect the input signal to the output directly. Again, the output voltage is one half of the input voltage. In order for this circuit to work, the output stage in the op-amp must be CMOS so that the output can go completely to 0V and have an output impedance high enough not to short out the signal voltage from the potential divider. This is the reason the CA3130 is used. Furthermore, this is a relatively fast device which ensures that the full wave rectifier will have a frequency response that covers the entire audio spectrum. The one disadvantage of the circuit is that it requires a high load impedance since the output signal for positive-going input signals is obtained from the potential divider and not from the op-amp itself. In this application the load is around 100k (R9) which causes negligible error.

The output of the full wave rectifier is fed simultaneously to an average filter formed by R9 and C6, and to the peak hold circuit formed by IC3 and its associated components. The peak hold circuit is really nothing more than a 'precision diode' that charges a capacitor to the peak voltage. The precision diode is formed by including a conventional signal diode in the feedback loop of a fast op-amp. If an input signal is applied which is less than the forward voltage drop of the diode, the stage is effectively in open loop gain (around 320,000 for the CA3130). The output voltage will rise vety quickly, turning the diode on. Since the output of the diode is connected to the inverting input of the op-amp, the stage functions with unity gain once the diode has been turned on. Capacitor C5 ensures stability of the stage while preset RV2 allows adjustment of dc offsets due to this stage. The output of the peak hold circuit charges capacitor C7 through resistor R10. The combination of R10 and C7 defines the attack rate of the peak detector.

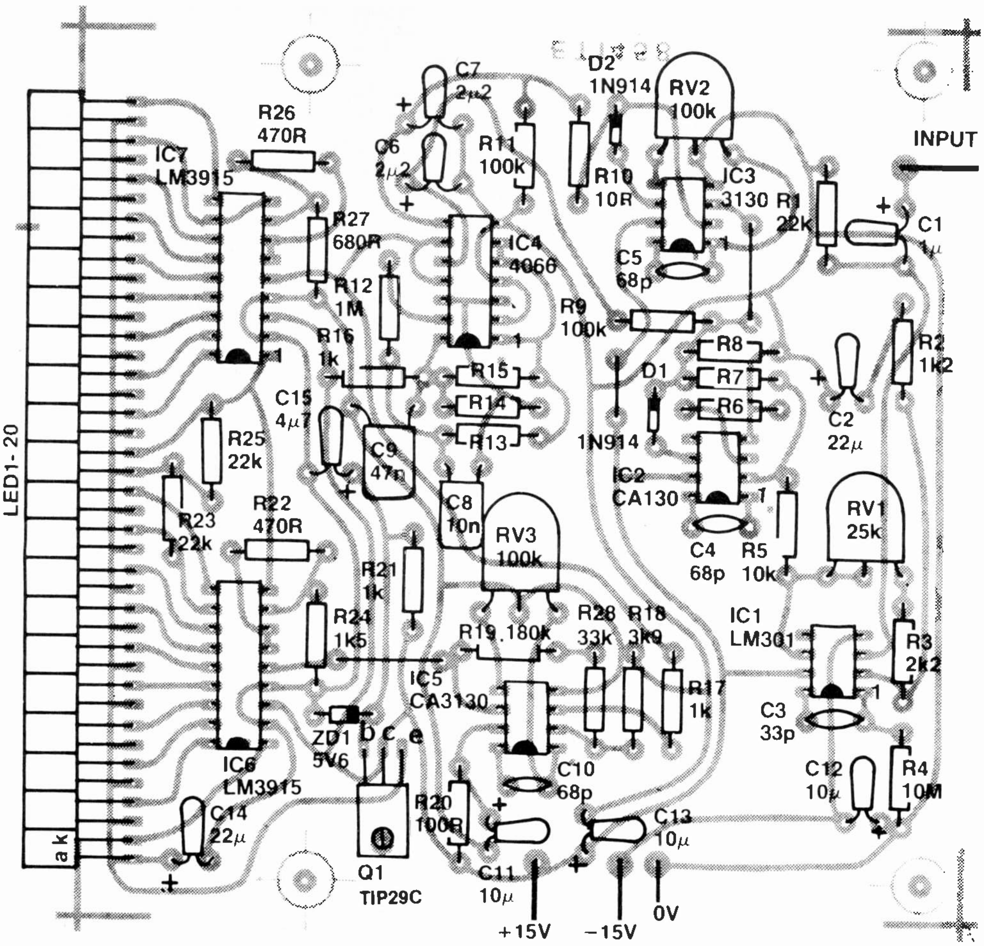
As shown, the value of R10 is 10 ohms and this is small in comparison to the output impedance of the CA3130, but is included in case some applications requrie the peak detector to have a slower attack rate. With the values shown, the LED level meter will display single 50 uS pulses accurately and this is entirely adequate for any audio application.

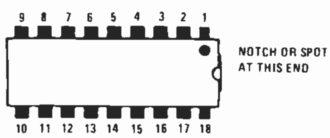
Resistor R11 discharges the capacitor and its value of 100k dictates a decay rate of around one second. This gives the level meter its rapid attack, slow decay characteristic and enables even short transients to be spotted.

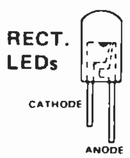
As explained in the text, both the average and the peak levels of the signal are displayed simultaneously. This is accomplished by multiplexing the outputs of the peak and average detectors. This is done by switching between the output of these two circuits at a relatively high frequency (say a few hundred Hertz). In the circuit, this is done with CMOS transmission gates. The 4066 was chosen mainly because its on resistance is a little lower than the older 4016 and this enables the remaining two gates in the package to be used as the driving oscillator. The oscillator is formed by resistors R12 to R15 and capacitor C8, with the associated two transmission gates. The frequency of the oscillator is determined by the values of R13 and C8 at around 150 Hz.

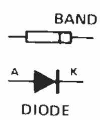
IC5 functions as an amplifier stage as discussed in the text. Once again dc offset adjustment is provided, this time by RV3. Capacitor C10 provides the necessary compensation to ensure stability. Details of the two LED drivers and the amplifier formed by IC5 are in the main text.

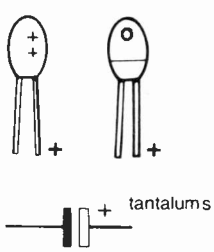
The transistor Q1 and the associated components R21, C15 and ZD1 form a simple 5V regulator to power the LM3915s. Capacitor C16 is essential for stability of the LED drivers and must be mounted close to the LEDs.




## PARTS LIST

**Resistors (all ½ W, 5% unless marked otherwise**

| | |
|---|---|
| R1,23,25 | 22k |
| R2 | 1k2 |
| R3 | 2k2 |
| R4 | 10M |
| R5,14,15 | 10k |
| R6,8 | 15k |
| R7 | 4k7 |
| R9,11,13 | 100k |
| R10 | 10R |
| R12 | 1M |
| R16,17,21 | 1k |
| R18 | 3k9 1% |
| R19 | 180k 1% |
| R20 | 100R |
| R22,26 | 470R 1% |
| R24 | 1k5 1% |
| R27 | 680R 1% |
| R28 | 33k 1% |
| RV1 | 25k min trimpot |
| RV2, RV3 | 100k min trimpot |

**Capacitors**

| | |
|---|---|
| C1 | 1u/6V tant. |
| C2,14 | 22u/16V tant. |
| C3 | 33p ceramic |
| C4,5,10 | 68p ceramic |
| C6,7 | 2u2/25V tant. |
| C8 | 10n greencap |
| C9 | 47n greencap |
| C11,12,13 | 10u/25 V tant. |
| C15 | 4u7/16V tant. |

**Semiconductors**

| | |
|---|---|
| IC1 | LM301, 8-pin DIL |
| IC2,3,5 | CA3130, 8-pin DIL |
| IC4 | 4066 |
| IC6,IC7 | LM3915 |
| D1,D2 | 1N914 or sim |
| ZD1 | 5V6 zener diode |
| Q1 | TIP29C |
| LED1-20 | Siemens LD80-2 or sim. |

**Miscellaneous**

pc board (double-sided); one bolt and nut.

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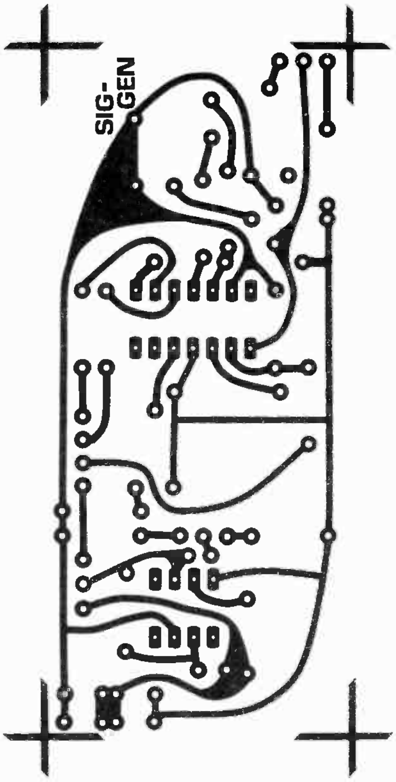
*Circle No.9 on Reader Service Card.*




The foil pattern of the Audio Signal Generator

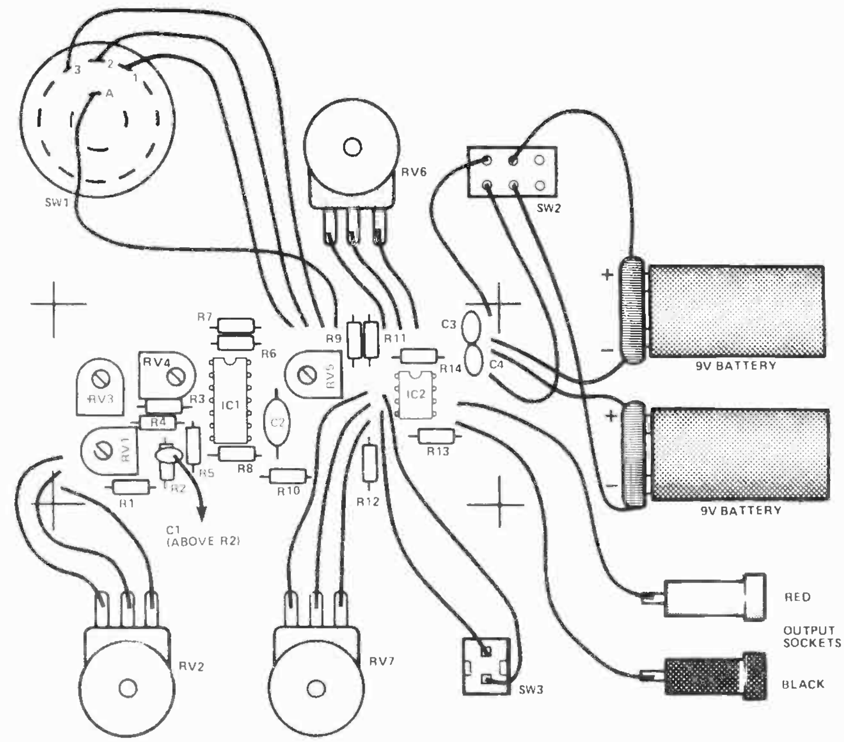



Fig. 2 Overlay of the PCB and connection details of the Audio Signal Generator.

## 6809 REVIEW

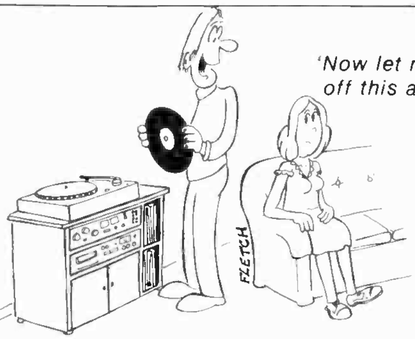
*Continued from page 42*

gramming the 6809, and, if you are planning to design dedicated processor systems using this chip, this computer will serve nicely as both a trainer and a development system. It's a good way to learn machine language programming, and there is no reason why a higher level language could not be implimented on this thing, software pending. If you're up for creating some kind of large, dedicated system happenings, like a word processor, this is a convenient way to start. It can also be programmed to do things like make a dumb terminal into a smart terminal, be a process controller, and probably handle communications for larger systems.

All in all, quite agreeable. . . sort of a latter day KIM. Like the Multiflex, the U of T board is supported by Exceltronix's service department, and anyone with questions about it, its software or it's colour scheme (green, you know), can contact them.

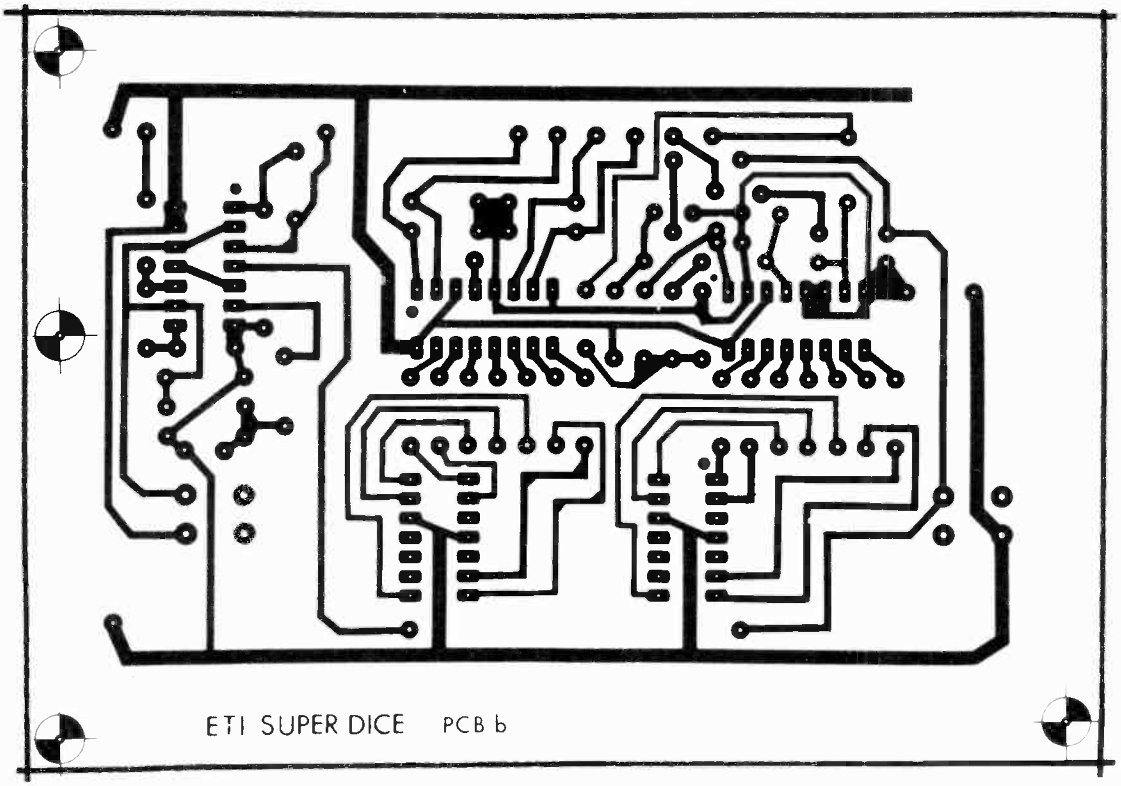
If nothing else, it's a computer the whole family will *not* want to use, and you'll be able to get something done on it.

*(Having spent all this time plugging this fine little computer, we should also give ourselves one; If you decide to get yourself a U of T board, you may also be interested in having* The 6809 Companion, *book number BP102, a useful programming manual for this chip. It's available from the ETI book service for $8.10.)*




*'Now let me play you a few cracks off this albumn'*

*Continued from page 55*




**The Superdice display board.**



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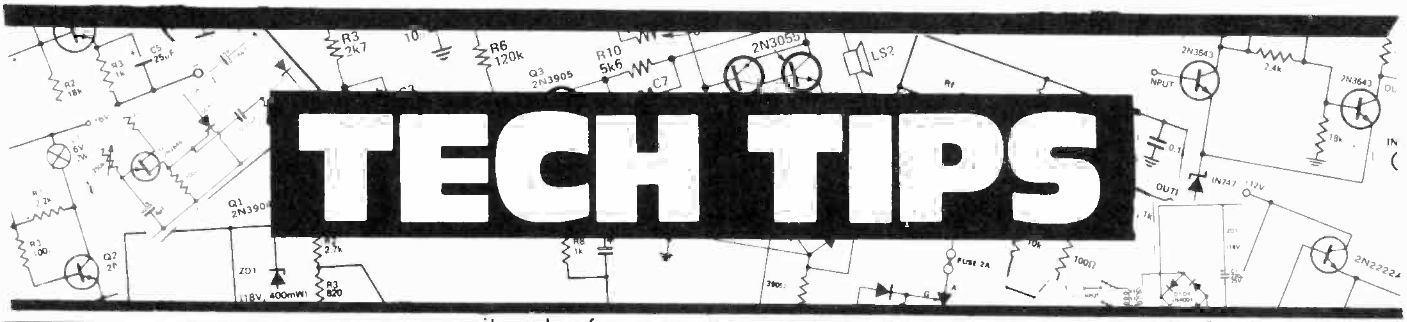
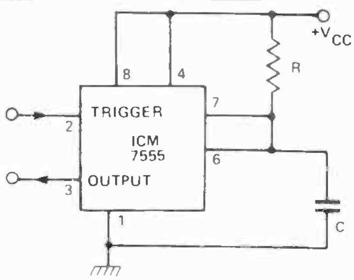
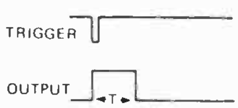



## Capacitance multiplier

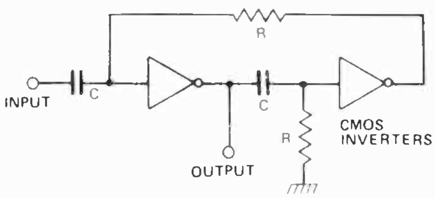
When an audio circuit calls for a large value capacitor — such as in a filter — then this circuit can substitute for those very difficult to get, expensive high-value capacitors. The circuit only synthesises the required impedance, it will not store energy.

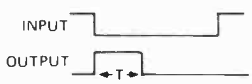
## Monostables




CMOS 555
T = 1.1RC




CMOS inverters
T = 1.38RC
Keep R greater than 47k

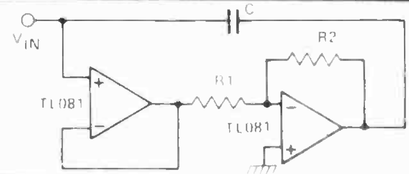
A commonly-used circuit block is the monostable. There are several convenient ways to realise one and these two general circuits show how. Suitable CMOS inverters for the upper circuit would be 74C04, 4009, 4049 and 4069. Inverters can be made by typing the input of NAND gates together, don't forget. 'Rule of thumb' timing equations are given.

The ICM7555 is a CMOS version of the ever-popular 555. In this application the input is pin 2, output is pin 3.

The input, at $V_{IN}$, looks like a capacitor ($C_{IN}$) and you can calculate its value from:

$$C_{IN} = C(R1 + R2)/R1$$

Note that TL071 or NE5534 op-amps could be substituted for the TL081 specified.



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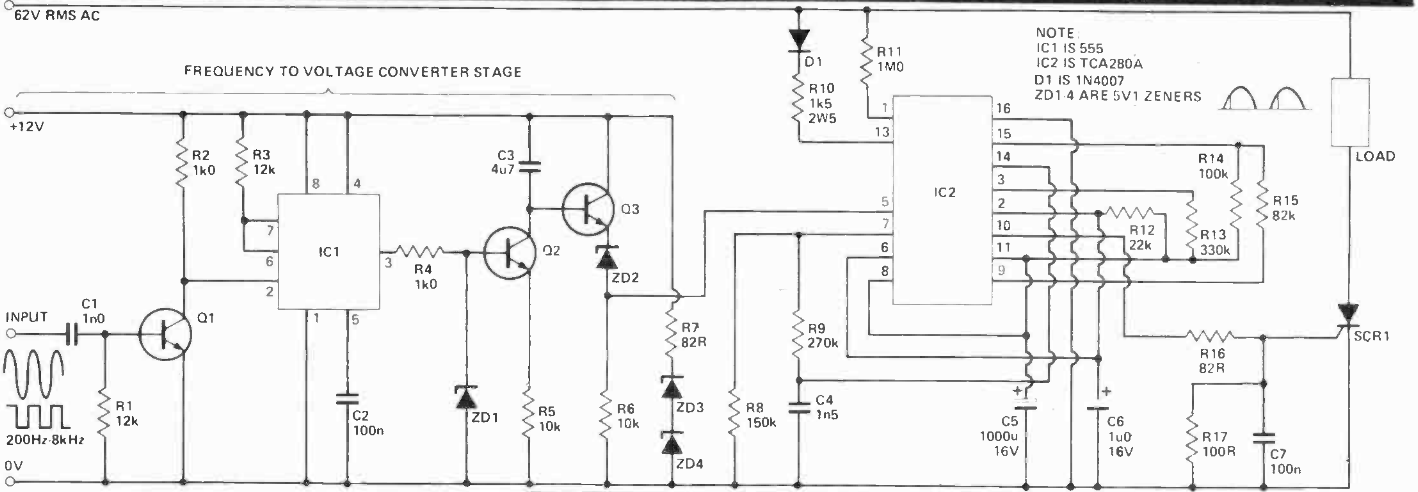


## Frequency-To-Phase Controlled Power Supply

Dilbay Singh (B.Tech)

The circuit shown in the diagram was initially designed to obtain a phase-controlled power supply to use with a ¼ horsepower stepping motor. The phase angle can be varied over the complete cycle period and is dependent on the frequency of the input. Clearly the circuit can be used to control resistive loads such as lamps or motors.

The first stage of the circuit consists of a frequency-to-voltage converter C1, R1, and Q1 effectively differentiate and amplify the input signal waveform to provide triggering pulses for the 555 timer, which is used in the monostable mode. The output of the monostable is used to charge C3 by a constant amount of charge every time a pulse is received at the base of Q2. The voltage across C3 acts as an input to the common collector stage formed by Q3. The voltage across C3 is DC shifted by means of the zener diode ZD2 to a suitable value, providing the input to the trigger IC (the Mullard TCA280A). The TCA280A provides the phase control signal for the gate of the thyristor.

A triac may be used inplace of the thyristor, if phase-controlled AC is required.

The component values shown are suitable for providing phase control using frequencies in the range 200 Hz 8 kHz on the control input. The firing angle can be varied from 0° at 8 kHz to 170° at 200 Hz.

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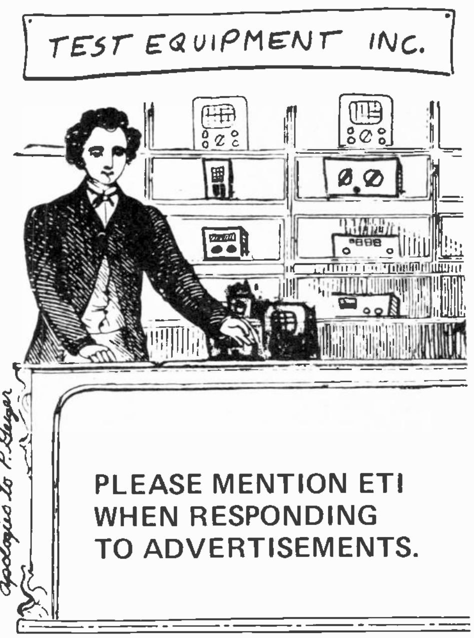
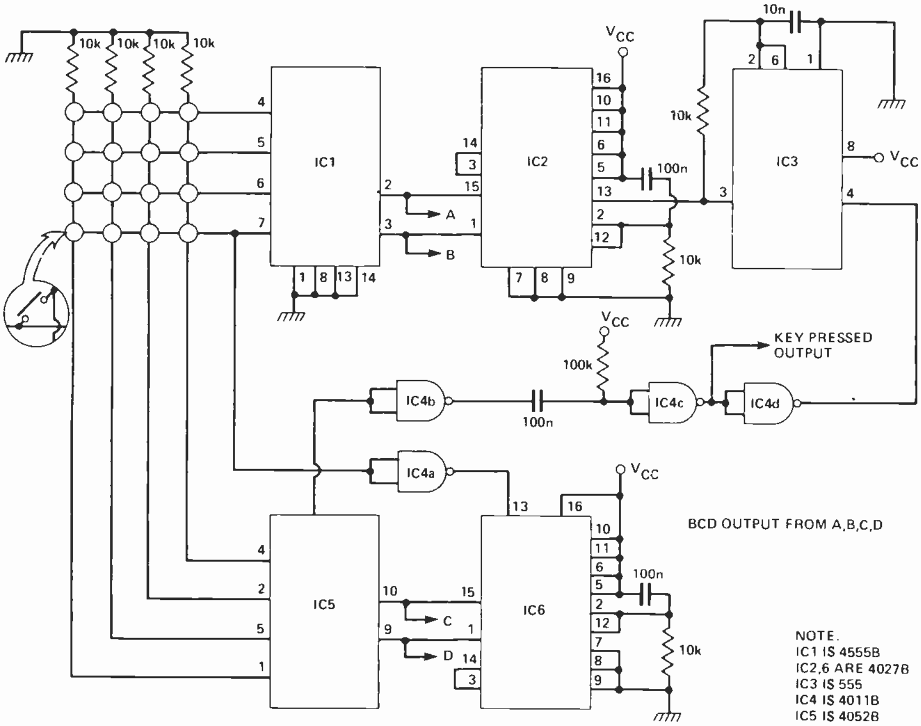


## Fully Debounced Keyboard
Graham Kyte




This circuit produces a debounced output whenever a key is pressed. Each matrix point is scanned in turn and the output of the 4052 data distributor goes high when a pressed key is detected. This stops the scanning oscillator (555) for about 10 mS and a 'key pressed' output is produced, thus enabling the BCD output to be stored in a latch or otherwise made use of. The use of CMOS ICs enables current consumption to be minimised, making the circuit suitable for operation in a car. The circuit is easily modified for a larger number of keys by using an eight-way data distributor (with relevent counter made from three j-K flip-flops rather than the two as used here).

Continued from page 30

Gerald Feinberg (well Feinberg wasn't the first to suggest the idea — that credit belongs to O. Bilaniuk and E. Sudarshan — but it was Feinberg who popularised the idea) that relativity doesn't actually say that nothing can travel faster than light — just that nothing could be accelerated from a speed less than that of light to one greater. Suppose, Feinberg suggested, that there were particles which always travelled faster than light; these particles would never be able to travel slower than light, and would be called tachyons, from a Greek word meaning 'fast' (why scientists of all kinds have such a love of Latin and Greek words is something I have never quite understood).

Tachyons, if they exist, would show some rather remarkable properties. They would, for instance, have 'imaginary' lengths and masses — that is, masses and lengths that were multiples of the square root of -1. This is bad enough, but if they do exist, tachyons are also likely to upset our basic ideas of causality and the direction of time flow. Relativity, and possibly a lot of the rest of physics, would need very thorough revision if tachyons were ever to be found experimentally, and most physicists would probably be very happy if this never happened. Nevertheless, there is research going on at present, trying to find experimental evidence of the existence of tachyons. It is hoped that this might to done by the detection of something called Cherenkov radiation, but that too is another story altogether.

So how can all this possibly help us? Even if tachyons do exist (and until now, there has been no acutal experimental evidence whatsoever that they do), can this help us travel faster than light ourselves? Well, no, but it might just possibly give us the next best thing; FTL communication. Earlier on in this article, we mentioned that the speed-of-light barrier was a problem, not just because it prevented us from travelling at FTL speeds, but because it also prevented our messages from doing so. It might just be possible to indulge in interstellar colonisation even without FTL travel if we had at least got some method of sending messages faster.

## Talking With Tachyons

So how do tachyons give us FTL communication? Think of the way AM radio works; a beam of electromagnetic radiation (or photons, since radio signals, like light, consist of 'particles') is modulated in strength. We transmit messages over the radio by using the message to modulate the strength of the beam. suppose we have a controllable beam of tachyons; by modulating it in the same way as we do radio signals, we could transmit messages at whatever speed the tachyons travelled at. If tachyons do exist (and that's a big if), if we can make and control a beam of tachyons (and that's an even bigger if), and if we have some method of detecting the beam and changes in its strength at the other end (no comment), then we have the problem of FTL communications solved. Should tachyons be found, then, even if the theoretical physicists groan, no doubt many of the space technologists (and, of course, science fiction writers) will rejoice.

It looks, then, as though FTL travel is not likely to be on the list of forthcoming attractions. In fact, there seems to be only the slimmest of chances that FTL communication will be. And the Galactic Empire? I'm afraid that for the moment, at least, it stays in the movie studios.

But we can always hope . . .



Continued from page 40

## Practical Forms

Practical passive radiator systems may take many forms. The most common is one in which the drone is an undriven cone whose compliance and mass are about twice that of the driven unit. They can also be different, and can have different in-box resonances. In fact, the relationships follow the same rules governing Thiele alignments of bass reflex systems. In fact, a passive radiator system is actually a bass reflex system. The differences lie in the physical construction.

Passive radiator systems have been built using different diaphragms. For example, several years ago Octavian introduced a subwoofer in which the outer walls of the cabinet formed a slotted duct. These same walls were compliantly mounted, thus providing controlled radiation from the walls of the system.

The Orchestrad system used resonator panels as part of the cabinet walls to provide a similar effect.

Frequently a passive radiator is built without the builder's knowledge. For example, insufficient bracing of cabinet walls will result in their acting as passive radiators. Similarly, dual woofer systems in which each woofer has a different resonant frequency will often exhibit bizarre response characteristics due to the action of one driver at resonance upon the other.

For those readers wishing to experiment, two suggestions are offered. First, don't throw out a damaged driver. As long as the cone is intact and free to move it might make a swell drone. Or a styrofoam panel mounted in an opening by means of rubber or plastic sheeting can be tuned by adding mass or adjusting its size.

Then your friends can drive *you* nuts by pushing on the cone.

**Fig. 4. Simplified bass reflex equivalent circuit**

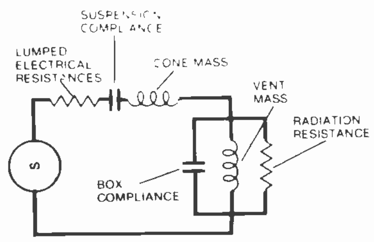
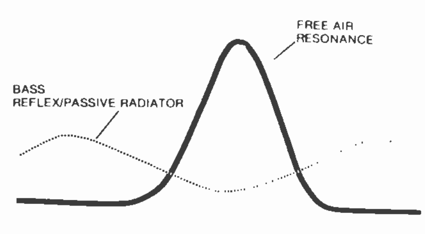



**Fig. 5. Comparison of impedance curves**

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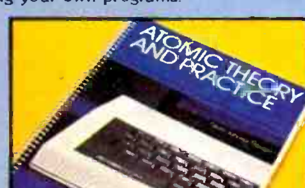


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