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December 1983

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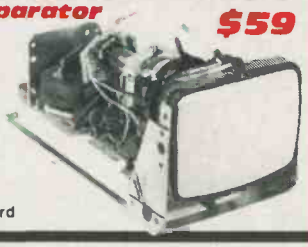

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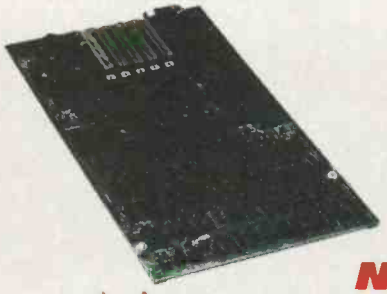

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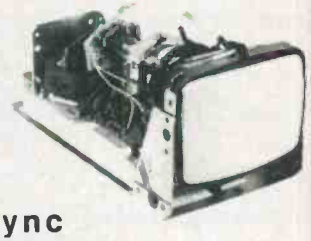

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The Magazine for Electronics & Computing Enthusiasts

Electronics Today INTERNATIONAL

December 1983
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Our Cover

Various batteries and related circuits are covered in this issue; photo by Bill Markwick. The Sord M5 is reviewed on page 39; photo by the Unknown Editorial Assistant.

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Will high-tech eliminate getting envelope glue on your tongue? Roger Allan reports on mail-by-satellite.

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Rubber keys meet dynamite BASIC graphics.

45 Designer's Notebook
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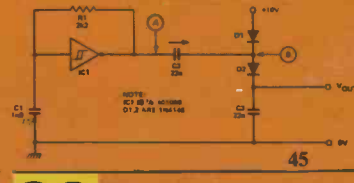

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Projects

20 NiCad Charger/Regenerator
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23 Expanded Scale Voltmeter
Keep an accurate eye on battery packs and power supplies with this 10 to 15 V meter project.

60 Playmate Part 2
In which we finish up constructional details of this instrument amp and (blush) correct an error in the original schematic.

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We can supply photocopies of any article published in ETI Canada; the charge is $2.00 per article, regardless of length. Please specify both issue and article.

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 5.60hms 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.

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B—C—D Electronics, P.O. Box 6326, Stn. F, 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.
Beyer & Martin Electronic Ltd., 2 Jodi Ave., Unit C, Downsview, Ontario M3N 1H1.
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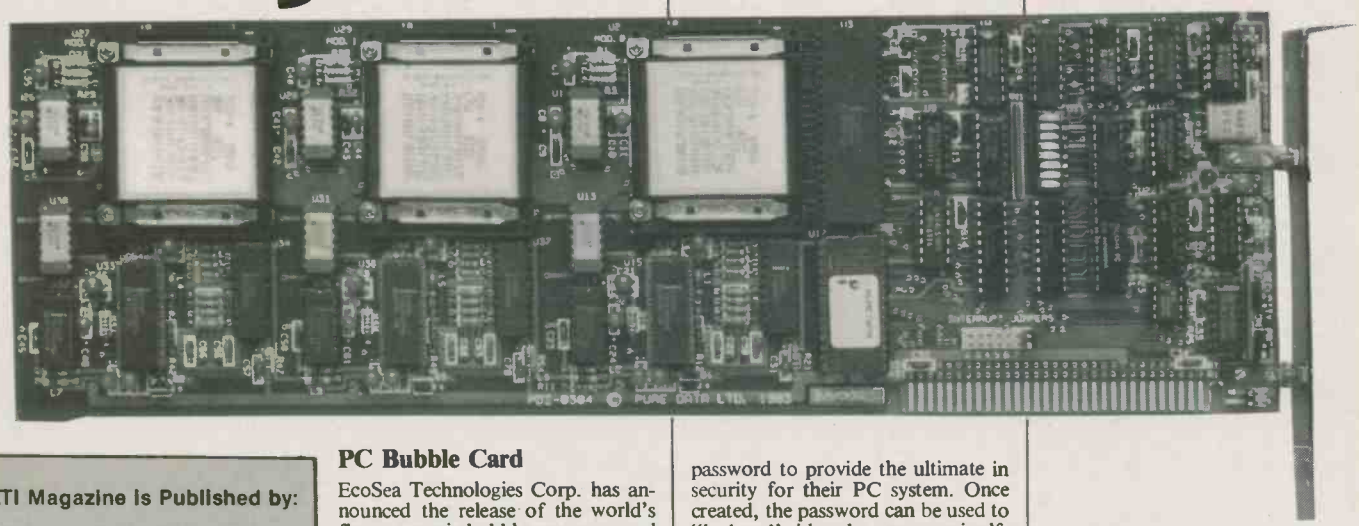

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Editorial Queries
Written queries can only be answered when accompanied by a self-addressed, stamped envelope. These must relate to recent articles and not involve the staff in any research. Mark such letters ETI-Query. We cannot answer telephone queries.

PC Bubble Card

EcoSea Technologies Corp. has announced the release of the world's first magnetic-bubble memory card for the IBM PC and IBM PC-XT.

The Pure Data PDIBI28 and PDIB384 provide either 128K or 384K respectively, of non-volatile memory storage using only one slot of the IBM backplane. Unlike a floppy disk, the cards are entirely solid-state, with no moving parts. This means that the devices are impervious to dust, dirt, fumes or vibration.

Another first is the feature of password protection in hardware. The end users can create their own password to provide the ultimate in security for their PC system. Once created, the password can be used to "lock-up" either the computer itself, the bubble card only, or both devices. This password protection cannot be bypassed by any means, and no method exists to "read" the password.

Used as a virtual disk drive, the bubble card is many times faster than a floppy disk drive, and much more reliable. The bubble card operates as a standard DOS 2.0 disk-type device, is compatible with all DOS software, and does not require any patching of system files. The PDIB128 and the PDIB384 use two I/O lines and no memory space. Both DMA and interrupts are supported, but not required.

Comprehensive diagnostic software and other utilities are provided free of charge with the card, along with a full illustrated installation and operation manual.

EcoSea Technologies Corp., 465 King Street East, Unit 13, Toronto, Ontario M5A 1L6 (416) 366-1000 is Canadian distributor for these and other products manufactured in Canada by Pure Data Ltd.

Commodore Computer is hosting The World of Commodore at the International Centre in Toronto, Canada on December 8-11 to mark its 25th anniversary. This is Canada's first truly international computer show, involving hardware and software exhibitors and seminar speakers from 10 countries including West Germany, the United Kingdom, Japan, Sweden, France, Hong Kong and the U.S.A. It is also the first major consumer exhibition mounted by a single manufacturer in Canada.

Chopper Analyzer

Helicopter maintenance time can be significantly reduced by a British instrument which is capable of analysing rotor performance and offering balance corrections in flight. Eliminating the dangerous, time consuming and often inaccurate conventional methods of assessment, the microprocessor-based Rotortuner uses a low-power short-range radar unit on the body of the helicopter to measure damper performance and blade position. Variations in height and angular displacement are displayed at each selected flight speed. These findings analyse during flight any necessary adjustments to be made to the weights on the blade tips, blade bolts, balance points or blade sweep. As the instrument includes a memory, findings can be combined with known characteristics of the system, with a trend analysis from one servicing to the next and with data from other aircraft in the production series. It can then recommend the maintenance test procedure to be adopted. By additionally providing a logical sequence for these tests to be carried out and also eliminating any need for reference to data tables and charts, it further reduces maintenance time.

The analyzer is marketed by Helitune Ltd., 16a Reading Rd. South Fleet, Hampshire, England GU13 9QL Telephone: Fleet (02514) 4798 Contact: David Bloxham, Commercial Director Enquiries from potential customers/agents are welcomed by the company.

for your information

Tingle Filter

Electricians and contractors in rural areas should recognize the profit potential of this newly developed Tingle Voltage Filter for applications on farms where stray or tingle voltage related animal productivity declines are a problem. Tingle voltage or stray voltage is a phenomenon resulting from small electric potential, usually 2 to 3 volts, being present between grounded metal farm equipment (such as watering troughs, feeders, metal penwork etc.) This potential causes many behavior problems in farm animals who come in contact with the equipment.

Most farms will have some degree of tingle related problems, which can result in many problems to the farmer; milk productivity losses, breeding problems, mastitis, pig scours, and general stress reactions are common.

Until now, the only solutions were expensive or even dangerus: separation of the primary neutral line from the barn neutral greatly increases danger from lightning and can create safety problems; isolation transformers are a good solution but are very costly; equi-potential grid systems are only viable in new barn construction.

The Tingle Voltage Filter is about $300, and is easily installed at the main pole or at the main barn panel. It will reduce tingle voltage to below 0.2V in most areas. This is well below the threshold of dairy cattle and other farm animals.

Contact: Hammond Manufacturing Company Limited, 394 Edinburgh Road North, Guelph, Ontario, Canada N1H 1E5.
Telephone: (519) 822-2960 or (416) 456-3770.

New PCB DIN's

Preh, a leading manufacturer of DIN connectors for computer and telecommunications applications, has introduced a new line of receptacles that permits peripheral grounding of the inserted connector shell.

The aspect of a reliable ground connection between the DIN receptacle and cord plug is important due to R.F.I. problems in computer applications. The grounding also eliminates the problems associated with static electricity.

Preh, is now represented in Canada by Atlas Electronics Limited, 50 Wingold Avenue, Toronto, Ontario, with branch offices in Montreal, Ottawa, Winnipeg, Calgary, and Vancouver.

For further information or to contact: Bruce Petty, at (416) 789-7761.

American Telephone & Telegraph Co. is planning to introduce a microcomputer system within the next six months, according to a new 237-page research report from International Resource Development Inc. The report predicts that the microcomputer will use 32-bit architecture based on Western Electric's Bellmac microprocessor, and that the software will be based upon Bell Laboratories' Unix operating system. The combination of the longer word length (32 bits, as compared with 16 bits on the IBM Personal Computer) and the powerful Unix-based software, will enable the new AT&T microcomputer to "upstage" the IBM PC, according to the report.

AT&T will have difficulty catching up with IBM's lead because of the accelerating production of PCs. "We are aware of specific IBM component and sub-system contracts which point to definite production plans for two million PCs in 1984," says the report, which states that AT&T will be "lucky if Western can manage to make 30,000 of the AT&T micros in 1984."

Bell Laboratories has received its 20,000th patent. World famous as the research and development arm of AT&T, Bell Labs has averaged nearly a patent a day since its founding in 1925, with innovations including long-distance TV transmission in the 1920's, microwave radio transmission in the 30's, the transistor in the 40's, semiconductor electronics in the 50's, communications satellites in the 60's, digital switching in the 70's, and lightwave transmission in the 80's.

The 20,000th patent — another lightwave innovation — is for a new technique, using a gas to etch extremely smooth surfaces on semiconductor compounds which offer advantages over silicon for many devices. The ultra-smooth surfaces are of particular interest for use in tiny lightwave circuits comparable to today's electronic integrated circuits.

The Bank of Montreal has committed to become the first multinational corporation to use Teleglobe Canada's new international private satellite business services. Using a small 4.5 m earth station antenna mounted atop the 72-story First Canadian Place building in Toronto, Teleglobe Canada will provide the Bank with a highly reliable and cost-effective integrated digital communications network, initially between the Bank's offices in First Canadian Place and Bucklersbury House, London, England. The service is scheduled to begin in January.

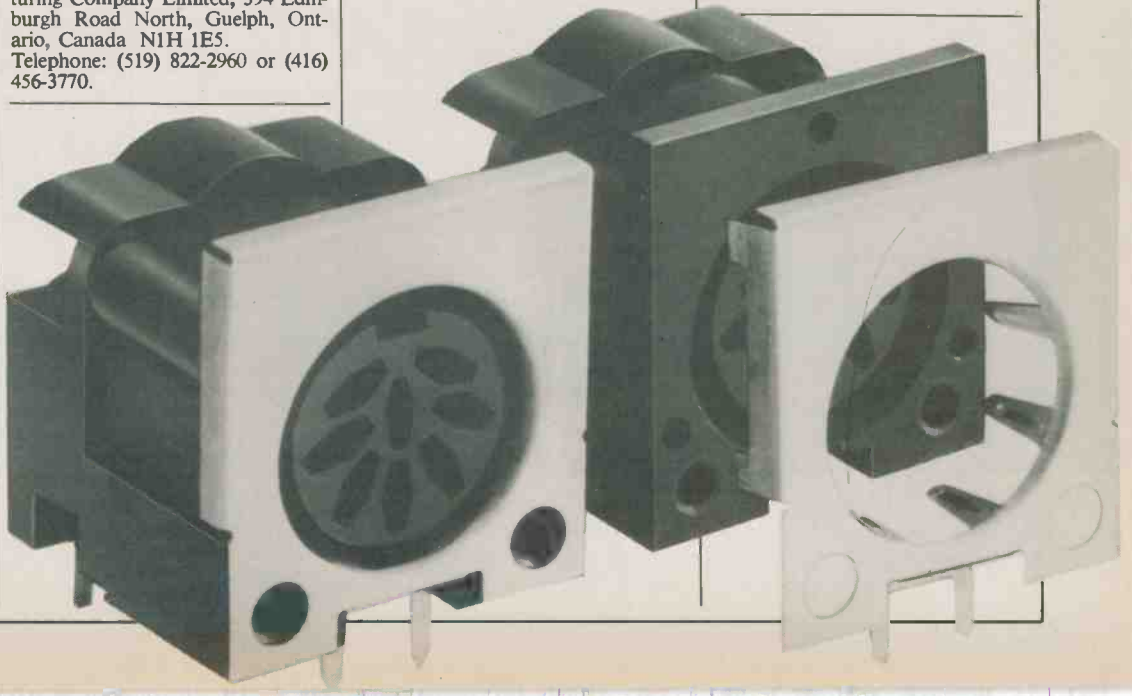
New Trim Pots

Preh has just released its new Trimming Potentiometer for P.C. board mounting and automatic insertion. Measuring 8.6 mm, it is available in bakelite or Cermet and is completely washable. The wiper assembly is shroud protected and the actuator has an inside taper to accommodate automatic adjustment tools. A choice of hex or cross slot actuators is available, allowing adjustment from either the top or bottom.

For further information, please contact Atlas Electronics, 50 Wingold Ave., Toronto, Ont. M6B 1P7 (416) 789-7761.

The world's first regular broadcast service of computer programs — Telesoftware — is to be started in Britain by the BBC this year (1983). Test transmissions have already been broadcast.

Most of the early programs will be educational ones, intended mainly for use in schools and colleges. Indeed, one of the major suppliers will be the British Government's $20 million Microelectronics Education Programme, which was set up to train teachers and provide software. Later a full range of programs will be transmitted, for home and business applications, and there will also be video games.



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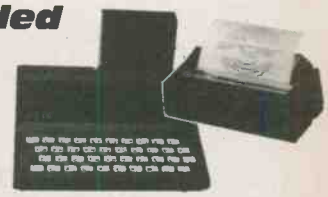

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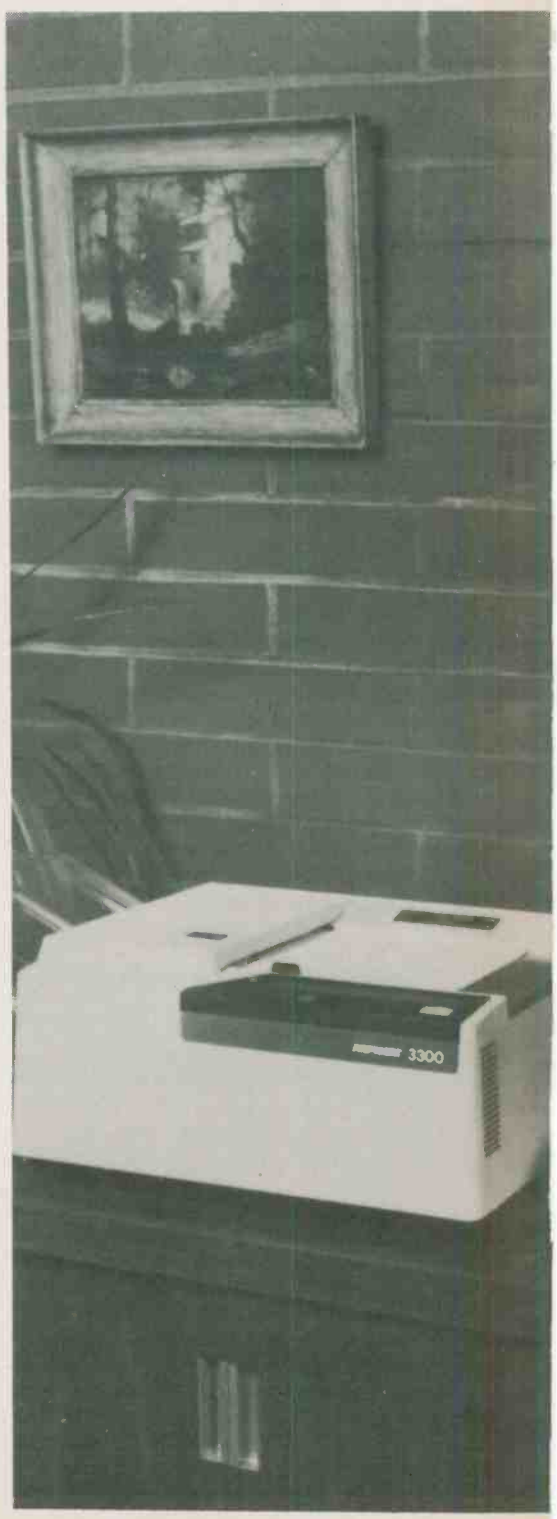
Electronic Mail

Is the postman hanging up his bicycle clips for the last time? We'll let you decide.

By Roger Allan



THE DEVELOPMENT OF new technologies for high-speed transmission is a logical extension of the growth of data processing evident over the last 20 or 25 years. Without the necessary data transmission links, economies associated with large scale processing of data would generally not be available to relatively small branch offices of large corporations and governments. The linking of even quite large regional branches to centralized data banks or the access by small outposts to powerful programming is made more attractive by the development of improved transmission quality and volume capability by common carrier networks.

It would be expected that expansion of computer based electronic mail would closely follow, upon the establishment of easy to use decentralized processing and access systems. Mail and message functions should almost be a by-product of the new technologies. While the initial impetus is to link dispersed branches of large corporations, once the necessary transmission facilities, networking and software are in place for these purposes, then the means for links between more disparate organizations would also be *in situ*.

It has been depicted that the development of electronic mail should chronologically fall into three main evolutionary stages:

- characterized by the communication, primarily inter-company, of like machines: fax-to-fax, communicating-typewriter-to-communicating-typewriter, Telex-to-Telex, *et al;*
- characterized by the capability of totally different kinds of equipment to "talk" to each other;
- characterized by satellite and fibre optic links (see "Fibre Optics", ETI, June 1982) established reducing line costs.

Interfaced equipment for a variety of communications and processing functions will have proliferated. This final stage would also be marked by serious competition for control and direction of electronic mail, and for control interfaces between equipment to see that the entire system is used efficiently and economically as possible, usually to the financial benefit of the government of the day.

However, the provision of software for linking the many types of presently incompatible electronic office equipment both within and between businesses may prove to be a considerable obstacle to the adoption of integrated electronic mail systems. An internationally accepted protocol for communicating word processors, called Teletex, has been devised. Meanwhile, attempts are being made to develop the first formal representation encompassing all types of electronics message systems (EMS). Besides the problem of a common language, the development costs required to integrate individual office systems already established into a general electronic mail network will tend to constrain the rate of development of a general system.

Another problem for users of electronic communications systems is the perceived lack of security of information transfer. To a large extent, this can be overcome by encryption of messages, although probably no encryption technique is impossible to break and it could make the encryption of messages too expensive. Until potential users come to accept this aspect of electronic mail, physical delivery will continue to have an important advantage in this respect.

As such, the development of electronic mail will be related to the extent to which the current mail system meets user requirements. Complaints made by postal

The major impact of electronic mail will be on business communications. The facsimile unit shown is a Canadian unit from Rapicom, Ottawa.

users in Canada, the U.S. and Australia indicate a significant level of dissatisfaction, particularly among business users, with the adequacy of services, specifically by the criteria of timeliness of delivery.

Knocking the Postie

Prima facie evidence of dissatisfaction with the speed and/or reliability of the postal system for some business needs is the growth of courier services. Although courier services have been in existence since the early 1930s, growth in the industry has been especially strong over the last decade. Similarly, the growth of document exchange centres providing reliable and speedy services for specialized business needs is a further example of document transmission outside the national postal systems. The "pressure" created by commercial users for reliable alternatives to the postal system is probably directly related to the existing standard of service. One writer has indicated that both British and West German authorities are less optimistic about the success of an electronic mail system than commerical systems producers because of the high standard of the present system. The Postfax system in Britain, for instance, is not thought to be widely used because next day delivery is virtually assured for domestic users.

There is, however, little doubt that the major initial impact of electronic mail systems will be on intra- and inter-business communications. Significant inroads can be expected in government related mail and in mail received by households from business and government under future electronic mail systems. The initial diversion of mail away from the postal system is likely to be in areas which provide, at present, a significant proportion of the cross-subsidy for serv ices to remote areas and registered publications. This will probably place a higher burden on those users not able to divert mail electronically, specifically the householder.

Further, in the long-term, courier services are likely to face significant competition from electronic systems. In a widely quoted dramatic exmaple, 90% of one major U.S. courier service's income in 1969 was from cancelled cheque deliveries. After the introduction of the Federal Reserve electronic funds transfer system, this proportion had dropped to 42% by 1975. While this example does not specifically involve electronic mail, similar such occurrences are expected. Courier services may benefit in the short term, however, from some services, such as facsimile, where one "leg" of transmission may require rapid physical delivery from a receiving terminal or to a sending terminal.

From the point of view of the national postal services, a critical aspect is the extent to which developments in electronic mail techniques and facilities will generate additional communications as opposed to diverting communications from the customary mail system. It is felt that in the early stages such techniques can be expected to increase the number of communications, but that in the long run there will be a substantial and permanent diversion of communications away from the traditional or customary methods.

Basic Types

There are essentially two generic types of electronic mail systems: facsimile and "pure" electronic.

The facsimile process is an outgrowth of British Telecom's "Bureaufax" system inaugurated in 1980 which provided high-speed facsimile transmission to and from a large number of overseas countries (59 in 1982). It was primarily designed for business users. In the same year, it very rapidly resulted in the establishment of INTELPOST, involving the satellite transmission of facsimile documents (via Canada INTELSAT) between London and Toronto for both business and non-business users. This system has now been expanded to provide high-speed electronic mail links between 100 towns and cities in Britain, some dozen cities in Canada (with more coming on stream each month, and some cities having a number of pick up and devivery stations) and relatively similar numbers of stations in the Netherlands, the United States, Australia, Germany, Argentina and Switzerland. More countries are expected to join shortly.

As explained by John Hovey, Service Manager at Rapicom's Ottawa office, the manufacturer of the equipment used by Canada Post (Rapicom 3300 Desk Top Digital Facsimile Transceiver and the Rapicom 6300 Digital Facsimile Transceiver), the process of transmission is quite straightforward. The Sheet containing the communication is inserted into a device which looks like a photocopier. There it is configured by being scanned by a charge coupled device (CCD), the information is processed, compressed, passed through a modem and transmitted at high frequency in digitized form over ground lines. For transmission within Canada, the connection between stations is strictly by telephone line, though for overseas transmission the INTELSAT satellite system is used. When the communication is received at the other end, it is formatted, printed *a la* photocopier, put in an envelope and consigned to the customary post office dissemination process. The transmission rate is 9600 bits/second.

According to David Weinberg, Manager of Canada Post's Electronic Messaging Service in Ottawa, the cost is $5 for two pages, regardless of where in the world the message is to be sent. Upon

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receipt, the envelope can be sent through the regular mails at no additional cost, or sent special delivery ($1.06 extra in Canada, $5 in Germany, for instance). Further, the recipient can be telephoned upon receipt of the message, and can stop at the post office and pick it up. Theoretically, a message can be sent from Toronto to, say, Calgary and picked up at that end a mere few minutes after its receipt. It is supposed to be very good for typewritten matter and drawings, though it does not have the capability of colour.

Way of the Future?

According to Weinberg, "handwritten mail is on the way out," and electronic mail "is the way of the future. Unless Canada Post jumped into electronic mail, we would be left behind." Today, INTELPOST has not been pushed by Canada Post, but there is a large publicity campaign planned for the fall and spring of 83/84. Details as to the volume generated over the past three years was not available, though a spokesperson for Canada Post has said, "it's not much."

The two countries which have heavily invested in electronic mail via the national postal system (as opposed to private carriers or the adjuncts to various telephone companies) are Britain and the United States.

In Britain, the system is known as Telecom Gold, in which a laser beam optically reads the printed document and then transmits it to any one of several thousand electronic mail boxes, or vice versa. Further, the system links into international services so that documents can be transmitted to micro-computer users worldwide. Should the recipient not have a microcomputer, the mail is sent from the nearest receiving station by traditional methods for the last leg of its transmission journey.

It is, however, the U.S. Post Office's E-COM system which seems to be the current state of the art in this area.

As explained by E.M. Alexander of the RCA Corporation which provided the equipment for E-COM to the USPO, "INTELPOST is not the bellwether for future electronic mail systems," though E-COM is. The difficulty lies in the quality of the finished product; INTELPOST, being a facsimile reproduction system, isn't really very good, while E-COM uses good quality dot-matrix printers (numbering from 3 to 9, depending on the receiving station of which there are currently 25) on good quality bond paper and provides a quality which is superior and far more business-like than INTELPOST's finished product. Further, facsimile transmission requires the company to either possess a piece of special equipment into which the document can be fed, or to physically take it to the nearest USPO which would have such a device (similarly in Canada). With E-COM, on only needs a modem, and a member of staff who has received a few hours training and a practice session.

RCA first became interested in the subject and commenced research on how to do it some seven years before the USPO awarded them a $38.1 million dollar contract to provide the hardware, a training station and set-up help. The system developed is dependent on land lines using common carriers, due to FCC regulations. It is TTY synchronous, operating at 300 or 1200 baud rates, with 2400 baud (and up) rates available with additional equipment. When received by any one of the 25 offices currently available in the U.S., the computer, on-line twenty-four hours a day, automatically tapes the message at the front end by a dumb processor. The message is then automatically transmitted to the nearest available station to the recipient, where it is re-processed, electronically sorted, the message typed out (on 80-character lines at 600 lines per minute), automatically sorted, placed in the envelope which is typed, and sent either through the regular mail system or by special delivery. The *modus operandi* of the computer transmission follows the ASCII guidelines, specifically an eight bit, alphanumeric system providing upper and lower case. As such, a message, in a distinct envelope, can be received anywhere in the contiguous United States within two days.

The E-COM system will accept messages in three different formats:

- Single Address Messages (SAM) which are those in which a unique text accompanies each address;
- Common Text Messages (COT) which are those in which a common text is accompanied by a list of addresses (eg. for bulk mailings);
- Text Insertion Message (TIM) which are those in which a common text is accompanied by both a list of addresses and

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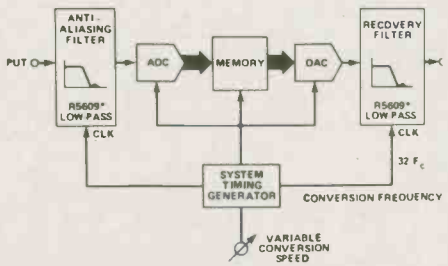
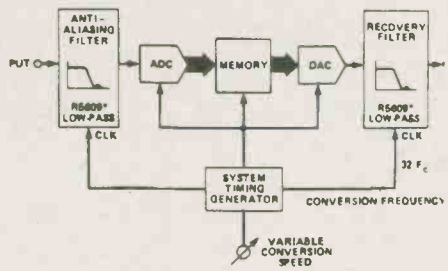
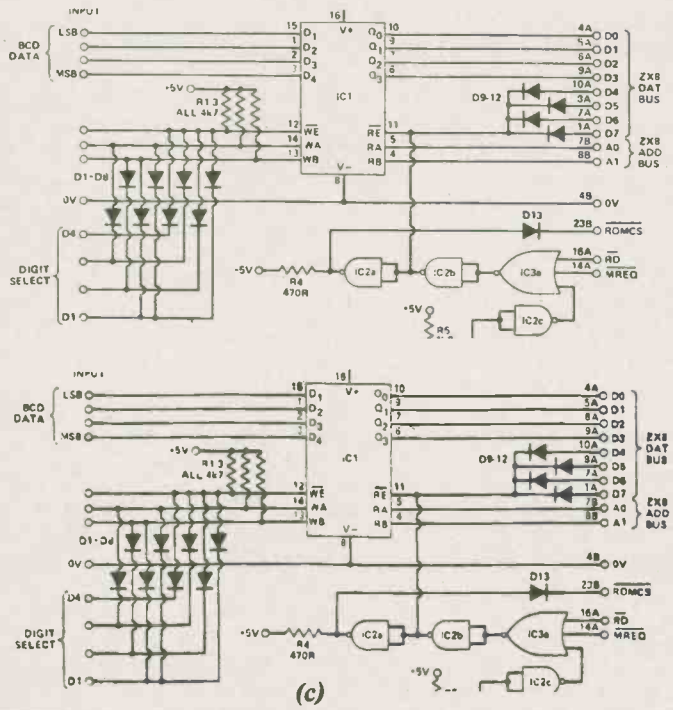
(a)





(b)



(c)

Examples of the reproduction quality of the electronic mail service. A good quality typewriter (a) produced the best copy, along with original line drawings (b). Photocopies (c) were somewhat fuzzy, and original photographs were not usable at all.

a unique text to be inserted in each printed message.

To date, the use of this system is running at about 1 million messages a month.

Small Business Users

At a cost of 31¢ (US) per page, and an additional 9¢ for subsequent pages, the price is comparable with regular mailing services. There are, however, two problems with the system. One is that a sender must send a minimum of 200 items per transmission, though this may be one item to 200 addresses. For small businesses this can be a problem, though there are intermediary companies which stand between the USPO and the user who will collect messages in less than 200 and "batch lot" them for an additional fee. Secondly, very small businesses who have not as yet purchased or leased a microcomputer for the initial composition of the message must likewise use an intermediary organization for an additional fee.

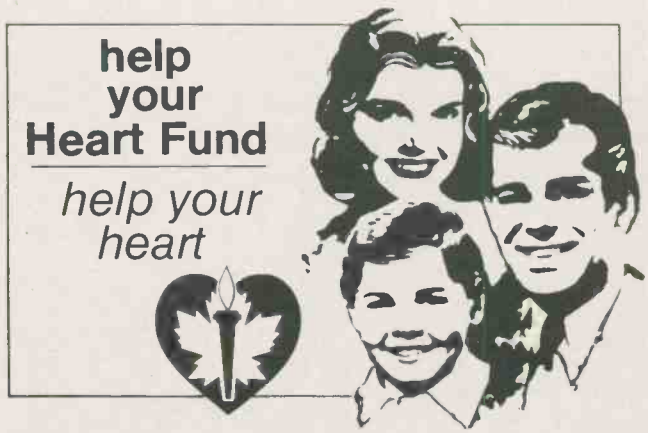
Without a great deal of publicity, and recognizing that there are a few wrinkles in the system to be worked out or adjusted, such as permitting smaller batch lots to bring more small businesses into using it, the provision for a business reply or courtesy card reply, *et al,* the system has nonetheless grown quickly. Further, according to Alexander, the USPO has "not received so much as a single complaint from a user." The expected volume of transmissions for this system is 1.1 billion pieces per year by 1986.

And as for the postman about to hang up his bicycle clips? Well, there will always be little towns and hamlets left to service.

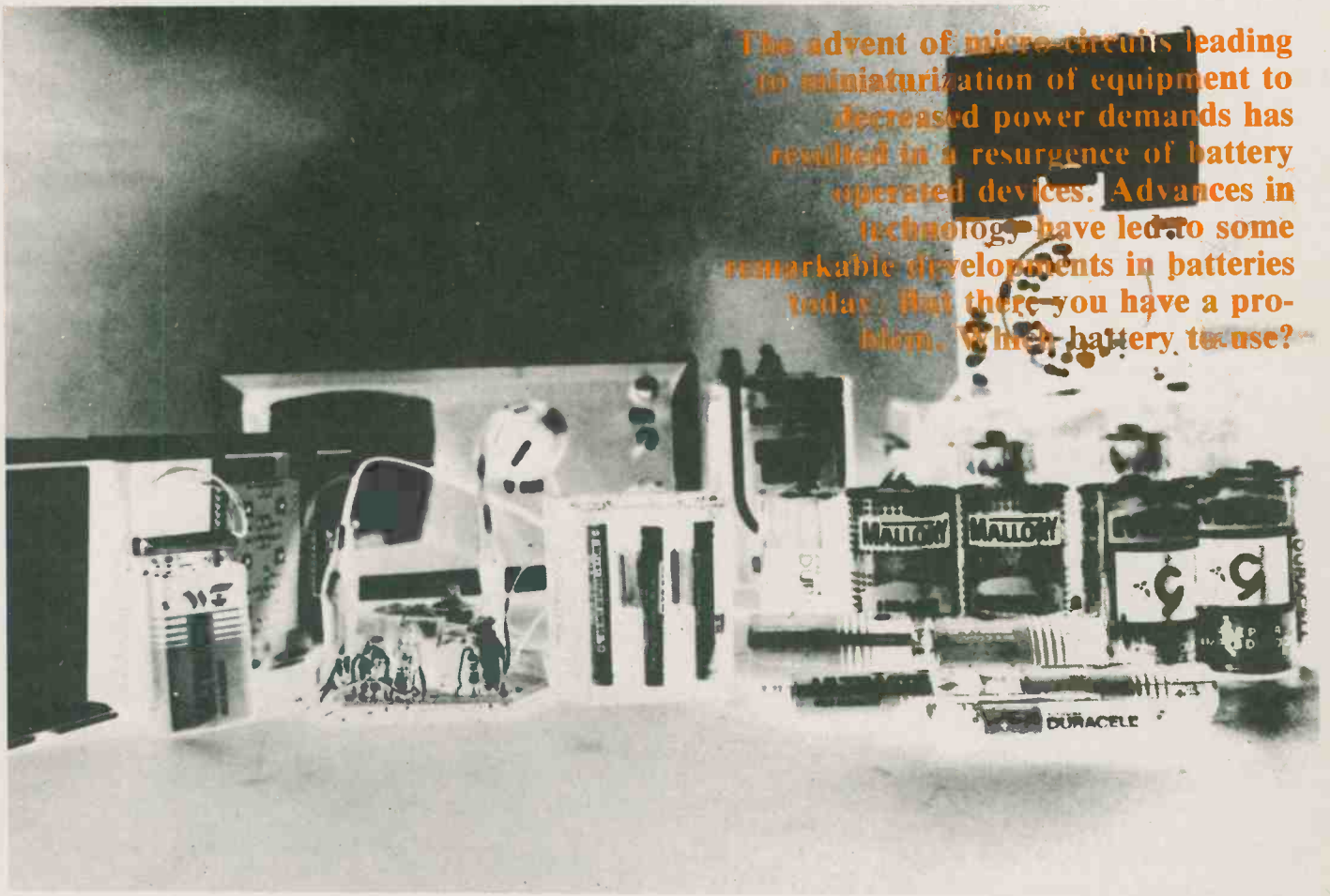
INTELPOST permitted ETI to partake in a demonstration of the facsimile electronic mail system. The art department kindly made up a specimen melange of bits and pieces, which this author then physically took down to the Canada Post Office on Front Street, Toronto. First problem was that the pictures and diagrams were mounted on thin card. This didn't fit the machine, so with the help of a staffer and a pair of scissors we transferred the items to a piece of paper. The paper didn't fit the machine, being too wide. Further use of scissors. Finally it worked.

The item was transmitted at 10:30 Toronto time on a Friday, and was collected from the mail box by Our Man In Calgary, Mr. B.J. McLauren, at five-thirty the same day. He immediately consigned it to the mails to be returned to us; it arrived on Monday morning.

ETI



Which Battery To Use?



The advent of micro-circuits leading to miniaturization of equipment to decreased power demands has resulted in a resurgence of battery operated devices. Advances in technology have led to some remarkable developments in batteries today. But there you have a problem. Which battery to use?

MANY PEOPLE HAVE a tendency to replace conventional 'dry' cells with the rechargeable nickel-cadmium type simply to avoid replacement costs, but this practice may not be cost effective and can even lead to reduced equipment performance and greater cost. In order to make some form of meaningful comparison between types, it was necessary to select one common size of cell and look at the performance under similar load conditions. Also, because the performance of carbon-zinc cells is more dependent on usage than alkaline or NiCad cells, a definite statement as to which is best, cannot readily be made.

The purpose of this article is to try to present a guide to the selection of cell type best suited for an application, bearing in mind equipment performance, duty cycle, current demand, weight and cost. The information presented here has been obtained from the data sheets of many manufacturers and should not be regarded as typical of any particular make. Because of the variation in performance of carbon-zinc cells with differing loads, the presentation has been optimized to give a reasonable overall guide to performance without being too optimistic.

Cells Tested

The basic cells compared are the nickel-cadmium rechargeable type, the ordinary carbon-zinc dry cell, both normal and heavy duty (leclanche type), and the manganese dioxide-alkaline type. The size of the cells selected for comparison are the 'AA' or UM-3, SAA designation R6. In the case of the NiCad, this is a 450 mA hour capacity cell. The load characteristic selected was a current drain of 30 mA for four hours per day. This is typical of much portable equipment such as walkie-talkies, portable radios, calculators, etc. This was also the load which was easiest to compare on a range of data for various cells.

Result of Comparisons

Generally, the comparison here shows alkaline cells to have a performance about twice that of ordinary carbon-zinc cells; however, they can be many times better, depending on usage. Alkaline cells have higher efficiency when used for continuous or heavy load (high current) applications where the conventional carbon-zinc cell is less effective. The rechargeable NiCad is good for heavy current applications, provided the correct supply voltage can be achieved. Unfortunately, carbon-zinc and alkaline cells are not directly interchangeable with NiCad cells due to differing terminal voltages. This is caused by the different types of materials and construction used for these cells. The result is that while carbon-zinc and alkaline cells have a terminal voltage of 1.5 V, the NiCad cell has a voltage of only 1.2 V.

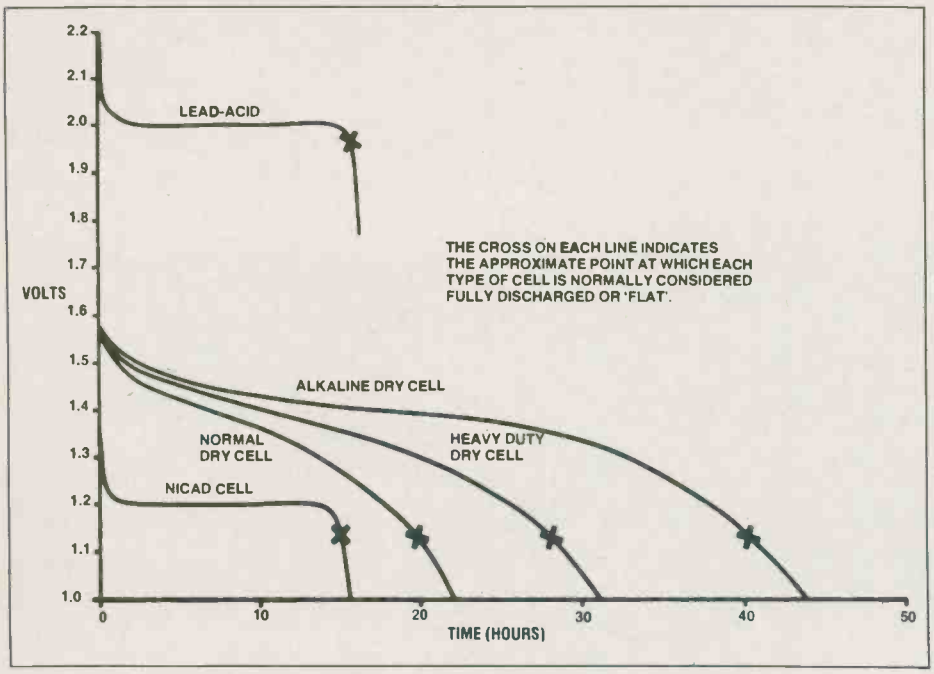


Fig. 1. The discharge performance of various cells. The discharge characteristics of a lead-acid cell are shown for comparison. Note that terminal voltage cannot be used to indicate the state of charge of NiCad cells.

Figure 1 shows the performance of the various cells and that of a similar capacity lead-acid cell for comparison. It is important to note that the terminal voltage cannot be used to indicate the state of charge of the NiCad cell, but can be used as an approximate indicator for 'dry' cells. NiCad cells are about 25% to 30% heavier than 'dry' cells and because more of them may be required for the same voltage, this could mean a substantial weight penalty in portable equipment.

Batteries At Work

The place where these various cells must work is in the equipment, and this is where many factors become important. The points to be considered are: *duty cycle* — is the load to be continuous or intermittent high current, or is it to be low current, continuous or intermittent? *Operating environment* — will the power be required at extremes of temperature? What is the design voltage of the equipment and can sufficient cells be accommodated to provide this? *Replacement or recharging* — in a particular situation one option may be preferable to the other, and which option is cost effective? *Operational life* — how long will the selected cell operate before recharge or replacement is necessary? *Shelf or storage life* — how good is a particular cell after a period of no use?

Duty Cycle

This will have a major effect on the performance of cell in any situation. Conventional carbon-zinc cells perform best at a relatively light load when operated intermittently. This allows a degree of recovery between periods of use. The service life of alkaline cells is relatively constant regardless of whether use is continuous or intermittent. This type of cell then shows its advantage mainly when continuous use is required. It can have a service life of three to ten times that of carbon-zinc cells in ideal circumstances.

Another advantage of the alkaline cell is its ability to supply considerably higher currents than the carbon-zinc type. In fact, the current available from alkaline cells can approach that from NiCad rechargeable cells in some circumstances. For high current loads, intermittent or continuous, the NiCad cell may be preferred, either because other cell types cannot supply the required current or because discharge is so rapid that continual replacement would be necessary. Substitution of carbon-zinc or alkaline cells with NiCads should only be undertaken after consideration of all the factors involved, including operating environment, equipment voltage requirements and storage life.

Operating Environment

Carbon-zinc cells deteriorate quickly at temperatures above about 50°C and become rapidly unable to deliver useful current below -18°C. Alkaline cells show better operating characteristics at extremes of temperature. Although it is difficult to determine the upper temperature limit of these cells, it is considerably better than carbon-zinc cells. Alkaline cells perform reasonably well down to temperatures of -40°C.

NiCad rechargeable cells have an operating temperature range of about -20°C to +45°C but should not be exposed to temperatures below 0°C while charging. Generally, their operating temperatures are about the same as for carbon-zinc cells. There may be some tempterature rise in NiCad cells during charging or heavy discharge, and this factor should be considered if these cells are used as a replacement for 'dry' cells in sensitive or critical equipment.

Design Voltage of Equipment

This is an important factor when consideration is being given to replacing carbon-zinc or alkaline cells with rechargeable NiCad types or replacing NiCads with 'dry' cells. In equipment such as portable transceivers, satisfactory operation depends greatly on the available supply voltage. Some of this equipment is designed to operate from NiCad cells while the other is intended to use 'dry' cells. Most such equipment has a specified operating range of voltages and attempted use outside of this range will result in severely degraded performance, no operation at all, or possible damage to the equipment. Typical ranges for nominal 12 V equipment are 11 V to 14 V or 10 V to 15 V. There is a temptation to replace carbon-zinc or alkaline cells with an equal number of rechargeable NiCad cells but because of the difference in terminal voltage (1.5 V as compared to 1.2 V) a fully charged NiCad battery may not meet the minimum voltage requirements of equipment.

Figure 2 shows the performance of various battery types in a piece of 12 V rated equipment such as a portable transceiver. Note that if provision is only made for eight cells, then replacement with lower voltage types can result in insufficient supply for the correct operation of the equipment. Often the mere fact that the equipment operates at all under these conditions is more a tribute to the designer than the performance of the power source! On the other hand, replacement of NiCad cells with 'dry' cells could allow the equipment voltage specification to be exceeded.

Replacement or Recharging

Which is best here will depend very much on the user requirement. For example, a transceiver used by emergency services might be more quickly restored to service by replacement of batteries than by recharging. For personal use, where failure due to battery discharge is not so critical, recharging may be acceptable. If the equipment is in heavy or continuous use, then recharging may be a viable alternative to replacement.

The cost of any option will depend on how often replacement is required, the

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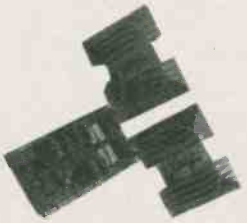

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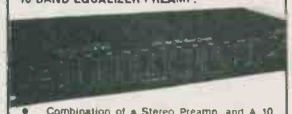

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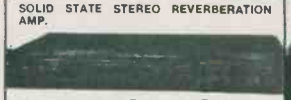

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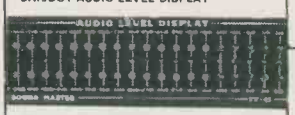

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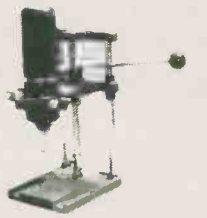

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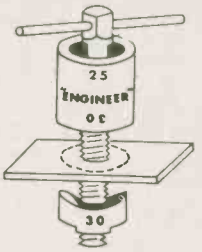

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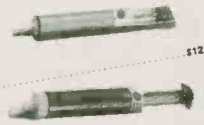

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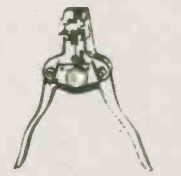

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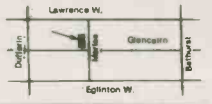

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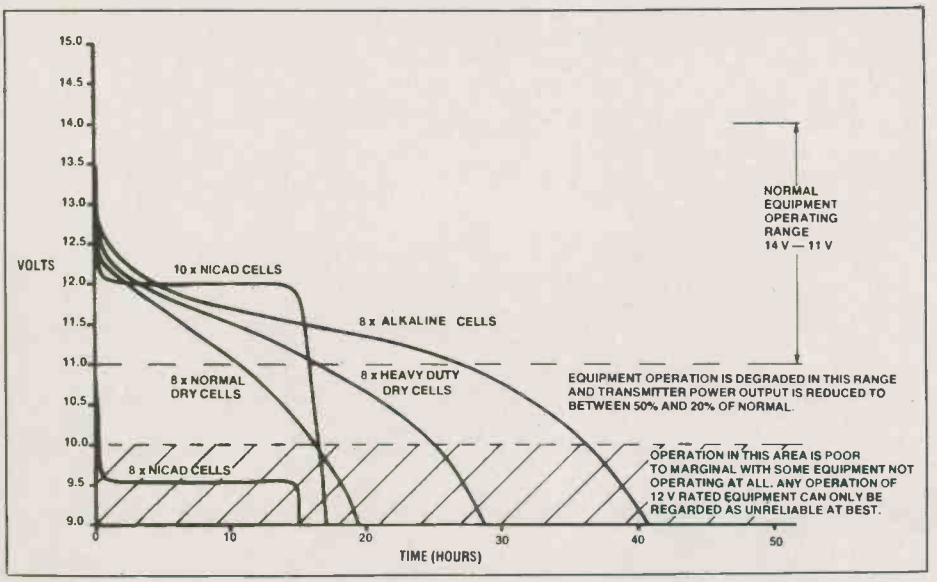


Fig. 2. The performance of various battery types in a 12 V operated handheld transceiver. Note that you cannot expect to replace eight dry cells with eight NiCads.

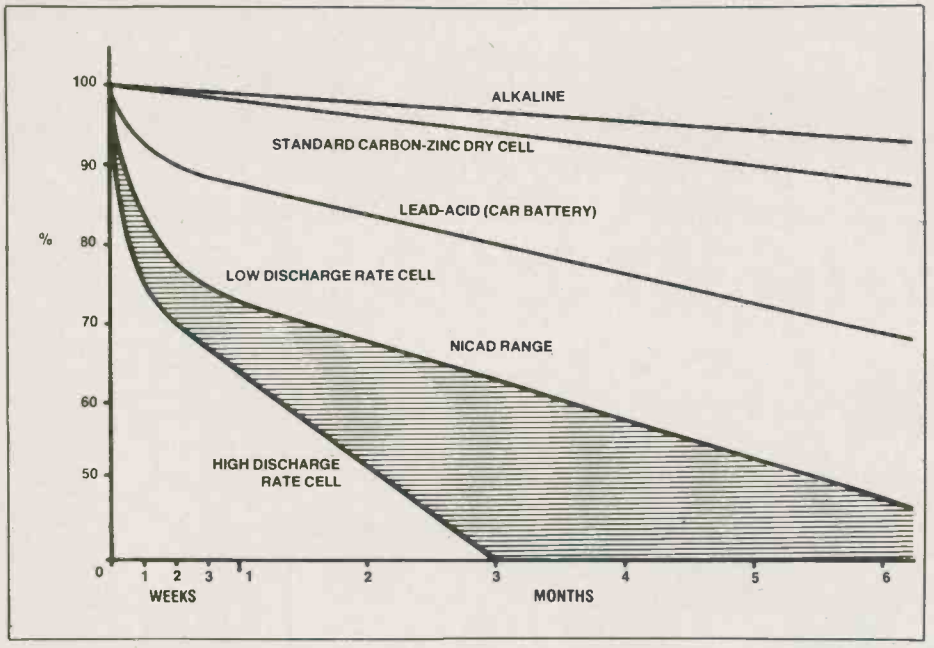


Fig. 3. All secondary cells self-discharge, which gives them a certain 'shelf life'. Here, the self-discharge characteristics of the various cells are shown. A lead-acid cell is included for comparison.

higher initial cost of rechargeable cells, (and you may need more of them), the cost of a charger and the cost of an additional battery pack if operation is needed while recharging is in progress. Another important factor, especially in an emergency environment, is the availability of power for recharging. If such a source is not readily accessible, a user may be ill-advised to use rechargeable batteries at all.

Operational Life

The effective operational life of a battery may become very important if access to replacement or recharged cells is difficult. As can be seen from Figure 2, the NiCad cells under this load will supply power for about 15 hours of operation. This is conditional on the battery being fully charged and in good condition. Ordinary carbon-zinc cells will provide about the same service life and heavy duty ones about twice this. Alkaline cells can be expected to have a greater operating life, about three times or better, than either NiCads or carbon-zinc as compared here.

There is a further factor which should be considered where the use of NiCad cells is contemplated. It has become recognized that NiCad cells tend to develop a 'memory' of their usage pattern. What appears to happen is that if a cell is used to, say, only 50% of capacity and then recharged, after a few cycles of this pattern, the cell then becomes only capable of delivering 50% of rated capacity before going 'flat'. This condition can be reversed by correctly cycling the cell through several discharge and charge cycles, but unless this condition is recognized as developing, it may seriously degrade the operational life of the equipment in which it is used.

Shelf Life or Self Discharge

All cells will discharge by themselves when not in use, to a greater or lesser degree. This self discharge will determine the length of time for which a cell can be left unused and still be able to deliver a reasonable proportion of its original charge. The major factors which influence the rate of self discharge are storage temperature, amount of charge at storage, and the condition of the cell.

The definition of shelf life is somewhat variable, but for carbon-zinc and alkaline cells appears to be the time taken to decrease to 90% of initial capacity. Accepting this definition then, gives the following approximate storage lifetimes for cells in good condition.

Carbon-zinc cell .....8 to 9 months
Alkaline cell .....Over 2 years
NiCad cell .....3 days to 4 weeks

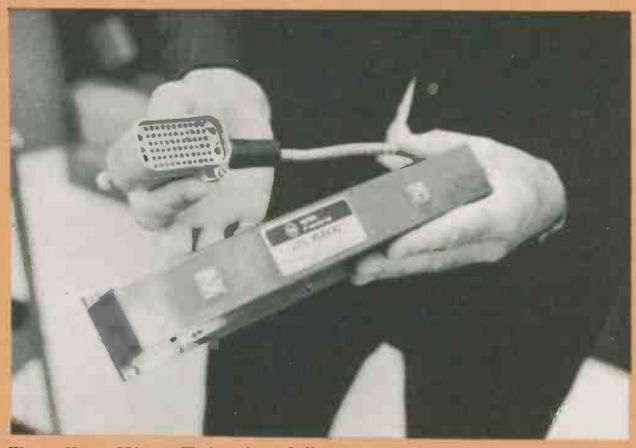
These storage times are based on a constant temperature of about 20°C to 25°C. Storage life may be improved by storing the cells at 5-10°C. Generally, higher temperatures cause more rapid degradation. Storage life is also shown in graphical form in Figure 3. An approximation for a lead-acid car battery type cell is shown for comparison. NiCad cells appear to show up poorly in this regard and some manufacturers now claim to have substantially improved this characteristic. The self discharge of NiCad cells depends on the type of cell, whether it is intended for high or normal current discharge. The condition of the cell is also important, whether it has been cycled correctly, the age (number of cycles), the environment in which it has been used and the state of charge at storage.

Consideration of the information provided here may be able to assist you to make a better informed decision as to the best power source for your battery operated equipment. It is not practical to cover all the eventualities and applications in a short article, but at least this should provide some guide to the cost effectiveness and practicability of the battery that you select. Most manufacturers will provide design and engineering data on request should you need to make a more detailed analysis of your particular needs. ETI

ETI next month

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.

Micros in Appliances
With 1984 approaching, you'd expect your appliances to be listening in to your every word. Eric McMillan looks at the current state of the art and proves that you have nothing to worry about ... yet.



Travelling Wave Tube Amplifiers
Roger Allan continues his high-tech inquisition with a look at Travelling Wave Tube Amplifiers. Find out why travelling wave tubes need to be amplified.

PLUS!
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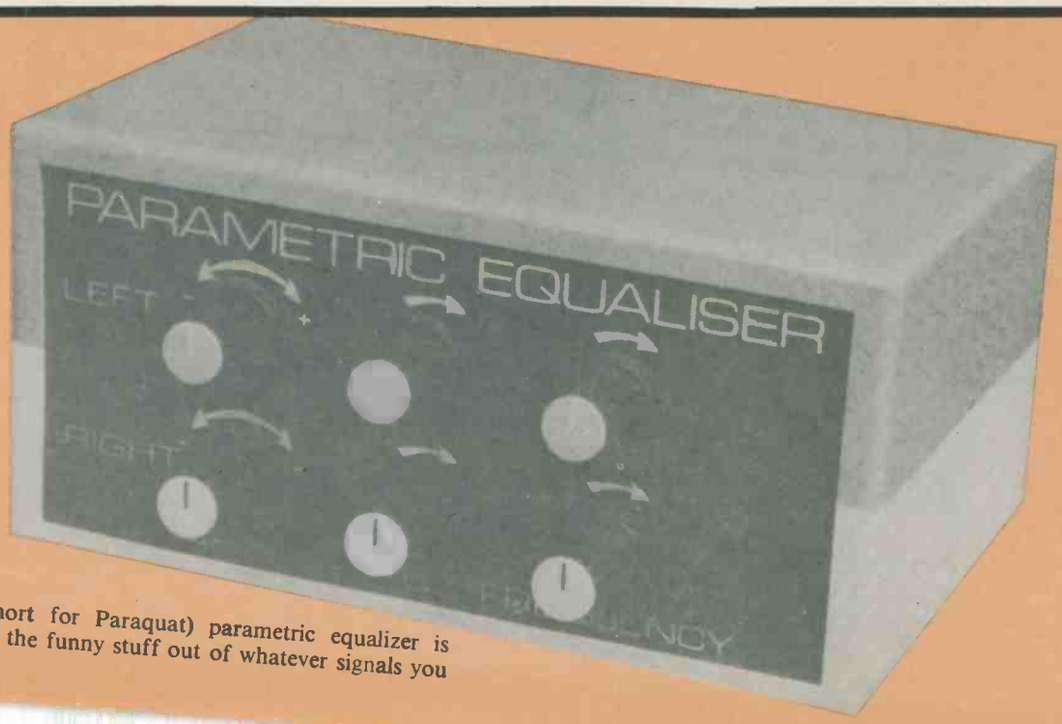


Para-Q
The Para-Q (short for Paraquat) parametric equalizer is designed to take the funny stuff out of whatever signals you put through it.

NiCad Charger/Regenerator

To accompany our battery article, here is a NiCad charger which extends battery life my minimizing "memory" and metallic deposits.

by Mike Punnett

NICKEL-CADMIUM BATTERIES (NiCads) are becoming increasingly popular as replacements for conventional dry batteries in a wide range of equipment. Properly used, they can give an enormous cost saving over the life of the equipment, but if misused, tend to fail early.

Since NiCads have a tendency to self-discharge over a few months, they have to be charged regularly. Furthermore, to avoid the inconvenience of a flat battery, they are often "topped up" with charge even when far from discharged. This leads to an effect known as whiskering, where fine deposits of cadmium build up, which can partially short-circuit the cell, as well as reducing the active electrode size. This leads to a loss of capacity; a 500mAh cell may be reduced to 300mAh after a year of light service and frequent charges.

It has been found that "cycling" NiCads can return them to an almost-new condition. This process involves discharging the battery hard (at the 1 hour rate, e.g. 500mA for a 500mAh battery), until it reaches the minimum safe voltage — NiCads can be easily damaged by over-discharging. A full charge at the 10 hour rate follows. This rather rough treatment disintegrates the whiskers of cadmium, and the full charge redeposits the metal on the electrodes. However, cycling NiCads "by hand" is a risky business, since they can easily be damaged.

The ETI NiCaddy was designed to cycle NiCads correctly and easily. It uses a minimum of components, and has two "programs": *cycle* and *charge*. Operating the unit is very straightforward: the NicCad is connected to it, and the appropriate button for the required program pressed. Cycle mode discharges the battery to its minimum safe voltage, and then switches to charge mode, in which the unit functions as a constant-current charger, automatically turning off when the battery reaches full charge. If the NiCad is already below its minimum safe voltage when connected up, the unit will automatically enter charge mode, overriding the switches, which are re-enabled when the battery rises above minimum safe voltage.

Construction

Construction of the unit is quite straightforward, either on the PCB or stripboard. Sockets are recommended for the ICs particularly IC2 which is a CMOS device. Do not forget the three wire links on the PCB.

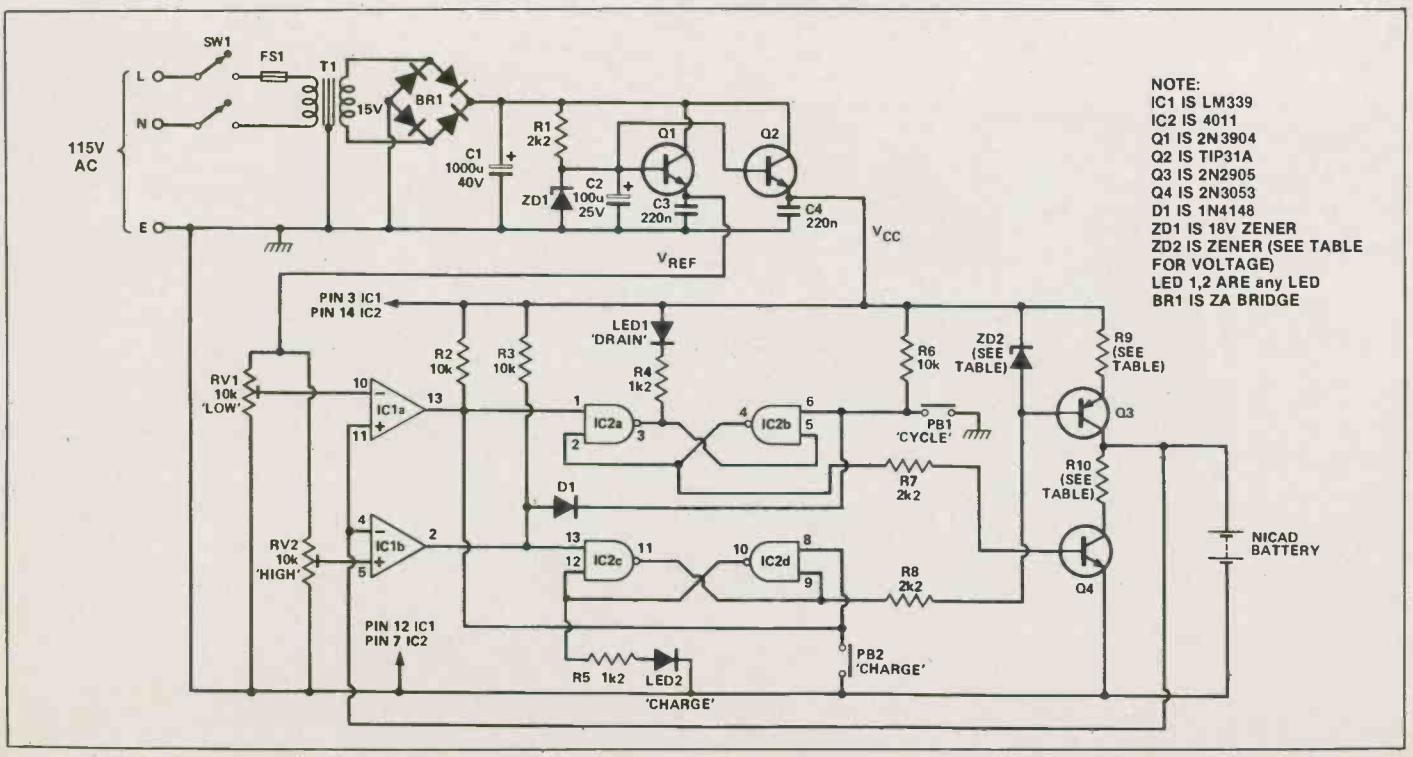
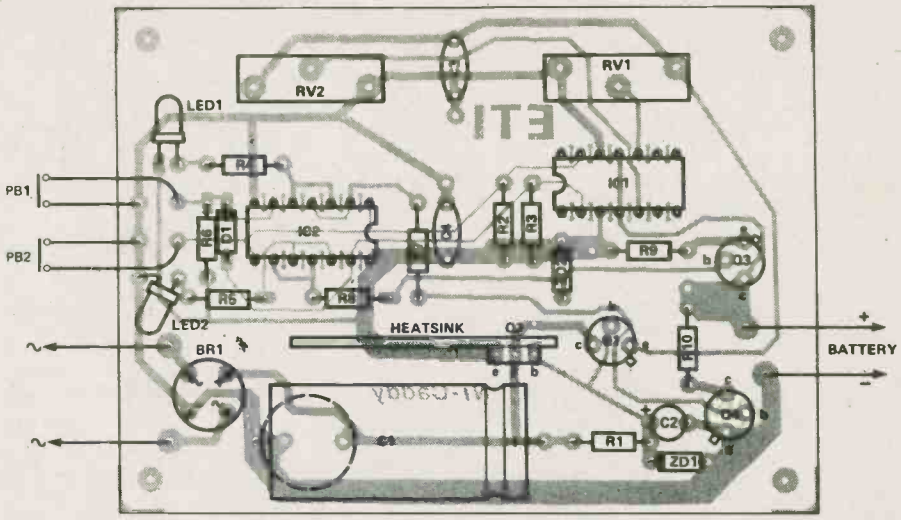


Table 1 gives component values for AA size (500mAh) cells (see later for details of use with other battery sizes). The circuit will work with batteries of up to eight cells. Remember that R11 will get hot, since the battery is discharged through this. For power ratings over 4 W, this component should be mounted off the board, preferably outside the box, to aid heat dissipation. Some of the transistors are fitted with heatsinks; Q1 has an aluminum heatsink (see overlay), Q3 and Q4 have push-fit TO5 heatsinks.



Testing and Calibration

Check the voltages across C3 and C4. Both should be in the range 16.5-17.4 V. If not, the power supply section should be investigated. The precise values do not matter, since the calibration will allow for some variability.

If the power supply is working properly, the unit can be calibrated. RV1 is set to the minimum safe voltage for the battery; this is 1.1 V per cell (i.e., 4.4. V for a four cell battery). An accurate, high resistance voltmeter connected to pin 8 of IC1 will enable the voltage to be checked. RV2 (full charge voltage) must be set rather more accurately, since the step in voltage which a NiCad exhibits as it reaches full charge is quite small. The best method is to set the voltage too high at first; about 1.7 V per cell on IC1 pin 11 is adequate. The operation of the unit is then checked with a battery which is known to be in full working order; at this stage the circuit should perform as described above, except that it will not turn off after charging. The charging current can be checked; it should be 0.1 of the cell capacity (i.e., about 50mA for 500mAh (AA) bateries). The test battery is then left on charge for a long period — 20 hours if flat. This guarantees that it stabilizes at full charge voltage. Since the charging is constant-current, there is no risk of damaging the battery by charging for too long. At this point, RV2 can be slowly turned down until the circuit just switches off, and the setting re-checked. The unit is now completed.

Table 1

No of cells	D3 voltage V	R9 ohms/watts	R10 ohms/watts
2	10	210/1	4.7/2
4	8.2	160/0.5	10/4
6	5.1	100/0.5	13/7
8	3.6	68/0.25	18/10

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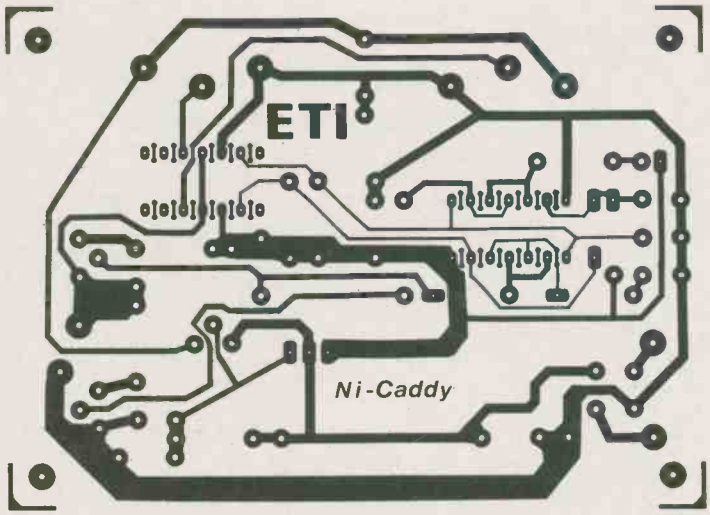
Modifications

The circuit was originally designed for AA size (500mAh) NiCads, since these are the most widely used, but it can easily be adapted for other sizes by changing R9 and R10. These are calculated from the quoted values simply by reducing the resistance and increasing the wattage in proportion to the capacity; so for a 1 Ah six-cell battery, R9 would be 50R 1W and R10, 6R 15W. (The values do not have to be absolutely exact, of course). For cells over 1 Ah capacity, it is best to uprate Q3 and Q4; since the circuit will be on for long periods, it is advisable to rate components generously, especially heatsinks. Replacing Q3/Q4 with TIP32/TIP31 respectively, mounted off the PCB on a suitable heatsink, will enable the unit to cope with cells up to about 4 Ah. As a rough guide, allow 1 Watt dissipation per Ah cell capacity when choosing heatsinks. Remember that the heatsink on Q1 may need uprating also. Allow a dissipation of 1.2 W per AH cell capacity.



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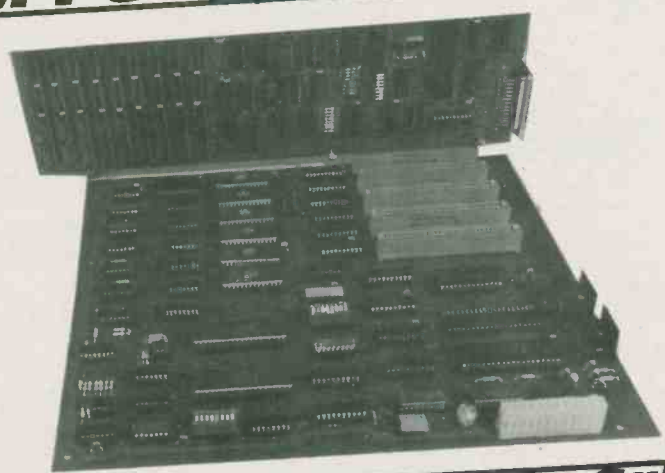

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HOW IT WORKS

The power supply section is quite straightforward, using a very simple voltage regulator. V_{cc} is not critical, but the reference voltage, V_{ref}, must be stable, even though the precise voltage is not important. With a separate regulating transistor (Q1) the circuit shown is quite adequate. The two reference levels (the points at which discharge and charge respectively terminate) are derived by RV1 and RV2.

IC1 is a dual comparator which has a number of advantages over similar units, including single-rail operation, the ability to accept inputs at near-ground potential, very low offset, and open-collector outputs. In the circuit, the output of IC1a goes low to indicate that the battery has reached minimum voltage, and that of IC1b goes low when maximum voltage is reached.

IC2 is wired as two flip-flops, one for discharging (IC2a,b) and one for charging (IC2c,d). Pressing "Cycle" sets the dicharge flip-flop and clears the charge flip-flop (via D2). When the battery reaches minimum voltage, or "Charge" is pressed, the discharge flip-flop is cleared and the charge flip-flop is set. The battery reaching full charge clears the charge flip-flop but does not set the discharge flip-flop. The status LEDs are driven directly by the two flip-flops, which also drive the output stage. The latter consists of a discharge circuit — when Q4 is turned on, the battery dicharges through R11 — and a constant current circuit consisting of Q3 and its ancilliary components, which is turned on by an active-low signal (when IC2 pin 11 is high, Q3 is driven fully off and passes no current).

PARTS LIST

Resistors (all ¼W 5% unless stated)	
R1,7,8	2k2
R2,3,6	10k
R4,5	1k2
R9,10	See text
RV1,2	10k multi-turn preset pot
Capacitors	
C1	1000u 40V PCB mounting electrolytic
C2	100u 25V PCB mounting electrolytic
C3,4	220n polyester
Semiconductors	
IC1	LM339
IC2	4011B
Q1	2N3904
Q2	TIP31A
Q3	2N2905 (but see text)
Q4	2N3053 (but see text)
D1	18V 400mW Zener
D2	1N4148 or similar
D3	400mW Zener (see Table 1)
LED1,2	Any 0.125" LED
BR1	2A bridge rectifier
Miscellaneous	
PB1,2	Min push-to-make switches
SW1	Two-pole power switch
FS1	1A power fuse and holder
T1	Power transformer, 15V 1A secondary (but see text)

Two 14-pin DIL sockets, case to suit, battery connectors, heatsinks as required (see text).

Expanded Scale Voltmeter Covering The 10-15 V Range

A simple, low-cost instrument that can be built into power supplies or used as a portable or fixed 'battery condition' monitoring meter.

COMMON STORAGE batteries to power nominal 12 V DC electrical systems have a terminal voltage that ranges from a little over 10 volts when discharged to around 15 volts when fully charged, the operating voltage being somewhere in the range 11.5 V to 13.8 V. Lead-acid batteries, for example, may have a terminal voltage under rated discharge that commences at around 14.2 V and drops to about 11.8 V. A 12 V (nominal) nickel-cadmium battery may typically have a terminal voltage under rated discharge that starts at 13 volts, dropping to 11 volts when discharged.

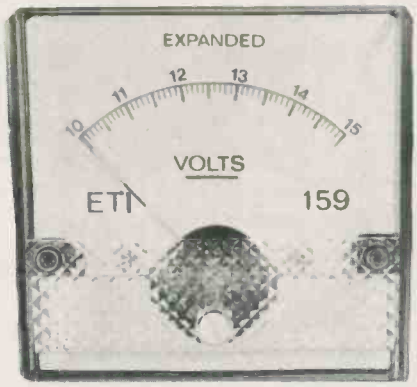
Equipment designed to operate from a nominal 12 V DC supply may only deliver its specified performance at a supply voltage of 13.8 V — mobile CB and amateur transceivers being a case in point. Other DC operated equipment may perform properly at 12.5 V but 'complain' when the supply reaches 14.5 V.

To monitor the state of charge/discharge of a battery, a battery-operated system or the output of power supplies, chargers, etc., a voltmeter which can be easily read to 100 mV over the range of interest, i.e., 10 to 15 volts, is an invaluable asset. This project does just that.

This instrument, being of the true analogue type, is intended for exacting measurement and is better characterized as a test instrument.

The Circuit

An LM723 variable voltage regulator IC is employed to set an accurate 'offset' voltage of 5 V, and the meter (M1) plus the trimpot RV2 and R3 make up a 5 V meter, with the trimpot allowing calibration. The negative terminal of the meter is connected to the output of the 723 so that it is always held at 5 V 'above' the circuit negative line. The positive end of the meter goes to a zener which will not conduct until more than 5 V appears between the circuit +ve and -ve lines. Thus the meter will not have forward current flowing through it until the voltage between the circuit +ve and -ve rails is greater than



10 V, and will read full scale when it reaches 15 V (after RV2 is set correctly).

The meter scale limits may be adjusted by setting the output of the 723 higher or lower (adjusted by RV1) and setting RV2 so that the meter has an increased or decreased full-scale deflection range.

A variety of meter makes and sizes may be used.

HOW IT WORKS

The meter, M1, is a 1 mA meter with series resistance — made up of R3 and RV2 — so that it becomes a 0-5 V voltmeter. The negative end of the meter is maintained at 5 V above the circuit negative line by the output of IC1, a 723 adjustable regulator. The positive end of the meter is connected to the circuit positive line via ZD1, a 4V7 zener diode. Thus, no 'forward' current will flow in the meter until the voltage between the circuit negative line and the circuit positive line is greater than 5 + 4.7 = 9.7 volts.

Bias current for the zener is provided by a FET, Q1, connected as a constant current source so that the zener current is accurately maintained over the range of circuit input voltage. This ensures the zener voltage remains essentially constant so that meter reading accuracy is maintained.

The trimpot RV1 sets the output voltage of the 723. This determines the lower scale voltage. Trimpot RV2 sets the meter scale range. More resistance increases the scale range, less resistance decreases it.

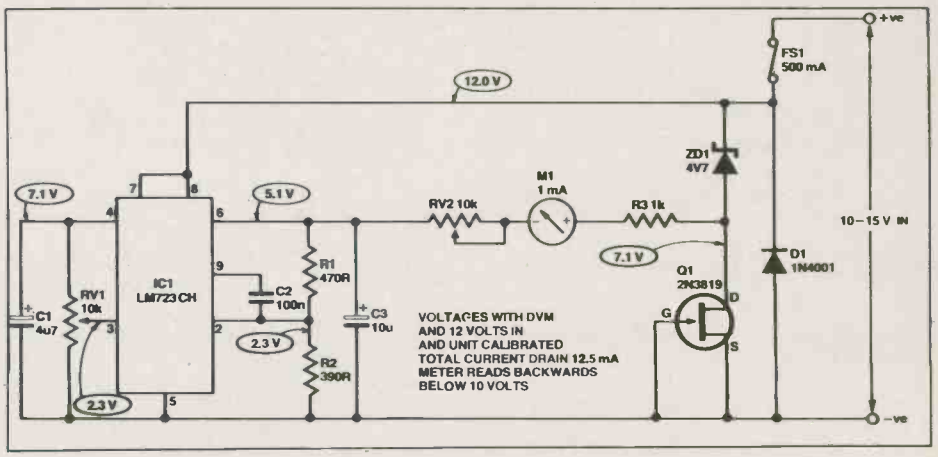
Diode D1 protects the circuit against damage from reverse connection.

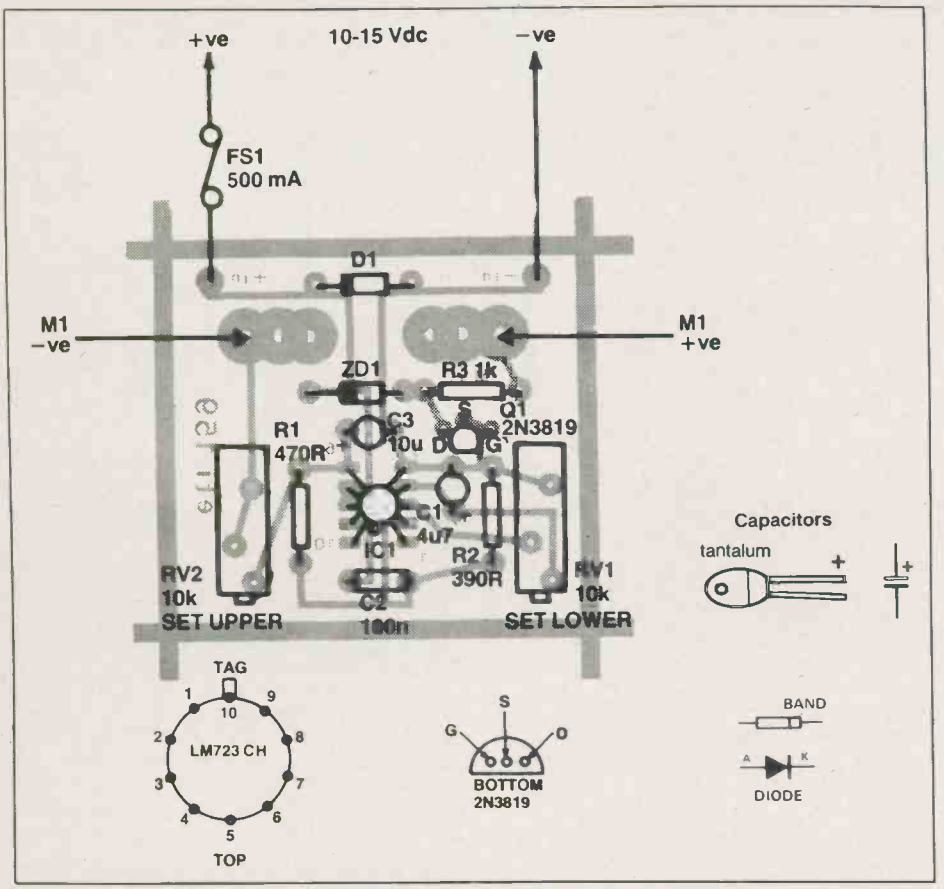
Construction

Mechanical construction of this project has been arranged so that the pc board can be accommodated on the rear of any of the commonly available moving coil meter movements. We chose a meter with a 55 mm wide scale (overall panel width, 82 mm). A meter movement with a large scale is an advantage as it is considerably easier, and more accurate, to read than meters with a smaller scale. It also pays to buy a 2% fsd accuracy meter for best accuracy.

Having chosen your meter, drill out the pc board to suit the meter terminal spacing first. The components may then be assembled to the board in any particular order that suites you. Watch the orientation of the 723, ZD1, the FET and particularly D1. The latter is an 'idiot diode'. That is, if you have a lapse of concentration or forethought and connect your project backwards across a battery, the fuse will blow and not the project. Fuses are generally found to be cheaper than this project!

Seat all the components right down on the pc board as the board may be positioned on the rear of the meter with the





components facing the meter The size of C2 may give you a little trouble. We used a 'Monobloc' type capacitor — as commonly used on computer pc boards as bypasses. Alternatively, a 100n tantalum capacitor (+ve to pin 2 of IC1) may be used. The actual value or type of capacitor is not all that critical.

We have used multiturn trimpots for RV1 and RV2 as they make the setting up a whole lot easier.

PARTS LIST

Resistors (All ½W 1% or 2% metal film)

R1	470R
R2	390R
R3	1k
RV1,RV2	10k cermet multiturn horizontal trimpot

Capacitors

C1	4u7/10 V tant.
C2	100n ceramic
C3	10u/10 V tant.

Semiconductors

IC1	LM723CH
ZD1	4V7, 400 mW or 1W zener
Q1	2N3819
D1	1N4002 or similar

Miscellaneous

M1	1 mA meter (see text)
FS1	500 mA fuse and in-line fuse holder

pc board; meterscale to suit meter.

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2. Color R.F. Modulator	$14.00
3. Joystick (Self-centering) two adjustable controls	$39.00
a) Parallel Printer Card	$69.00
b) 16K RAM Card	$59.00
c) 80 Column Card	$79.00
d) Disk ControllerCard	$55.00
e) Z80 Card	$60.00
f) Communication Card	$67.00
A. 6502 48K KIT or (A&T)	**$499.00**
B. 6502 64K KIT or (A&T)	**$539.00**
C. 6502 64K built in Z80 or (A&T)	**$699.00**

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Battery Condition and Terminal Voltage

The 12 V battery, in its many forms, is a pretty well universal source of mobile or portable electric power. There are lead-acid wet cell types, lead-acid gel electrolyte (sealed) types, sealed and vented nickel cadmium types, and so on. They are to be found in cars, trucks, tractors, portable lighting plants, receivers, transceivers, aircraft, electric fences and microwave relay stations — to name but a few areas.

No matter what the application, the occasion arises when you need to reliably determine the battery's condition — its state of charge, or discharge. With wet cell lead-acid types, the specific gravity of the electrolyte is one reliable indicator. However, it gets a bit confusing as the recommended electrolyte can have a different SG depending on the intended use. For example, a low duty lead-acid battery intended for lighting applications may have a recommended electrolyte SG of 1.210, while a heavy-duty truck or tractor battery may have a recommended electrolyte SG of 1.275. Car batteries generally have a recommended SG of 1.260. That's all very well for common wet cell batteries, but measuring the electrolyte SG of sealed lead-acid or nickel-cadmium batteries is out of the question.

With NiCads, the electrolyte doesn't change during charge or discharge.

Fortunately, the terminal voltage is a good indicator of the state of charge or discharge. In general, the terminal voltage of a battery will be at a defined minimum when discharged (generally between 10 and 11 volts), and rise to a defined maximum when fully charged (generally around 15 volts). Under load, the terminal voltage will vary between these limits, depending on the battery's condition.

Hence a voltmeter having a scale 'spread' to read between these two extremes is a very good and useful indicator of battery condition. It's a lot less messy and more convenient than wielding a hydrometer to measure specific gravity of the electrolyte!

The charge and discharge characteristics of typical lead-acid and sealed NiCad batteries are given in the accompanying figures.

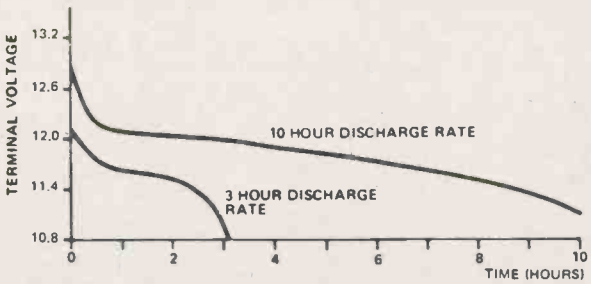


Fig. 1. Typical discharge characteristics of a 12 V (nominal) lead-acid battery.

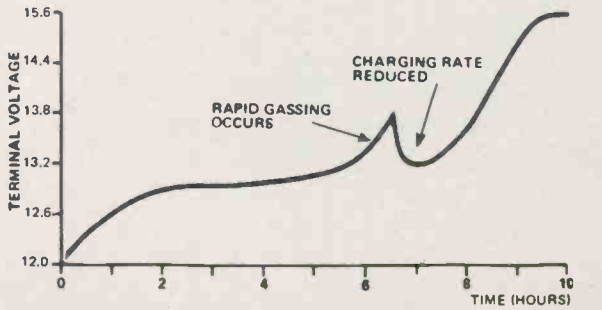


Fig. 2. Charging characteristics of a 12 V (nom.) lead-acid battery. The 'kink' in the curve near 6 hrs is explained in the text.

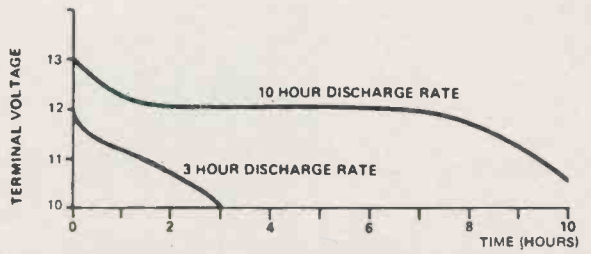


Fig. 3. Typical discharge characteristics of a 12 V (nom.) nickel-cadmium battery (usually consisting of 10 cells in series).

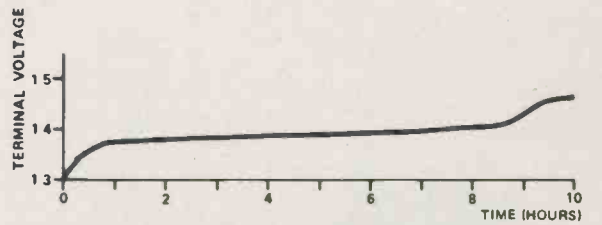


Fig. 4. Typical charging characteristics of a 12 V NiCad battery (10 cells) charged with a constant current at one-tenth rated capacity (0.1C).

Note that the fuse (to protect the project) is inserted in an in-line holder in the external connecting leads.

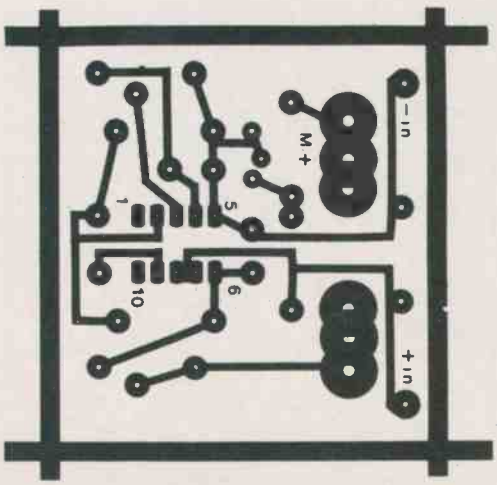
Calibration

For this you will need a variable power supply covering 10 to 15 volts and a digital multimeter (borrow one for the occasion).

First set the 10 V point. Connect the digital multimeter across the power supply output and adjust the power supply to obtain 10.00 volts. Set the mechanical zero on the meter movement to zero the meter's pointer. Connect the unit to the power supply output and adjust RV1 to zero the meter needle.

Next, set the power supply to obtain 15.00 V. Now adjust RV2 so that the meter needle sits on 15 V (full scale). Check the meter reading with the power supply output set at various voltages across the range. We were able to obtain readings across the full scale within ± half a scale reading (± 50 mV). With a 2% meter, the worst error may be about ± one scale division.

When set up, our unit drew 12.5 mA maximum current drain, which is probably typical, but current drain may be around 20 mA or so maximum. Note that, when the input voltage is below 10 V, the meter needle will move in the reverse direction.



ETI

Survey of 50 Systems

This month, we conclude last month's survey of fifty lower-cost microcomputers by presenting sixty higher-cost machines. As usual, we apologise for any inaccuracies, and we point out that prices may vary from store to store. Happy drooling.

System:	Associate
Operating System:	CP/M
Processors:	Z80A
RAM:	65K
Printer I/O:	2 S
Disk Drives Inc:	2 DS DD 5¼" floppy
Screen Format:	80x25
Graphics:	32 Graphics Characters
Sound:	N
Colour:	N
Keyboard:	Integrated
Software Included:	Microplan, Spellbinder, acc pak
Software Available:	Extensive
Primary Market:	Business or Personal
Manufacturer:	Associate
Available From:	Datacalc Technology Ind Corp.
Price:	$4495.00
Other:	

System:	BASIS 108
Operating System:	BASIC
Processors:	6502 & Z80A
RAM:	64K
Printer I/O:	P, S & 6 Exp
Disk Drives Inc:	Mounting for two 5¼" floppy
Screen Format:	80(40)x24
Graphics:	280x192
Sound:	Y
Colour:	Y
Keyboard:	Detachable
Software Included:	BASIC
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	BASIS Inc.
Available From:	Computer Systems Design
Price:	$4000.00
Other:	Apple compatible

System:	Orion 1 A
Operating System:	CP/M
Processors:	Z80A
RAM:	64K
Printer I/O:	S & 2 Exp
Disk Drives Inc:	Two 5¼" floppy
Screen Format:	80x24
Graphics:	N/A
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	CP/M
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	DY-4 Systems Inc.
Available From:	Prelco Electronics
Price:	$4500.00
Other:	Multi-user capabilities

System:	Columbia VP
Operating System:	CP/M-86, MSDOS
Processors:	8088
RAM:	128K
Printer I/O:	S & P
Disk Drives Inc:	Two ½ height DSDD floppy
Screen Format:	80(40)x25
Graphics:	640x200
Sound:	Y
Colour:	N
Keyboard:	Detachable
Software Included:	Perfect Series Fast Graphics, BASIC A
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Columbia Data Systems
Available From:	Hamax Data Systems
Price:	$4495.00
Other:	Portable, IBM PC software compatible

System:	Xerox 16/8 Prof. Comp
Operating System:	Supports CP/M-80, CP/M-86 & MS DOS
Processors:	8086 & Z80A
RAM:	128K
Printer I/O:	S & P
Disk Drives Inc:	Opt 2 floppy or 1 hard, 1 floppy
Screen Format:	80x24
Graphics:	Opt
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	BASIC
Software Available:	Extensive, supports CP/M-80, CP/M-86, MSDOS
Primary Market:	Business
Manufacturer:	Xerox
Available From:	Xerox Stores
Price:	Announced in Sept.
Other:	Stand-alone or workstation capabilities

System:	AJILE (portable)
Operating System:	MS DOS
Processors:	8088
RAM:	256K
Printer I/O:	S & P Exp Module
Disk Drives Inc:	One 5¼" DS DD floppy
Screen Format:	80x25
Graphics:	640x250
Sound:	Programmable
Colour:	N
Keyboard:	Detachable
Software Included:	Basic, In:Scribe, Multiplan and Communications
Software Available:	Extensive, IBM Comp at BIOS
Primary Market:	Business
Manufacturer:	BYTEC Management Corp.
Available From:	Anderson Jacobson Ltd.
Price:	$4285.00
Other:	

System:	Canon AS-100
Operating System:	CP/M or DOS
Processors:	8088
RAM:	128K
Printer I/O:	Opt S or P
Disk Drives Inc:	Opt 5" or 8" floppy or 5" hard
Screen Format:	80x25
Graphics:	640x400
Sound:	N
Colour:	Opt
Keyboard:	Detachable
Software Included:	2 BASICs
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Canon
Available From:	Canon Canada Inc.
Price:	$3200.00
Other:	

System:	Heath HZ-89
Manufacturer:	Heathkit
Available From:	Heathkit
Price:	$2295.00
Other:	Kit version of Zenith Z-89

System:	Heath HZ-100
Manufacturer:	Heathkit
Available From:	Heathkit
Price:	$3499.99
Other:	Kit version of Zenith Z-100

Computer Survey

System:	Computer Devices Dot Portable
Operating System:	MS DOS
Processors:	8088
RAM:	128K
Printer I/O:	2 S
Disk Drives Inc:	Two 3½" SS DD floppy
Screen Format:	80x25
Graphics:	1056x254
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	MS DOS
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Computer Devices
Available From:	Datamex
Price:	N/A
Other:	Printer included in price

System:	Kaypro II
Operating System:	CP/M
Processors:	Z80
RAM:	64K
Printer I/O:	2 S & P
Disk Drives Inc:	Two 5¼" floppy
Screen Format:	80x24
Graphics:	N/A
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	SBASIC, Profitplan, Select
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Kay Computers
Available From:	Computron
Price:	$2795.00

System:	Sharp PC 5000
Operating System:	MS DOS
Processors:	8088 & C-MOS
RAM:	128K
Printer I/O:	S
Disk Drives Inc:	Opt 128K Bubble Cartridge
Screen Format:	80x8 LCD
Graphics:	640x80
Sound:	N
Colour:	N
Keyboard:	Integrated
Software Included:	MS DOS, BASIC
Software Available:	Extensive
Primary Market:	Home or Business
Manufacturer:	Sharp
Available From:	Total Office Systems Inc.
Price:	To be announced in Sept.
Other:	Portable & printer included

System:	Sony SMC-70
Operating System:	CP/M
Processors:	Z80A
RAM:	64K
Printer I/O:	S, P & 5 Exp
Disk Drives Inc:	Opt SS DD 3½" floppy
Screen Format:	80x25
Graphics:	640x400
Sound:	Y
Colour:	Opt
Keyboard:	Detachable, Qwerty
Software Included:	CP/M
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Sony
Available From:	Total Office Systems
Price:	$4900.00

System:	MAGIC
Operating System:	CP/M
Processors:	Z80A
RAM:	64K
Printer I/O:	S & P
Disk Drives Inc:	DSDD IBM Media compatible
Screen Format:	80x24
Graphics:	96 Graphic Characters
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	Perfect Writer/Calc/Spell/File
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Magic Computer Co.
Available From:	Micro Bazzar
Price:	$2,695.00

System:	Nelma Persona
Operating System:	CP/M
Processors:	Z80A
RAM:	64K
Printer I/O:	2 S & P
Disk Drives Inc:	Two 5¼" floppy
Screen Format:	80x24
Graphics:	OPT
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	Wordstar, Calcstar and Communication Software
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Nelma Data
Available From:	Computerland
Price:	$2995.00

System:	Pronto 16/10
Operating System:	MS DOS
Processors:	80186 (16 Bit)
RAM:	128K
Printer I/O:	2 S, P & 4 Exp
Disk Drives Inc:	Two 5¼" floppy
Screen Format:	80x25
Graphics:	Opt 640x480
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	BASIC, word processor and spread sheet
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Pronto Computers, USA
Available From:	To be announced in Sept.
Price:	N/A

System:	NEC Advanced Personal Computer
Operating System:	CPM, MSDOS
Processors:	8086
RAM:	128K
Printer I/O:	S & P
Disk Drives Inc:	One or Two 8" floppy
Screen Format:	80x25
Graphics:	640x475 Display Window
Sound:	Y
Colour:	Opt
Keyboard:	Detachable
Software Included:	CP/M and MSDOS
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	NEC
Available From:	Microcomputers of Canada Inc.
Price:	$4 95.00

System:	NCR Decision Mate V
Operating System:	Choice
Processors:	Z80 & 8088
RAM:	64K
Printer I/O:	S & P
Disk Drives Inc:	2 flex or 1 flex & 1 hard
Screen Format:	80x24
Graphics:	640x400
Sound:	N
Colour:	Opt
Keyboard:	Detachable
Software Included:	BASIC, Financial & Word Processor Programs
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	NCR
Available From:	SGV Marketing
Price:	$4495.00
Other:	Choice of CP/M-80, CP/M-86 or MS DOS

Computer Survey

System:	TI Professional
Operating System:	
Processors:	8088
RAM:	64K
Printer I/O:	S & 5 Exp
Disk Drives Inc:	320K floppy
Screen Format:	80x25
Graphics:	720x300
Sound:	N
Colour:	Opt
Keyboard:	Detachable
Software Included:	
Software Available:	Supports MSDOS, CPM80, CPM86, USCD
Primary Market:	Business
Manufacturer:	Texas Instruments
Available From:	Lanpar
Price:	$3975.00
Other:	Voice management system available

System:	Tomcat PCX 1600
Operating System:	CP/M & MSDOS
Processors:	8086 & Z80A
RAM:	128K
Printer I/O:	S & P
Disk Drives Inc:	Two 5¼" DS DD floppy
Screen Format:	80x25
Graphics:	640x400
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	CP/M & MS DOS
Software Available:	Extensive, IBM Compatible
Primary Market:	Business
Manufacturer:	Tomcat
Available From:	Tomcat Computers
Price:	$3995.00

System:	Osborne Executive
Operating System:	CPM & UCSD
Processors:	Z80A
RAM:	128K
Printer I/O:	2 S
Disk Drives Inc:	Two 5¼" floppy
Screen Format:	80x24
Graphics:	
Sound:	N
Colour:	N
Keyboard:	Integrated
Software Included:	Wordstar, Mailmerge, Supercalc, Personal Pearl, C & M BASIC
Software Available:	Extensive
Primary Market:	Home or Business
Manufacturer:	Osborne Canada
Available From:	Lanpar
Price:	$3495.00

System:	Sord M23P
Operating System:	CP/M Comp
Processors:	Pips
RAM:	128K
Printer I/O:	2 S, P & 3 Exp
Disk Drives Inc:	Two floppy
Screen Format:	80x25 monitor
Graphics:	640x200
Sound:	N
Colour:	Opt
Keyboard:	Integrated
Software Included:	BASIC, spread sheet
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Sord
Available From:	Micos Computer Systems Inc.
Price:	$2995.00
Other:	Opt colour/green/LCD display

System:	Telcon Zorba
Operating System:	CP/M
Processors:	Z80A
RAM:	64K
Printer I/O:	IEEE, P & S
Disk Drives Inc:	Two 5¼" DS DD floppy disks
Screen Format:	80x25
Graphics:	N/A
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	Wordstar, Mailmerge, Calcstar, BASIC
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Telcon Ind. Inc.
Available From:	Micro Bazzar
Price:	$2995.00
Other:	

System:	Televideo TS 1603
Operating System:	CP/M
Processors:	8088
RAM:	128K
Printer I/O:	S
Disk Drives Inc:	Two 5¼" floppy
Screen Format:	80x24
Graphics:	Opt
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	CP/M-86 & MMM Ost Operating System
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Televideo
Available From:	Datamex
Price:	$4420.00

System:	Sharp YX 3200
Operating System:	CP/M & FDOS
Processors:	YX-3200
RAM:	64K
Printer I/O:	P & S Exp
Disk Drives Inc:	Opt 5¼" or 8" floppy
Screen Format:	80x25
Graphics:	N/A
Sound:	N
Colour:	N
Keyboard:	Integrated
Software Included:	2 BASICS
Software Available:	Extensive
Primary Market:	Home or Business
Manufacturer:	Sharp
Available From:	Total Office Systems
Price:	$2395.00

System:	Televideo TS 803
Operating System:	CP/M
Processors:	Z80A
RAM:	64K
Printer I/O:	S
Disk Drives Inc:	Two 5¼" floppy
Screen Format:	80x24
Graphics:	640x240
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	CP/M
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Televideo
Available From:	Datamex
Price:	$3704.00

System:	Sord M68
Operating System:	
Processors:	MC68000, Z80A
RAM:	256K
Printer I/O:	2 S, P & IEEE
Disk Drives Inc:	Two 5" mini floppy
Screen Format:	80x25
Graphics:	640x400
Sound:	N
Colour:	Opt
Keyboard:	Detachable
Software Included:	Not available
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Sord
Available From:	Micos Computer Systems Inc.
Price:	Announced in Sept.

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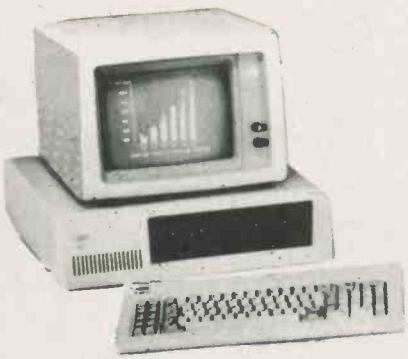
Computer Survey

System:	Tomcat 3000
Operating System:	MSDOS, CP/M-80, CP/M-86
Processors:	8086 & Z80A
RAM:	128K
Printer I/O:	2 S
Disk Drives Inc:	8" floppy, 5¼" hard
Screen Format:	80x25
Graphics:	640x400
Sound:	N
Colour:	Opt
Keyboard:	Detachable
Software Included:	CP/M-86, CP/M-80, MS-DOS
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Tomcat
Available From:	Tomcat Computers
Price:	N/A

System:	Intertec SUPERBRAIN II JR
Operating System:	DOS & CP/M
Processors:	Twin Z80A
RAM:	64K
Printer I/O:	2 S
Disk Drives Inc:	Two 5¼" floppy
Screen Format:	80x24
Graphics:	N/A
Sound:	N
Colour:	N
Keyboard:	Integrated
Software Included:	CP/M, DOS, BASIC
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Intertec Data System
Available From:	E.M.J. Data Systems
Price:	$2495.00



System:	IBM PC
Operating System:	DOS, UCSD P-System & CP/M-86
Processors:	8088
RAM:	64K
Printer I/O:	13 Exp.
Disk Drives Inc:	One 160KB Diskette
Screen Format:	80x25
Graphics:	640x200
Sound:	N
Colour:	Opt.
Keyboard:	Detachable
Software Included:	Operating Systems
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	IBM
Available From:	Local Dealers
Price:	$3,200.00
Other:	Opt. auxiliary storage with Expansion unit.

System:	Commodore BX 128-80
Operating System:	CBM
Processors:	6509 & 8088
RAM:	128K
Printer I/O:	IEEE & S
Disk Drives Inc:	Opt disks
Screen Format:	80x25
Graphics:	720x350
Sound:	Y
Colour:	N
Keyboard:	Detachable
Software Included:	N/A
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Commodore
Available From:	Local Dealers
Price:	N/A
Other:	Also available with 256K

System:	TRS-80 Model 4
Operating System:	TRS DOS
Processors:	Z80A
RAM:	64K
Printer I/O:	P
Disk Drives Inc:	Two SSDD 5¼" floppy
Screen Format:	80x24
Graphics:	Opt 640x240
Sound:	Programmable
Colour:	N
Keyboard:	Integrated
Software Included:	TRS DOS, BASIC
Software Available:	COMP CP/M, LDOS
Primary Market:	Business
Manufacturer:	Tandy
Available From:	Radio Shack
Price:	$2999.00
Other:	

System:	Zenith Z-89
Operating System:	Choice
Processors:	Z-80
RAM:	48K
Printer I/O:	Y
Disk Drives Inc:	100K
Screen Format:	80x25
Graphics:	Character symbols
Sound:	N
Colour:	Opt
Keyboard:	Integrated
Software Included:	CP/M and/or ZDOS
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Zenith
Available From:	Local dealers
Price:	$3745.00

System:	Zenith Z-100
Operating System:	Choice
Processors:	8088 & 8085
RAM:	128K
Printer I/O:	2 S & 1 P
Disk Drives Inc:	One 5¼" floppy DS DD
Screen Format:	80x24
Graphics:	225x640
Sound:	N
Colour:	Opt
Keyboard:	Integrated
Software Included:	CP/M and/or ZDOS
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Zenith
Available From:	Local dealers
Price:	$4675.00

System:	Apple IIe
Operating System:	DOS
Processors:	6502A
RAM:	64K
Printer I/O:	8 Exp. slots
Disk Drives Inc:	Opt. 5¼" floppy
Screen Format:	80x24
Graphics:	280x192
Sound:	Y
Colour:	Y
Keyboard:	Integrated
Software Included:	DOS, BASIC
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Apple Canada
Available From:	Local Dealers
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Other:	$2995.00 — 128K

System:	Heath HZ-89
Manufacturer:	Heathkit
Available From:	Heathkit
Price:	$2295.00
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System:	Heath HZ-100
Manufacturer:	Heathkit
Available From:	Heathkit
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System:	Columbia VP
Operating System:	CP/M-86, MSDOS
Processors:	8088
RAM:	128K
Printer I/O:	S & P
Disk Drives Inc:	Two ½ height DSDD floppy
Screen Format:	80(40)x25
Graphics:	640x200
Sound:	Y
Colour:	N
Keyboard:	Detachable
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Primary Market:	Business
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Printer I/O:	S, P & 5 Exp.
Disk Drives Inc:	DDDS 5¼" floppy
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Graphics:	512x256
Sound:	N
Colour:	Opt.
Keyboard:	Integrated
Software Included:	PCOS, BASIC, Tutorials
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Olivetti
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System:	Olympia "People"
Operating System:	CP/M & MSDOS
Processors:	8086
RAM:	128K
Printer I/O:	S & P
Disk Drives Inc:	Two floppy disk drives
Screen Format:	80x25
Graphics:	600x485
Sound:	N
Colour:	Opt
Keyboard:	Detachable
Software Included:	Wordstar, Supercalc, D BASE II
Software Available:	Extensive
Primary Market:	Home or Business
Manufacturer:	Olympia Int.
Available From:	Olympia Bus Machines Can Ltd.
Price:	$5950.00

System:	Hyperion
Operating System:	MS DOS
Processors:	8088
RAM:	256K
Printer I/O:	S, P & IEEE
Disk Drives Inc:	Two 5¼" DS DD floppy
Screen Format:	80x25
Graphics:	640x250
Sound:	Programmable
Colour:	N
Keyboard:	Detachable
Software Included:	Multiplan, text editor, 2 others
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	BYTEC Mang. Corp.
Available From:	Computerland
Price:	$4950.00
Other:	IBM compatible, portable

System:	Hewlett-Packard 200 Model 16
Operating System:	Opt
Processors:	MC68000
RAM:	128K
Printer I/O:	S & IEEE
Disk Drives Inc:	
Screen Format:	80x25
Graphics:	300x400
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	Choice of BASIC, HPL or PASCAL
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Hewlett Packard
Available From:	Hewlett Packard
Price:	$6079.00

System:	Victor 9000
Operating System:	CP/M, MSDOS
Processors:	8088
RAM:	128K
Printer I/O:	2 S & 2 P
Disk Drives Inc:	Two 5" SS floppy
Screen Format:	132(80)x25
Graphics:	800x400
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	Operating systems, BASIC
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Victor
Available From:	Compucollege Stores
Price:	$5495.00

System:	Commodore Executive 64
Operating System:	Basic
Processors:	6510
RAM:	64K
Printer I/O:	S & IEEE
Disk Drives Inc:	170K single disk drive
Screen Format:	40x25
Graphics:	320x200
Sound:	Y
Colour:	Y
Keyboard:	Detachable
Software Included:	Not finalized
Software Available:	CBM 64 software compatible
Primary Market:	Business
Manufacturer:	Commodore
Available From:	Local dealers
Price:	To be announced in the Fall
Other:	Portable

System:	Epson QX-10
Operating System:	Valdocs
Processors:	Z80A
RAM:	256K
Printer I/O:	S, P & 5 Exp
Disk Drives Inc:	Two 5¼" DS DD floppy
Screen Format:	80x25
Graphics:	640x400
Sound:	N
Colour:	N
Keyboard:	Detachable
Software Included:	Indexer, Word Processor, Mail System, Graphics
Software Available:	Extensive
Primary Market:	Business
Manufacturer:	Epson
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System:	Hitachi MB 16001
Operating System:	DOS, CP/M
Processors:	8088
RAM:	128K
Printer I/O:	S, P & 5 Exp
Disk Drives Inc:	DS DD 8" floppy
Screen Format:	80x25
Graphics:	640x400
Sound:	N
Colour:	Opt
Keyboard:	Detachable
Software Included:	MS DOS, CP/M, BASIC
Software Available:	Extensive
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Operating System:	MSDOS
Processors:	8088
RAM:	128K
Printer I/O:	S & P
Disk Drives Inc:	One half size floppy
Screen Format:	80x24
Graphics:	640x325
Sound:	Y
Colour:	N
Keyboard:	Detachable
Software Included:	Multimate, 2 Tutorials
Software Available:	Extensive, 4 IBM Compatible slots
Primary Market:	Business
Manufacturer:	Corona
Available From:	Scarsdale Computers
Price:	$3880.00

System:	Corona Personal
Operating System:	MSDOS
Processors:	8088
RAM:	128K
Printer I/O:	S and P
Disk Drives Inc:	One SS DD floppy
Screen Format:	80x25
Graphics:	640x325
Sound:	Y
Colour:	N
Keyboard:	Detachable
Software Included:	Multimate, 2 Tutorials
Software Available:	Extensive, 4 IBM Compatible slots
Primary Market:	Business
Manufacturer:	Corona
Available From:	Scarsdale Computers
Price:	$3880.00
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Graphics:	N/A
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Operating System:	CP/M
Processors:	Z80A
RAM:	64K
Printer I/O:	S & P
Disk Drives Inc:	Two 5¼" DS DD floppy
Screen Format:	80x25
Graphics:	640x200
Sound:	N
Colour:	Opt
Keyboard:	Detachable
Software Included:	2 BASICS, Word Processor, Spread Sheet & Data Base
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Disk Drives Inc:	One 5¼" DD floppy
Screen Format:	80x24
Graphics:	560x192
Sound:	Opt.
Colour:	Opt.
Keyboard:	Integrated
Software Included:	SOS
Software Available:	Extensive
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Designing Micros Part 4

Last month, Owen Bishop explained what a ROM chip is. This month, he tells you why. Read on.

A short program which enables the MPU to get started on its more important tasks is called a *boot-strap program*. It helps the MPU pull itself up by its bootstraps! Since such a program must already be in the computer from the moment power is switched on, the obvious course is to place this program there permanently in ROM. Most computers have additional ROM programs to instruct the MPU how to do other kinds of routine jobs, such as send output to the display. Quite often a message such as "APPLE II' or 'MEMORY SIZE?' is placed on the screen when the computer is switched on. The program to do this is held in ROM. The complete program may occupy a few kilobytes of memory. Such a program is generally called a *monitor program*. This is another use of the word 'monitor', the name usually given to a purpose-built computer video display (as opposed to a domestic TV set being pressed into service as a computer display).

The monitor program is usually written in machine code (see October's article), for this is the most compact way of instructing the MPU and allowing it to operate at its maximum speed. Most computer users prefer to communicate with the MPU by using a high-level language, such as BASIC. MPUs do not understand BASIC, so a program written in machine code is needed to interpret programs written in BASIC. Then the MPU can understand what it must do. The interpreting program (or interpreter) can be loaded from tape or disk into RAM, but since such a program is likely to be required every time the computer is used, it is more convenient to hold it in ROM. Thus the ROM of a microcomputer may have, say, 12K of ROM which holds all the routines (in machine code) for interpreting BASIC commands and executing them.

When buying a microcomputer it is essential to find out whether you need to buy BASIC on a disk and load it every time you want to use it, or whether the BASIC is resident in ROM. Usually the memory space quoted for a computer is the amount of RAM it has. A computer which is listed as having 48K will allow you to use almost the whole of that for your programs if its BASIC is in ROM. On the other hand, if the computer has 56K but no resident language, the language may use up 12K of that space when loaded in RAM, leaving you with only 44K for your own programs.

A Change Of Character

Another use for ROM is to hold tables which are to be frequently used by the computer. A good example is the 'character generator' ROM. Before it can put a character onto the screen, the MPU must find out exactly what pattern of dots are required to produce the letter, numeral, or symbol that is to be displayed. These patterns are held in the character generator ROM. The MPU reads the appropriate pattern from the ROM and sends it to the video area of RAM, causing the character to be displayed.

It is feasible to manufacture several different character generator ROMs, each containing a different selection of characters. There can be different typefaces, or the selection of letters and symbols can be chosen according to the country in which the computer is to be used. For example, Video Inc. manufactures a series of such EPROMs for the Apple II including the French, German, Spanish and Katakana (Japanese) alphabets, and one holding mathematical and Greek symbols.

Another type of plug-in ROM which is widely used holds a complete games program, educational program, or utility program. Instead of loading the program

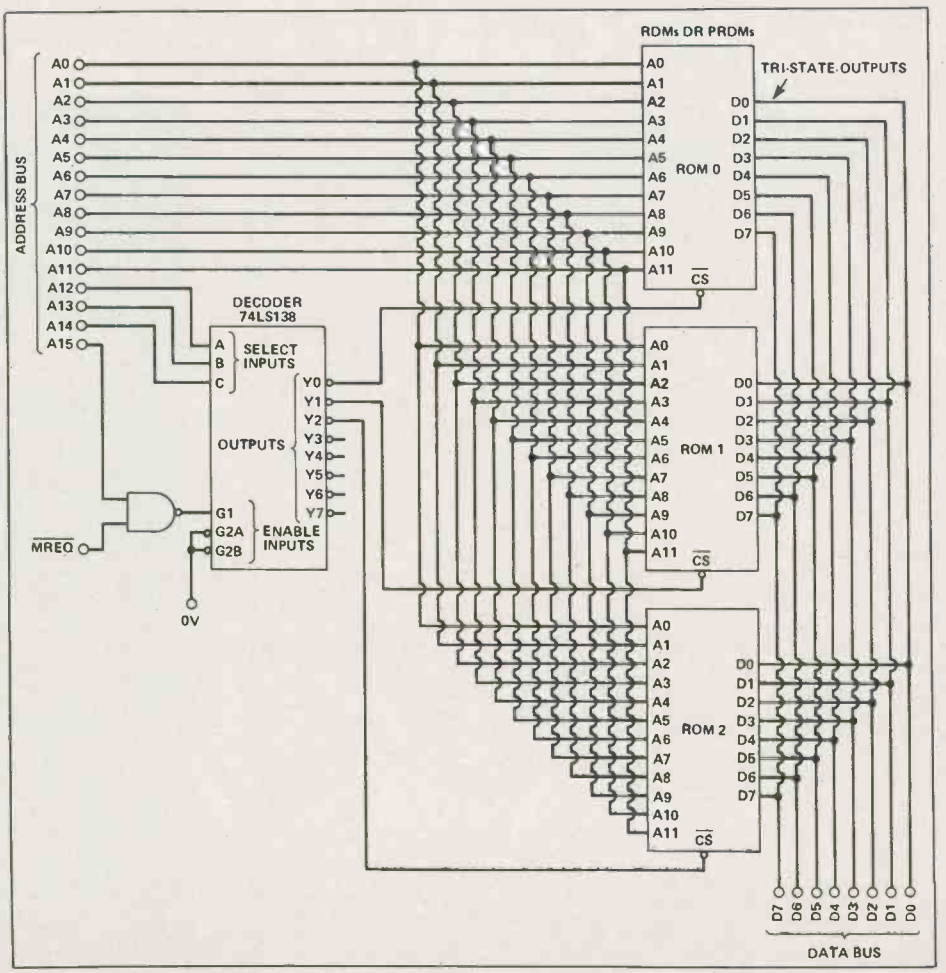

Fig. 1. Addressing three 4K ROMs.

TABLE 1

ROM NO.	ADDRESS RANGE		
	DECIMAL	HEXADECIMAL	BINARY
0	0 to 4095	0000 to 0FFF	0000 0000 0000 0000 to 0000 1111 1111 1111
1	4096 to 8191	1000 to 1FFF	0001 0000 0000 0000 to 0001 1111 1111 1111
2	8192 to 12287	2000 to 2FFF	0010 0000 0000 0000 to 0010 1111 1111 1111

from tape or disk, the user simply plugs in a module containing a pre-programmed ROM. The Atari and Tandy TRS-80 Colour Computer are examples of machines with this facility, as are many of the more specialized TV games machines.

Addressing Memory

We have often referred to the MPU addressing a given byte in memory at a particular address, without giving any indication of how this is done. Let us look into this in a little more detail. As an example, consider a ROM (it might be a regular mask-programmed ROM or some type of PROM) which stores 4 kilobytes. Each bit of these 4096 bytes is represented by a memory cell. This very-large-scale integrated circuit (VLSI) therefore contains 32768 memory cells, each consisting of a transistor which is set on or off depending upon whether it corresponds to a 0 or a 1. It also contains the logic circuits required to ensure that when any one of the 4096 possible combinations of voltage levels (the 4K addresses) is put on the lower 12 lines of the address bus (lines A11 to A0), the eight bits of information stored by the corresponding eight transistors will be gated onto the eight lines of the data bus.

The extreme complexity of such a circuit is difficult to imagine, yet it is commonplace on the computer circuit board. To accommodate a monitor program and a resident language we may need three such ICs, giving a total ROM memory of 12K. Suppose that this is to run from the very bottom of the computer's memory (from address 0000 onwards). The addresses corresponding to the three ICs will be shown in Table 1. From the binary address it is clear that the lower 12 address lines are responsible for differentiating between all the addresses held in a single ROM. The state of the upper four address lines (A15 to A12) tell us which, if any, of the three ROMs is to be addressed at any particular time. Thus the address 4295 (10C7 in hex) appears on the bus as:

0001 0000 1100 0111

and refers to ROM1. The address 8391 (20C7 in hex) appears on the bus as:

0010 0000 1100 0111

and is located in ROM2. All three ROMs receive the signals on lines A11 to A0. How can we ensure that only ROM1 responds to the address 10C7, while only ROM2 responds to 20C7?

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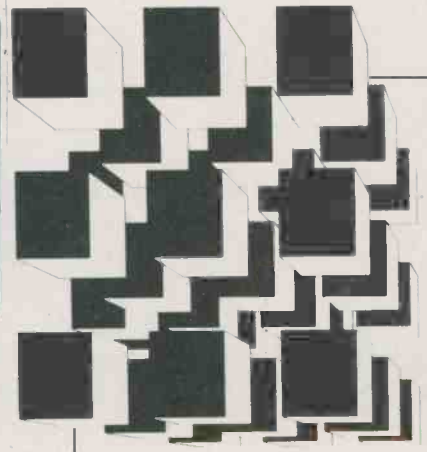

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The outputs of the ROMs to the data bus are *tri-state* outputs. That is to say, they normally present a very high impedance; they are virtually disconnected from the bus, and they are incapable of either sending or receiving signals. Each ROM has one (more in some types) special input known as *chip select* ($\overline{CS}$). The bar over the $\overline{CS}$ indicates that this is an active-low input. When the $\overline{CS}$ input is made low, data outputs go to a low-impedance state and whatever data is present on the set of cells currently being addressed is put on to the data bus. Fig. 1 shows how we control which ROM is to be active at any given time.

Go Low To Go

The function of the circuit is to enable one ROM at a time by making its $\overline{CS}$ input go low. The ROM to be selected is determined by the signals present on the upper four address lines and on a control line which indicates when the MPU is ready to read data. In the Z80 this is the $\overline{MREQ}$ line, which is active-low. The 74LS138 is a 3-to-8-line decoder which is typical of the ICs used for decoding address lines in computers.

Lines A12, A13 and A14 go to the A, B, and C inputs of this IC. Their states are treated as a three-bit binary input. Outputs Y0 to Y7 are normally high, but provided that the IC is enabled, one of the outputs is low at any one time, depending on the binary input to A,B,C. Thus when A is low, B is high and C is low, this corresponds to 010 (equivalent to decimal 2), and output Y2 goes low. This makes the $\overline{CS}$ input of ROM2 low, so ROM2 is enabled while the other ROMs remain disabled in the high-impedance state. The location in ROM2 which is to be addressed is then determined by the state of the other lines (A11 to A0) of the address bus.

The decoding of inputs A, B and C as described above, takes place only if the decoder itself is enabled. It has three enable inputs, G1, G2A and G2B. To enable the chip, G1 must be high and either G2A or G2B must be low. You will notice the convention on the drawing that small circles are drawn at G2A and G2B to indicate that they are active low. The outputs also have these circles, for the same reason.

There are several possible ways of using the enable inputs to make sure that the chip is enabled only when address line A15 is low and the $\overline{MREQ}$ line is low too. The solution shown here is to NOR A15 and $\overline{MREQ}$ together and feed the result to G1. This makes G1 high only if both A15 and $\overline{MREQ}$ are low. Inputs G2A and G2B are not used and are grounded.

Let us sum up the procedure of reading from ROM. In order to address any particular cell of ROM, the MPU puts its address on the bus. In the example given, the address will be received along lines A0 to A11 in all three ROMs. The states of lines A12 to A14 are to be decoded by the 74LS138 and line A15 must be low to allow the decoder to be enabled. Then the MPU takes its $\overline{MREQ}$ output low to indicate that it wishes to read data. This makes the NOR gate output go low, enabling the decoder. One of its outputs then goes low, enabling one of the ROMs. The ROM so addressed puts the data on the bus and this is read by the MPU.

The procedure outlined above must be carried out according to a strict time schedule. For instance, if the decoder acts too slowly, the MPU may be trying to read data before it is there. Some mention of this problem was made in Part 1, and we shall discuss it again in connection with RAM, next month.

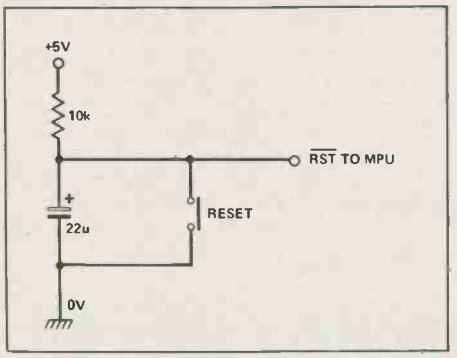

Fig. 2. A simple resetting circuit.

ROM At The Top?

Readers who have taken the trouble to look at the circuit diagram of a computer and compare it with Fig. 4 may find that the ROM of their computer does not appear to be decoded to the low addresses in memory. This is the case if the computer concerned is based on the 6502 MPU. Unlike the Z80 and several other MPUs, the 6502 does not begin reading its program at 0000 after being reset. The 6502 has the special feature of *zero-page addressing;* this means that addresses in the range 0000 to 00FF can be addressed by using the lower byte only (00 to FF). This greatly simplifies and shortens programs, making this area of memory a very useful place in which to store frequently referred-to variables and tables. To take advantage of this facility, this part of memory must be allocated to RAM. Consequently, it is better if ROM is located at the top end (higher addresses) of memory instead. When the 6502 is reset, it first reads the two bytes which are stored at FFFC and FFFD, addresses almost at the top of memory. It is essential to place ROM so that it covers these addresses.

Memory cells FFFC and FFFD in ROM contain the two bytes which are the address of the beginning of the monitor program. In the Apple II with the Autostart ROM, for example, these bytes are 62 and FA, respectively. The 6502, having read these two bytes, sets its program counter to the address they indicate (FA62 in this example) and then goes to that address to begin reading and executing the monitor program.

Integrating ICs

Nowadays there is a move toward reducing the number of ICs required in computer systems. This is particularly important for special-purpose computers that are to be used in control applications, such as those in washing machines or video-recorders. The program required may be relatively small (perhaps only 2K or 3K) so there is no reason why the ROM should not be accommodated on the same slice of silicon as the MPU. If we have ROM, why not have RAM as well, and any other useful devices such as input/output ports and timers? A good example of this approach is the Zilog Z8 'computer-on-a-chip'; a similar device is the Mostek MK3870. The Z8 not only has an MPU but also 2K of ROM, 128 bytes of RAM (enough to use as a 'scratch-pad' to hold temporary data), four eight-bit I/O ports, two counter/timers, and an asynchronous serial interface. The ROM in the Z8 has to be mask-programmed, so this IC is not one that the hobbyist is likely to be using. The professional can obtain a version of the Z8 or the MK3870 with an EPROM mounted on it in piggy-back style. This can be programmed during the course of development and after all has been settled, the final program can be mask-programmed into the internal ROM of the production version.

A special version of the Z8, known as the Z8671, has the ROM pre-programmed with a Tiny BASIC interpreter as well as its monitor program. This can be used as the basis of a simple computer system. It has 144 bytes of RAM for use as a scratch-pad, but it can address up to 124K bytes of external RAM or ROM for the storage of programs. This version with its general-purpose BASIC in ROM has a wider appeal than custom-programmed versions, so it can be manufactured in quantity. Prices are falling and already several development boards are on sale which feature this IC. The phrase 'chips with everything' can now be taken to mean 'chips with everything on them'!

Next month, RAM: Reading, 'Riting, but no 'Rithmetic.

ETI

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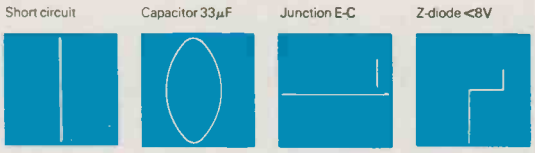
Examples of Test Displays:



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For HM307, HZ62, and HZ64	HZ44	$39.00
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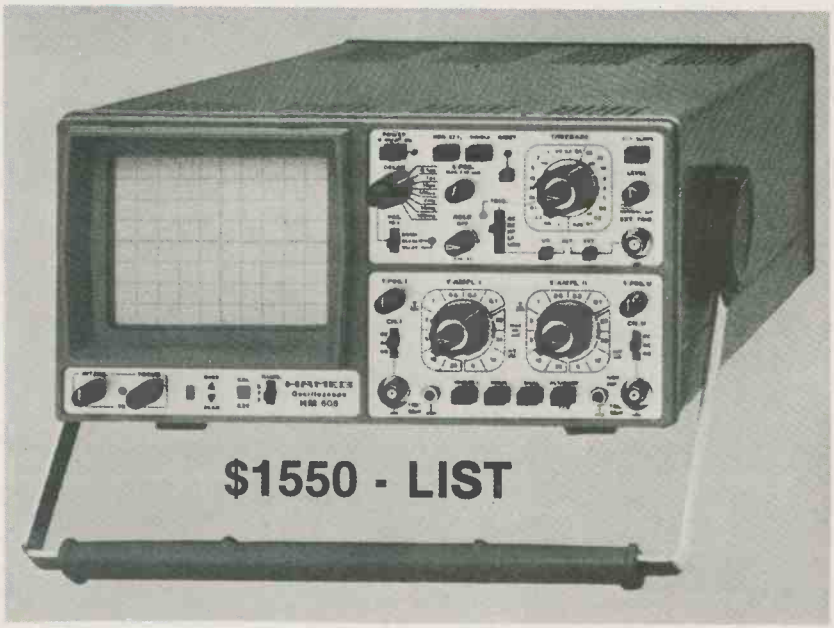

The **multitude of operating modes** of the **HM605** make it a universal oscilloscope — one which satifies a wide variety of **laboratory demands**. Its expanded Y-axis sensitivity of **1mV/cm** allows extremely small signals to be displayed. Despite this high sensitivity, vertical amplifier drift is extremely low. Vertical overscanning of the usable screen area is indicated by LEDs. A built-in **delay line** permits **viewing** of the **trigger leading edge**.

Triggering is possible up to at least **80MHz**. Triggering facilities allow, among other things, the display of two **non-time-related signals**. Line triggering, single sweep, and variable hold-off time are also available. A sweep range of from **5ns/cm to 2.5sec/cm** ensures **high resolution** as well as display of extremely slow signals. Analysis of small signal sections of a waveform is possible using the **sweep delay** feature, which allows **X-expansion by 1000** or more.

A rectangular **14kV CRT** with an illuminated graticule provides exceptionally **bright, sharp diplays**. The HM605 incorporates a switchable **fast-rise-time 1kHz/1MHz square wave generator** for high frequency probe compensation and system checks — a **unique feature** for scopes in this price range. This feature makes it possible to check transmission performance of the Y-amplifier, **compensation** of modular attenuation probes and optimum utilization of the entire bandwidth of the **instrument and probes**.

As with all new HAMEG flat-line oscilloscopes, a **component tester** is also incorporated in the **HM605**. The **outstanding price/performance ratio** of this oscilloscope is not likely to be matched by the competition in the near future.

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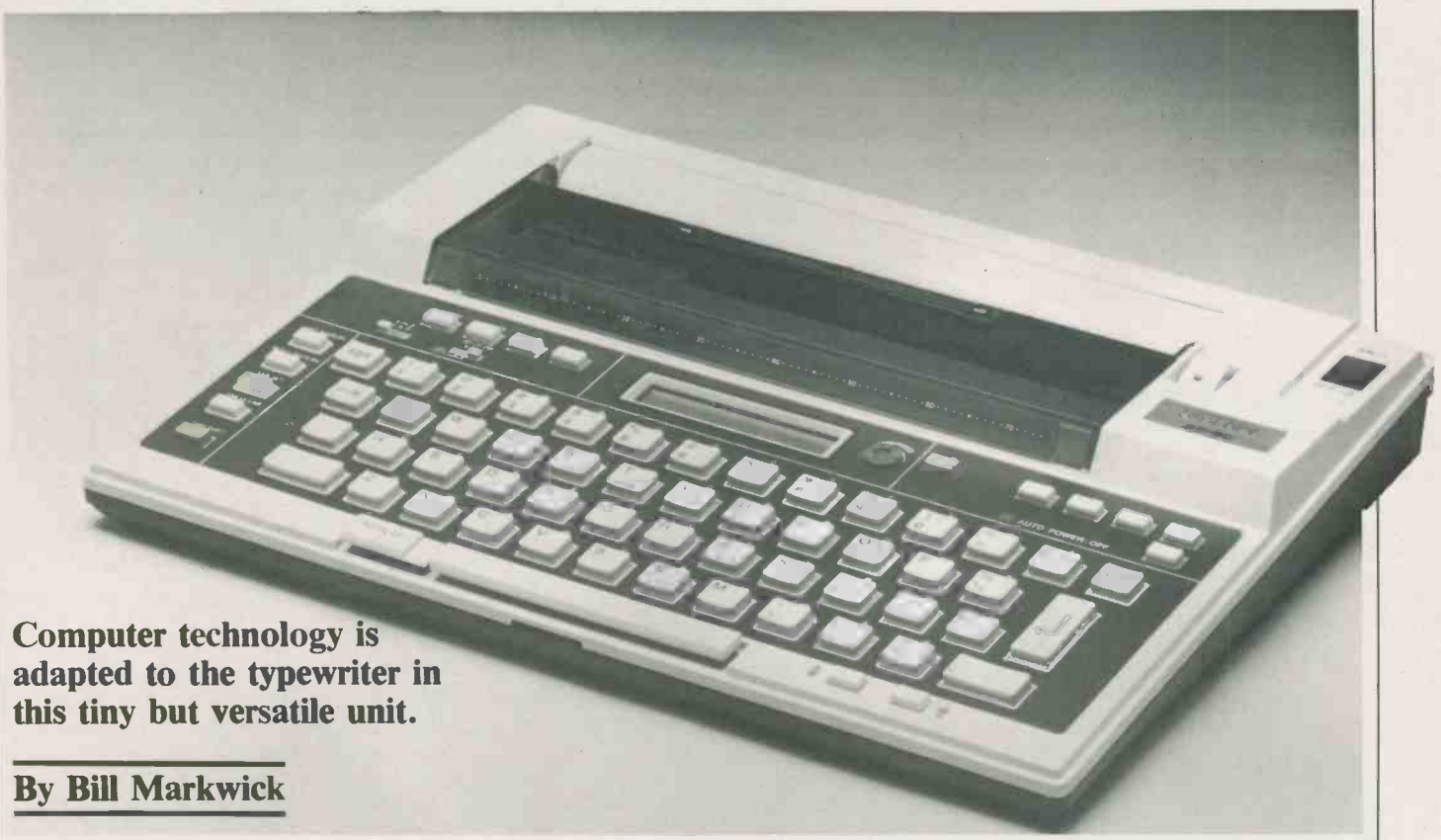
Product Review

Brother EP20 Electronic Typewriter



Computer technology is adapted to the typewriter in this tiny but versatile unit.

By Bill Markwick

THE BROTHER Company, well-known for its larger typewriters, has had the portable EP20 on the market for a bit less than one year. Its price of just under $300 aims it at the low-end portable market, but its unique features put it in a class by itself.

The first thing you'll notice about the EP20 is its tiny size (315 x 237 x 44 mm) which allows it to fit into a briefcase, and the second is that it has a full-size QWERTY keyboard that sits comfortably under the fingers for touch-typing. The keyboard has all the functions of a larger typewriter: tabs, margins, backspace and so forth, and also a second shift key which allows 44 special characters, such as foreign language accents and math symbols.

Getting acquainted

Power it up using the supplied AC adaptor, or four D-cells, and insert the paper. Press the paper-feed button, and the platen winds it in for you; there's the usual paper release lever for adjustments. You now have three options via a slide-switch: You can type directly to the paper, as you'd expect, or you can use the 16-character correction buffer before printout, or you can just use the buffer for practice typing without printing. Select the correction mode, which is the one you'll probably be using the most, and begin. As you type, the characters march past in the little window above the keyboard. If you should change your mind before typing 16 characters, there are control keys for moving the little cursor to insert and delete characters. When you've typed in the full 16, the miniature print head begins to print out the first keystrokes that you entered. Towards the end of the line the entire buffer is printed and a little motor whirs the print head back for another go. You soon get used to the fact that the keyboard is 16 characters ahead of the printer, and you'll soon be catching all your mistakes before they reach the paper.

The print head holds the little ribbon cassette. It uses a plastic film ribbon, and this film is responsible for the very high readability of the printout from the 5 x 7 matrix. Unfortunately, it can't be rewound (all the carbon is transferred to the paper) and being so tiny, the number of pages you can get from one cassette is about twelve or so.

The impression you'll be left with from typing away is the remarkable smoothness and silence of the EP20. There's only a slight ticking noise as it prints out, and only a gentle whir as the head returns to the left. Try putting in accents: type the one you want and the cursor will wait until you type the letter under the accent. Beautiful! The only drawback is that a 5 x 7 matrix can't do proper descenders, the part of the letter that pokes down below the baseline; letters such

Continued on page 76

Sord M-5 Review

Like programming video games? Hate writing assembler code? Have lots of money to throw around? Anthony DeBoer looks at the computer for you.

ONCE UPON A time, there was but one computer. It was lonely. Some time after this, however, there were many computers to keep it company, so many, in fact, that they had to be cloned to keep up with demand. Shortly after this, the Sord M-5 arrived on the scene.

Opening the box in which an M-5 arrives, you find a cute little computer, about the size of a good book (or a pair of paperbacks), nicely done up in two shades of grey and one of yellow. Examining it more closely, you find it has those eraserhead keys we've all come to know and love, a space key instead of a space bar, and an external power supply. The joysticks (the manufacturer calls them joypads) are the flat pad variety that are rather cumbersome to use. The intrepid user soon finds that the top back half of the machine's cover lifts off to reveal, yes, a cartridge slot. In other words, it looks much like your basic modern, mass-produced microcomputer.

Before we throw it in the corner with all the others of its ilk, let's give it half a chance and turn it on. It is, in fact, not until you turn it on that the M-5 shows any redeeming features at all. This machine has an extremely fast, compact BASIC that enables one to write decent video games without having to use machine code at all.

For $460, the purveyors of this machine are willing to part with not only the machine itself, but also a pair of joypads, a BASIC-G cartridge, a case, and whatever other trivia is considered needful. This is rather steep for such a small machine, but on the other hand, the price might eventually come down.

Eraserheads

The keyboard is the standard QWERTY arrangement, with one major exception: the space bar is missing. One finds, all the way to the right, just under the return key, a key marked SPACE. One does get used

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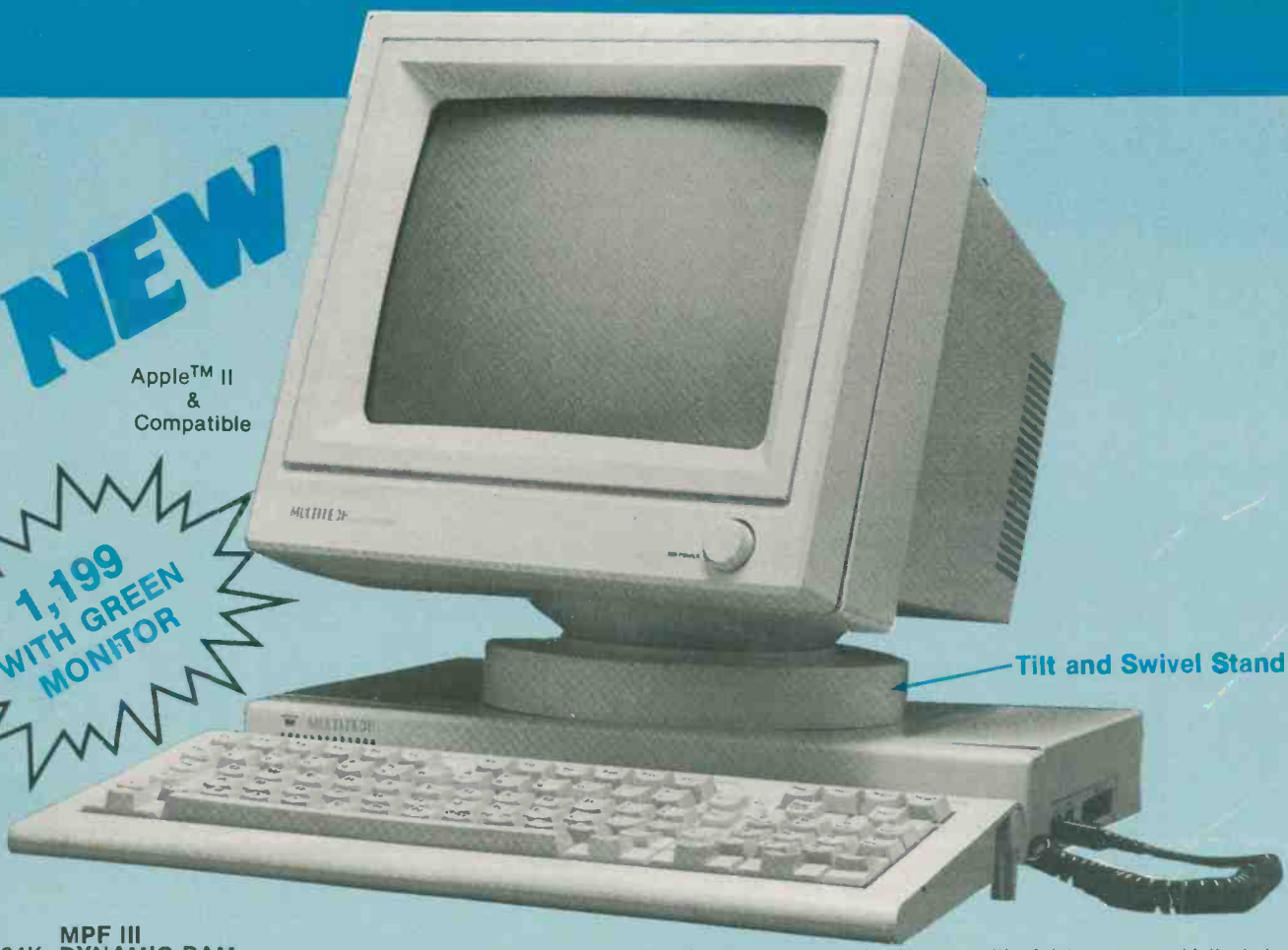

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7 INTERFACES FOR A WIDE ARRAY OF I/O DEVICES The MPF-III has a standard 7 interface port configuration that gives you the ability to interface with disk drive, printer, cassette recorder, Z-80 CP/M card, Chinese character card and monitor or television.

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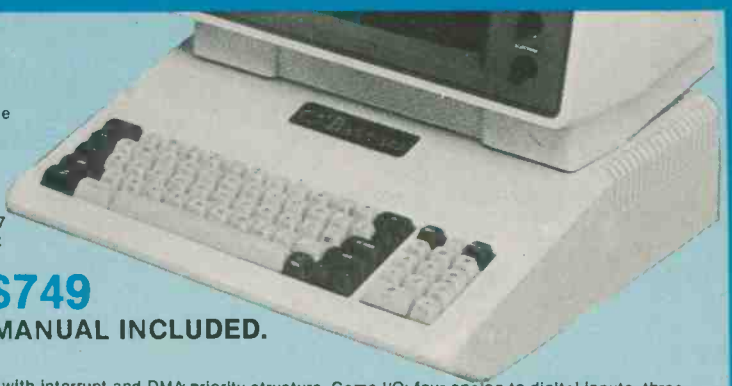

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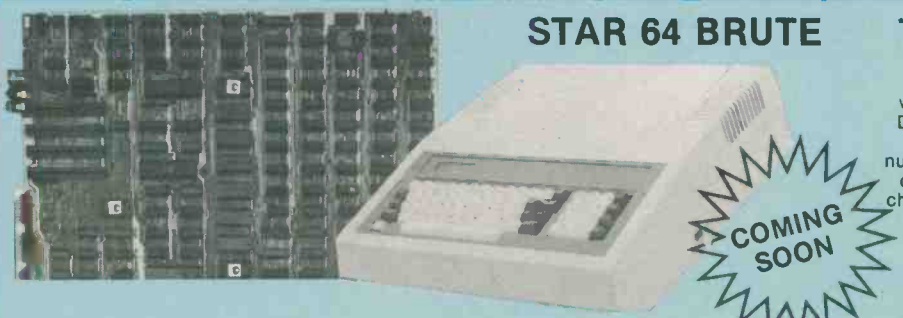

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KEYBOARD: Fully detachable keyboard, function compatibility with IBM PC keyboard ● Transmit serial 1/p ● 95 keys ● 10 Function keys ● 15 numerical keys ● 57 Alpha/num keys ● 8 cursor control ● 5 other keys.

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to this after a while, but it's a problem at first. The keys themselves are of the dark grey rubber pencil-eraser variety, each being square (or in some cases rectangular), with the lower right-hand corner cut off (except for the keys all the way on the right side, for which it's the lower left-hand corner). The keyboard is quite usable, although it's not exactly the expensive professional variety you would expect at the price given.

In addition to the usual SHIFT and CTRL keys, you get a FUNC key, which allows access to a number of keywords. FUNC-A, for example, causes the word "AUTO" to appear, just as if you had typed the whole thing yourself. There are also three modes: normal lower case, capitals, and graphics, this last allowing you to type in the graphics symbols that appear in yellow on the key caps.

Screen editing is also provided. You can move up to an offending line with the cursor arrows, delete things, insert things, and then hit return to re-enter the line. You soon discover that whenever you hit return, BASIC tries to act on the line you were on, regardless of what it consists of. This is an advantage, in that you don't need to copy over an entire line to change it, but can also be a disadvantage since it makes it impossible to splice bits of different lines together. It can also provide the occasional shock if you hit return over a line consisting of the word "NEW".

Plug-ins

With the review machine came five cartridges: two BASIC's, two games, and a spreadsheet program.

The first BASIC, BASIC-I (meaning "Introductory"), seemed to be just a simple beginner's version of the other, BASIC-G (which stands for your choice of "Graphics" or "Games"). BASIC-I is a fairly decent BASIC, as such things go, but you need BASIC-G to get at all the capabilities of the machine, which is what the proud owner of an M-5 will naturally want to do. As far as we could tell, anything you could do in BASIC-I could be done just as well, if not better, in BASIC-G.

The two games, "Tank Battalion" and "Step Up" (a Donkey Kong variant), were mildly entertaining, but not as good as they could have been with real joysticks. The FALC spreadsheet was functional if somewhat unwieldly.

Turning the machine around, you find other connectors. There are two DIN plugs, for the power and cassette interface, a 16-pin connector marked "PRINTER", two joypad connectors, and RCA jacks for sound, video, and RF. Around the corner is a mysterious little switch, marked "H" and "L", that the manual doesn't mention.

Internally, the machine has a Z-80A processor running at the nice even speed of 3.579545 MHz. Well, why use two crystals when one will do? There's nothing wrong with letting the whole machine run at the speed of its video output. Some internal firmware is included, containing standard stuff that most, if not all, cartridges would need, and at least one custom chip.

Basically BASIC

BASIC-G is a fairly powerful BASIC with lots of features. Among the most notable are sprites and interrupts. (More on these later). The BASIC is quite easy to use, especially once you get used to all the nice little features (the editing and so on).

This BASIC is of the integer-only persuasion, which is good for its intended purpose of playing games, where speed is everything, or almost everything, but decidedly bad if you want to do scientific calculations or anything involving floating-point numbers. The BASIC-G manual mentions something called BASIC-F, which might be more useful here.

On power-up, the review machine claimed to have 7067 bytes free, although the technical literature mentions that 32K of external RAM can be added. This almost-8K is certainly enough for most simple BASIC programs.

One thing that you notice almost immediately is that this BASIC doesn't like it when you concatenate two keywords. You can't say "PRINTA" or "IFB=CTHENGOTO592". You have to put in the spaces and say "PRINT A" or "IF B=C THEN GOTO592". When you list your program, it will automatically insert all appropriate spaces for readability, lowercase BASIC keywords, and uppercase variables. Program listings look nice with this computer.

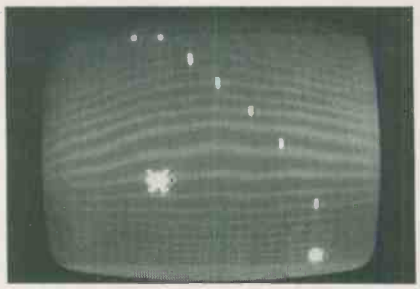
One bug with the program listings is that the LIST command, given a single line number (LIST 400, for example), will list from that line through to the end of the program. To list a single line, you have to type in LIST 400,400.

You can redefine the character fonts if you wish. The command STCHR "EF8485C5858585F5" TO &45,1 will, for example, change the capital E to a miniature ETI logo. You can have lots of fun making the screen completely unreadable by changing all the characters. This pales after a while.

You eventually discover that a string variable cannot hold more than 18 characters. One supposes that this makes life easier for the BASIC, and you usually don't need more. The more elaborate applications that might need longer strings are generally done on larger machines with real keyboards and lots of disk space anyway.

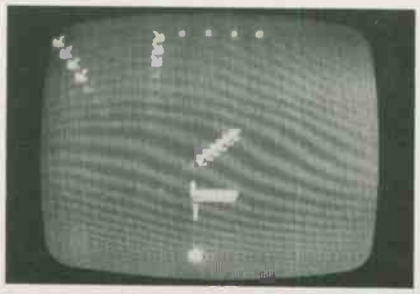
Aliens

The M-5 can generate some extremely



Sprites used in a video game. The large alien is composed of four sprites, connected using the JOINT statement.

The alien is hit, and disintegrates in a most satisfactory manner. The individual sprites are clearly visible.



respectable graphics. No less than 32 sprites reside in the dark, if somewhat miniscule, interior of a TMS-9918A video display chip, along with the other workings for high-resolution colour pictures.

The BASIC-G software provides such tricks as drawing circles, boxes, bars (solid boxes), filling in areas (although the user is warned against filling in donut-shaped areas, since this can apparently result in an infinite loop), and the like.

The sprites are, however, the main feature of the graphics section. Individual sprites are little 8 by 8 bit beasties. The STCHR function is first used to redefine a convenient character in the alternate character set. One then uses the SCOD and SCOL statements to set a sprite to a character code and to colour the sprite respectively. The LOC statement can then be used to pop the sprite up onto the screen.

Moving sprites around is easy with this BASIC. You tell the machine to MOVE a given sprite either to a certain point or in a given direction, at a given speed. The machine then moves the sprite as directed. The BASIC program can then go off and do something else. Two important advantages arise from this fact, that a BASIC program does not need to move the sprites itself. First, the program is simpler. Secondly, and more importantly, the program executes more quickly, since the heavy work is done in machine code. This is probably the single most important feature in making BASIC video games run quickly.

You can join four small sprites into one big 16 x 16 bit sprite. You can also double the size of the sprites. You can thus create really large sprites that blow up very realistically (just like the rocks in Asteroids) when hit, by having the component sprites fly off in random directions. This can keep the kids thrilled for hours.

100 GOTO 100

One of the most notable features of the M-5 is its interrupt-driven BASIC. What, you may ask, is an interrupt? Well, an interrupt is an event, either in software or hardware, that causes the computer to set aside whatever it's doing at the moment, go do something in response to that event, and then return to its original task. The M-5 provides six different interrupts: ERROR (whenever it hits a BASIC error), EVENT (a timer that can be set to provide an interrupt every second or so), ALARM (at a given time on the M-5's hours-and-minutes clock), COINC (two sprites colliding), JOY (any movement of the joypads), and KEY (any keyboard key, or the joypad fire buttons being depressed).

To use an interrupt, you give the computer a command like ON COINC GOSUB 1000, followed by COINC ON to enable the thing. Your program can then meander merrily along, happily flinging sprites across the screen at each other. Whenever two sprites manage to impale themselves on each other, the subroutine at line 1000 will be called. This routine can then sort out the debris. Add interrupt routines for EVENT (let the aliens change direction and drop bombs twice a second), JOY (so you can fly around), and KEY (so you can blaze away at them with your laser cannons), and you have a complete video game. The main part of the program simply sets everything up and then does nothing: 100 GOTO 100. Whenver anything happens, it wakes up, handles it, and goes back into its infinite loop.

Two complaints about the interrupt capabilities: First, on a COINC Interrupt, it is difficult to tell immediately exactly what hit what. There is a function, COINC(X), that tells you what, if anything, sprite X hit, but there should really be a better way. Second, there should be an interrupt on MOVE completed, such that you could then cause whatever had been moving to do something else.

These features, the sprites and the interrupts, make the BASIC ideal for programming games in. Your program provides only the control functions — what the screen should look like, what moves around and how, and what happens when things collide — and BASIC handles the real work in its machine code. The result, since so little is done at the speed (or lack thereof) of BASIC, is that games act as if they were written in asembler, without the associated programming headaches. You can write decent video games without being a programming genius.

Sounding Off

Also included in the M-5's internals is an SN76489AN sound generator chip. This can produce all kinds of weird and not so weird sounds. For example, the command PLAY "EAO6E" causes the first bar of "Lucy in the Sky with Diamonds" to be played. You can change the tempo, the volume, the type of sound, and so on. The PLAY command can be made to play harmonies, by giving it three things to play at once. Sharps, flats, triplets, octaves, dotted notes, rests, and staccato are included.

Should your musical tastes be less conventional, you can access the sound generator directly. There are four channels, three of which produce tones. The fourth produces noise (explosions, etc.). Everything needed to produce the sound effects for your video games is here.

On the other hand, a really high brow video game would be done completely without sound effects. To be technically accurate, it would have to reflect the reality that sound doesn't travel through the vacuum of space. Besides, it's really neat to be able to kill in silence.

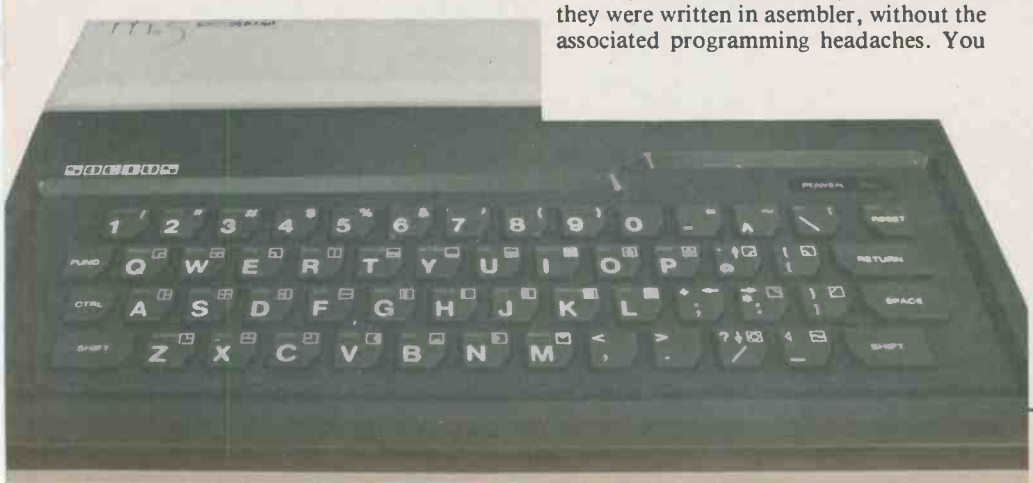
Moving Up

Beyond the games and graphics that the machine is so good at, there seems to be little room for expansion. One glaring omission that the experienced programmer will notice immediately is that there appears to be no provision for a disk interface. Such an interface might possibly be made through the cartridge connector, though. The technical manual mentions a serial interface that can be connected here, but absolutely no mention of a disk controller is made. Without disks, you can save programs only on cassette, which limits both what you can do and how eager you will be to do it. The FALC spreadsheet cartridge, for example, is rendered nearly useless by the lack of a disk.

A printer output is provided. Although we have not seen the printer that is supposed to go here, its capabilities supposedly include reproduction of graphics from the screen.

Conclusions

The one thing that the M-5 does exceptionally well is to program games in BASIC. Its capabilities here make it an extremely worthwhile machine, if you're willing to pay the price. If, on the other hand, you're into serious data processing, and you want to save your programs on a disk at the end of the day, $460 could go a long ways toward buying a clone. The Sord M-5 is a computer for people who want a cute little machine to have lots of fun with. ETI



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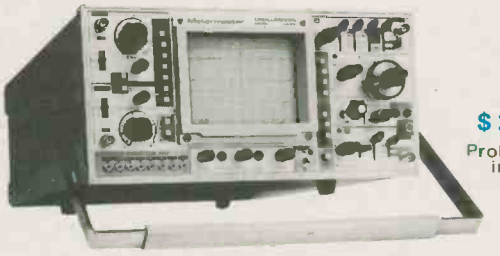

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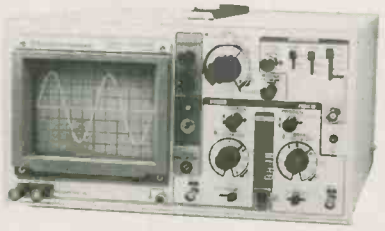

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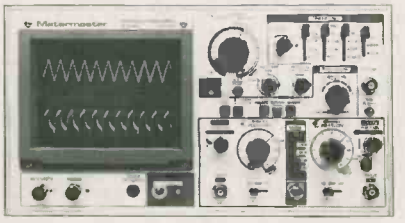

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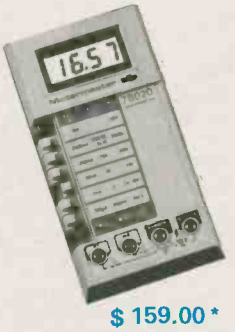

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Designer's Notebook

Who needs to bother winding miles of wire onto a bobbin when high voltages can be generated with some inverters and a handful of diodes and capacitors? Rory Holmes shows how it's done.

IN THIS MONTH'S Designer's Notebook we shall be looking at a variety of interesting voltage multiplier circuits that can be built using ordinary CMOS gates and common-or-garden 1N4148 signal diodes. DC-to-DC converters for a number of applications became possible by simply driving voltage multiplier chains with an AC clock signal, again implemented with CMOS gates. The initial supply voltage can be multiplied both positively and negatively to give, for example, a split rail op-amp supply from a standard 5 V TTI supply. Negative and positive voltage references used in analogue-to-digital conversion and other signal conditioning circuits can also be generated, as can general purpose high voltage bias rails.

By using a novel 'chain' of inverter gates to independently drive each node of a diode-capacitor ladder, some rather unique circuits result.

Chain Reaction

First, let's look at the usual multiplier circuits shown in Fig. 1a. These are normally used with rectifier-type diodes, low frequency AC inputs (sine waves) from transformers, and electrolytic smoothing capacitors. At first glance there seems to be no common pattern between them, and little similarity to the multiplier chains used in TVs and other high voltage power supplies.

However, in all cases the AC input waveform is fed via capacitors to appear at those circuit junctions marked 'A' in Fig. 1a, while those junctions marked 'D' will maintain a steady DC potential relative to the ground point. We can thus redraw the circuits by connecting up the capacitors in two series chains (assuming their values are altered accordingly) and still preserve the same circuit action. One chain carries the AC signal, while the other accumulates the DC voltage shifts. Figure 1b shows these redrawn circuits, which now appear as extensions of the standard ladder network. The doubler, of course, remains in its original form since it only has one set of capacitors.

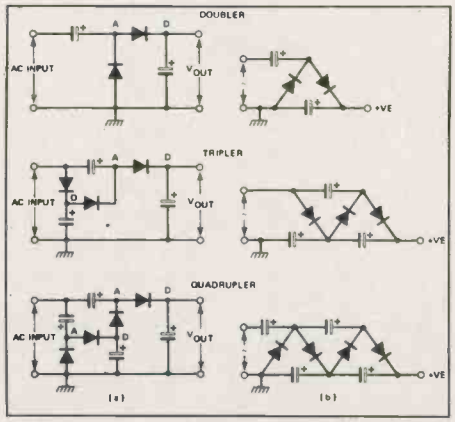

Fig. 1. Standard voltage multiplier circuits.

Starting with the doubler, we can build a very simple DC-to-DC converter in one CMOS gate as shown in Fig. 2. The Schmitt inverter gate is configured as a square wave oscillator running at about 100 kHz — the multiplier capacitors C2 and C3 will therefore have a low impedance at this frequency, which is also within the switching speed capability of the 1N4148s. For this reason, rectifier diodes such as the 1N4001, which have much slower switching speeds, cannot be used in these circuits.

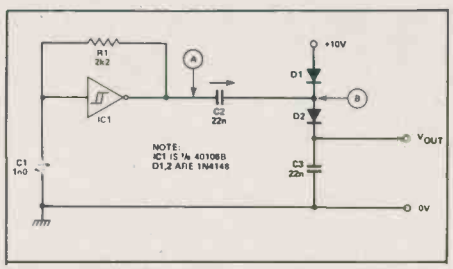

Fig. 2. A CMOS doubler circuit.

The oscillator output at point 'A' will therefore be switching between the 0 V and 10 V supply levels. When the output is at logic low, capacitor C2 will charge up positively (in the direction of the arrow) via D1. D2 is reverse biased and so effectively out of circuit. When point 'A' goes high to +10 V, the positive end of C2 at 'B' will be raised to +20 V. This reverse biases D1 and allows C3 to charge up through D2. The voltage on C3 is thus maintained at about +20 V less two diode drops (i.e., at 18V6) as the cycle repeats itself. This is known as a diode charge pump.

Building An Extension

This principle can be extended using exactly the same chainlike structure as illustrated in the positive and negative multipliers of Fig. 3. In both cases the inverter gates are cascaded and driven from a square wave oscillator at around 100 kHz. Each inverter gate contributes its own output current (a maximum of around 2 mA) via the capacitors into the multiplier chain; because of this, the available output current will always be the same no matter how many times the voltage is multiplied (two times in this case).

The positive multiplier output of Fig. 3a includes the initial positive supply potential, and so generates three times this voltage less the three diode drops of 0V7 each. The negative multiplier of Fig. 3b, on the other hand, is referenced to the round rail, given -2 times the voltage (again less the diode drops).

As mentioned before, all the diodes are 1N4148s; the multiplier capacitors C2-4 are all non-critical and may be anything from 10nF to 100nF. C4 may be

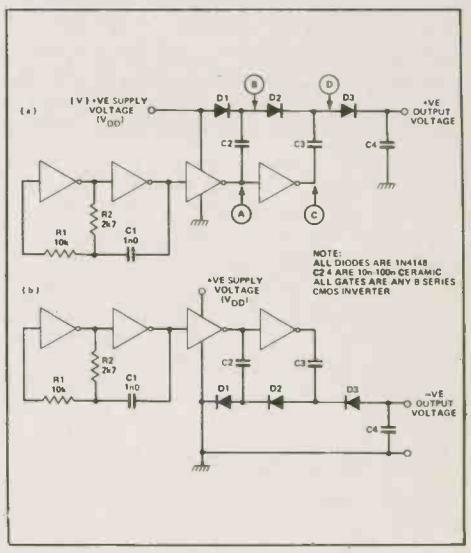

Fig. 3a. A two-stage positive voltage multiplier (multiplies by +3). b. A two-stage negative voltage multiplier (multiplies by -2).

a polarised tantalum capacitor of a few microfarads to provide further smoothing. Any type of CMOS gate which can be connected as an inverter could be used, as well as all the standard inverters, though the 4049B hex inverter offers slightly more output current. It's also possible to use the 74C series types such as the 74C04 or 74C14. Pin-outs for these chips are given in Fig. 4 and not on any of the circuit diagrams, since they differ from type to type.

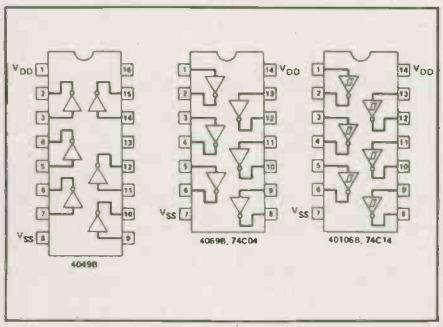

Fig. 4. Pin-outs for the standard hex inverter packages which may be used in the circuits given in this article.

The oscillator implementation and its frequency are also non-critical; you could experiment with anything from several kilohertz to several hundred kilohertz. Remember, though, that as the frequency decreases, the impedance for a given capacitor value will increase, so increasing the impedance of the multiplier output.

Table 1 lists out the different voltages you can expect from different chain lengths and supply voltages, based on the circuits of Fig. 3. The number of stages refers to the number of capacitors that are actively driven from inverter outputs. Using this table it becomes very easy to design a generator for any voltage requirement; the output voltage could be clamped to the exact level required using an ordinary zener diode regulator. But remember there isn't much current available, and as the output is loaded, the voltage will decrease due to the supply impedance. The higher supply voltages will generally provide more output current.

As an example, Fig. 5 shows a longer multiplier designed to give 110 V and built using only one hex inverter IC of the Schmitt trigger type (40106B). Using ceramic capacitors, this circuit could be built to a very small size.

Operating Principles

How do these multipliers actually work — the doubler circuit of Fig. 2 is straightforward, but what about the longer types? Voltage multiplier explanations are usually notoriously difficult to follow, let alone understand, and we shall therefore adopt a more graphic approach. If we measure the voltages at the lettered points in Fig. 3a and plot them against time, we get the waveforms shown in Fig. 6. These waveforms have been idealized for clarity — no account has been taken of the voltage

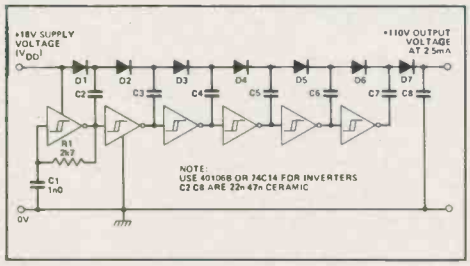

Fig. 5. A 110 V supply using one hex inverter IC.

drops due to the diodes in the circuit. From these it can be seen that the voltage across C2 (the difference between the waveforms A and B) is a constant 1V, where V is the supply voltage, while that across capacitor C3 (between points C and D) is 2V. We also know that the final output voltage across C4 is 3V. Moving down the chain towards the final output, then, we find that each capacitor maintains a DC charge which increases in integer multiples of the supply voltage. How so?

Consider capacitor C2 in Fig. 3a. At power-on it is discharged, but when point A switches low, it charges up to the supply voltage via D1 (neglecting diode drops). Point B is therefore at supply voltage. When point A switches high, then, point B is raised to twice the supply voltage. Point C must be at zero volts since it is the inverse of point A, so current flows via D2 (which is now forward biased) from point B into C3 until C3 is charged up to the voltage at B (i.e., twice supply). The next clock pulse takes point A low, so point B is at supply less the voltage that has leaked into C3, and C2 is topped up via D1 again. Meanwhile point C has switched to supply voltage, so point D is now at three times supply and D2 is reverse biased, preventing C3 from discharging back into C2. C3 can discharge into C4 via D3, however, so the the voltage across C4 is maintained at three times supply.

It should now be clear that no matter what the length of the multiplier, each capacitor in the chain maintains a steady

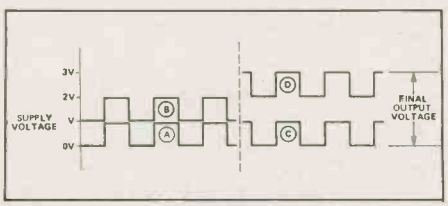

Fig. 6. Waveforms for a two-stage positive multiplier (idealized for clarity with diode drops ignored).

DC charge which equals that on the previous one plus the supply voltage, and each capacitor tops up the next one in the chain on each alternate half-cycle. Figure 7a, for example, shows five stages of a multiplier chain driven by a square wave signal, while Figs. 7b and 7c use a waveform to represent the voltage levels at each capacitor node for each half of the cycle. The direction and voltage of the DC charges on each capacitor is also shown — remember these are constant as shown by the graph of Fig. 6.

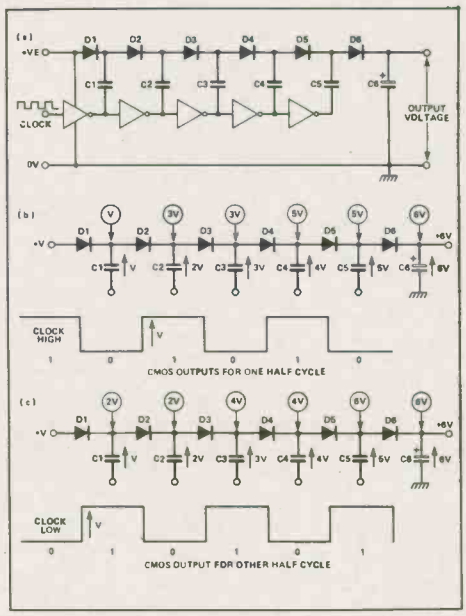

Fig. 7. How multiplier voltages accumulate down the chain.

Looking at C1 and C2 in Fig. 7b we can see that the positive (top) end of C1 will be at V volts (V is the supply voltage) while the positive end of C2 is at 3V volts (2V of its own, raised up a further V volts at the CMOS output). Diode D2 will therefore be reversed biased and effectively out of circuit. For similar reasons C3 will be at 3V volts (less that which has leaked away) and can therefore be charged up via D3 from C2. On the other half cycle in Fig. 7c, however, C3 will be raised up to 4V volts by the CMOS output, while C2 returns to 2V. So this time D3 is reverse biased and will not conduct. C1 is now raised to 2V and can thus charge C2 via D2. The conducting and non-conducting parts of the circuit for each half cycle are shown in Fig. 8, which gives a much clearer illustration of the diode charge pump action.

The Appliance of Science

Figure 9 shows the circuit of a split-rail power supply that generates ± 10V from a 5V supply input. It could be used to power

TABLE 1

OUTPUT POLARITY / NO. OF STAGES	CMOS SUPPLY VOLTAGE 5V +	5V −	10V +	10V −	18V +	18V −
1	8.6	3.6	18.6	8.6	34.6	16.6
2	12.9	7.9	27.9	17.9	51.9	33.9
3	17.2	12.2	37.2	27.2	69.2	51.2
4	21.5	16.5	46.5	36.5	86.5	68.5
5	25.8	20.8	55.8	45.8	103.8	85.8
6	30.1	25.1	65.1	55.1	121.1	103.1
7	34.4	29.4	74.4	64.4	138.4	120.4

Table relating supply voltage and number of stages to the (unloaded) output voltage, for positive and negative output multipliers based on the circuits of Figs. 3a and 3b and allowing 0V7 for each diode drop.

low current op-amp circuitry and other CMOS circuits from a standard TTL power supply. Again, only one hex inverter pack is required and we recommend that the 4049B is used with its slightly higher output current capability. The circuit takes advantage of the three cascaded inverters that drive the positive multiplier chain, by also using them to form a 'ring-of-three' oscillator. The multiplier chain is therefore self-oscillating!

The positive side in turn drives the negative chain of IC1d,e and f. From Table 1 we would expect the available output voltages to be +17V2 and -12V2, which are then clamped to the ±10 V levels by zeners ZD1 and ZD2. Series limiting resistors for the zener diodes are unnecessary due to the current-limited output of the multiplier.

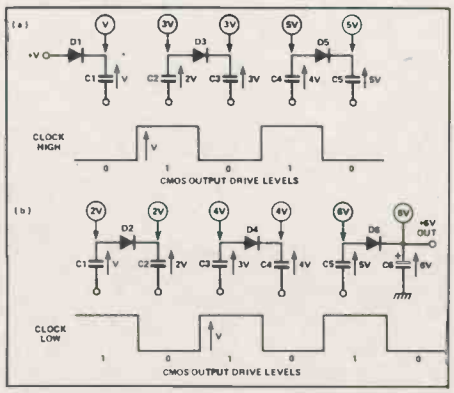

Fig. 8. Charging paths for an extended multiplier chain. The diagrams only show those diodes which are forward biased (conducting) during alternate half cycles of the drive waveform.

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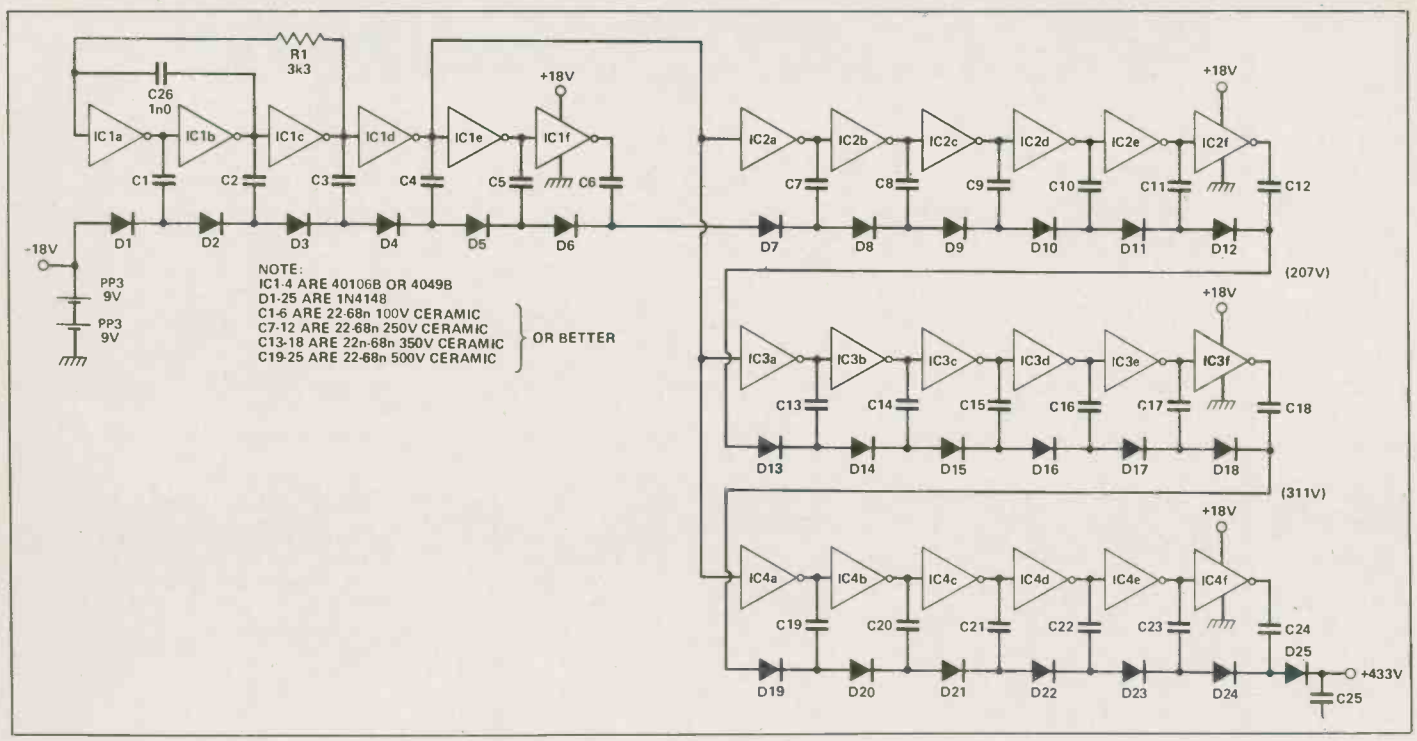

Fig. 11. A 433 V generator using a 24-stage positive multiplier and an 18 V supply.

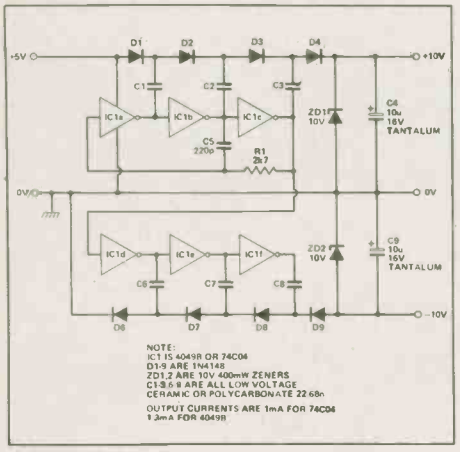

Fig. 9. A split-rail supply using one hex inverter package.

Figure 10 shows a variation on the previous circuit's positive multiplier section, using all six inverters to provide more output current at ± 10 V. To achieve higher output currents, simply parallel the CMOS gates that drive the capacitor chain; the available currents will add together due to the nature of the CMOS output FETs. This technique is useful for CMOS operating at low supply voltages.

Figure 11 gives the circuit for a 24-stage positive multiplier to generate a high-voltage, low-current supply. This could be used for a solid state 'megger' (high resistance meter and insulation tester). The 24 stages can be achieved using only four hex inverter packs, and will provide 433 V from an 18 V supply. This circuit illustrates the fact that the inverters may be wired up in any fashion so long as alternate capacitors receive opposite phases of the square wave.

The circuit will deliver at least 2 mA at 430 V! — not lethal but pretty painful, so be careful. We suggest the addition of a 1M0 series resistor in the positive supply lead to limit the available current to about 40 *u*A. A 100 *u*A meter would provide suitable megaohm readings.

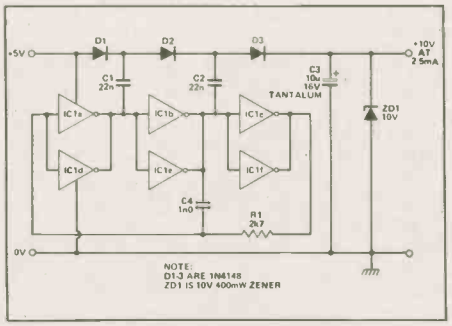

Fig. 10. Paralleling inverter stages to give a higher current supply.

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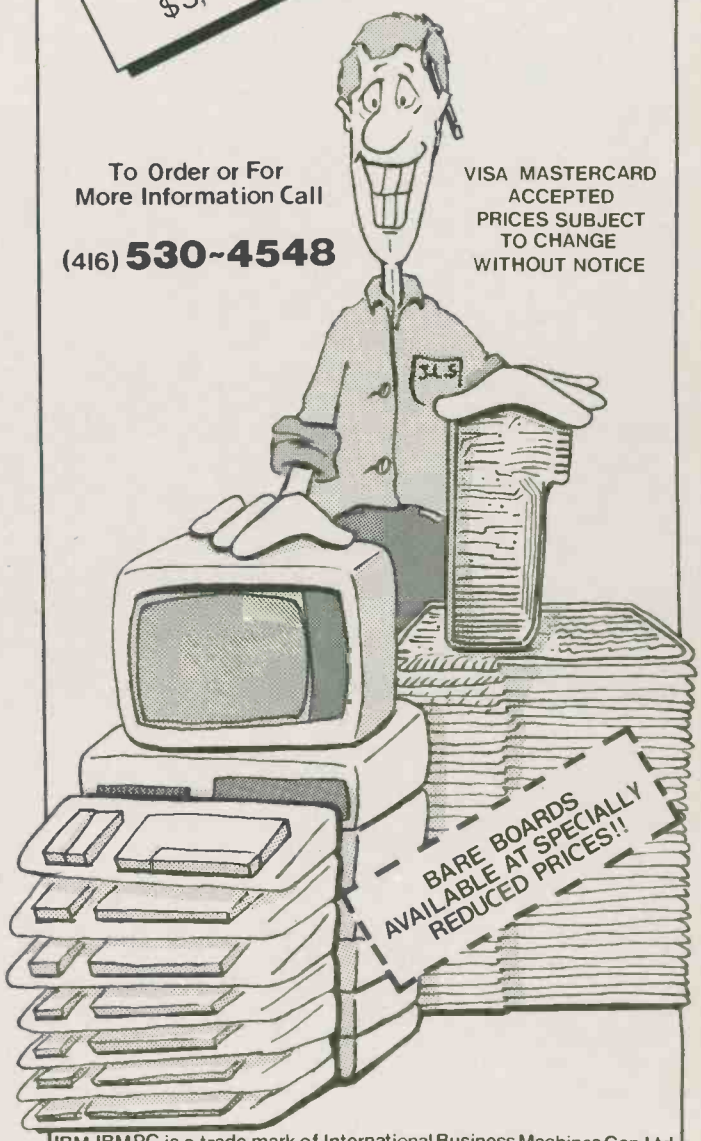

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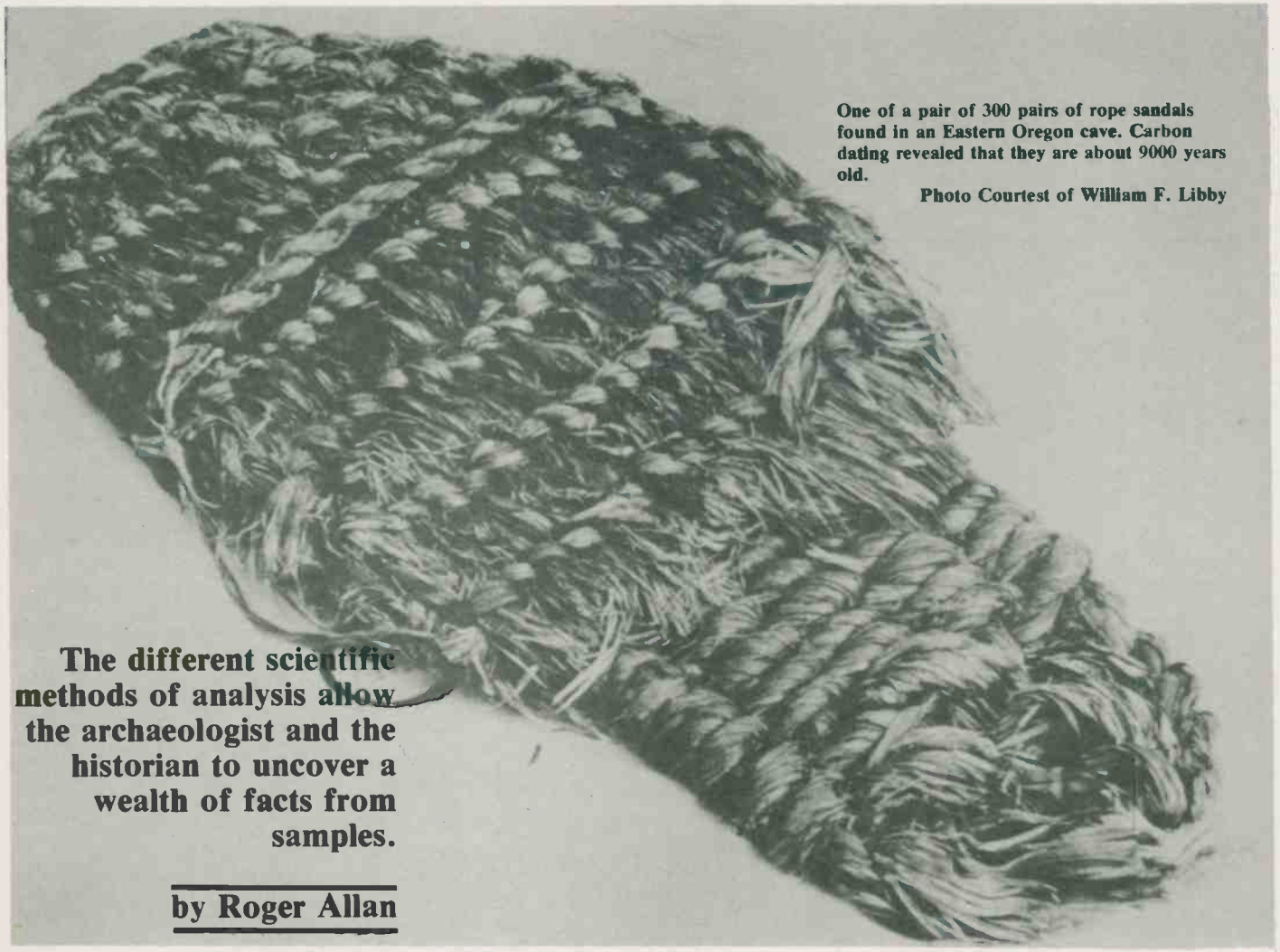
Nuclear Applications in Archaeology



One of a pair of 300 pairs of rope sandals found in an Eastern Oregon cave. Carbon dating revealed that they are about 9000 years old.

Photo Courtest of William F. Libby

The different scientific methods of analysis allow the archaeologist and the historian to uncover a wealth of facts from samples.

by Roger Allan

CUSTOMARILY, LAYMEN'S knowledge of the application of nuclear techniques to archaeology can be summed up with a single method: the dating process via Carbon-14. It is well known, earning the Nobel Prize in 1960, for its discoverer, Willard F. Libby. Its ripple effect on the study of Archaeology is incomparable, oftentimes related to the discovery of the periodicity of elements in the field of chemistry. But it is only one of a number of such nuclear applications, and while being the first, foremost and most generally useful of such techniques, cannot answer a number of questions about artifacts which Archaeologists need to know. It has its drawbacks. Its primary use is in the dating of wood and vegetable matter, with increasing difficulty in use for the dating of bone, textiles, ivory and iron (iron can in some circumstances be dated using this method because iron from very old samples contains carbon derived from wood charcoal).

A quick overview of the theory and process: The earth is being constantly bombarded with cosmic radiation, one form of which is neutrons. These react with nitrogen in the upper atmosphere to produce carbon-14. The flux of such neutron bombardment has been constant throughout history, up until about 1900 when man commenced to disturb the natural environment and unbalanced the carbon-14 constancy of uptake. This carbon-14 reacts in the atmosphere to form carbon dioxide. The carbon dioxide is taken up by all forms of vegetation, and hence into all life forms that eat vegetation. The amount of uptake ceases at the conclusion of the animal or plant's life, resulting in a set amount of carbon-14 in the artifact. Carbon-14 has a half life of 5730 years. By taking a sample of the artifact, one can measure the amount of remaining carbon-14, and hence date the artifact. (The word "artifact" properly means a man-made object, but is often used to mean any object under archaeological examination.)

There are a number of ways of actually doing the dating process. Libby initially used a process called a "screen wall" counter, basically a form of geiger

counter. There are two major processes used today, the gas proportional counter and the liquid scintillation counter. The decision as to which process to use is dependent largely on the size of the sample to be tested; the gas proportional counter can use small samples while the liquid scintillation counter can handle large samples, but not vice versa.

Gas Proportional

In the gas proportional process, a fine wire, charged to a high voltage, is strung down the center of a metal tube. The sample is introduced in the form of a gas produced from the carbon in the sample. When carbon-14 decays, the radiation it emits produces free electrons in the gas, which are collected by the wire where an electrical impulse is generated. This is counted and the number of impulses, expressed as disintegrations per minute (dpm). A fresh sample, that is, one that has recently died, will have a dpm rate of 15, one 5730 years old a dpm of 7.5 and so on. It is accurate up to about 50,000 years.

The difficulty with this system is the amount of background radiation affecting the counter while the sample is being tested. The overcome this, an anticoincidence counter is arranged such that if it registers a disintegration at the same time as the counter registers a disintegration, the disintegration is automatically discounted. This is because the disintegration registered by both counters could only have occurred by some external radiation source, and not from the sample being tested. The disadvantage to this system is that it must be made quite large to accommodate a large sample, since the gas is of a relatively low density. when the counter becomes large, the background rate goes up, the shielding and anticoincidence counter become still larger, and the advantages are generally outweighed by the disadvantage of size.

Liquid Scintillation

A second method to test for carbon-14 is the liquid scintillation counter system. The carbon in the sample is converted into an organic liquid such as benzene. Other chemicals, added to the benzene, emit flashes of light (scintillations) when radiation passes through them. The solution is placed in a glass bottle and monitored with photomultipliers which convert the scintillations into electrical impulses which can be counted. The difficulty with this system is that low backgrounds cannot be obtained because of the minimum amount of electrical noise in this type of system. However, for large samples, this disadvantage is overcome because the liquid is relatively dense.

There are a number of other similar

A terra-cotta statuette originally thought to be of Etruscan origin between 510 and 490 BC. Thermoluminescence dating disclosed that the statue was a fake of modern origin. Photos courtesy of Stuart Fleming Research Laboratory for Archaeology.

such processes, involving the half-lives of radioactive potassium-argon-40 (used to date *Zinjanthropus,* the "human" skull found in 1959 at Olduvai Gorge by Dr. Leakey), rubidiumstrontium, lead-204 and some twenty others. Each has an especial, limited use and a writer on this subject quickly gets into the grey area between Archaeology and the dating of geological formations.

One of the most common artifacts found at an archaeological dig are potsherds, the remnants of broken pottery. A method for dating them, originally derived at Oxford University, involves thermoluminescence.

Thermoluminescence

The method itself is based on the principle that radiation distorts the electronic structure of insulating materials and so stores energy within the material. This process may be likened to the stretching of a spring. When the material is heated to a certain temperature, the forces holding the electrons "out of place" begin to "loosen", the structure relaxes as a stretched spring would and the stored energy is released. The released energy is emitted in the form of light. The radiation that produces this deformation comes mainly from naturally occurring radioactive materials like uranium, thorium and potassium which are present in the pottery in low concentrations. The soil in which the pottery was buried also contains naturally radioactive material which affects the pottery in the same way. Cosmic radiation also contributes to the radiation damage. As time passes, the pottery absorbs more and more radiation, starting from the last time the pottery released its stored energy, that is, when it was annealed (baked or fired).

By carefully powdering a sample, taking care not to heat it (so that the thermoluminescence is not inadvertantly released), and then gently heating it in a precisely controlled oven, the release of light can be detected by photomultipliers and recorded. Then the examiner must deduct the amount of thermoluminescnce expected to have been absorbed by the sample from the surrounding soil since the last time it was annealed, and further, deduct the amount of cosmic ray uptake. When all the arithmetic has been done, then a fairly accurate reading can be obtained as to the sample's age. Not only potsherds, but ceramic and terra-cotta statuary can be analyzed this way, resulting, on occasion, in the finding of forgeries. Its major disadvantage is that it is destructive.

A second method utilizing radiation damage was developed in the early Sixties and is called fission-track studies.

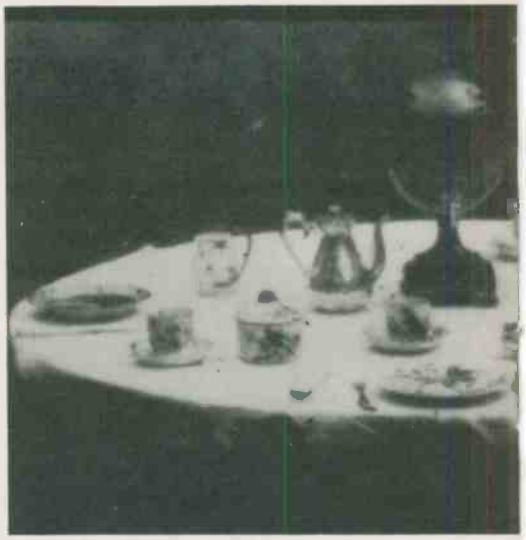
Tracking Uranium

Essentially, uranium-238 occasionally splits into two parts, similar to the reaction in a nuclear reactor. It does not, however, happen very often; only 84 spontaneous emissions occur per million atoms per million years.

When the fission occurs in a piece of pottery, the two parts of the split atom leave a tiny trail of damage in the crystal structure of the material. If this happens close to the surface of the specimen, the trail will penetrate the surface and can be detected.

The detection process consists of taking a tiny slice of the specimen (as small as a square millimeter) which is then cleaned and polished. An acidic solution is then applied to the surface. This attacks the specimen and eats away at its surface. The tracks of the fission become enlarged to such an extent that they can then be observed with an ordinary microscope. By counting these holes, or etch pits, in a known area, one obtains the number of fissions that occurred in that area since the pottery was annealed.

The second step in the dating process is to determine how much uranium is present in the area where the tracks were counted. By irradiating the specimen with a known quantity of neutrons, one can cause the uranium-235 atoms to fission.



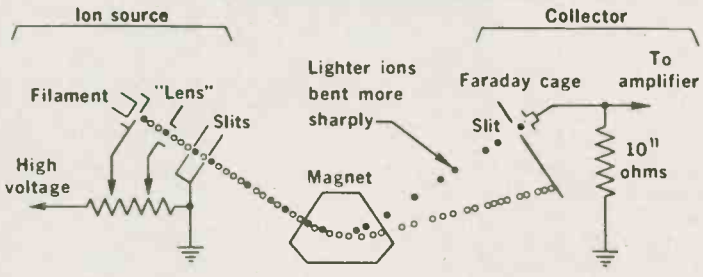
Because the uranium-235 is customarily considered to be in a fixed proportion to the uranium-235 (though see OKLO, ETI, July, 1983), the number of new fission tracks in the area previously observed is a measure of the amount of uranium-238 in that area and may be easily calculated.

The accuracy of this method is dependent on the amount of uranium found in the clay from which the pottery was made, customarily 1 part per million. Such a concentration permits the determination of ages as recent as 100,000 years with an uncertainty of 10%. However, as the concentration of uranium goes up to, say, 100 parts per million, ages as recent as 1,000 years can be determined. With a concentration of 1%, ages as recent as 10 years can be determined. Further, glass, which has had uranium deliberately added as a coloring agent, can have its age determined by this method.

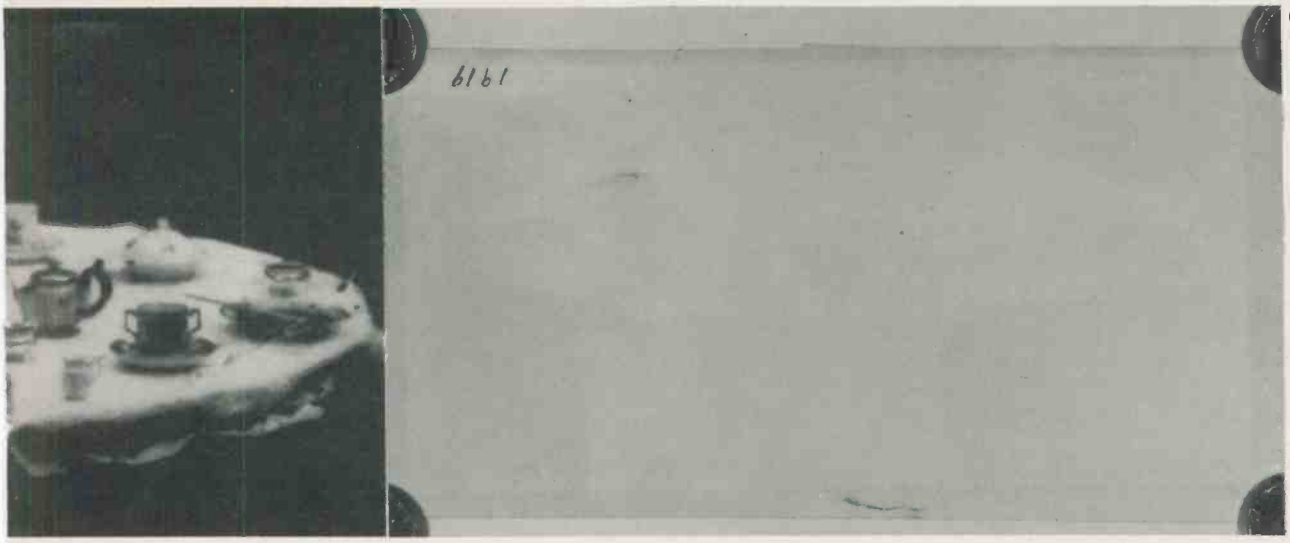
Fingerprints and Neutrons

Fingerprinting, that is, the determination of trace elements (less than 0.01%), is a non-destructive way of measuring very small quantities of elements such that similarities and differences can be determined, which in turn permit a better understanding of archaeological economics.

While trace elements can be determined by ordinary chemical methods large samples would be required that might ruin valuable objects. The main form of fingerprinting, the neutron activation process (NAA), has the great advantage that it is non-destructive. Analysis by means of this method (outlined in more detail in ART, ETI, July, 1983) consists of bombarding the atoms of a element in a sample with neutrons in a reactor. This causes some of the atoms to absorb a neutron. In most cases, this will result in some fraction of these atoms becoming radioactive.



Essential parts of a mass spectrometer. Atoms to be analyzed are changed to ions in the source. Then the ions are accelerated by high voltage, deflected in a magnetic field according to their mass, and the intensity of the separated beams is measured in the collector.



(Upper photo) A faded photographic plate by photo pioneer William Henry Talbot. (Far left) Using the neutron activation process, the original photo scene is restored. Both photos courtesy of the Smithsonian Institution.

For example, sodium: when bombarded by slow neutrons, the sodium absorbs a neutron to become a sodium nucleus with 12 rather than 11 neutrons (sodium-24). This decays to a magnesium atom, emitting a beta particle and energy in the form of gamma rays. the number and energy of the gamma rays is unique for the decay of sodium-24 and thus constitutes a kind of signature. Further, measuring the half-life of sodium-24 is also a means of identification. In other words, by this method one can determine that sodium is present by later observing the energies of gamma rays from sodium-24 and can determine how much is present by measuring how many such gamma rays are emitted. The sensitivity of this process is very good, with gold being capable of being detected in quantities as small as a millionth of one millionth of a gram (one picogram).

An example of the use of the NAA process involved determining the source of material for Indian arrowheads made of obsidian. At the University of Michigan, Adon A. Gordus was able to pinpoint the material used by the Hopewell Indians, a group that inhabited what is now Ohio, Illinois, Michigan and Wisconsin during the period 300 BC to 500 AD.

The puzzle was that while obsidian arrowheads were found in Hopewell burial mounds, the closest sources of that material are in the Western U.S., Mexico and Alaska.

Using NAA, Gordus analysed the arrowheads and the obsidian from all the North American sources for two elements, sodium and manganese. He found that only three sources contained these two elements in concentrations similar to those of the arrowheads. He then used NAA to check for 15 other elements in these sources and found that only the composition of obsidian from one source, Obsidian Cliff in Wyoming's Yellowstone National Park, corresponded to the composition of the arrowheads. Archaeologically, this means that there was some sort of trade route between the two areas.

A second example of NAA is more recent. Early photographic plates tend to become blanched with age, such that the picture can no longer be seen. However, by irridating the plate with slow neutrons, and then placing a photographic film in contact with the plate, the gamma decay will effect the modern photographic plate, permitting an image of the previously "unseeable" picture to become apparent.

Carbon-14 dating is only one of a number of nuclear applications which answer questions about archaeological finds.

One specific example of this is the 19th century picture currently in the Smithsonian Institution, taken by the English antiquarian, physicist and pioneer in optics and photography, William Henry Fox Talbot. Talbot's plate is now blank, but under NAA reveals the original picture, a table setting.

Sparks and Spectrums

A second form of fingerprinting involves spark source mass spectrometry. In this method, a sample from an artifact is subjected to a very hot, electrically produced spark. A small part of the specimen, usually metal, is vaporized and the individual atoms become electrically charged or ionized. This process takes place at one end of a curved metal tube that has been evacuated to a low pressure. The metallic ions are then accelerated in an electrical field of about 1000-2000 volts in such a way that a narrow beam of ions travel down the tube.

At the point where the tube bends, there is a magnetic field that bends the path of the ions. The important point is that the amount that the path of an ion bends is determined in part by its mass. The arrangement produces a separation of ions into numerous beams according to their mass. The beams eventually strike a photographic plate that upon being developed, shows a series of lines corresponding in position to the masses of the ions which struck the plate. The intensity or blackness of each line is a function of the concentration of the element at that mass number. By comparing such photographs from different sources, and different finished products, the archaeologist can determine ancient trade patterns, eg. equating a coin minted in Rome with a gold mine in Spain, for instance.

Lead Isotopes

A third type of fingerprinting used by archaeologists involves lead isotope ratios. The metal lead has been used by man in one form or another for thousands of years. It is obviously present in things made mainly of lead, but is also a minor constituent of many alloys, including bronze and brass. In addition, glazes containing lead have been used in pottery, and glass sometimes is colored by having lead compounds added to it.

The fingerprint for lead is the relative amounts of the four stable (non-radioactive) isotopes of lead found in nature: lead-204, -206, -207 and -208. The ratios of the lead isotopes in any given lead ore deposit were initially determined by the timing of the geological event that took place when the deposit was being formed.

The relative amounts of the isotopes in a sample can be determined with a mass

spectrometer similar to the one detailed above. However, only the four isotopes of lead and their ratios are of interest. The four separated beams which are obtained bombard the metal plate one at a time. By slightly varying the beam accelerating voltage to focus each mass on the plate in succession, the number of ions of each mass striking the plate can be measured with a device called an electrometer. Accuracy is within 1%.

The main disadvantage in studying lead isotopes and their ratios is that these ratios are not unique to any given lead mine. However, the method can be used to prove that the lead in an object did *not* come from a particular place. When this information is used in conjunction with other information (trace element patterns, perhaps) it can be quite useful in establishing the ultimate source of material, and indirectly, the trading habits of the peoples who created them. For example, Swiss workers were able to trace the sources of lead used in Roman water piping to various ancient lead mines in England, Spain and Central Europe.

Beta Backscatter

Energetic electrons, better known as beta rays, are another tool used in archaeological studies. Emitted by many radioactive atoms, beta rays striking a surface are either absorbed or penetrated a little way and are bounced back (backscattered). Elements having a higher atomic number are more efficient backscatterers.

This process has been used as a non-destructive means of measuring the amount of lead in leaded glass and in pottery that has been finished with a lead glaze. Essentially, a beta ray emitting radioisotope is allowed to shine on the surface being analyzed and a geiger counter measures the beta rays that are reflected. The more lead there is in the surface, the more scattered radiation is measured by the counter. An example of its use was in the study of the famous English crystal glass known as Ravenscroft, produced towards the end of the 17th century. Analysis of pieces from that time and from a century later showed that the amount of lead used was increased as time when on.

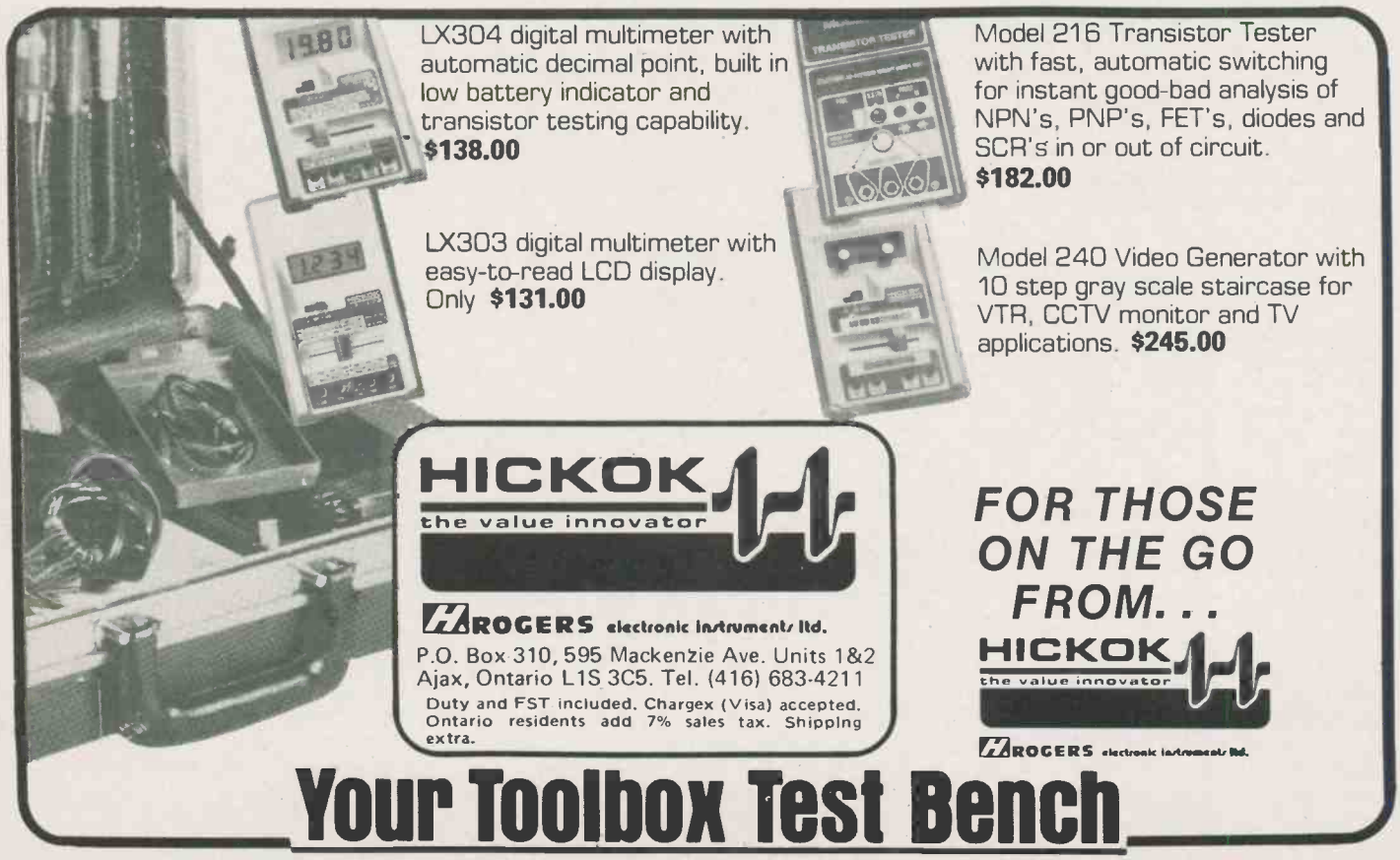
One of the more interesting applications of nuclear processes to the study of archaeology involves the Mossbauer Effect, first determined in the late 1950s by Rudolf Mossbauer. He then discovered the key to a method in which the nuclear properties of certain elements can be affected by their chemical and physical circumstances. While relatively few elements can be studied by this means, iron happens to be the easiest, which is archaeologically fortunate, since iron compounds, especially oxides, have been used to add color to pottery for thousands of years.

Resonance Absorption

In the case of iron, one begins with a specially prepared radioactive source containing cobalt-57. The radiation from this source is allowed to pass through a thin layer of the sample and then falls upon a detector where the amount of radiation is measured. While part of any radiation is absorbed when passing through any material, some of the radiation from the cobalt-57 source is very special, archaeologically.

This special radiation, which consists of gamma rays with an energy of about 14 keV, tends to be preferentially absorbed by the nuclei of iron-57 atoms because it is exactly the right energy; in other words, the iron-57 is resonance-absorptive. The exactness is important, as the slightest alteration will destroy the resonance absorption.

Utilizing the Mossbauer effect, the scientist moves the radioactive source at various velocities back and forth and measures the radioactivity reaching the detector at each one. If the iron in the sample is at a particular state, dependent upon its heat when being annealed, a state



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which is different from the iron atoms in the decaying source, then a certain velocity will exactly compensate for the difference and restore the resonance absorption.

A graph showing the measured radioactivity at each of many velocities is called a Mossbauer effect spectrum, and will show one or more dips in it depending on how many and what kinds of iron compounds are present.

An example of its use is in the study of medieval English pottery. Researchers found that they could estimate the firing temperature of the pottery as well as tell the difference between pottery that was similar in appearance but from different sources. It is believed that this technique will eventually permit archaeologists to reconstruct some of the ancient practices such that they will know more about the technology of the people who made the pottery.

Occasionally, one-shot nuclear applications to archaeology are required. An example is the study of the Second Pyramid of Chephren in Egypt. This pyramid, which is about the same size as the Great Pyramid of Cheops, did not have as complex an internal structure as Cheops. In the latter, a hidden upper chamber was discovered in the 19th century, 3,400 years after its construction. But in Chephren's pyramid, there is only one known chamber, and archaeologists had wondered if there existed a second, hidden chamber.

In 1960 a group from the University of California determined to answer once and for all if such a second chamber existed. They used the highly penetrating components of cosmic rays known as muons. Essentially, they tried to produce an X-ray picture of the pyramid. To do this a detection system was placed in the chamber located under the centre of the base of the pyramid. The detection system consisted of spark chambers and scintillation counters that enabled the group not only to detect the arrival of a muon but to tell exactly from the direction it came. Some 700,000 muons were detected and encoded on magnetic tape that was later fed into a computer.

The computer turned the process inside out. By pretending that the detector was the source of the muons, and by tracing each one back to an imaginary plane above the pyramid (analogous to an X-ray film), the computer was able to build up a picture on that plane. The greater the number of muons coming from a given point on the plane, the less stone they pass through on the way into the detector from that point.

The resulting picture, corrected for various geometric factors in the detector construction and location, clearly showed the four corners of the pyramid. The computer was also able to see the limestone cap that covers the point of the pyramid. Lastly, the study demonstrated once and for all that no secret or hidden chamber exists in this pyramid.

Essentially, then, the applications of nuclear technology to the study of archaeology are numerous. One can determine where something comes from (NAA) and where something does not come from (lead isotope ratios); its age (carbon-14), how it was made (Mossbauer effect), whether or not something exists (muons), and whether it got from point a to point b (spark source mass spectrometry). While certainly archaeology is as much art as it is science, the application of nuclear science provides a number of tools for the archaeologist to get on with the art portion of his work.

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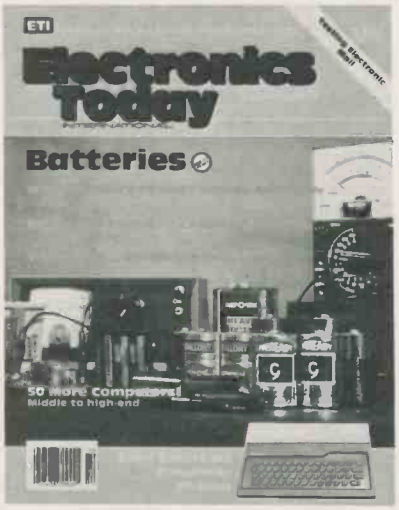

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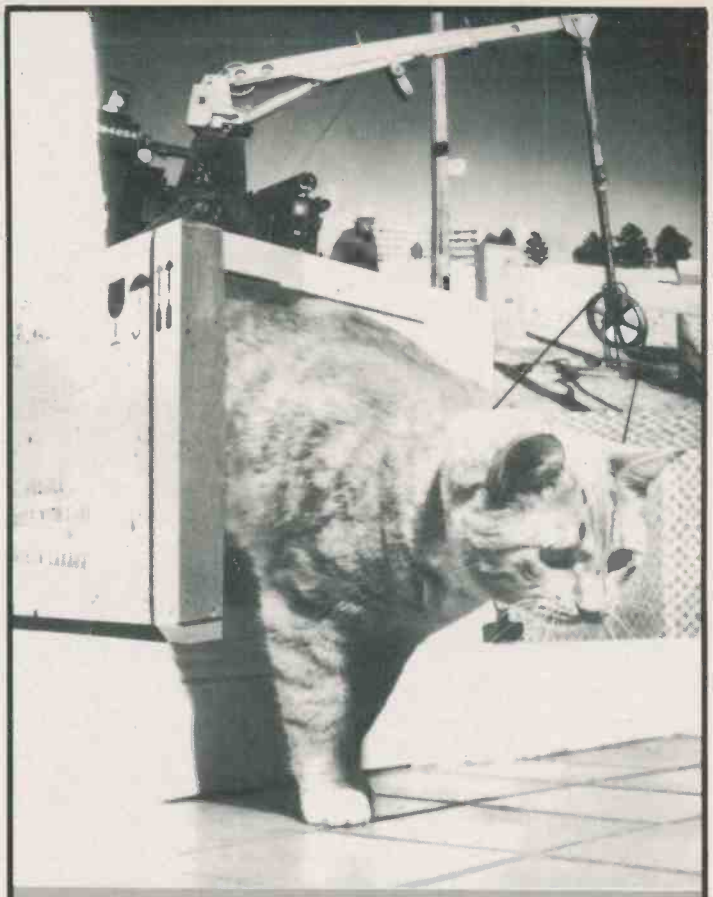

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Electronics

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ELECTRONIC THEORY

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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.

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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.

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Windscreen wiper delay, darkroom timer and metronome projects are included. Some of the more complex circuits are made up from simpler sub-circuits which are dealt with individually.

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BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING **$8.10**
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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.

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This book allows the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible, the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P.C.B. all of the projects.

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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.

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

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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**
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F.G.RAYER, T.Eng.(CEI),Assoc.IERE
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IC ARRAY COOKBOOK
JUNG
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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.

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This book is designed to aid electronics enthusiasts who like to experiment with circuits and produce their own projects rather than simply follow published project designs.
The circuits for a number of useful building blocks are included in this book. Where relevant, details of how to change the parameters of each circuit are given so that they can easily be modified to suit individual requirements.

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Z. MEIKEIN & P. TACKRAY
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AUDIO

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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.

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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.

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 $16.45
An excellent source book for the hobbyist who wants to build up his work bench inexpensively. Projects range from a simple signal tracer to a 50MHz frequency counter. There are circuits to measure just about any electrical quantity: voltage, current, capacitance, impedance and more. 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 $10.45
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 test 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.

PH246: ELECTRONIC TEST EQUIPMENT $20.45
Covers analog and digital meters, oscilloscopes, frequency generation and measurement, and special measuring instruments.

Tab1532: THE COMPLETE BOOK OF OSCILLOSCOPES $20.45
This totally up-to-date handbook is both an in-depth reference source and a practical applications guide. Information is included on both ordinary service and laboratory 'scopes, waveform analysis, vectors, vectorscopes, high and low frequency analysis, sampling, storage, digital scopes, and signature analysis. The author, Stan Prentiss is one of the leading technical writers in the U.S.

INTERRELATED INTEGRATED ELECTRONICS CIRCUITS FOR THE RADIO AMATEUR, TECHNICIAN, HOBBYIST AND CB'ER
MENDELSON
HB29 $11.45
This book provides a variety of appealing projects that can be constructed by anyone from the hobbyist to the engineer. Construction details, layouts, and photographs are provided to simplify duplication. While most of the circuits are shown on printed circuit boards, every one can be duplicated on hand-wired, perforated boards. Each project is related to another projects so that several may be combined into a single package. The projects, divided into five major groups, include CMOS audio modules, passive devices tohelp in benchwork, test instruments, and games.

BASIC CARRIER TELEPHONY, THIRD EDITION
TALLEY
HB28 $16.45
A basic course in the principles and applications of carrier telephony and its place in the overall communications picture. It is abundantly illustrated, with questions and problems throughout, and requires a minimum of mathematics.

Tab1309: THE ACOUSTIC AND ELECTRIC GUITAR REPAIR HANDBOOK $25.00
Literally everything the amateur or professional musician needs to know to properly maintain his instruments, plus all the how-to's for making repairs from simple tuning to major overhauls.

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING $8.10
R.A. PENFOLD
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

ELECTRONIC TROUBLESHOOTING HANDBOOK
AB019 $12.45
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 $10.45
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.

REFERENCE

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.

BP108: INTERNATIONAL DIODE EQUIVALENTS GUIDE $8.35
ADRIAN MICHAELS
This book is designed to help the user in finding possible substitutes for a large user orientated selection of the many different types of semiconductor diodes that are available today. Besides simple rectifier diodes also included are Zener diodes, LEDs, Diacs Triacs, Thyristors, Photo diodes and Display diodes.

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 $9.95
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.

Tab1538: ELECTRONIC DATABOOK — 3RD EDITION $30.00
Any electronic job will be easier and less time consuming when you have instant access to exactly the nomogram, table, chart or formula you need, when you need it. All this and much more is included in this completely revised and updated version of one of the most respected information source in the electronics field. Generously indexed, this handbook is divided into six sections: Frequency Data; Communication; Passive Components; Active Components; Mathematical Data; Formulas and Symbols and Physical Data.

Tab1516: TOWERS INTERNATIONAL MICROPROCESSOR SELECTOR $31.45
Towers Selector books have gained an international reputation for completeness and usefulness. This volume gives you all the data you will normally need to select the right chip.

ROBOTICS

THE COMPLETE HANDBOOK OF ROBOTICS
TAB No.1071 $16.45
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 $14.45
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.

Tab1421: HANDBOOK OF ADVANCED ROBOTICS $24.45
Here's the key to learning how today's sophisticated robot machines operate, how they are controlled, what they can do and how you can put this modern technology to work. Also included are details on building your own hobby robot.

BUILD YOUR OWN WORKING ROBOT
TAB No.841 $11.45
Contains complete plans — mechanical, schematics, logic diagrams and wiring diagrams — for building Buster. Buster is a sophisticated experiment in cybernetics you can build in stages. 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.

VIDEO

BP100: AN INTRODUCTION TO VIDEO
D.K. MATHEWSON $8.10
Presents in as non-technical a way as possible how a video recorder works and how to get the best out of it and its accessories. Among the items discussed are the pros and cons of the various systems, copying and editing, international tape exchange and understanding specifications.

Tab1519: ALL ABOUT HOME SATELLITE TELEVISION $23.45
Covers such aspects as where to buy, problems in setting up your TVRO station and how to solve them, antenna siting and equipment selection.

Tab1490: VIDEO CASSETTE RECORDERS: BUYING, USING AND MAINTAINING $14.45
A complete handbook for the video enthusiast. You'll learn about how the systems work and how to choose as well as take a technical look at the inside workings. There are also sections on making your own video recordings.

MISCELLANEOUS

BP101: HOW TO IDENTIFY UNMARKED IC'S $2.70
K.H. RECORR
Originally published as a feature in 'Radio Electronics', this chart shows how to record the particular signature of an unmarked IC using a test meter, this information can then be used with manufacturer's data to establish the application.

AUDIO AND VIDEO INTERFERENCE CURES
KAHANER
HB21 $9.45
A practical work about interference causes and cures that affect TV, radio, hi-fi, CB, and other devices. Provides all the information needed to stop interference. Schematic wiring diagrams of filters for all types of receivers and transmitters are included. Also, it supplies simple filter diagrams to eliminate radio and TV interference caused by noisy home appliances, neon lights, motors, etc.

BASIC TELEPHONE SWITCHING SYSTEMS
TALLEY
HB27 $16.00
The Revised Second Edition of this book, for trainee and engineer alike, includes updated statistical data on telephone stations, and new and improved signaling methods and switching techniques. It also includes E & M signalling interface for electronic central offices and automatic number identification methods used in step-by-step, panel and crossbar central offices.

See order form in this issue. All prices include shipping. No sales tax applies.

Playmate Part II

For aspiring artists we conclude our portable guitar amp with added ingredients fuzz and wah. Design and development by Phil Walker.

BEFORE WE CONTINUE with our analysis of the circuit theory, we have to apologize for the manpower shortage last month which meant that the Playmate circuit diagram missed out on our usual thorough checking. Naturally the perversity of the universe ensured that this was the project that had several errors, so we're reprinting the circuit diagram with mistakes and duplicate component numbers corrected and all pots marked CW or CCW to tie up with the front panel wiring diagram. Meanwhile, back to the plot . . .

The State-variable Filter

Things start getting a bit heavy now! The following equations are the transfer equations for a state-variable filter such as that in Fig. 2:

$$V_x = [(R1/R3) \times V_{in} + (R2/R3) \times V_y] + R5/(R4 + R5) \times [1 + R3(R1 + R3)/(R1R2)] \times V_o$$

If R1 = R2 = R3 = R5, then:

$$V_x = -(V_{in} + V_y) + R1(1 + 2)/(R4 + R1) \times V_o$$

$$V_x = \frac{3R1V_o}{R4 + R1} - (V_{in} + V_y)$$

$$V_o = -1/sCR \times V_x,$$

$$V_x = -sCR\,V_o$$

$$V_y = -1/sCR \times V_o$$

Substitute (2) and (3) in (1):

$$-sCR\,V_o = \frac{3R1\,V_o}{(R1 + R4)} - (V_{in} + (-1)/sCR\,V_o)$$

$$\frac{V_{in}}{V_o} = (sCR + 3R1/(R1 + R4) + 1/sCR)$$

$$= j\omega CR + \frac{3R1}{(R1 + R4)} + 1/j\omega CR$$

($s = j\omega$, $\omega = 2\pi f$, f = frequency

Compare this with the equation for an LCR tuned circuit:

$$V_{in} = (j\omega L + 1/(j\omega C) + R)\,I_{out} \quad \text{(Fig. 3)}$$

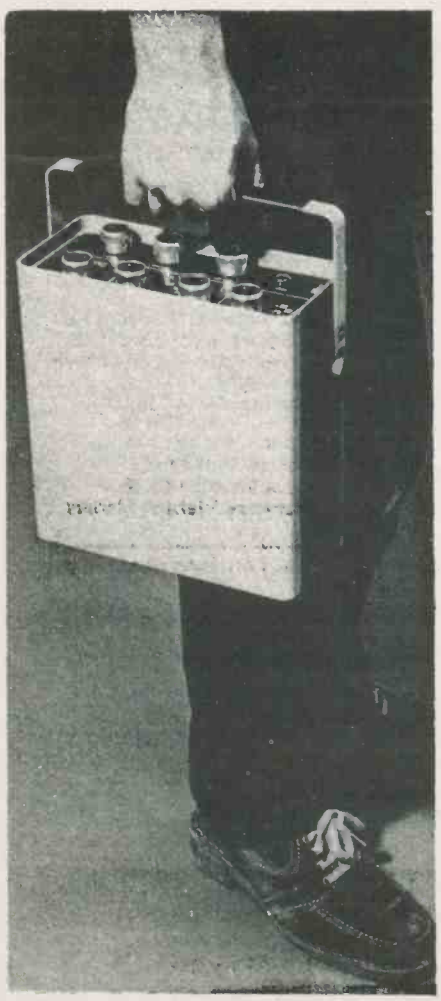
$$\frac{V_{in}}{I_{out}} = j\omega L + R + 1/(j\omega C) \quad \text{(LCR circuit)}$$

$$\frac{V_{in}}{V_{out}} = j\omega CR + \frac{3R1}{(R1 + R4)} + 1/(j\omega CR)$$

(State variable filter)

From this it is apparent that these responses are similar except that the LCR circuit gives a current output rather than a voltage. For this type of LCR circuit, the frequency of minimum attenuation or maximum gain (the resonant frequency) is given by:

$$f = \frac{1}{2\pi\sqrt{LC}}$$



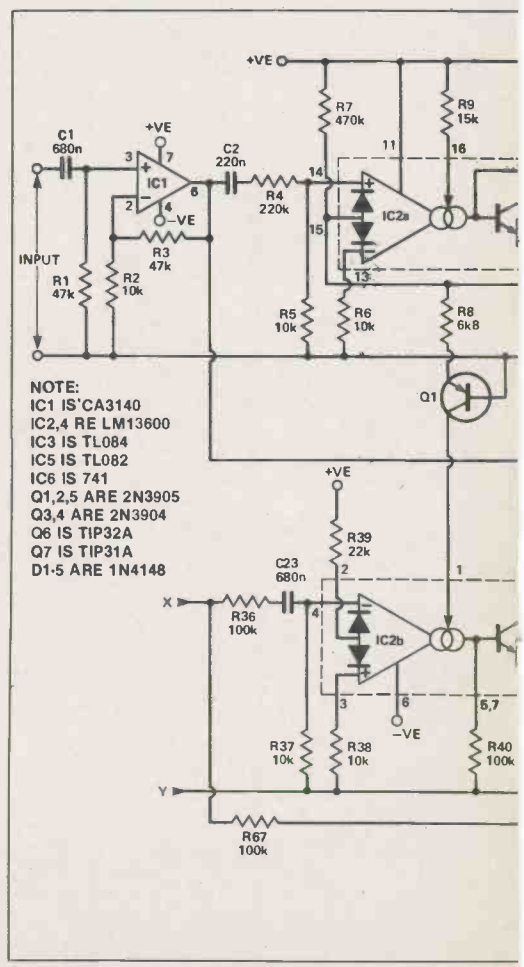


Fig. 1. (Right) The correct version of the circuit diagram — sorry ...

For our circuit this is: —

$$\frac{1}{2\pi\sqrt{CR.CR}} = \frac{1}{2\pi CR}$$

The 'Q' factor influencing the bandwidth is given by:

$$Q = \frac{2\pi f L}{R} = \frac{2\pi \times (1/2\pi CR) \times CR}{3R1/(R1 + R4)}$$

$$= \frac{R1 + R4}{3R1}$$

Figure 4 shows the configuration necessary to use the LM13600 as a filter of this type. Last month we found that the transfer function of the LM13600 with no diode current is given by:

$$I_{out} = \frac{I_{abc}}{26 \times 10^{-3}} \times V_{in}$$

As we are using a capacitative load, this output current will generate a voltage of·

$$V_{out} = I_{out} \times \frac{1}{j\omega C}$$

$$= V \times \frac{I_{abc}}{26 \times 10^{-3}} \times \frac{1}{j\omega C}$$

$$= V_{in} \frac{R1}{R1 + R} \times \frac{I_{abc}}{26 \times 10^{-3}} \times \frac{1}{j\omega C}$$

Since we are not dealing with a normal type of op-amp, analysis of the circuit is not as easy as the normal filter, but the result is an equation of much the same form. We do not show all the derivation here as it would occupy most of a page. However, the end result is that the centre frequency of the filter pass band is proportional to the amplifier bias current. Therefore we have an easy way to control the wah wah effect.

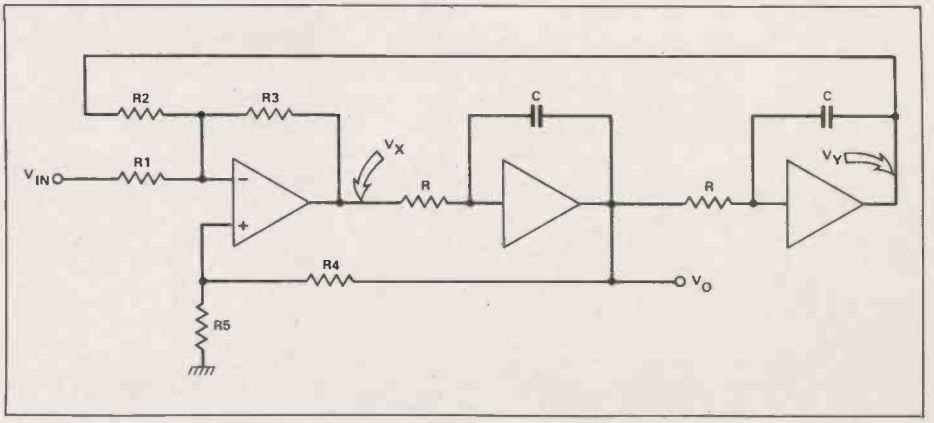
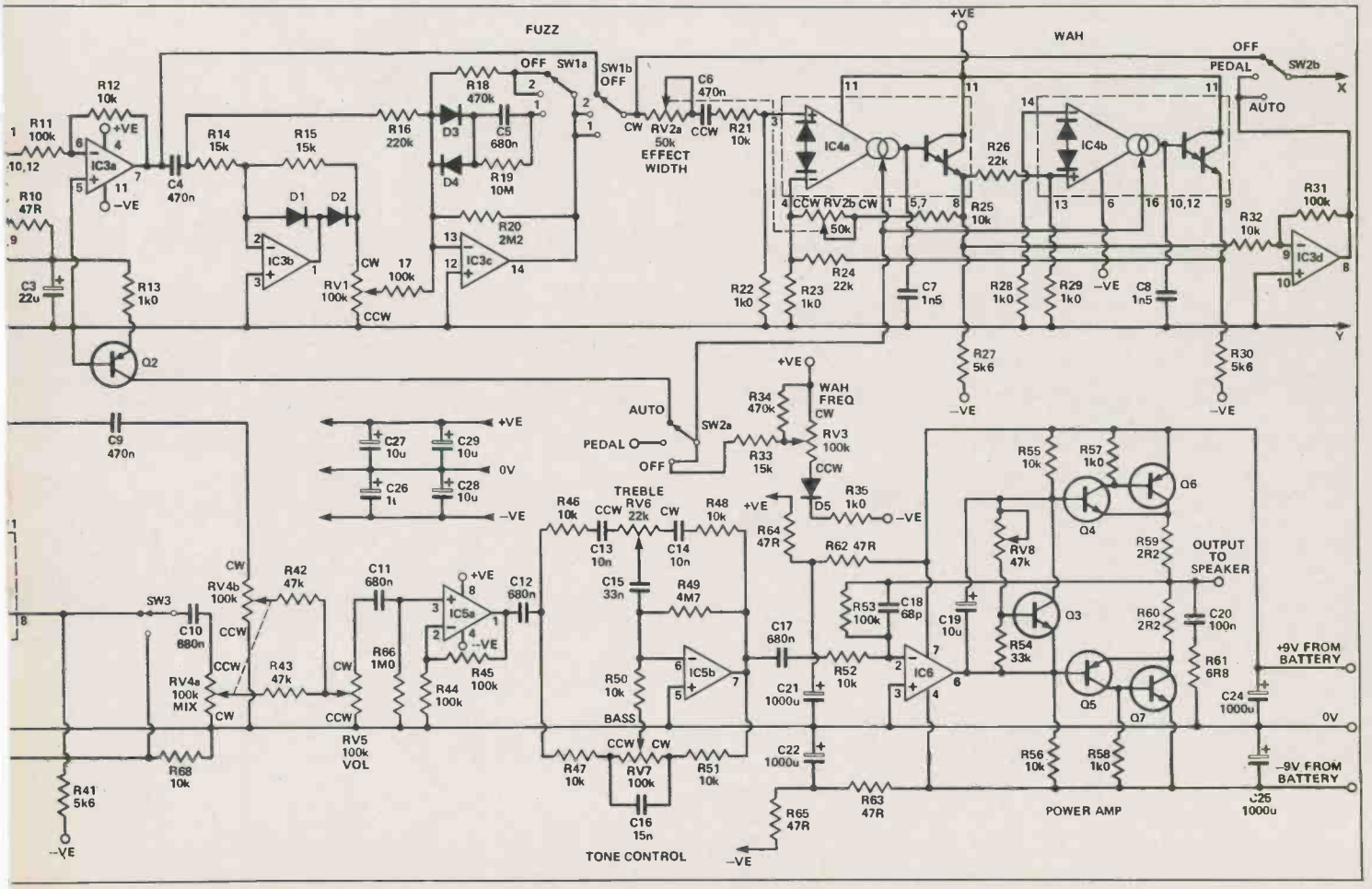


Fig. 2. Generalized state-variable filter.



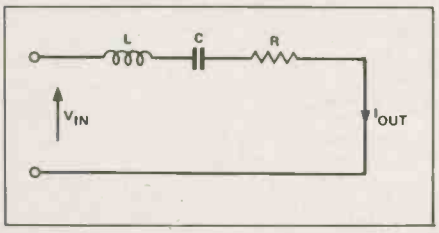


Fig. 3. Generalized LCR tuned circuit.

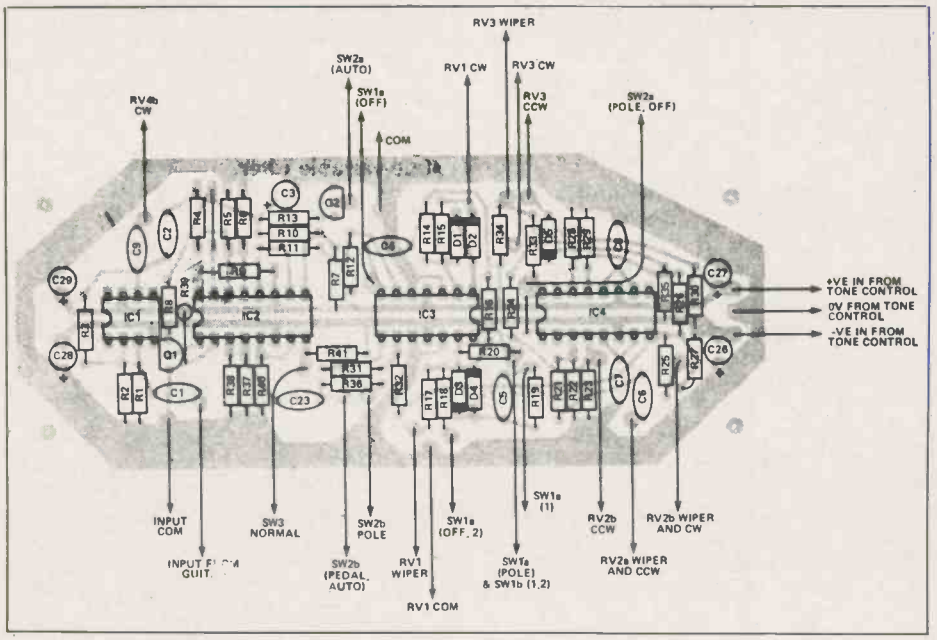
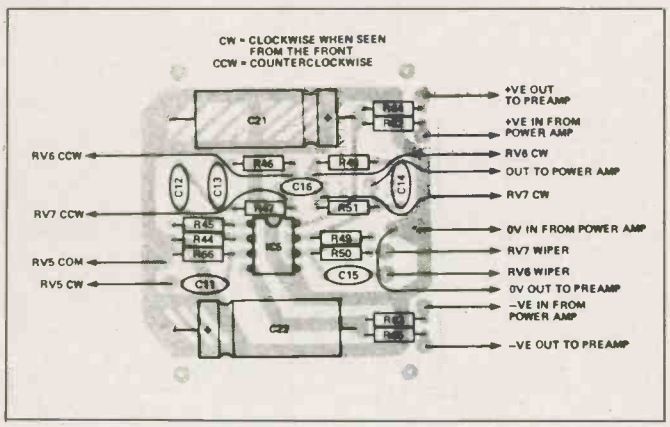
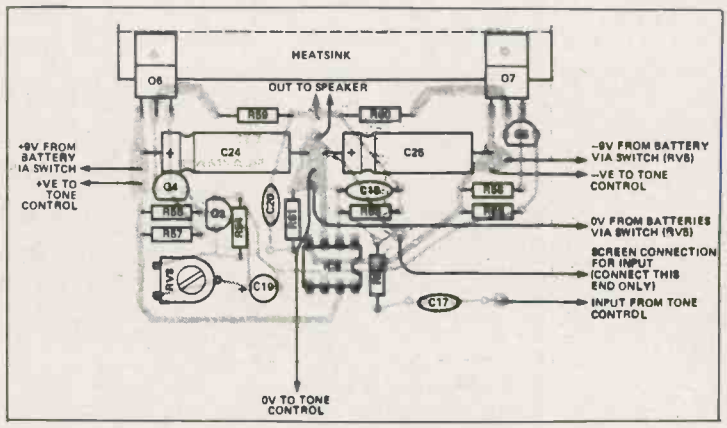


Fig. 5. (Right) Component overlay for the preamplifier board.

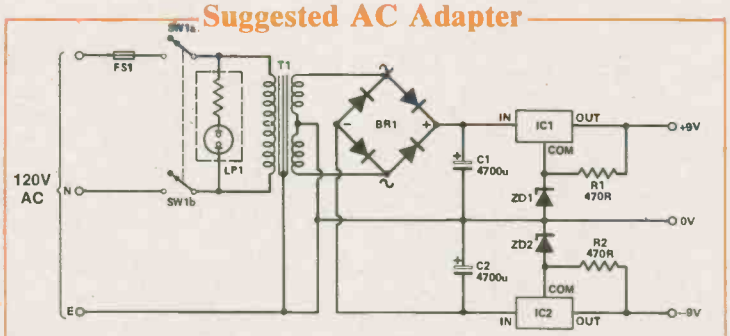
Fig. 6. (Below) Overlay for the tone control board.

Fig. 7. (Far Right) Overlay for the power amp of the Playmate.





Suggested AC Adapter



Parts List

R1,2	270R ¼W 5%	T1	9-0-9 12 VA transformer, 100 mA or more
C1,2	4700u 25 V electrolytic	SW1	DPDT miniature rocker or slide switch
IC1	7805	FS1	1 A 200 mm fuse and holder
IC2	7905	LP1	120 V panel neon with integral resistor
ZD1,2	3V9 400 mW zener		
BR1	1 amp bridge rectifier		

Construction

Except for the controls, almost all the components for this project are mounted on the three PCBs. The preamplifier board is the largest and most densely packed. It is advisable to use sockets for the ICs and don't forget the links. The capacitors used in the project should be as small as possible, otherwise you will have difficulty fitting them. A fine tipped soldering iron will be useful when assembling the boards and care should be taken to avoid creating short circuits between tracks with accidental solder splashes.

Ensure that all the diodes, transistors and other polarized components (especially IC3) are fitted the correct way round. On the power amplifier board the output transistors are mounted on top of a short length of ½'' x ½'' aluminum angle which acts as a heatsink. The transistors and the angle are held in position by the transistor mounting screws.

PARTS LIST

Resistors (All ¼W 5%)

R1,3,42,43	47k
R2,5,6, 12,21,25, 32,37, 38,46-48, 50-52,55, 56,68	10k
R8	220k
R7,18,34	470k
48	6k8
R9,14,15,33	15k
R10,62-65	47R
R11,17,31, 36,40,44, 45,53,67	100k
R13,22,23, 28,29,35, 57,58	1k0
R19	10M
R20	2M2
R24,26,39	22k
R27,30,41	5k6
R49	4M7
R54	33k
R59,60	2R2
R61	6R8
R66	1M0

Potentiometers

RV1,3,7	100k linear
RV2	50k linear dual gang
RV4	100k linear dual gang
RV5	100k logarithmic with two-pole switch
RV6	22k linear
RV8	47k miniature horizontal preset

Capacitors (All polycarbonate except where stated)

C1,5,10-12 17,23	680n
C2	220n
C3	22u 16 V tantalum
C4,6,9	470n
C7,8	1n5
C13,14	10n
C15	33n
C16	15n
C18	68p
C19	10u 35 V tantalum
C20	100n
C21,22,24, 25	1000u 10 V axial electrolytic
C26-29	47u 10 V PCB electrolytic

Semiconductors

IC1	CA3140
IC2,4	LM13600
IC3	TL084
IC5	TL082
IC6	741
Q1,2,5	2N3905 or equiv.
Q3,4	2N3904 or equiv.
Q6	TIP32 or equiv.
Q7	TIP31 or equiv.
D1-5	1N4148

Miscellaneous

SW1,2	2-pole, 3-way miniature slide switch
SW3	1-pole, 2-way miniature slide switch

PCBs; case (220 x 105 x 230mm), Vero Ref. 75-2443A; wire (single, single screened and double screened); 4" or 5" loudspeaker (8 ohms, 5 W); standard ¼" jack socket for input; stereo jack socket for foot switch (if required); 75 mm or 12 x 12 mm aluminum angle; two 9V batteries and clips.

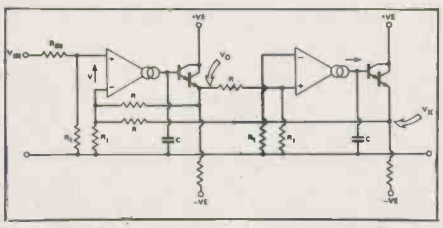
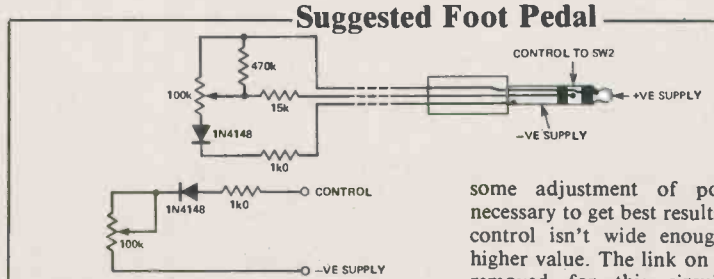


Fig. 4. Using the LM13600 as a state-variable filter.

Suggested Foot Pedal



The first diagram shows the circuit used with a three-connection (stereo) jack. This will duplicate the effect of the panel-mounted control. As the angular rotation of foot pedal controls is sometimes limited, some adjustment of position may be necessary to get best results. If the range of control isn't wide enough, change to a higher value. The link on SW2a should be removed for this circuit. The second diagram shows a simple circuit for use with ordinary jack connectors which can be used if the link between SW2a pole and off position is retained.

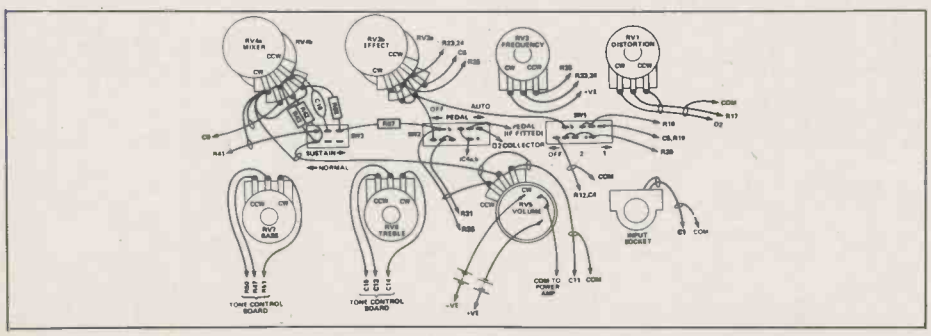


Fig. 8. How to wire the front panel. Compare with the front panel photo last month.

Mount the control switches and potentiometers on the front panel (see photo for our layout) and make the necessary interconnections and fit the three components needed around the balance control. The wiring from the front panel to the preamplifier/effects and the tone control boards should be carried out using thin flexible wire for control signals and miniature screened cable for any sound signals. These should be short, but allow enough slack to be able to fit them in position easily (it is probably easier to connect all the wires to the circuit boards first). The power amplifier board was fitted to the metal base plate of our case using the angle on which the transistors were mounted. It was positioned so that it fitted neatly between the two batteries in the bottom of the case. Together with the loudspeaker, the amplifier board holds the batteries without any further help.

The small loudspeaker for this project was mounted on the plastic case of the box through which a number of holes were drilled to let the sound out. If required, a small mains power unit capable of 9-0-9 V at 100 mA or more may be used to power the unit.

A foot pedal control for controlling the wah wah effect could be plugged into a jack socket. This would need to be one of the three-connection or stereo type so that positive and negative supplies as well as the control signal could be connected.

ETI

VIC-20
High Res Graphics

J. Ennis

The recommended way to create high-res graphics on the VIC-20 is to bit-map as much of the screen as you have memory for. But even with memory expansion cartridges, the maximum size is about 160 by 160 pixels because character memory cannot be located in the expansion cartridge.

The following program does not try to bit-map the entire screen, so it avoids this limitation. When plotting graphs and the like, only a small portion of the screen is actually used.

To turn on a single pixel, the program PEEKs into screen memory at the place the pixel will appear when it is plotted. If the character there is a space, it POKEs another character in its place and then POKEs into character memory to turn on a single dot within that character.

Thus, when a graph is plotted, most of the screen is filled with spaces and the remainder with other characters.

Within the program the plotting of points on the screen is achieved by two machine-language routines which must be POKEd into memory before running. The first of these clear out the character memory in RAM, sets the character memory pointer to 5120 (decimal), clears the screen and sets the 8116 character size.

The second routine plots a point whose x and y co-ordinates are stores in locations 0 and 1 respectively. Both routines are relocatable but only work on the unexpanded VIC-20, although they could be modified.

Type in Program 1 and save it immediately, taking special care with the data statements; a mistake there may well crash the program later. Erase the first program, then type in Program 2 and save it on tape immediately after Program 1.

To use it, load and run Program 1, which POKEs the machine language into memory; unless there is a mistake, it will then automatically load and run the second program on the tape, the one that does the plotting.

When run as above, the second program will plot the graph, in Cartesian co-ordinates, of a function defined in line 5. To do this, it will ask for the domain of the function, i.e.: the range of values on the x-axis for which values of the function are to be plotted.

It will then ask for the plotting density, i.e.: how close together it will plot the points, where 1 gives the highest density and 4 the lowest.

Once plotted, the graph will remain on the screen until the user presses the CTRL key and then the space bar.

Both parts of the program should be typed in without any spaces between words as this saves using too much memory space.

MACHINE-LANGUAGE GRAPHICS

Program 1

```
10 REM LOADS MACHINE-LANGUAGE
20 CH=0:FORI=5892TO6119:READA:POKEI,A:CH=CH+A:NEXT:IFCH<>33481
THENPRINT"ERROR":END
30 FORI=5892TO6119:POKEI-1000,PEEK(I):NEXT:POKE631,131:POKE
198,1:END
40 DATA173,3,144,9,1,141,3,144,169,8,141,15,144,169,253,141,5,
144,169,147,32,210,255
50 DATA169,0,133,251,169,30,133,252,169,150,160,0,145,251,200,
192,0,208,249,230,252,165
60 DATA252,201,32,208,237,169,20,133,252,169,0,133,251,160,0,
145,251,200,192,0,208,249
70 DATA230,252,165,252,201,30,208,235,96,169,0,133,251,133,252,
133,253,133,254,165,0
80 DATA24,105,248,230,251,176,249,198,251,165,1,24,105,240,230,
252,176,249,198,252,166
90 DATA252,169,0,24,105,22,202,224,0,208,248,24,101,251,133,253
164,253,185,0,30,201
100 DATA150,208,9,173,255,29,153,0,30,238,255,29,133,253,165,1,
166,252,56,233,16,202
110 DATA208,250,133,254,169,20,133,3,165,254,166,253,24,105,
16,144,2,230,3,202,224,0
120 DATA208,244,133,2,165,0,166,251,56,233,8,202,224,0,208,248,
133,252,169,7,56,229
130 DATA252,170,169,1,24,133,251,101,251,202,224,0,208,246,133,
252,201,0,208,2,230,252
140 DATA160,0,177,2,5,252,145,2,96
```

Program 2

```
5 DEFFNA(X)=SIN(X)
10 POKE36878,9:PRINTCHR$(147)SPC(48)"VIC GRAPHICS":PRINTSPC(90)
;:INPUT"DOMAIN(A,B)";A,B
20 IFA>=BTHENPRINTSPC(50)"ERROR":POKE36876,200:FORI=0TO1500
:POKE36876,0:GOTO10
30 PRINTSPC(45);:INPUT"PLOT DENSITY(1-4)";C:IFC<1ORC>4THENC=4
40 SYS4892:POKE7679,1:D=C*(B-A)/175:U=0:L=0:FORI=ATOBSTEPD:C=
FNA(I):IFC<LTHENL=C
50 IFC>UTHENU=C
60 NEXT:H=175/(ABS(L)+U):W=175/(B-A):IFB<0 ORA>0THEN80
70 POKE0,-A*W:FORI=0TO175:POKE1,I:SYS4968:NEXT
80 POKE1,175-ABS(L)*H:FORI=0TO175:POKE0,I:SYS4968:NEXT
90 FORI=ATOBSTEPD:C=FNA(I):X=(I-A)*W:Y=175-(ABS(L)+C)*H:POKE
0,X:POKE1,Y:SYS4968:NEXT
95 POKE36875,180:FORT=0TO600:NEXT:POKE36875,0:WAIT653,4:WAIT
197,32
100 POKE36879,27:POKE36869,240:POKE36867,PEEK(36867)AND254:POKE
198,0:GOTO10
```

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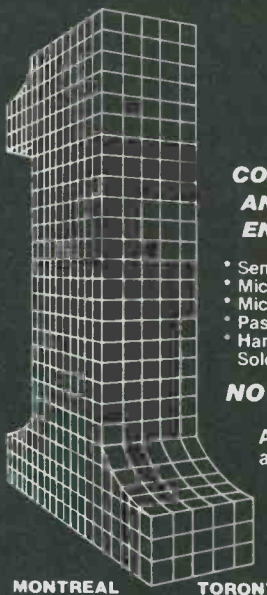

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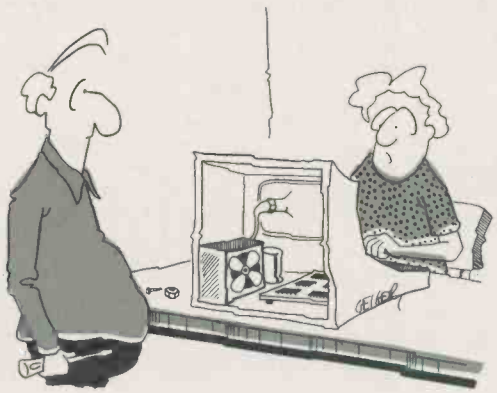
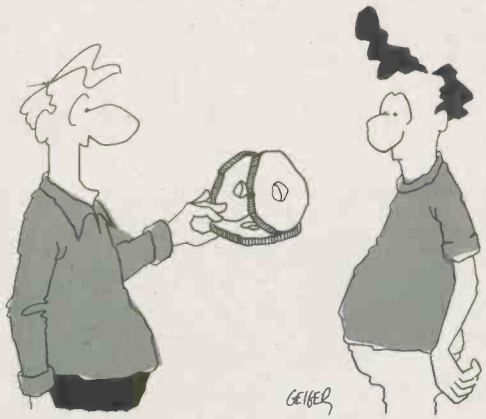


"He says he likes the new fan, but would have preferred slave girls waving palm leaves."



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Book Review

Mathematics for Electricity/Electronics

Miller/Culpepper, Collier MacMillan Canada Ltd., ISBN 0-02-818220-0. Paperback.

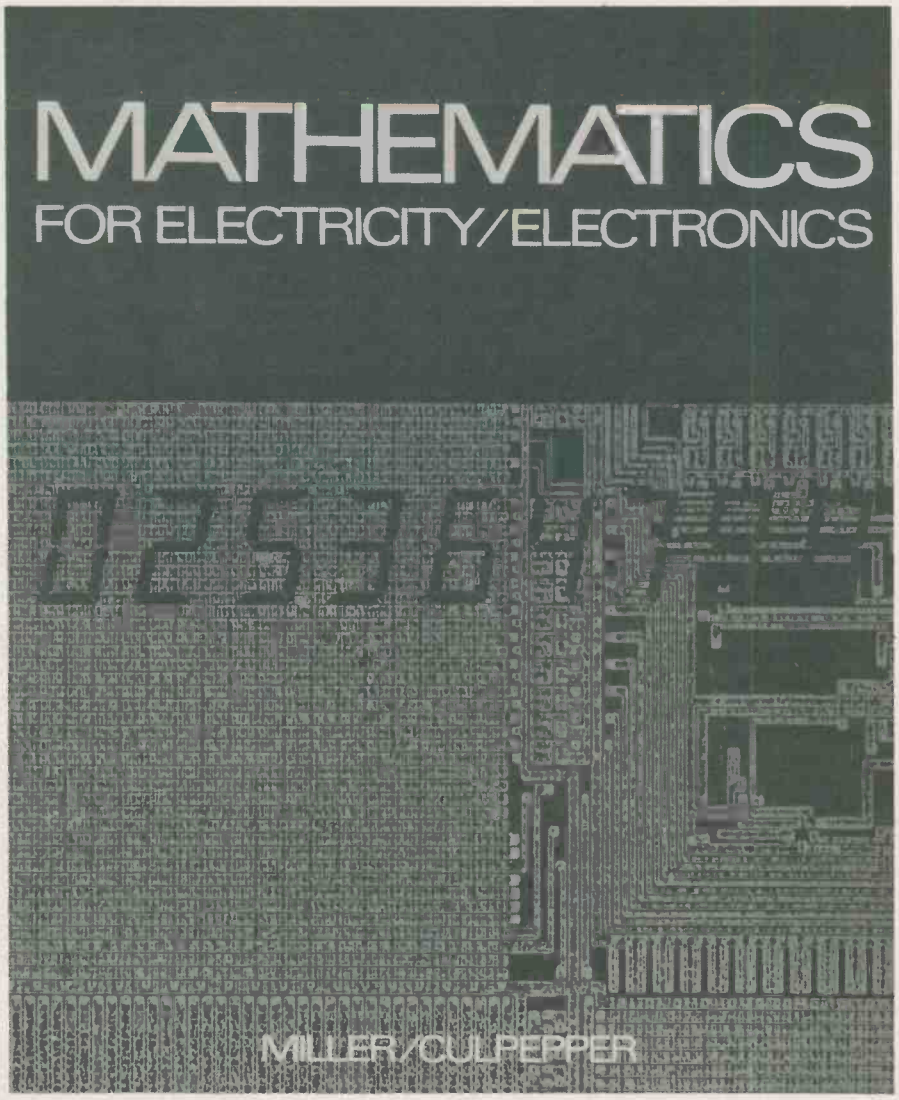
ALTHOUGH THIS book is intended for use in an electronics course, it's an excellent choice if you'd like a reference book of basic information and equations. For instance, who can remember Delta-Wye transforms unless you use them daily? With this handy manual, you have the information you need, and wonder of wonders, it's all easy to find, thanks to excellent layout.

The book is divided into 30 chapters, or units. Each unit consists of an introduction to the basic topic, relevant tables and test problems for the eager. The main formulas are placed in boxed inserts for readability. The answers to the tests, unfortunately, are in a softbound book which must be purchased separately; after all, it's meant to end up in classrooms, and we can't have people peeking.

Taking the first unit, Resistance, as an example of the format, you'll find a one-page discussion of the various factors affecting the resistivity of conductors. Two pages of tables and examples follow; the tables include the determination of the resistance of a material given the dimensions, the effects of temperature, and standard wire gauges. The examples are expertly concocted by someone who has the rare ability to put himself in the place of the information-seeker. Seldom-used terms are neatly explained. There is a lack of metric units, for which some may breathe a sigh of relief, but naturally the book's largest market would be in the U.S.

Problems accompanying each unit are of a practical nature; they describe the sort of situations one might be expected to find outside the classroom: for instance, finding the resistance of an electric clock coil given the length, wire, and temperature. You may rarely need to know about clock coils, but if you wind any type of coils, say, speaker crossovers, you can appreciate the practicality of the approach.

Unit 2 applies resistivity using Ohm's Law. Three examples are given, along with 25 questions. Interestingly, the authors give the old high school rule-of-thumb for remembering the Law: divide a pie into three and cover the unit to be found; the other two are then shown in the proper relationship. The problem with this, as I recall from high school, is that nobody can ever remember which letters go in which sections of the pie.



The following units cover manipulation of series and parallel resistances, with Unit 6 being particularly excellent at showing how to reduce complex resistor networks to easily useable equivalents. This should give a good grounding for later work in network analysis.

There are units on the basics of meter movements, and the ways to go about turning them into ammeters, voltmeters, or ohmmeters. Kirchhoff's Laws and series-parallel current flow are covered in a simple but concise manner; the authors have cleverly managed to cram the equivalent of an electronics course into three-page sections. (Quick. What are Kirchoff's Laws?)

Inductance formulas are given in two units; you can even find formulas for winding your own coils, should you be so eager as to actually do that. I used to pass on building any project that required coil-wind-

Continued on page 78

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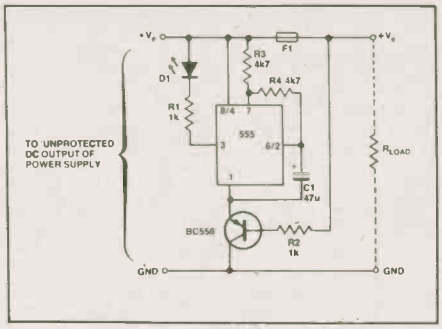
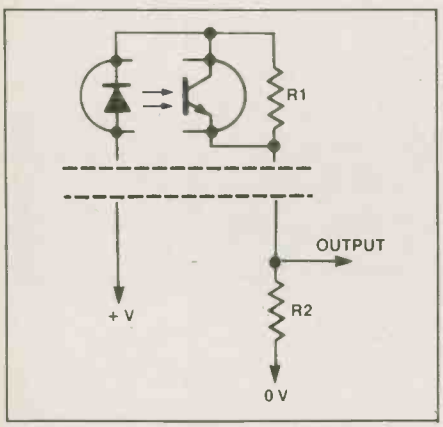


Two wires for opto-switch
F. Arfort

Here's a simple way to run two wires instead of four to a remote opto-switch, as in the case of a wind speed indicator which provides pulses proportional to the rotational speed of a perforated disc.

An opto-coupler consisting of a LED and a phototransistor, either of the packaged variety or made from discrete devices, normally requires four connections. However, twin-pair cable is common, cheap and convenient and it's more economical (and more elegant) to use two wires rather than four for a remote sensor. The further away the sensor may be located from the indicator, the more attractive a two-wire system becomes.

In the circuit, resistor R1 provides a 'starting' current for the LED. Current through R1 and R2 will provide a certain dc level at the output when the path between the LED and phototransistor is blocked. When the path is unblocked, the phototransistor saturates, virtually shorting out R1, thus providing more current through R2, increasing the output dc level. This change can be sensed and used as required.



Fuse fail indicator
R.N. Sinclair

This circuit indicates an open circuit fuse by flashing the LED D1.

The circuit is based around the popular 555 timer IC which is arranged as a multivibrator with its frequency/period determined by C1, R3 and R4. R1 is the current limiter for D1.

When the fuse is intact, the BC558 is off but when the fuse fails and there is an open circuit the BC558 switches on, supplying power to the input of the 555 (pin 1). A load must be present to switch the transistor on and consequently the LED.

The fuse fail indicator must not be used when the power supply is greater than 15 V.

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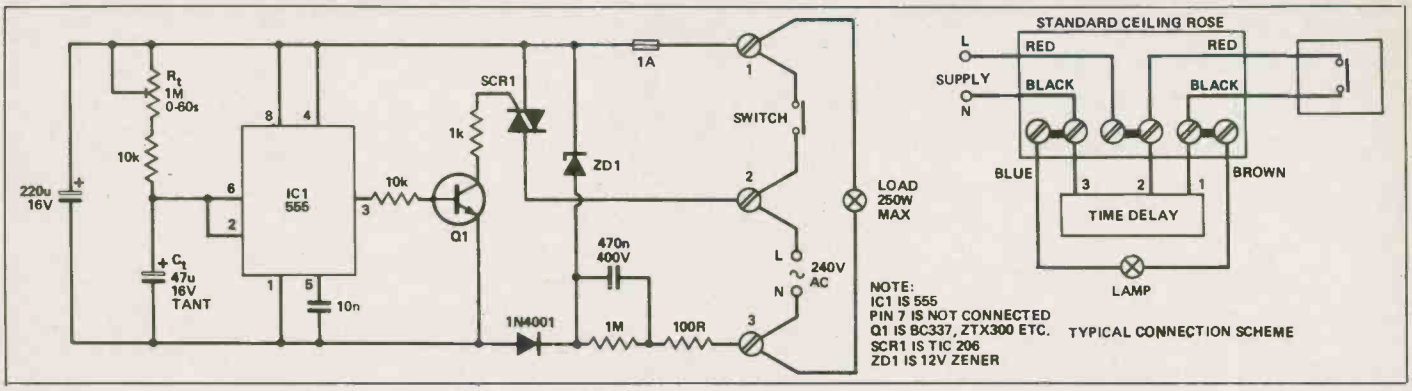

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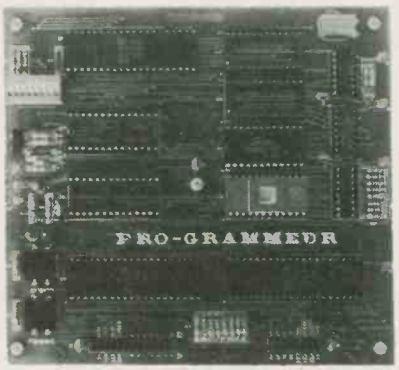

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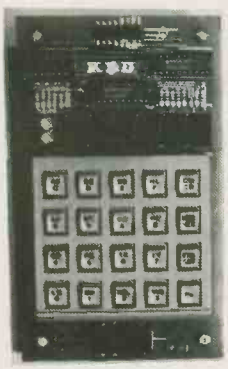

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Low-Cost Mains Time-Delay Switch
Alex Gray

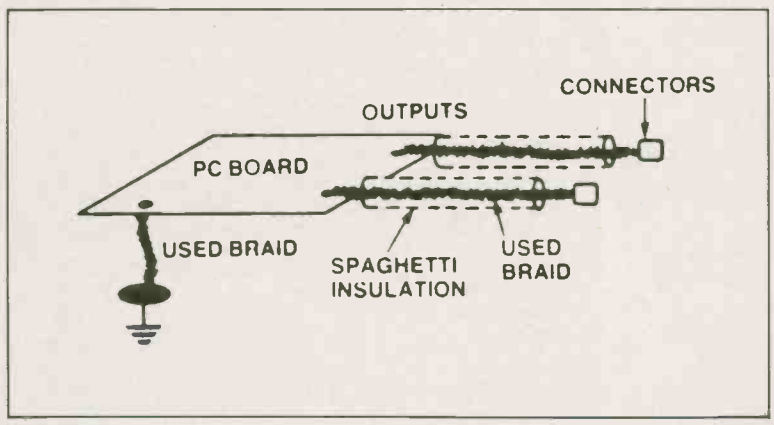
This circuit offers a cheap, reliable replacement for mechanical and pneumatic time-delay switches such as used for corridor lights. It can also be used to protect equipment which is upset by power being applied and removed too rapidly.

When the switch is closed and reopened, the load is switched on for a preset time - $1.1R_tC$. During this period, the circuit also switches on its own power. At the end of the time-delay both the load and the circuit are disconnected. In the event of a circuit failure, the push button will still allow the load to be switched on for safety (e.g. in corridor lighting).

If the switch is a normal latching type, the load will be powered as long as the switch is closed, subject to a minimum period. This prevents rapid cycling of the power on and off and may be used to protect equipment susceptible to damage from this situation.

The usual precautions with AC wiring must be observed. In particular, remember that, although the 555 is on a 12V supply, that supply is superimposed on 120 V AC above ground. The switch and the 470nF capacitor must be types designed for high voltage operation.

Reuse spent solder braid
Peter Alter



Don't throw away those used pieces of Dri-Wick or other brands of desolder braid. It is an excellent, very low resistance conductor.

It can be used as a ground strap from circuit boards and connectors to the chassis or central earth point. Covered by spaghetti or heat shrink tubing, it makes an ideal low impedance lead for power supplied and amplifiers etc.

It has much lower resistance than hook-up wire, doesn't cost anything, and being rigid makes a good supporting strengthener for the pc board.

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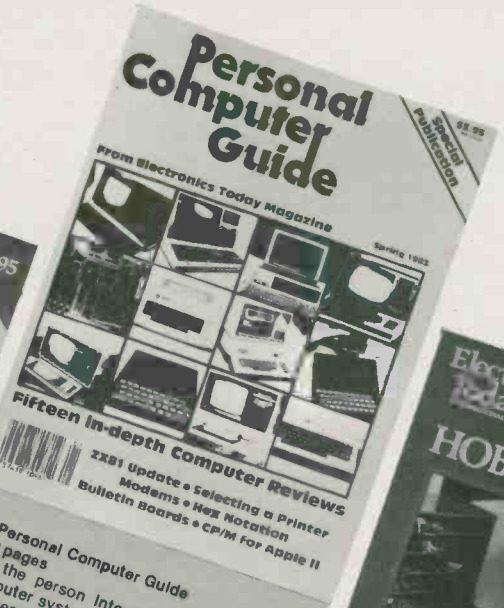

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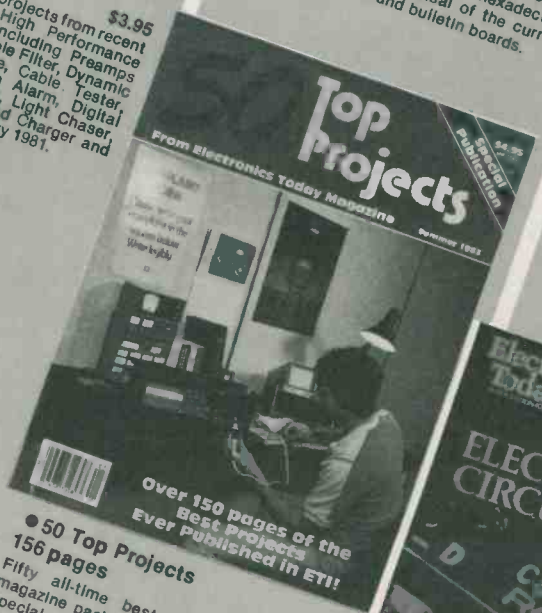

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Tech Tips

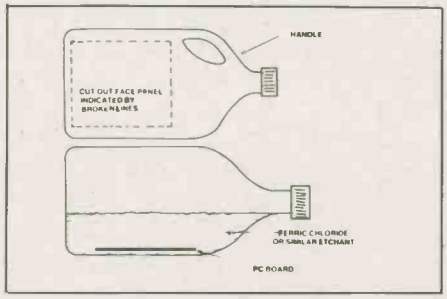
Etching tank
N.F. Bush

A discarded plastic bottle is a simple, but effective, etching tank.

I was recently making up several pc boards and found that I did not have a suitable etching tank. The containers which I have used on other occasions were flimsy and etchant was always spilt all over the place. So I grabbed an old bottle and cut it out as shown on the diagram.

I was amazed at how successful it was as I could move it around and didn't spill a drop.

The used etchant can be discarded easily by unscrewing the lid and pouring it out. There's not much mess to clean up afterwards and the bottle can be washed thoroughly and stored until needed again.



Flashlight Communicator
Chris McRae

This simple, portable, visually-aligned transceiver is quite effective and can be easily built into a flashlight.

The lamp current, modulated at an audio frequency, modulates the light beam. The light beam is detected by a photodarlington transistor and drives a small speaker for audio output.

The lamp is driven by an ac signal which cuts the RMS voltage to about one-third of the six volts, which is why a 1.5 V bulb is used in a 6 V circuit.

The photodarlington can be mounted on the axis of the beam or you may get better sensitivity by placing it so that it faces the reflector of the flashlight just above the bulb (the bulb filament is at the focal point of the reflector).

Fidelity is not high due to the low pass characteristics of the bulb filament, but I have been able to have intelligible conversations at distances up to 30 metres.

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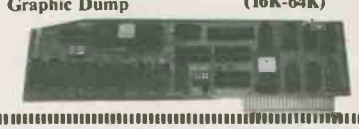

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Brother EP-20 Electronic Typewriter

as "g" or "y", or letters with descending accents, will ride up a bit higher than the rest. On the other hand, a 5 x 7 print head keeps the cost down.

Calculating

In the upper right corner, you'll find five buttons marked with the usual calculator functions. A typewriter with a built-in calculator? So it is. As you're typing up a storm, you can do four-function calculations up to 12 digits and print them along with the text. If you just want to calculate without actually printing it, you can switch to the non-print mode. There's a Clear key next to the LCD readout, but it has to be used with care, because it likes to print out the contents of the buffer before clearing the display. The delete key can be used to get rid of unwanted characters if you've been calculating and don't want numbers printed.

Other features include a Repeat key which repeats the last character entered, including Return and Backspace, which have auto-repeat anyway. The Tab and Margin functions are set electronically; just space to the desired point and press a button. Up to 16 tabs can be set. There is no visual indication of where the margins or tabs are located.

Summary

A number of people, including other reviewers, have said that while the EP20 is an interesting toy, it has no real uses. I didn't find this at all. Here are the reasons I have one:

First of all, for the same price as the average electric, you get the 16-character correction feature. This may not sound like much, but I've found that the main reason I use a word processor is to be able to instantly correct typing errors as the happen; it would be nice to be able to manipulate text, but that's unlikely to be available for the price.

Secondly, the machine is easily portable and fits in a small space. I've never really wanted to type on a bus or airplane, but I like being able to slide the typewriter into a bookcase when desk space is needed; you can't easily do this with most portables.

Thirdly, the EP20 is virtually silent in operation. This means that you can type late at night or when someone is listening to the stereo.

On the negative side, there's the high cost of replacing the ribbon cassettes. Brother has a thermal paper available which eliminates the need for a ribbon, but the thermal quality isn't up to the excellent quality of the ribbon printout. The return function is very slow, presumably to reduce strain on the tiny motor; this wasn't a serious drawback. I wasn't too keen on the smoked acrylic print head cover; it tended to obscure the text for quite a few lines, and you couldn't leave it off because the platen rollers are incorporated into it.

But these points don't detract from the fact that the EP20 is one of the best applications of microcircuitry I've seen in a long time; it's a pleasure to own and use one.

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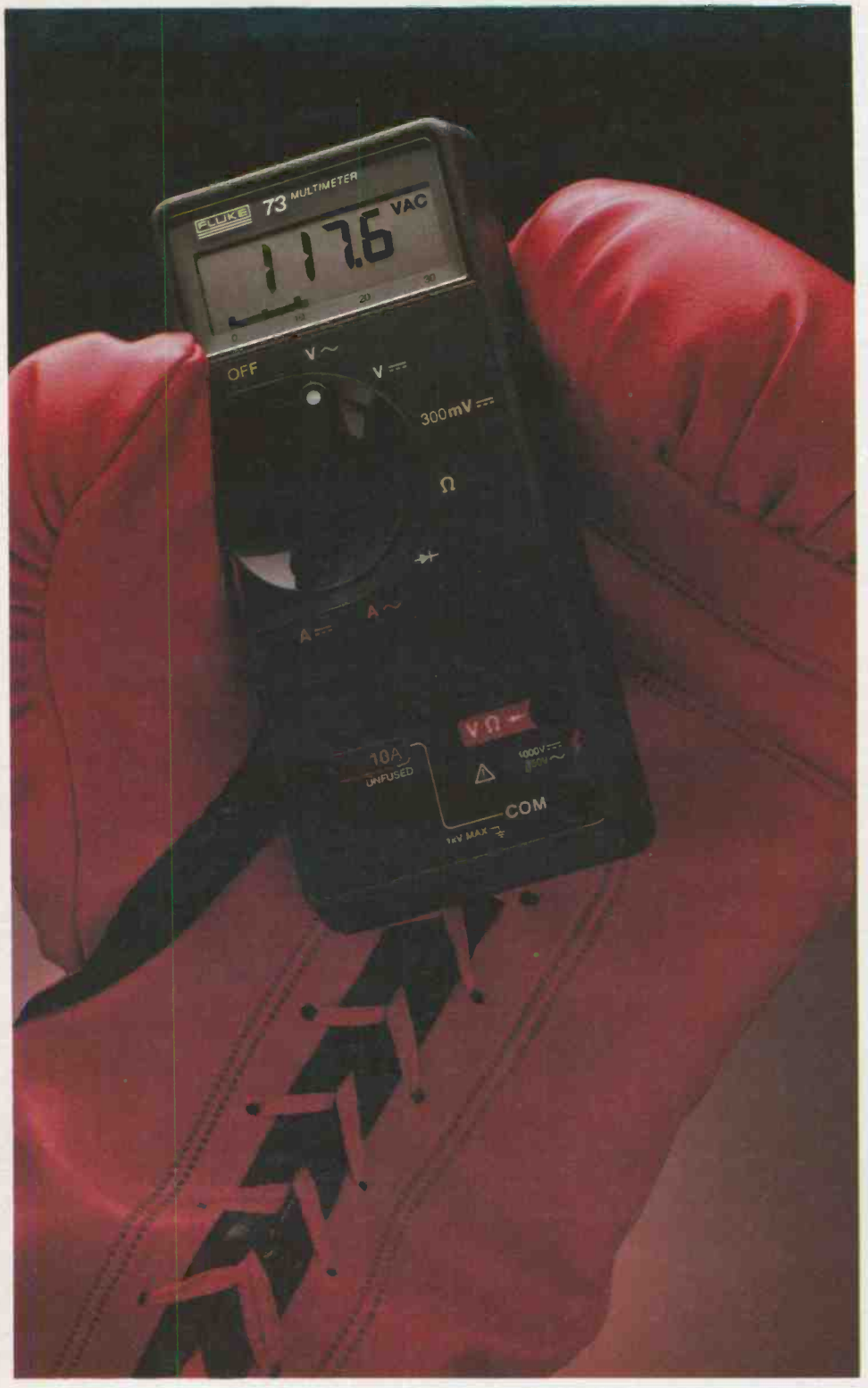

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Mathematics for Electricity/Electronics

ing. The section on peak/RMS follows. The explanation given here is not of the same calibre as the rest; I can understand the reluctance to get into a subject requiring a knowledge of statistics sampling, but there must be thousands of students and hobbyists who know only that peak equals RMS times 1.414, or at best, the root of the means squared.

This brings up another interesting point. The root of two is shown in this section as 1.414, yet some of the examples in the book have been worked out to eight decimal places or more. This is an impossible degree of accuracy, but on the other hand, it lets you know whether or not your calculator is bang-on, or whether you've hit it by a lucky accident.

Inductive reactance, basic capacitance, and basic transformers are well-explained, and lead into eight units which are concerned with the characteristics of RC circuits. The beginning unit of these covers the RC time constant. This one seemed to me to sum up even more than the RMS problem the tightrope on which handbook authors teeter: if you insert clarifying text, you may get taken to task for overdoing things. If you don't, people will say that the equations are inadequately explained. With this in mind, I thought that there should have been a better explanation of why the mysterious 63.2% keeps turning up in time constants. At some point, the student will likely stumble across the fact that it derives from *e*, the base of the natural logs, but it would be nice to have it spelled out.

Now we get to the fun stuff. If you can get the hang of capacitive reactance, you're on your way to understanding impedances, and then it's only a step to complex circuit design. The author have wisely chosen the simpler formulas which read out in ohms; for example, the RMS sum of reactance and resistance yields the impedance in ohms. Now, I'm not saying that the *j* operator shouldn't be used instead; only that it's cumbersome, and delays being able to grasp the intuitive idea of impedance. Once you get the impedance concept stuck into your head, it's only a matter of learning any necessary equations. Until then, the student may only be parroting symbols without knowing why.

The book ends with units on series and parallel LC circuits; the format is the same as those mentioned in the last paragraph. The appendices are jammed full of useful information; some of it a recap of the units themselves, and some of it additional.

This is a text that should be owned by anyone interested in electronics. The negative points mentioned are, of course, a difference of opinion as to how much supplementary text should be included in a reference book. The superbly organized layout makes it a pleasure to use, and even stimulates the reader into doing more research on a topic. Oh, yes, I almost forgot. Mr. Kirchhoff pointed out that voltage drops around a circuit add to the supply voltage, and that current is the same in all parts of a series circuit.

by Bill Markwick

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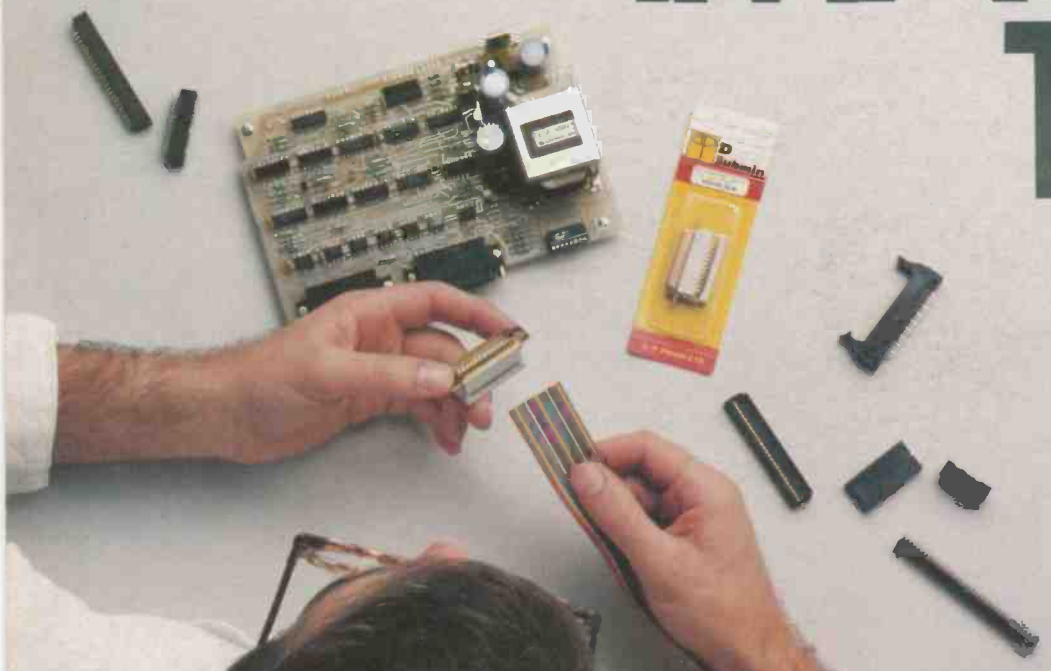

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