

Electronics Today

INTERNATIONAL

June 1982

Lasers in Hi-Fi

Intergalactic Sound

Leptons

Joy of Particle Theory

Hertz

Son of C/S

Phono Preamp

Hi-est of Hi-Fi



Roulette

Revolutionary Game



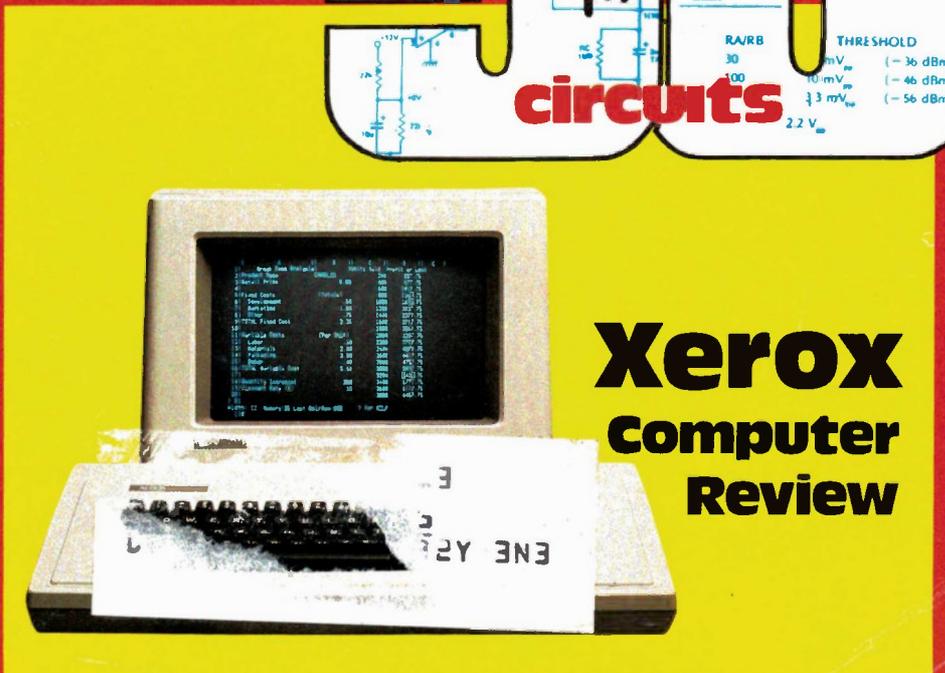
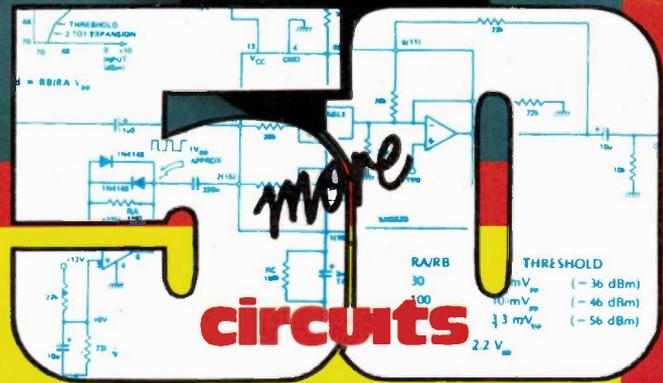
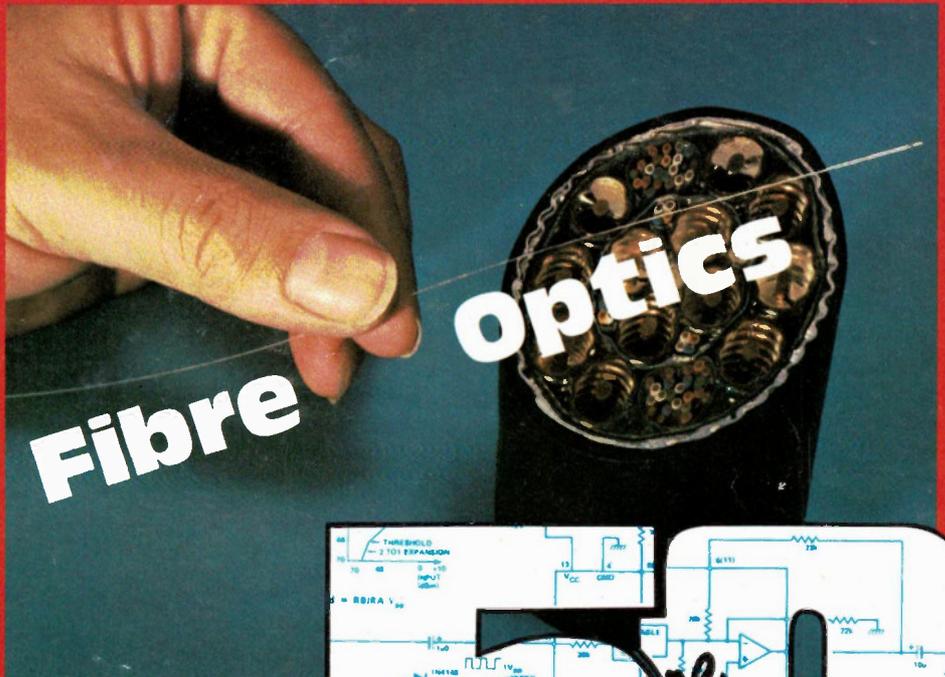
Light Wand

A Bright Idea



Stylus Organ

Quicky Project

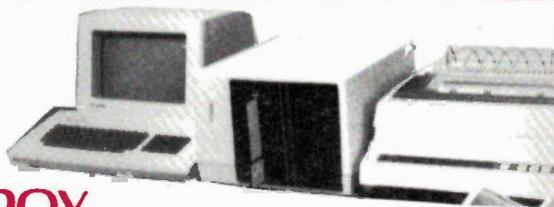


Xerox Computer Review



NEW COMPUTERS IN STOCK COME AND COMPARE IN OUR SHOWROOM

Exceltronix
Components & Computing Inc.



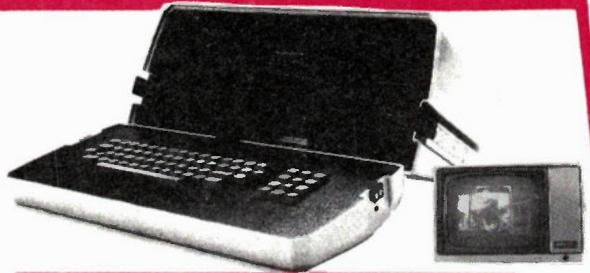
XEROX 820 INFORMATION PROCESSOR

This extremely versatile system can not only be a powerful CP/M based computer, but it can also be a low cost word processing system. Its standard features include: dual 5 1/4 inch disk drives (8" drives optional); CP/M operating system; 80 by 24 display screen; Z80 microprocessor; 64K RAM; 2 serial ports; 2 parallel ports; and "ETHERNET" compatibility. Also available is a 40 cps daisywheel printer.

820—1 with 5 1/4" disc drive (no printer) \$4395
820—2 with 8" disc drive (no printer) \$5395

THIS MONTH ONLY

If you buy the Xerox System you get a 20% discount off our regular MX100 Printer (one only)



OSBORNE 1

The Osborne 1 computer is one of the most exciting developments in the field of small systems in the recent times. Its low prices, combined with its small size and large features make it in high demand all over the world. The hardware features include: * a Z80A CPU with 64K RAM * dual floppy disk drives with 90K storage * 5" CRT * RS232 Interface * IEEE 488 interface * business keyboard. The software included is: * CP/M operating system * WORDSTAR word processor (c/w MAILMERGE) * SUPERCALC spreadsheet * CBASIC * MBASIC. And all this for the

amazingly low price of just **\$2495** special, and this month only, we throw in a 12" Zenith green screen monitor at no extra cost. **DON'T MISS OUT ON THIS OFFER.**



SANYO

COMPUTER

We, at EXCELTRONIX, are very pleased to introduce the SANYO FDS-1000 computer system. This remarkable system has a Z80A CPU with 64K RAM, an ASCII keyboard with 5 programmable function keys, an 80 x 25 green phosphor CRT display, and a 5 1/4" double-sided double-density disk drive all in one attractive package. The CP/M operating system is also included with the system for the price

of just **\$2725.00 SPECIAL**

*** New Daisy Writer
in stock please call**

ZENITH



COMPUTERS

The Zenith Z89 and Z90 are complete, personal microcomputers consisting of computer, keyboard, and video terminal in a single, compact unit. These computers feature up to 64K RAM, an 80 by 24, green phosphor CRT, 3 serial I/O ports, special graphics symbols for business users, an optional floppy disk drive, with either the CP/M or HDOS operating systems and wide software support. These superb all-in-one computers are priced as follows:

SYSTEM NAME	MEMORY SIZE	FLOPPY DRIVE?	PRICE
Z89-0	48K	NO	\$2895.00
Z89-1	48K	YES	3375.00 (Includes CP/M or HDOS)
Z90-0	64K	NO	3350.00
Z90-1	64K	YES	3650.00 (Includes CP/M or HDOS)

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**FOR ORDERING INFORMATION SEE
OPPOSITE PAGE.**



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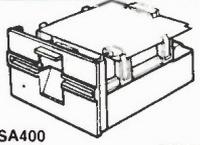


- 4164-150ns \$10.95
- (1 x 64K single (+5V) supply)
- 4116-150ns (1x16k) \$2.50
- 4116-200ns (1x16k) \$2.25
- 4116-300ns (1x16k) \$1.95
- 2114L-200ns low power. \$2.49
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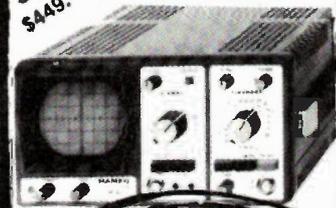


- SHUGART SA400 (5 1/4", SS) \$390.00
- SHUGART SA450 (5 1/4", DS) 549.00
- SHUGART SA801 (8", SS) 689.00
- SHUGART SA851 (8", DS) 950.00
- CDC 9406 8" DOUBLE DENSITY DD SPECIAL PRICE 649.00

\$100 COMPONENTS

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S100 Connectors **\$5.75 ea**
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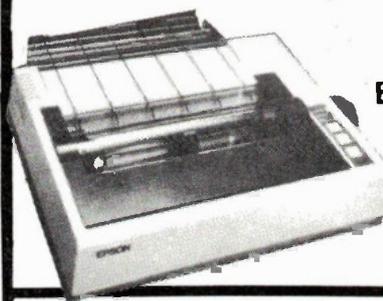
- LSA-1K Logic Analyzer kit without case \$295.00
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Send a certified cheque or money order (do not send cash). Minimum order is \$10 plus \$3 minimum for shipping. Ontario residents must add 7% provincial sales tax. Visa and MasterCard accepted; send card no., signature, expiry date and name of bank.



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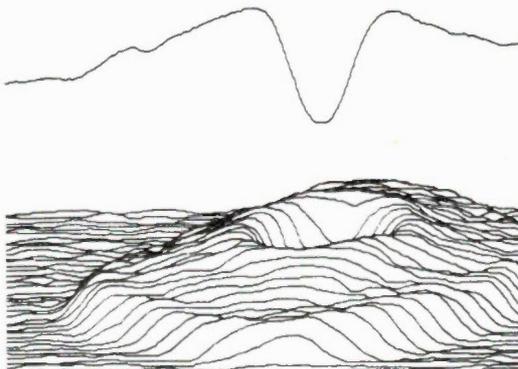
Become illuminated.

Stylus Organ64

A quick music project.



* Our Cover: Fibre optic technology is fast advancing to the point where phone wires may be as common as phone cranks. Picture © Bell Northern Research. Roger Allan explains, beginning on page 10. Also, the Xerox business system is scrutinized, on page 35.



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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.

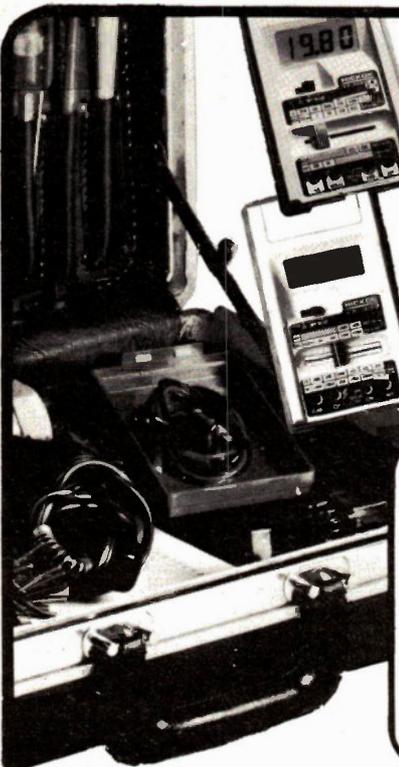
COMPONENT NOTATION AND UNITS
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!
Firstly decimal points are dropped and substituted 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 5.6ohms is 5R6.

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

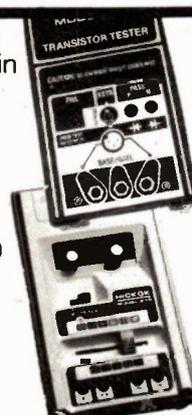
K.S.K. Associates, P.O. Box 54, Morriston, Ont. N0B 2C0.
BR Electronics, P.O. Box 6326F, Hamilton, Ont., L9C 6L9.
Wentworth Electronics, R.R.No.1, Waterdown, Ont., L0R 2H0.
Danocinths Inc., P.O. Box 261, Westland MI 48185, USA.
Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5V 2A5.
Beyer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

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Second Class Mail Registration No.3955. Mailing address for subscription orders, undeliverable copies and change of address notice is: Electronics Today International, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.

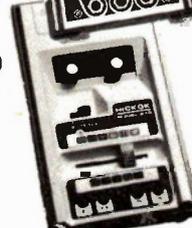


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Coronas, Invincibles, Cigarillos, Slim'n mild.

5-Volt LED Indicators

A series of new LED indicators that do not require the addition of external current-limiting resistors is now available from Industrial Devices, Inc. The LEDs are T-1 3/4 high-dome size in red, amber and green colors. Current-limiting resistance incorporated within the LED itself maintains current of about 15 mA at an applied voltage of 5V dc.

The new indicators are available as bare unpackaged LEDs, as panel-mounted assemblies which snap into 1/4-in. holes, and as right-angled PC board mounted assemblies.

For further information and a free sample write to Industrial Devices, Inc., Edgewater, N.J. 07020 or phone (201) 224-4700.

Temperature-controlled Solder System

A modular temperature-controlled soldering system has been added to the advanced "Soldering System 9000" series by the Ungar Division of Eldon Industries.

The System 9200 is intended for use where variable soldering temperature is not desired. Operating temperature of 600°F, 700°F, or 800°F is determined by the selection of a modular heater, which can be quickly changed.

Heater voltage is only 24 VAC, and the balanced soldering iron handle has a "soft touch" cool handle to reduce operator fatigue.

Any of the 14 standard Ungar tips or nibs can be used.

Further information is available from Eldon Industries of Canada, Markham, Ont. L3R 1H5. Telephone (416) 495-9407.

300/1200 BPS MODEM

A microprocessor-based Bell 212A-type modem which operates at 300 and 1200 bits per second and incorporates an auto-dialer is now available from Cermetek Microelectronics, Inc., either as a stand-alone modem, as an OEM board product, or as a licensed design.

The new modem is compatible with Bell's 103/113, 300 baud standards as well as with the Bell 212A, 1200 baud standard. It operates along an RS-232C interface.

As a single PC board ready for insertion into an OEM product, the CBP 212A is \$496.15 each in orders of 100. Size of the board is 8.25 x 11 inches (21 x 29.2 centimeters). Power supply is plus 5V at 600 mA max.; plus 12V at 200 mA max.; and minus 12V at 200 mA max.

For further information, contact Cermetek Microelectronics, Inc., 1308 Borregas Avenue, Sunnyvale CA 94086, telephone (408) 734-8150.

Disk Controller

Western Digital Corporation has announced their WD1010 Single chip Winchester Disk Controller. The device is a MOS/LSI circuit designed for use with Seagate ST506, 512, Shugart SA1000, 506, RMS500 series and others. The controller requires only a single +5 volt supply. It is designed to operate with an external sector buffer memory and to interface directly with TTL logic. The WD1010 is fabricated in NMOS silicon gate technology and comes in a 40 pin, dual inline ceramic or plastic package.

For more information, contact Weber Electronics Div. of DGW Electronics Corp., 105 Brisbane Road, Downsview, Ontario M3J 2K6, telephone (416) 663-5670.

TV/Video Sync Primer

Understanding the fundamentals of video and associated waveforms is made easier with a new TV/video sync primer and product note published by Hewlett-Packard.

This 16-page primer, with 13 drawings and three photographs, has special sections that include the U.S. NTSC broadcast standards and nomenclature, a discussion of PAL, NTSC and SECAM systems of color transmission and a glossary of TV and video terms.

Other sections cover theory of operation, typical setup, specifications and the features and applications possible when a TV/video sync option is added to any currently-manufactured HP 1700-series oscilloscope.

The applications in this product note (5953-3900) are relevant to such industries as medical imaging, consumer video products and television broadcasting.

For more information, contact Hewlett-Packard (Canada) Ltd., 6877 Goreway Drive, Mississauga, Ontario L4V 1M8. Telephone (416) 678-9430.

Pearl III

The Pearl III program generator is now available for Zenith Data Systems Z89 and Z90 microcomputers.

Pearl III is designed as a tool for systems integrators and experienced programmers, permitting them to develop software for custom applications. It operates under the CP/M operating system and is priced at \$795.

The Pearl III software creates an applications program in the CBASIC language with custom menus, data verified by type and length, custom reports, computation capabilities, file sorting abilities, and the ability to post journal files to a master file.

A Zenith microcomputer system with 56K of memory, the Z37, Z47 or Z67 disk drive, CP/M operating system, and CBASIC are required to use Pearl III.

Zenith Data Systems microcomputer products are available from authorized Zenith Data Systems dealers nation-wide and from Heathkit Electronic Centres in Vancouver, Calgary, Edmonton, Winnipeg, Mississauga, Ottawa and Montreal.

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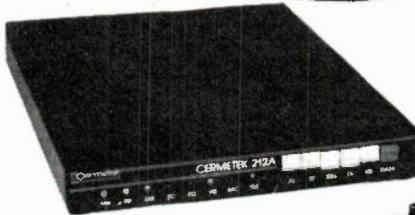
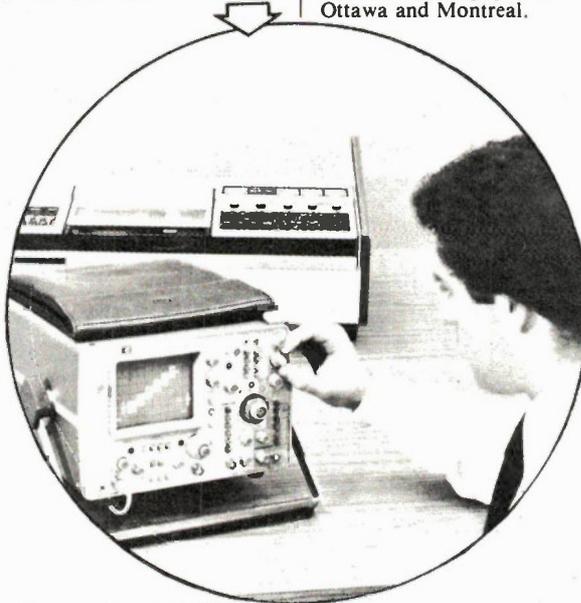
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LIABILITY

While every effort has been made to ensure that all constructional projects referred to in this magazine will operate as indicated efficiently and properly and that all necessary components are available, no responsibility whatsoever is accepted in respect of the failure for any reason at all of the project to operate efficiently or at all whether due to any fault in the design or otherwise and no responsibility is accepted for the failure to obtain component parts in respect of any such project. Further no responsibility is accepted in respect of any injury or damage caused by any fault in design of any such project as aforesaid.

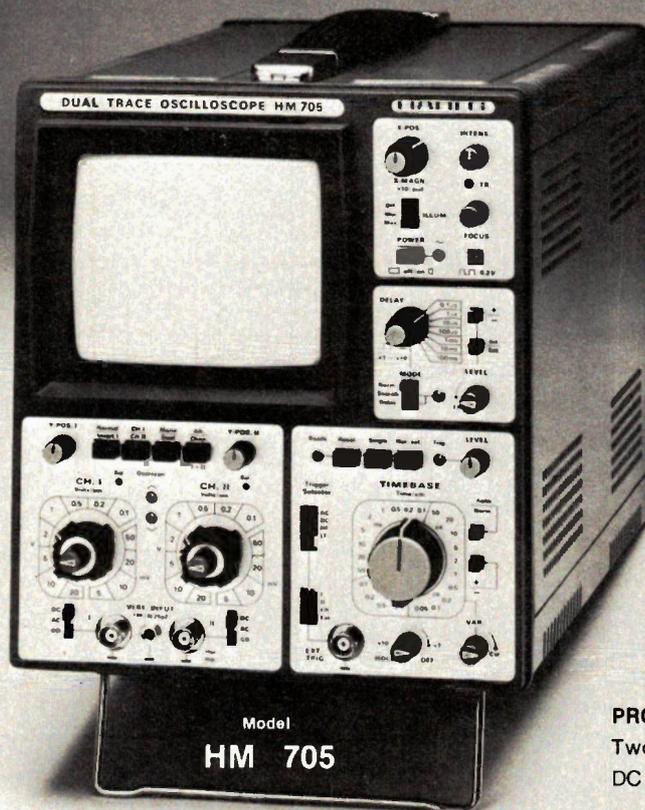
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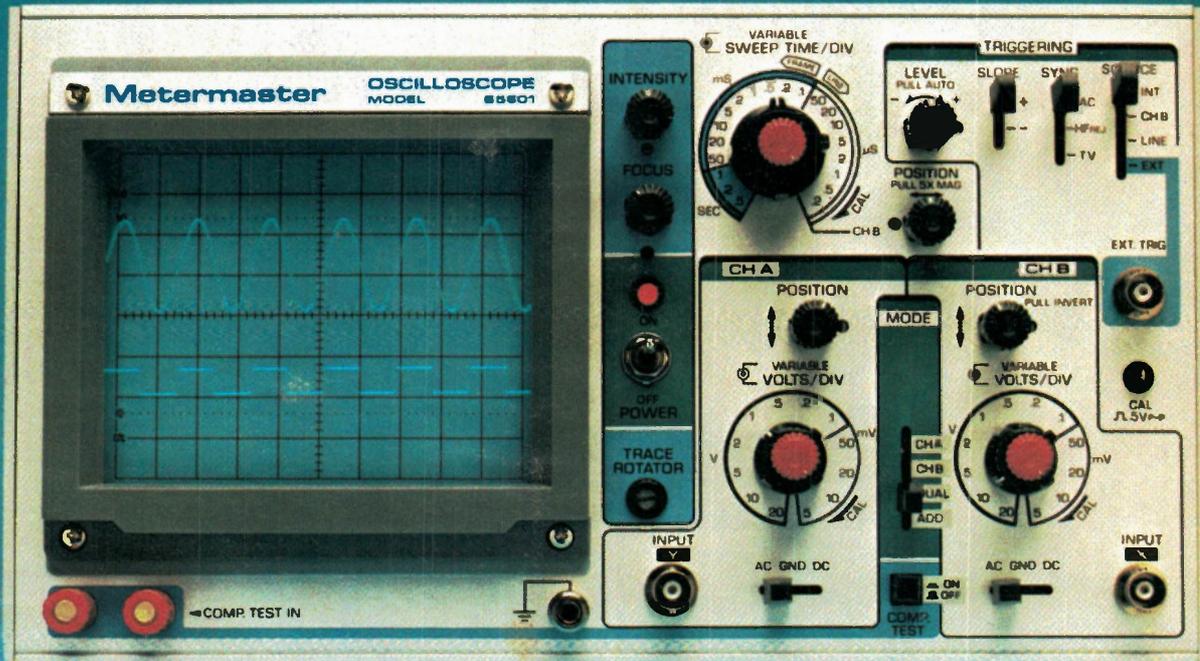
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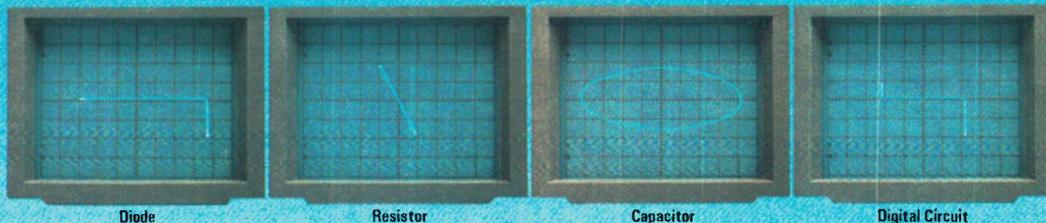


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NEWS

Robot Launch

Mitsubishi have just launched a micro-robot on the Japanese market which is designed for training operators, as a teaching aid, as a point-of-purchase display as well as for hobbyists. It goes by the name of "Move Master"!

The 10 in high unit is a six-axis articulated arm with five degrees of freedom of movement — it can lift up to about 1 lb. It can be controlled from either a dedicated robot controller or your personal computer. Repeatability of movement is claimed to be ± 0.3 mm, which is as good as industrial robots.

There is an incorporated microcomputer so instructions can be given in a robot language known as M-ROLY (Robot Oriented Language by Yahagi — the M is presumably for Mitsubishi) or in BASIC.

Price is reported at \$2400 for the robot, \$2600 for the controller; an available date in Canada is not yet known.



Turin Shroud Dated To Crucifixion?

An American theologian, the Rev. Francis Filas of Loyola University, has subjected the area of the cloth around the eyes of the image to computer analysis, using image analysis equipment at Log E/Interpretations Systems in Overland Park, Kansas. Past analysis had established the presence of coin-identifiable markings on the 'buttons' over the eyes of the figure, but Rev. Filas in this case enlarged the eye sections to produce high-contrast, three-dimensional digitised photos that washed out the weave of the cloth without destroying the pattern.

These images are claimed to have revealed a three-dimensional image of a Roman coin (on the right eye) bearing the representation of an astrologer's staff and the letters 'UCAI'. With the help of a numismatist Filas was able to determine that these letters were an abbreviation for words meaning 'Of Tiberius Caesar', and the coin fitted the description of ones minted by the Romans between 29AD and 36AD, around the time of the crucifixion.

The identification of Roman coins placed over the eyes certainly adds a little more weight to the arguments that the Shroud at least dates from Roman times and is not a mediaeval fake. However, it could also be argued that a forger could have obtained Roman coins in order to add authenticity to his creation. . . and so the controversy continues.

Letter Quality Printer

The new Commodore 8300P Letter Quality Printer, designed especially for use with PET and CBM Computers, has been announced.

A version of the Diablo Model 630 Receive-Only Terminal, the 8300P includes the following standard features: immunity to electrostatic discharge, end-of-ribbon sensor, paper-out detection, cover-open interlock, internal self-test diagnostics, 320-byte printer buffer and automatic bi-directional printing.

Standard control panel features include: form-feed, pause and reset switches, as well as two lights indicating ready/error and power-on. Switch selectable features available by raising the access cover are printwheel select, pitch, parity, protocol, baud-rate and self-test.

Optional support of languages other than English is available. Optional accessories include an adjustable-width continuous forms tractor mechanism.

The standard ribbon supplied with the CBM 8300P is the Diablo multi-strike film ribbon. The CBM 8300P directly supports use of most Diablo metal or plastic printwheels.

An IEEE to RS-232C printer adaptor will be supplied with the printer. All CBM printers are equipped with a standard PET-IEEE interface connector.

For further information, Donna Green, Market Coordinator, Word Processing, Commodore Business Machines Limited, 3370 Pharmacy Avenue, Agincourt, Ontario. M1W 2K4, telephone (416) 499-4292.

Also....

The Science Council of Canada has called for action to be taken to overcome a predicted shortfall of 12,400 engineers by 1985 in the electronics and aerospace industries.

The DOC have changed the regulations to allow isolated logging, mining and exploration camps to apply for satellite reception licences; until now licences have been severely restricted.

It came home to us how recent a development electronics is when we received a British press release that Marconi's widow, Marchesa Maria Cristina is not only alive but recently inaugurated a new communications headquarters!

Two thousand Teldon terminals are planned to be in operation by this summer in Ontario for the use of tourists. They will be located in hotel lobbies, malls and government tourist offices. The Infomart data base will be used and 50,000 pages will be available.

Last summer Project Cabot in Newfoundland was a similar scheme and there are plans to expand it for 1982.

Six pay-TV operations are planned for Canada starting next year. However a recent survey in the US has predicted 141 different cable networks will be active by the end of the decade! The same report predicts cable and pay TV audiences in the US will overtake broadcast TV viewers by the summer of 1983.

The Central Ontario Amateur Radio Fleamarket will be held on June 5th 1982 at Regal Hall, 340 Woodlawn Rd., W., Guelph, Ontario. Hours 8-4. For information call (519) 843-4618 or (519) 824-1157.

The McLeyvier Musical Computer, invented by Dave McLey of Toronto has been given an Award of Excellence for Industrial Design. Ten years in development, the computer can store 4,000 different pieces of music and 10 million musical notes; it will even write the score on the screen as it is being played.

Canada's first annual consumer-oriented electronics exhibition, Electronics Showcase, will be held at the Automotive Building at the CNF grounds, September 16th to 19th.

Types of exhibits will be personal computers, software, video systems, programmable telecommunications, advanced audio systems, pay TV, public information systems and home environment control products. Potential exhibitors should contact Intelevent at (416) 534-4790.

By 1990 there will be 30 million microcomputers in Japanese homes and business according to a recent survey. That works out at more than one per family or two computers for each car.

At present the Japanese have just 10% of the world market for computers, the US has 80% and the rest of us share the remaining 10%.

Australian and British scientists have found a quasar 18 billion light years away — 2 billion more than the previous record.

A report in the "Annex Computer Report" paints a dismal picture for the future of IBM. Serious economic troubles or even collapse are predicted by the end of the decade. This conclusion is drawn by looking at past trends in the company's development.

Bubble memory hasn't taken off as was anticipated: last year National Semiconductor, Rockwell and Texas all gave up on it - at least for the present. However, British Telecom who run the phone system and partially all other electronic communications have said they find bubble memory reliable and are backing it - a much needed boost for this technology.

Video Disc players from RCA are selling much slower than originally forecast. Despite an enormous advertising campaign, sales so far have reached just 60,000, just 30% of the target. Possibly to overcome this, RCA are planning to announce a stereo version in June.

71% of TV sets in Canada are now colour against 20% just 10 years ago. The proportion of homes with colour TV is however much higher as most monochrome receivers are now second or third sets.

By the end of 1982 it is estimated there will be 750,000 VCR machines in Canada. The figure for the US should reach 3,000,000.

According to a survey from EHL Research and Development, Toronto, there are now 9500 microcomputers in Canadian schools.

According to EEMAC shipments of electrical and electronic goods in Canada are up 10.8% (in dollar terms) from this time last year. Exports were up to 0.1%, imports up 8.5%. Average earnings in the industry in April were \$8.62 per hour, up 6.4% on the year.

Syquest Technology of California are planning to launch a 3" winchester disk in June; both fixed and removable disk versions are planned.

A dedicated maritime satellite has recently come into operation run by INMARSAT. It's a \$250 million venture designed to provide telephone, telex, fax, telegram and high and low-speed data for the 70,000 merchant ships over 100 tonnes in the world. Until now these facilities have been leased on the COMSAT satellites.

There are at present four earth stations but five more are coming into operation this year.

There are currently 1000 vessels with the ability to communicate with satellites.

ETI

Fibre Optics

Fibre optics are good for a lot more than making unusual lamps, as Roger Allan explains.

IT IS A TRUISM DERIVED from the history of science that virtually all physical they may initially seem, are built on a mere handful of equations that in themselves any school child can understand, or at least manipulate with a modicum of teaching. So much so, in fact, that one scientist with NASA once remarked that if you scrape away all the verbage and derivatives, isolating the kernals of physical truth, that the entire Apollo project of placing a man on the moon could be reduced to some nine simple formulas.

"But we have a harder job than the commercial aircraft designers," he added. "After all, a Boeing 747 can be reduced to seven simple formulas."

Such is the case with fibre optics, or waveguides as they are becoming increasingly called. To misquote Greene, the heart of the matter is one of the simpler formulas in physics, specifically Snell's Law which states that

$$n_1 \sin \theta_1 = n_2 \sin \theta_2 \text{ where}$$

n_1 = the index of refraction for the medium through which the light ray is initially passing.

n_2 = Is the index of refraction for the second medium the light ray passes through

θ_1 = the angle of incidence of the light ray

θ_2 = the angle of reflection

The law determines the change in direction that occurs when a light ray passes from one medium to another. If $\theta = 90^\circ$ for the case where n_1 is greater than n_2 , no light penetrates into medium 2. At this point, the angle of incidence is termed the critical angle and is defined as $\sin \theta = n_2/n_1$. For any angle of incidence greater than the critical angle, total internal reflection takes place.

On such a simple law is to be built a revolution in communications ability; fibre optical cable.



Essentially, a fibre optic cable, or waveguide, consists of optically pure glass made of pure silicon. It is very thin (about 0.125 mm), surrounded by a layer of silicon some 0.40 mm thick which in turn is surrounded by a layer of nylon. The nylon and the silicon provide strength members for the inner glass core, while the difference in the indices of refraction between the glass cladding and its central core provide the medium interface such that light shone through

the optically pure glass core will most usually strike the interface at an angle greater than it's critical angle and will be reflected back into the glass core. Commonly, this is referred to as the *solid coated* or *tight jacketed fibre* type. There are others, but they are of experimental use only as yet.

Fiberglass

The actual process of manufacture,

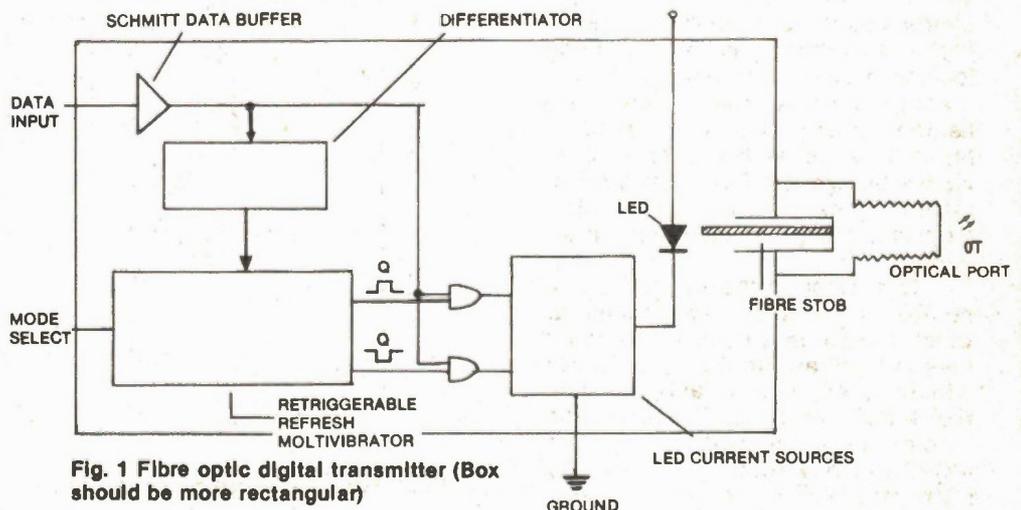


Fig. 1 Fibre optic digital transmitter (Box should be more rectangular)

regardless of which company is making the fibre optic cable, is based on Bell Laboratories' scientists work resulting in what is called the Modified Chemical Vapor Deposition Modified Chemical Vapour Deposition Method (MCVD). In this process, a vapor mixture of chemicals is introduced into a rotating glass tube composed of pure silica, which is heat source. In the resulting chemical reaction, oxide particles are sintered on the inner surface of the tube, consolidating to form a continuous layer. The tube and the layers of glass are then collapsed to yield a solid glass rod, or preform. The preform end is then heated to its melting point, and extruded into hairs some 1/1000 of an inch thick. Approximately ten miles of extruded fibre optic cable can be drawn from a thirty inch preform.

Acceptance of the MCVD process was due in part to the decrease in impurities over other methods, in turn due to the chemical reaction sintering process taking place inside the tube. The tube not only provides part of the fibre optic structure but also a protective environment for the chemical deposition process reducing external contaminants. It is said that the impurity rate (such as water, which is a major factor in decreasing the optic clarity of the fibre) is analogous to three grains of sand in a railroad car full of sugar. Were the ocean as optically pure, one would be able to see the bottom of the ocean at its deepest point while swimming on its surface.

A more recent advance was also a product of Bell Laboratory scientists' work. Essentially, the basics of the newer process are the same, but with the sintering process hastened by the creation of a plasma fireball, a highly energetic mixture containing ionized atomic fragments. In this plasma process, the vapours are heated not only by an external torch but are heated with a zone that includes the plasma formed and maintained inside the tube by electromagnetic energy produced by an induction coil.

This second process results in a number of benefits. The speed at which the process occurs can be increased to about 2.5 grams per minute, substantially faster than in the MCVD process. Transmission losses are comparable with the MCVD process, running at about 3.4 dB/km at 0.85 microns, and 1.5 dB/km at 1.2 microns. It is also cost effi-

cient, using the reagent chemical vapours more economically. For example, the most expensive chemical used, germanium, is utilized at the rate of 70%, compared to about 5% in the standard MCVD process.

With the cable manufactured, the next step in constructing a fibre optic system is getting the light into and out of the cable. Essentially, there are two basic methods, one based on analogue wave configurations, whereby a wave itself is modulated similar to AM radio waves, the other based on digital wave configurations. Systems based on analogue wave configurations were the first used, primarily because of the shelf devices were readily available from radio parts manufacturers, and these parts were cheap and of proven reliability. However, with the rise of digital system equipment and the increase in both its reliability and the decrease in its price, analogue methods are falling into disuse.

With the signal in digital form, it must now be translated into optical form. This can be done either of two ways, via a solid state laser or a GaAsP LED. The advantage of a solid

state laser generated signal is that the wavelength of light emission can be exactly controlled. Hence, an optical fibre can carry not only a number of messages by stacking the messages one on top of another in digital form, but by using two or more solid state lasers operating at different wave lengths, each one carrying a 'stack' of digital signals, the total information carrying capacity of the fibre optic cable can be substantially increased. To date, practical usage of a fibre optic cable can include more than 20,000 simultaneous conversations over a single fibre. And, by using two or more different light wavelengths, one each originating at either end of the cable, a single cable can carry two way transmissions.

Lasers are now used only for high data carrying circuits, such as connections between major telephone exchanges. More usually GaAsP LEDs are used, which, while not producing light as optically pure as lasers, more than fulfill the requirements for fibre optic usage.

There are a number of devices on the market for translating the electrical data into optical data. One of

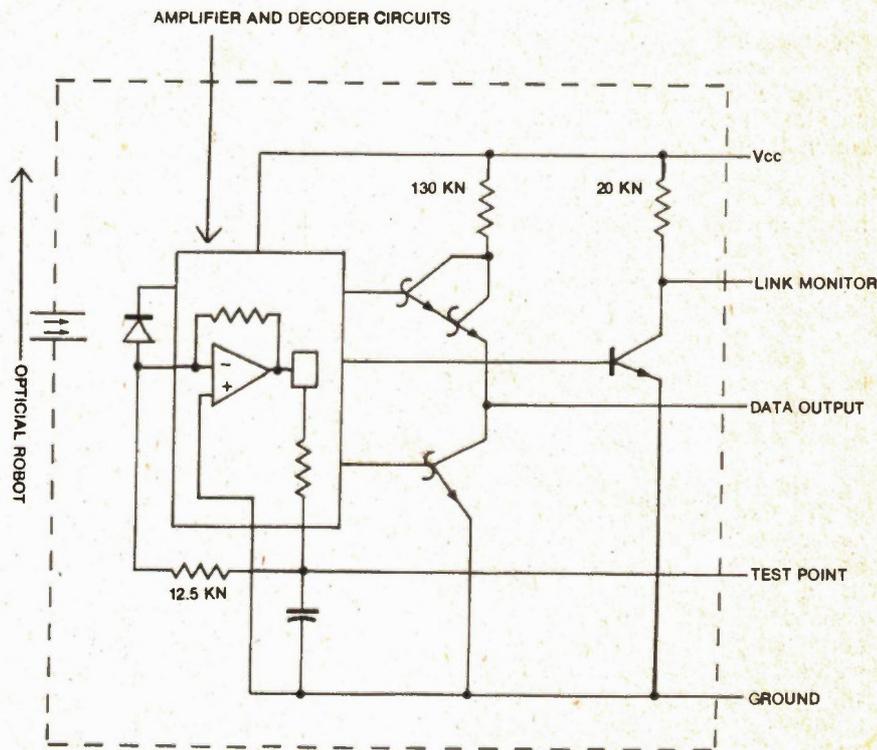


Fig. 2 Typical fibre optic receiver circuit

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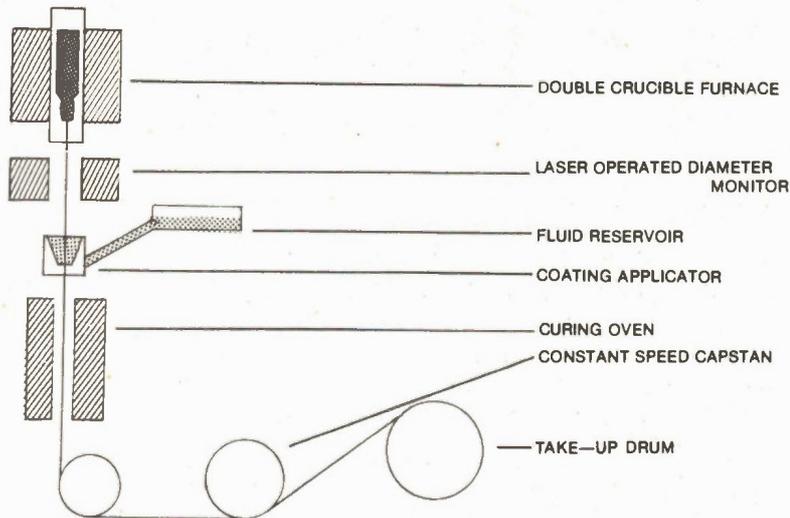


Fig. 3 Schematic of fibre pulling and coating apparatus.

the more typical off-the-shelf transmitters is the HFBR-1002 manufactured by Hewlett Packard. Measuring only some 44mm x 17mm x 6mm, the transmitter has two modes of operation, *internally coded* and *externally coded*. The selection of modes is determined by external wiring.

For internally coded operation, the optical signal generator produces a mid-level flux which has positive or negative excursions. A train of positive excursions is initiated when the data input goes "high" and conversely a negative train of excursions is initiated when the data input goes "low". These excursions are pulses of approximately 40 ns duration with a 300 kHz repetition rate. Each initiation of a pulse train starts with a full-duration pulse, but when data input changes state, the train is terminated, even at mid-pulse, as a new train of opposite-polarity pulses is initiated. The internally coded mode permits transmission of analogue information, while the externally coded mode permits digital coding. The optical signal generator is connected to a LED, which butts onto the end of the fibre optic cable.

A receiver must be placed at the other end of the fibre optic cable. The Hewlett Packard HFBR-2001, a typical off-the-shelf variety, measuring the same dimensions as the transmitter, consists of the optical flux entering via an optical fibre stub where a PIN photodiode converts it to a current. The current goes to an I-V (current to voltage) amplifier which utilizes DC feedback. The function of the DC feedback is to keep the average value of the signal centered in the linear range of the amplifier.

Customarily, the fibre optic cables are manufactured to user specified lengths. This is to cut down unnecessary butting or joints between individual fibres, for whenever there is a butt, the optical purity of the light wave is decreased. However, on occasion it is necessary to butt cables. Superficially, the process appears easy; just glue them together. But remembering Snell's Law, any failure to exactly and evenly butt and the end points will substantially decrease the reliability of the signal by increasing the dB/distance loss.

The first step in preparing a butt consists of preparing the cable. In this step the fibre optic cable is stripped of its jackets, and the strength members are terminated by the installation of crimp hardware. The prepared cable end is then assembled into the connector body using a high performance epoxy to stake the optical fibre. The epoxy is cured in ten minutes using a heater. The fibre end is then ground to an optically flat finish and inspected with a microscope, comparing the finishes of both ends and making sure that there are no micro-scratches. The two cable ends are then connected and held together mechanically.

There are many reasons for undertaking the above in an attempt to build a fibre optic network. Fibre optics have many advantages over conventional copper wire which cannot carry video images for any practical distance and over co-axial cable which can be used only for limited distances. Optical fibres permit the simultaneous transmission of voice, video and data signals, both uni- and bi-directional.

Cost-wise, fibre optic cable is significantly cheaper than coaxial cable, orders of magnitude cheaper than the price for an equivalent data carrying capacity in paired copper wires, and are rapidly closing the price gap with paired copper wire for simple, one message uni-directional type communications.

The fibres can routinely carry signals up to 10 km without having to be regenerated. This distance has been increased experimentally to some 45 km using a solid state laser. Coaxial and copper pair wire systems require a repeater every two miles or so. Further, the regeneration process in fibre optics is a total regeneration, unlike repeaters which lose some of the impulse quality every time they are repeated. Hence, regardless of how many times an optical signal is regenerated, the quality of the signal at the end point is identical with the quality of the input signal.

Optical fibres do not set up an electromagnetic field, hence making them extremely difficult to tap. Likewise, fibre optic systems do not pick up environmental noise and hence deliver a clean signal free from crosstalk. This is of especial use in factories, such as the GM plant in Oshawa, where the large number of electrical circuits in the plant severely effected the quality of communication between a computer and a series of mini-computers on the assembly line. Replacing the standard wire system with fibre optics completely removed any cross interference.

Due to the substantially reduced size of fibre optic cables, compared with twin-wired copper, they take up far less room where space is at a premium, such as in ducting. It is felt that if a major city were to be completely wired using fibre optics there would no longer be any need for digging up the streets to put in additional wiring.

Applications

Not surprisingly, as the technology has been largely invented in Bell Laboratories, though good work is being done in Canada at Northern Telecom and in the Communications Research Centre Laboratories. It is the Bell affiliated telephone systems in the U.S. which have been both the first and the most extensive (if poetically uninspired) users of fibre optic cables.

The first extensive field test of fibre optics for communication, and a bench mark trial it was, was under-

taken by the Bell System in Chicago in 1975, and is known as the Chicago Trial. It was the first waveguide system to provide a full range of communication services, and over its two year course, during which there was virtually no down-time due to equipment failure, the Bell System became convinced that fibre optics should be implemented in lieu of copper wire cable as extensively as possible.

In 1979, the Southern New England Telephone Company installed waveguide technology to connect that portion of the network between a telephone company switching office and its' customers' homes (known as a "loop plant"). In 1979, Pacific Telephone and Telegraph central switching offices were connected by fibre optics. In 1980, for the Winter Olympics, a temporary 2½ mile waveguide link carried television and voice links at Lake Placid, New York. By 1980, New York Telephone had installed a waveguide link in lower Manhattan, allowing users to communicate with each other via waveguide links. In 1980, Bell Labs/Western Electric/Pacific Telephone and Telegraph in Sacramento upgraded their waveguide system by generating signals at longer waveguide links. In 1980, Bell Labs/Western Electric/Pacific Telephone than more customary wave lengths and therefore fewer repeaters are required.

And the list goes on. 1981 installations include a 3.6 mile system in San Francisco capable of handling 13,000 simultaneous conversations, a 40.6 mile system in Pittsburgh capable of 20,000 conversations, and similar installations in San Francisco, White Plains, NY, and Philadelphia ranging in length up to 40.6 miles and 40,000 simultaneous conversations.

The biggest project has yet to be built. It consists of a 611 mile waveguide running from Boston to Washington, D.C. capable of handling some 80,000 simultaneous conversations. The first leg from New York to Washington will commence operation in 1983 by the Long Lines Department of A.T. & T., with the second leg to commence in 1984, at a cost of seventy nine million dollars in construction and operating costs by 1990.

The optimum any waveguide advocate can hope for is a totally wired city. This is not the stuff of dreams, but of reality.

The world's first wired city using fibre optics is the HI-OVIS project

(Highly Interactive Optical Visual Information System) in the Japanese city of Higashi-Ikoma, a commuter suburb of Osaka. Utilizing some 400 km of optical fibre, the project involves some 158 subscribers homes linked by optical fibres to a sub-centre in an interactive full two-way video television system. The system offers retransmission of six VHF and three UHF channels, 14 channels of video information services (which include full video stored on video tape cassettes in a mass video storage device, videotex stored in a computer memory and microfiche), as well as two channels for reservation services and four channels containing railway schedules. UHF is brought down from an antenna located on nearby Mount Ikoma on a 4 km repeaterless optic fibre link to a central station.

While the cost of this pilot project is high, being some 20-30 million dollars, the Japanese Ministry of Industry and International Trade has announced that HI-OVIS will be expanded at a cost of \$100 million to in-

posal that a city of 30,000 be wired. Which city, or what the capability of the wiring will be has not been announced, though it is believed that the French government wishes to secure for France a viable position in international fibre optics and hence decrease the risk of becoming a dumping ground for Japanese fibre optic systems. As such, it is expected that the optical wiring will be as near to the state of the art as French science and industry can produce.

Fibre optics in Canada seems to be developing a head of steam of its own, with new projects and expansion of existing projects becoming more and more frequent.

One of the first projects was commissioned by the Department of National Defense in 1976. The project resulted in a fibre optic system installed in its Ottawa headquarters. Essentially, the system was designed for increased security. With the cable supplied by Bell-Northern Research,

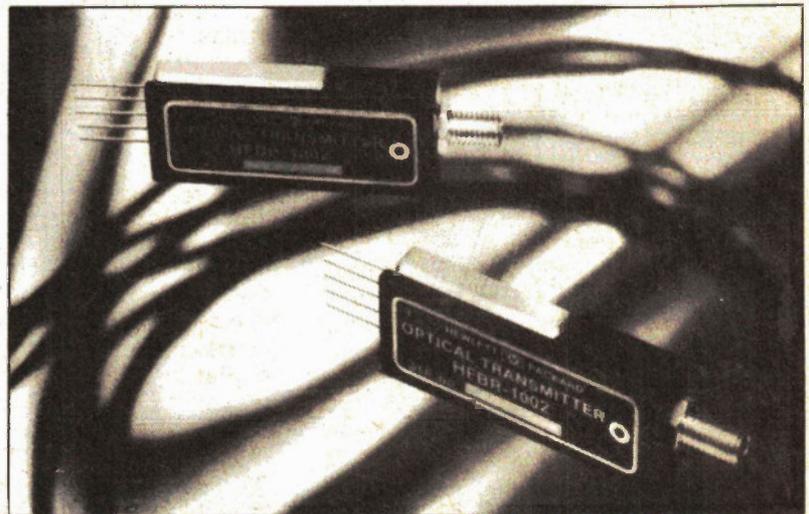


Fig. 4 Hewlett-Packard fibre optic transmitters and receivers.

clude the Japanese towns of Kobe and Nishin, totalling some 8,000 homes. Since its implementation in 1978, HI-OVIS has only experienced difficulties in the electro-mechanical mass video storage units. It is interesting to note that in the HI-OVIS system, there is no provision for telephone, a recognition of the Japanese priority for cablevision rather than the Canadian and US priority of telephones.

The only other major total city wiring project on the boards at present, is a French government pro-

telecommunications systems.

In October 1977, Bell Canada connected two switching centres in downtown Montreal with a fibre optic cable 1.5 km long containing six fibres. It is used for video conferencing.

A similar network was installed in the same year by British Columbia Telephone, linking North Burnaby with Vancouver. The cable, 7.4 km long, is used for transmission of voice and data signals.

In December 1978, Bell Canada instituted a project involving 35

residential homes in Toronto's Yorkville district. The project represents the first time that telephone subscribers have been linked to a central switching office by fibre optics, though the MGM Hotel in Las Vegas, Nevada, has had its room telephones connected to the hotel switchboard by fibre optics since January 1978.

In the realm of the strictly television, London, Ontario is the site of the world's first operational fibre optic cable TV super-trunk system using digital TV transmission. At a cost of 1.65 million dollars, partially paid for by the government as a research project, the one-half inch thick cable containing eight optical fibres is 7.8 km long and links a local TV station with London Cable TV. The system is capable of providing two-way video communication and has a transmission capability of 15 channels.

The largest fibre optic installation in Canada was built by the Alberta Government Telephone System. It connects Calgary and Cheadle, Alberta, via a 53 km fibre optic cable with a capacity of 20,160 telephone calls simultaneously over twelve channels. As a data handler, it can carry 274 millions bits per second. Interconnected with the 3,700 km long digital system from Calgary to Toronto, the project will also be used as an on-site test for an integrated fibre optic distribution system via connection to local nodes of telephone subscribers with provision for medical alert, FM, automatic meter reading security and fire alarm systems.

The largest project in Canada to date is being undertaken by SASK-Tel. This Broadband Network (BBN),

will consist of some 3,200 km of wave guide cable connecting some 190,000 households (560,000 people), making it both the longest and most extensive such system in the world. The total cost will be some 56 million dollars, and will take until 1984 to build, with the first link (a large scale field trial) to be between Regina and Yorkton involving some 200 km of cable. While primarily built for telephone communications, it will per-

mit later date introduction of cable television and other communications forms.

Of some concern with the SASK-Tel project is its relative value viz a viz satellite communications, concerns which have led to disagreements with the Federal Department of Communications, which has a heavy financial commitment in satellite technology.

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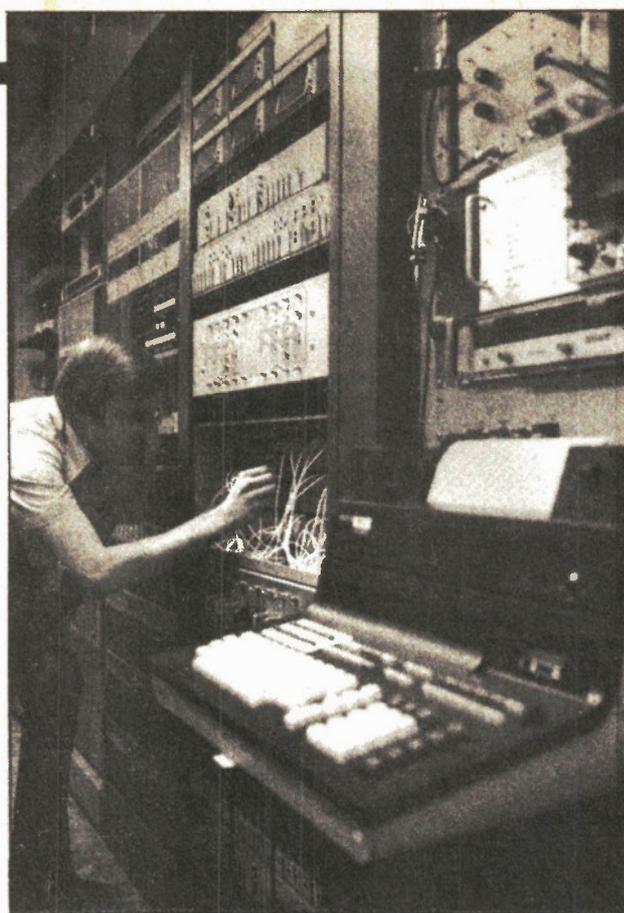


Fig. 5 A Bell fibre optic patch bay — courtesy of Bell Labs

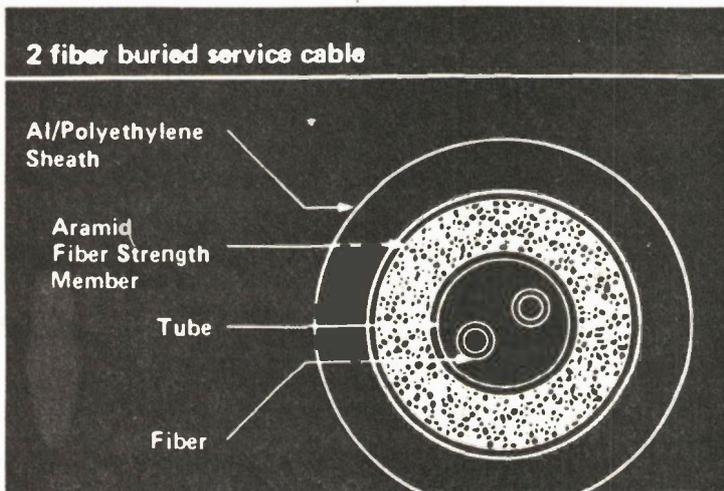


Fig. 6 Cross section of a waveguide

POSTSCRIPT

Shortly after we typeset this feature, fibre optics suddenly leapt into the news in Canada.

An Assistant Trade Representative at the Russian Embassy, Mikail Abramov, was ordered out of Canada reportedly for trying to buy fibre optic technology. Because of its potential military uses, NATO countries have banned its export to the Eastern bloc.

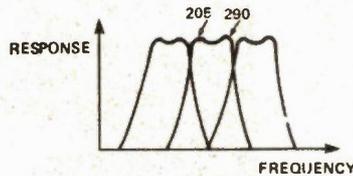
The implication is that the advances in fibre optics are probably far greater than has so far been made public. After all you can now buy samples of this technology at the retail level.

The Soviets deny that there's any basis for this affair but then they're hardly likely to admit it, are they!

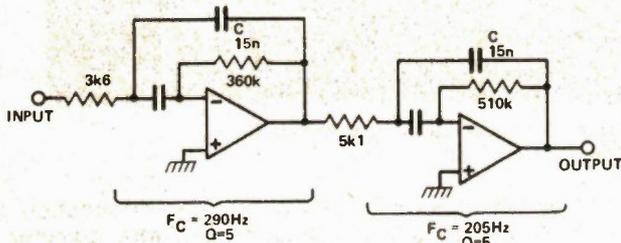
50 more circuits

1 Double Tuned Band Pass

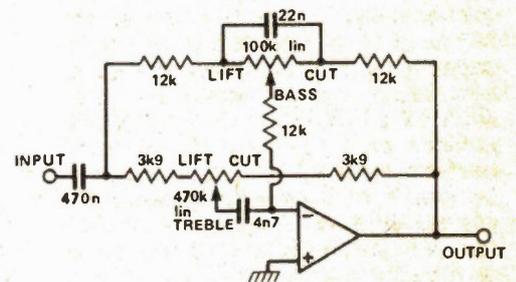
Filter section has been designed for one octave spacing. To alter the components for the other octaves, scale the resistors or the capacitors, ie changing C to 7n5 increases the filter frequency by one octave.



Typical filter bank response

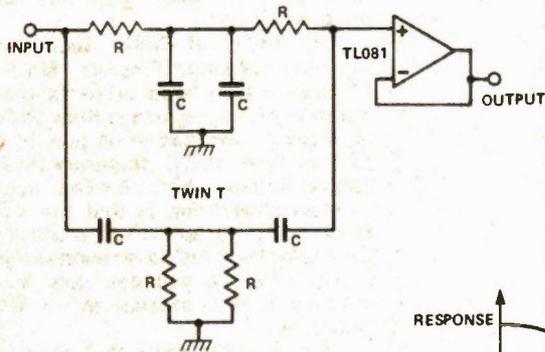


2 Bass And Treble Tone Control

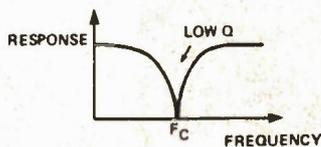


3 Active Notch Filter

The two R's in parallel represent R/2
The two C's in parallel represent 2C
For 80 Hz, R = 800k, C = 3n9 (a hum remover)

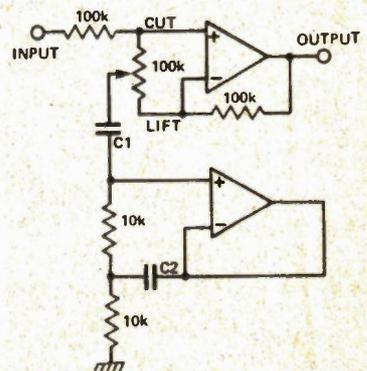


$$F_c = \frac{1}{2\pi RC}$$

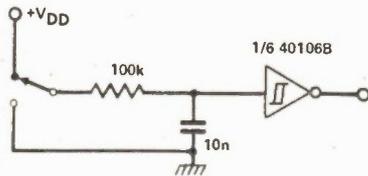
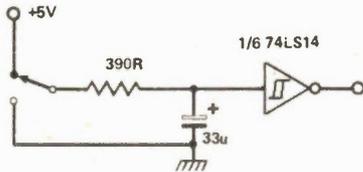
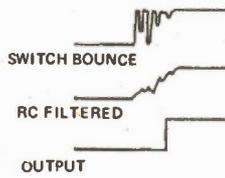


4 Middle Tone Control

Input must have a DC path to ground



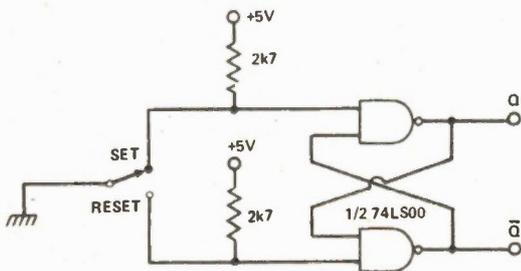
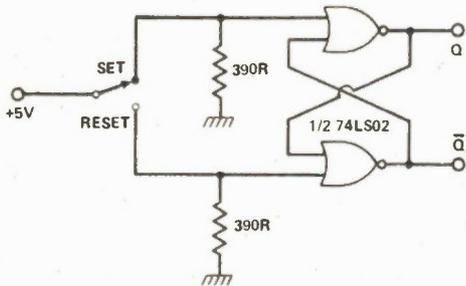
5 Switch Debouncing Using Schmitt Triggers



6 Switch Debouncing Using Flip-flops

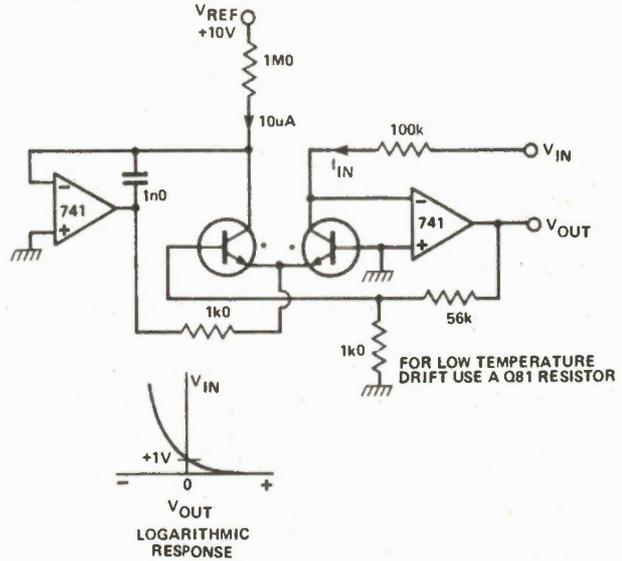
Flip-flop using NOR gates Flip-flop using NAND gates

S	R	Q	\bar{Q}	S	R	Q	\bar{Q}
1	0	0	1	0	1	1	0
0	1	1	1	1	0	0	1



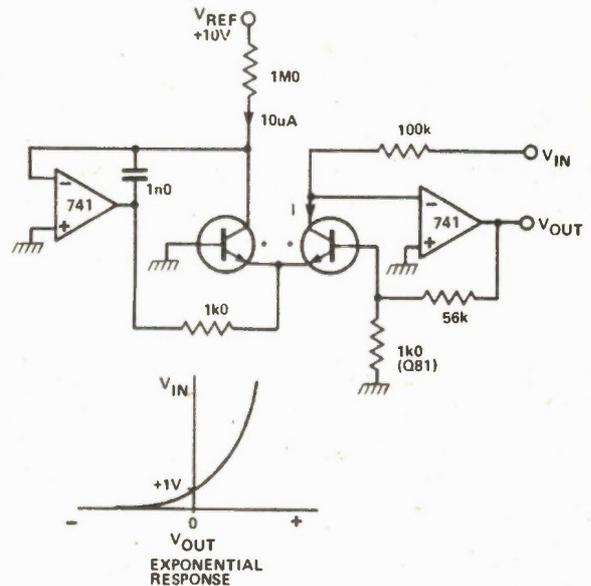
7 Log Converter

V_{OUT} changes by 1 V for every octave change of the I_{IN} current
 *The matched transistors can be two 2N3905 in thermal contact, or a dual transistor (LM394), or part of an array (CA3048).



8 Antilog (Exponential) Converter

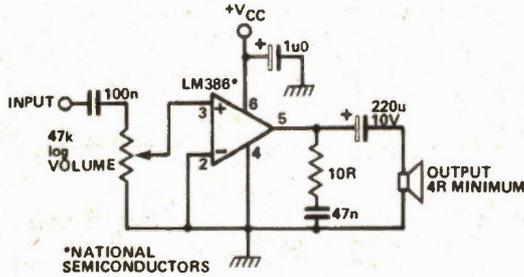
$V_{OUT} = I \times 100k$
 The current I doubles for every 1 V increase of V_{IN}
 When $V_{IN} = 0$ V, $I = 10 \mu A$



9

Low Voltage Power Amp

Voltage gain (fixed) = x 20 (26 dB)
 +V_{CC} range = +4 V to +12 V
 Typical quiescent current = 4 mA
 Output power = 0W7 (if +V_{CC} = 9V, speaker = 8R)
 THD = 10%

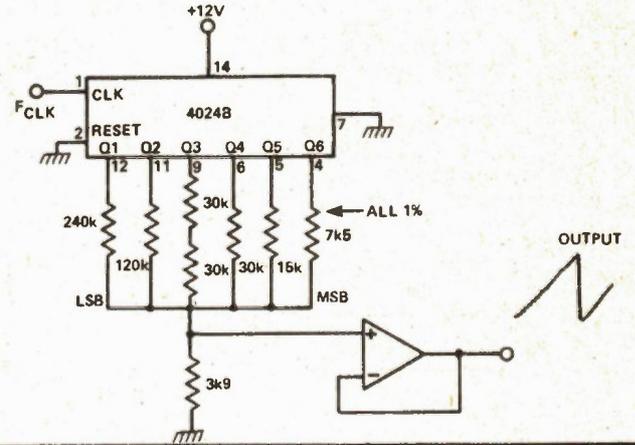


*NATIONAL SEMICONDUCTORS

11

Staircase Generator

Output frequency $F = F_{CLK}/64$
 Staircase is made up of 64 steps

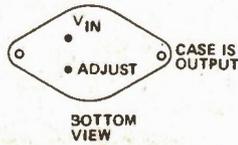
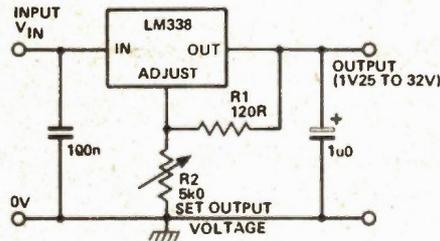


10

5 A Regulator

LM338 parameters:
 Maximum input/output difference = 35 V
 Maximum output current = 5 A
 Ripple rejection = 85 dB
 Thermal resistance, junction to case = 1°C/W

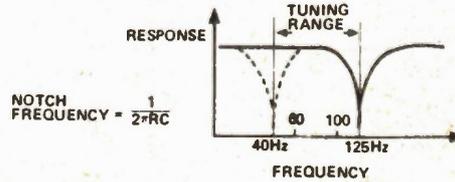
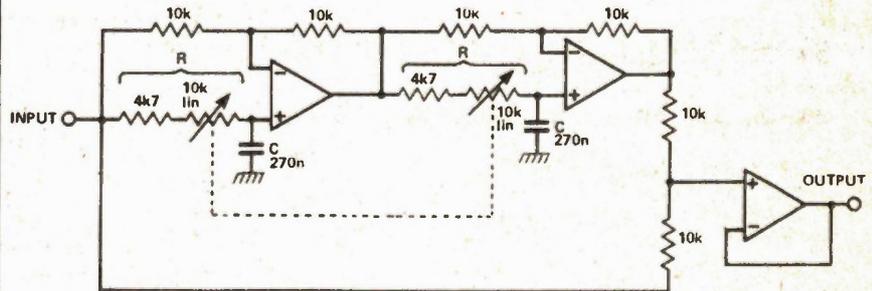
$V_{OUT} = 1.25 (R1 + R2)/R1$
 $P_{DISS} = I_{OUT}(V_{IN} - V_{OUT})$. Use a heatsink.



12

Notch Filter (Hum Remover)

Notch frequency = $1/2\pi RC$

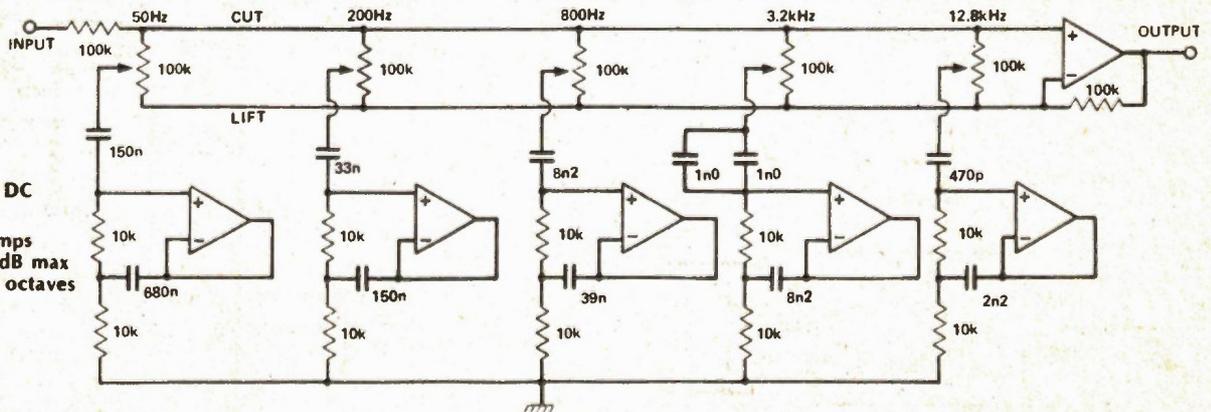


NOTCH FREQUENCY = $\frac{1}{2\pi RC}$

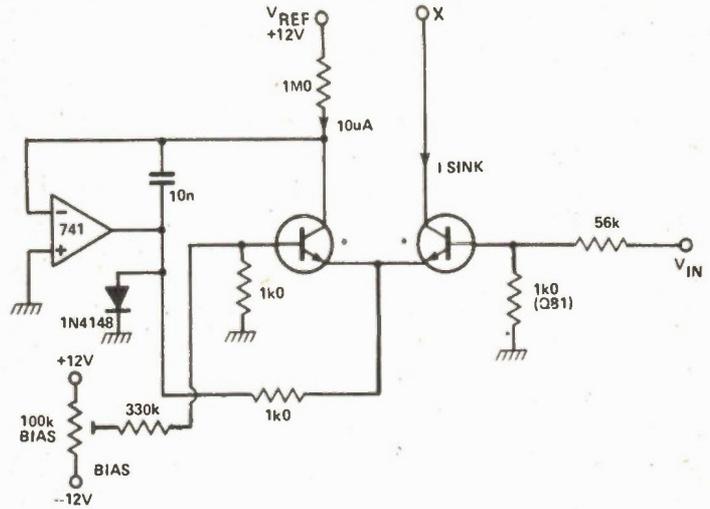
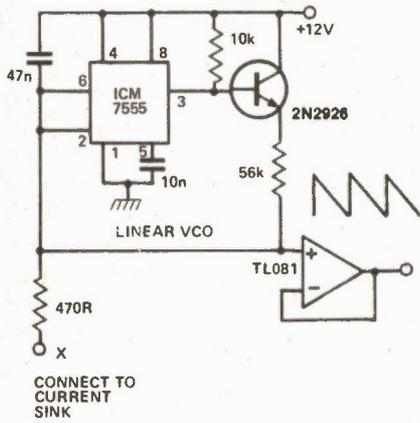
13

Graphic Equaliser

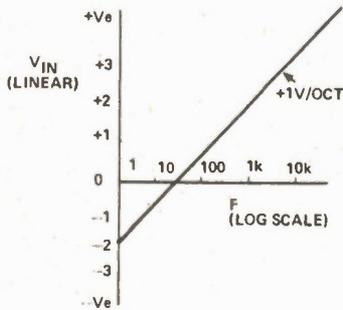
Input must have a DC path to ground
 Use 741's for op-amps
 Cut and lift = 13 dB max
 Filter spacing = 2 octaves



14 Exponential Current Sink



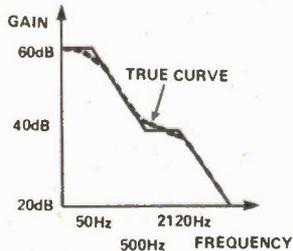
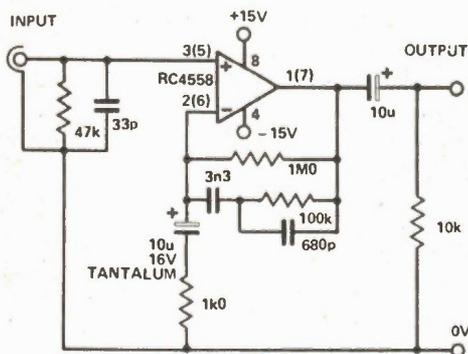
*Matched transistors in thermal contact



Frequency response of a linear VCO driven by an exponential current sink

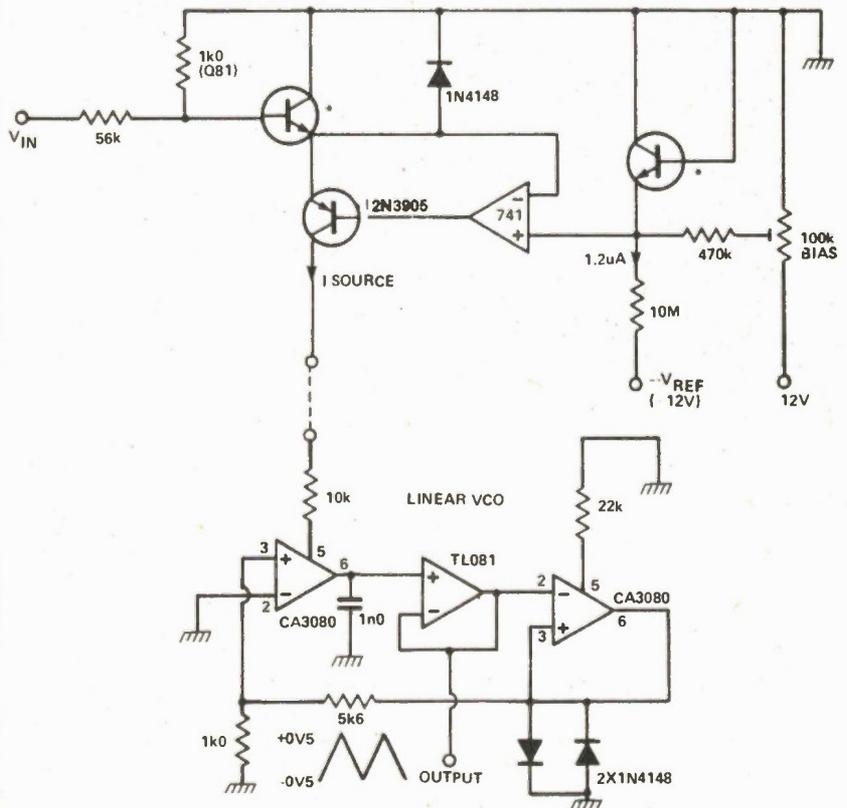
15 RIAA Preamp

Suitable for use with magnetic cartridge
Use RC4558 for low noise



RIAA playback curve

16 Exponential Current Source



An exponential current source can be used to drive a linear VCO.
The VCO then has a 1 V/octave response
Devices all powered from $\pm 12V$
*Matched transistors in thermal contact

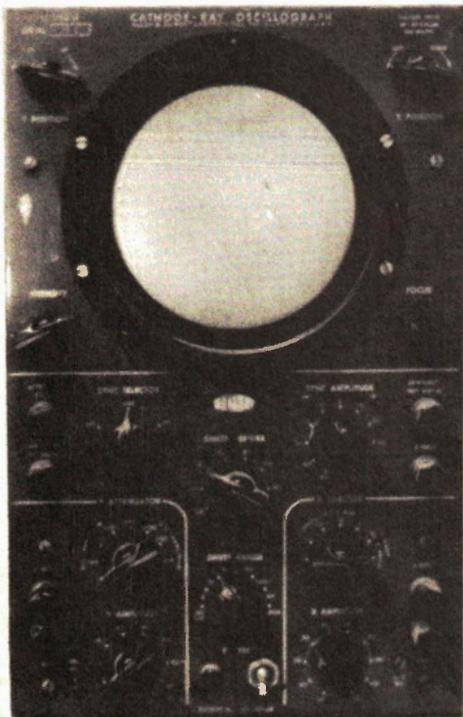
next month

Electronic Office

The influx of high technology into the workplace is freeing secretaries everywhere from the drudgery of walking the treadmills that power the machines and boil water for coffee. Next month, chips litter the carpeted halls.

The 'Scope

An oscilloscope is frequently more useful, all by itself, than a whole room of other paraphernalia. Next month we'll look into the fundamentals of these powerful instruments.

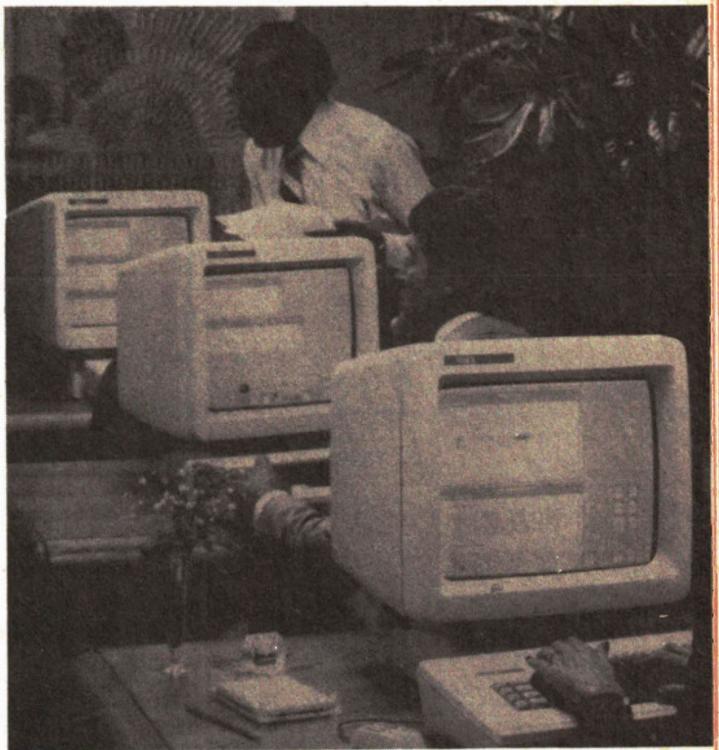


Negative Ion Generator

A fairly simple project that does everything the expensive ion generators do. . . whatever that may be. Cures colds, relieves tensions, straightens your toenails, puts hair on your chest (albeit a drag for women) and permits interstellar telepathic communication. . . all depending upon who you ask.

Plus!!!

The Amazing Hall Effect!
More Astounding Series 5000!
Mind Blowing Heath Computer Review!
Cosmically Magnificent Voltage Controlled Audio!
(All presented with our usual modesty and reserve)



Sticks

Possibly the singularly most degenerative effect upon the human consciousness yet devised, this electronic rhythm box produces the sound of five percussive instruments in any of six selectable patterns. Mesmerizes small animals, too.

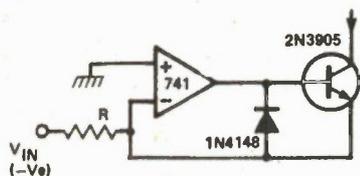
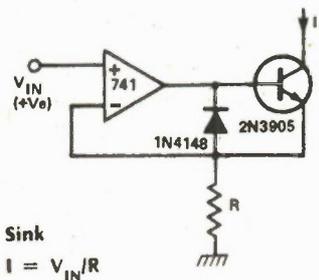
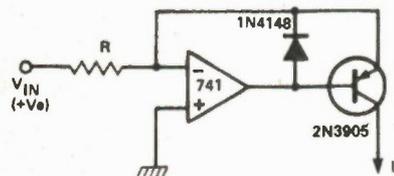
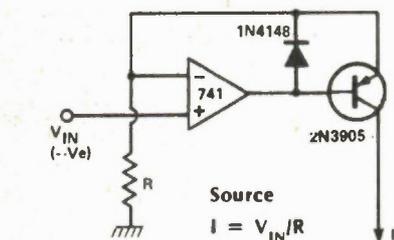


COMING TO ETI

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.

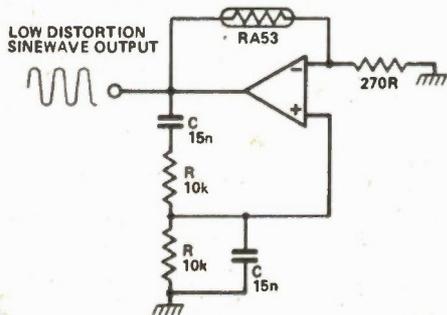
ETI—JUNE—1982—19

17 Voltage-to-current Converters



18 Wien Bridge Sine Wave Oscillator

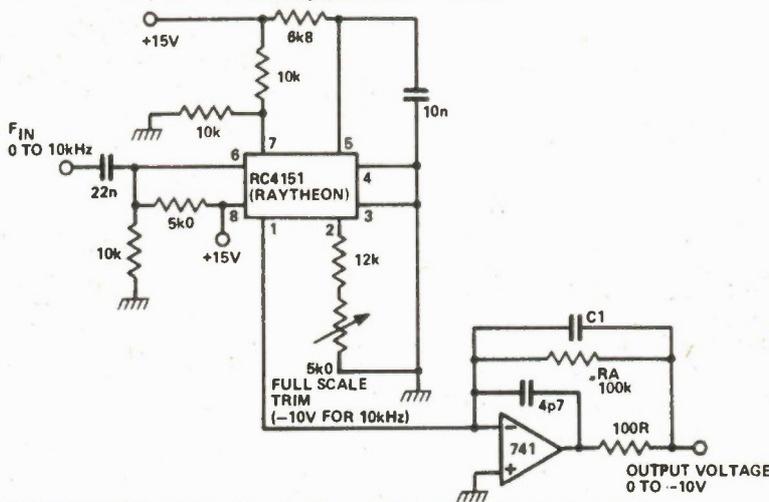
Output frequency $f = \frac{1}{2\pi RC}$ Hz



The RA53 is a negative temperature coefficient thermistor; it sets A_v to 3 for stable oscillation

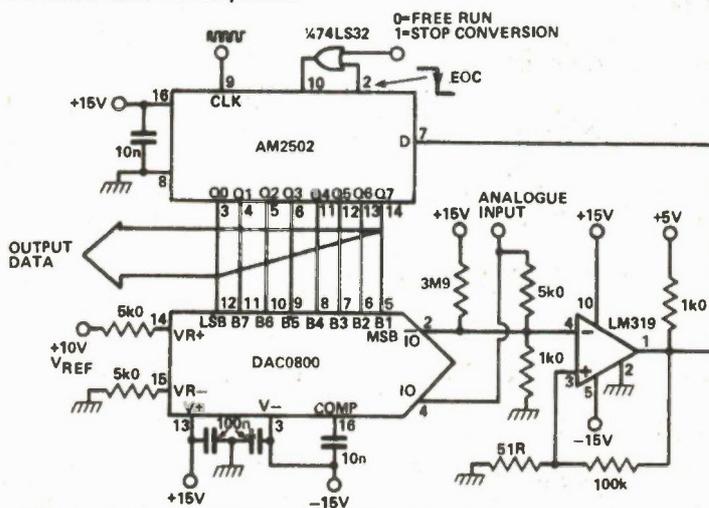
19 Frequency-to-voltage Converter

With $C1 = 100n$, ripple is 100 mV
Response time = $RA \cdot C1$
If $RA = 100k$, $C1 = 100n$, response time = 10 ms

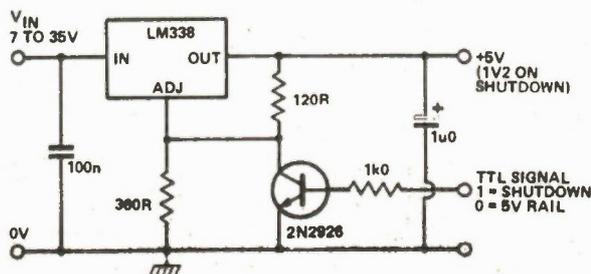


20 Eight-bit ADC

This circuit uses an eight-bit DAC plus a successive approximation register.
Conversion time 9 clock periods



21 Electronic Shutdown

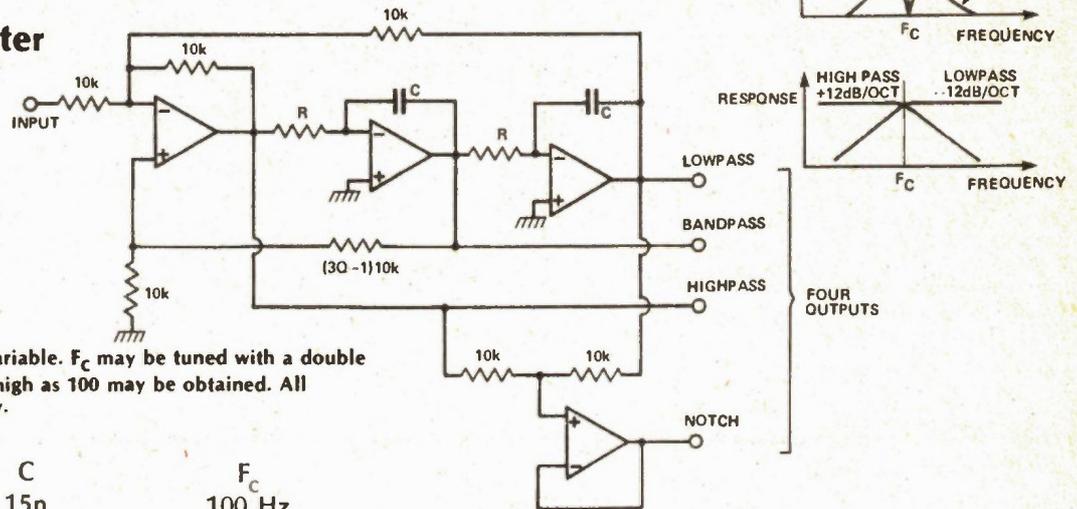


22 State Variable Filter

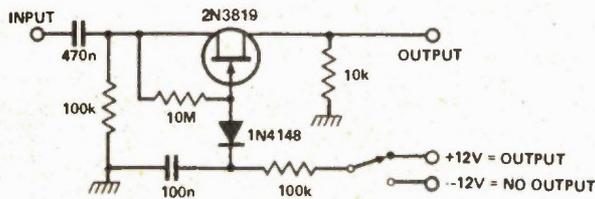
$$F_c = \frac{1}{2\pi RC} \text{ Hz}$$

Gain = Q
 Q and F_c are independently variable. F_c may be tuned with a double gang pot (for R). Q factors as high as 100 may be obtained. All responses track with frequency.

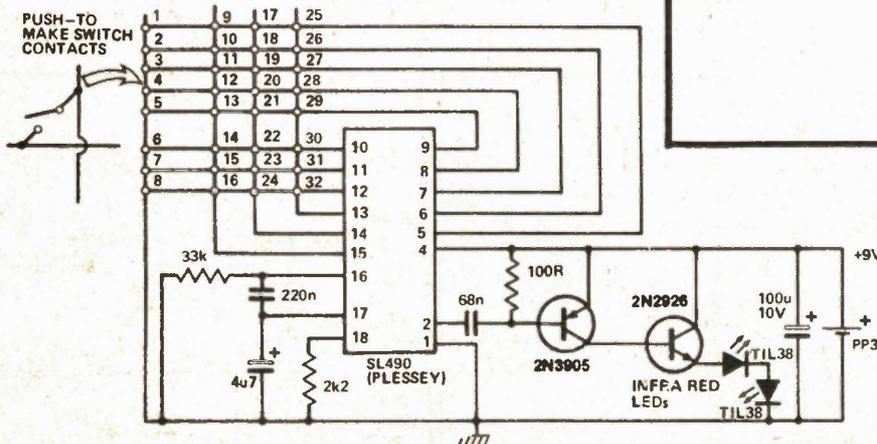
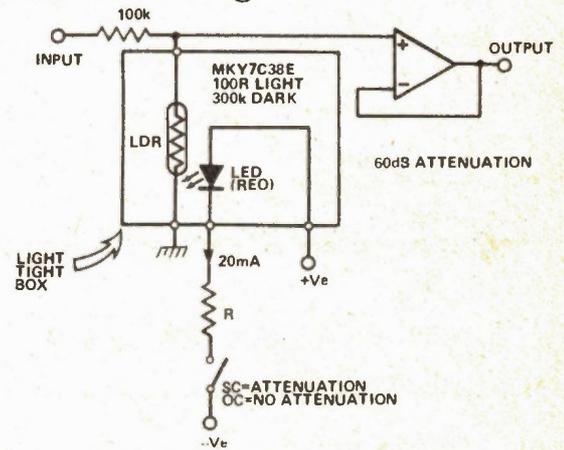
R	C	F_c
107k	15n	100 Hz
10k7	15n	1 kHz
10k7	1n5	10kHz



23 FET Audio Switching



24 LDR Audio Switching



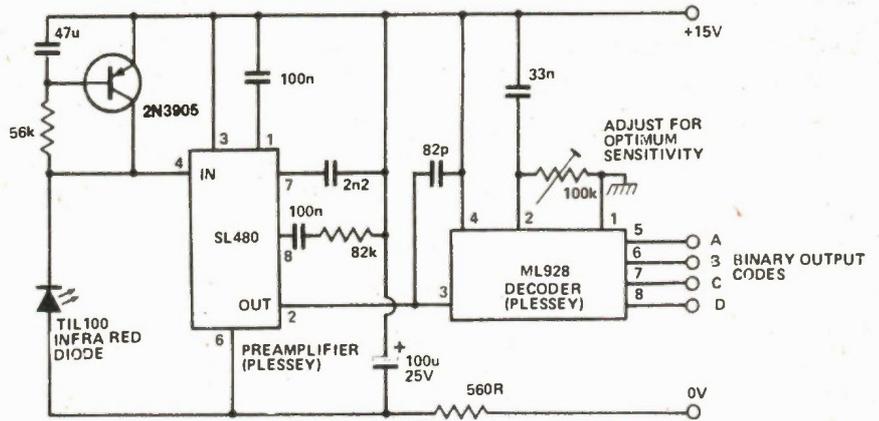
25 Infra-red Transmitter

Standby current = 6 μ A
 Operating current = 8 mA
 32 commands (five-bit code)

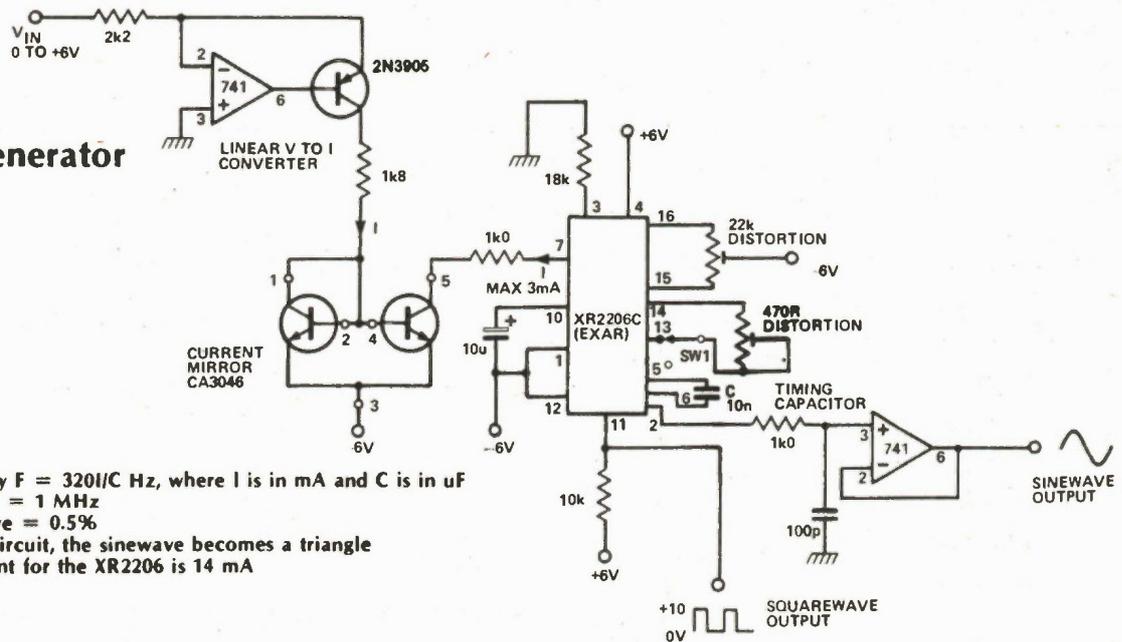
26 Infra-red Receiver

Plessey receiver chip range

- ML928 codes 1 to 16 latched
- ML929 codes 17 to 32 latched
- ML926 codes 1 to 16 momentary
- ML927 codes 17 to 32 momentary
- ML920 20 outputs and three analogue channels
- ML922 10 outputs and three analogue channels
- ML923 16 outputs and one analogue channel
- ML924 five bit code output
- ML925 multifunction for toys



27 Function Generator

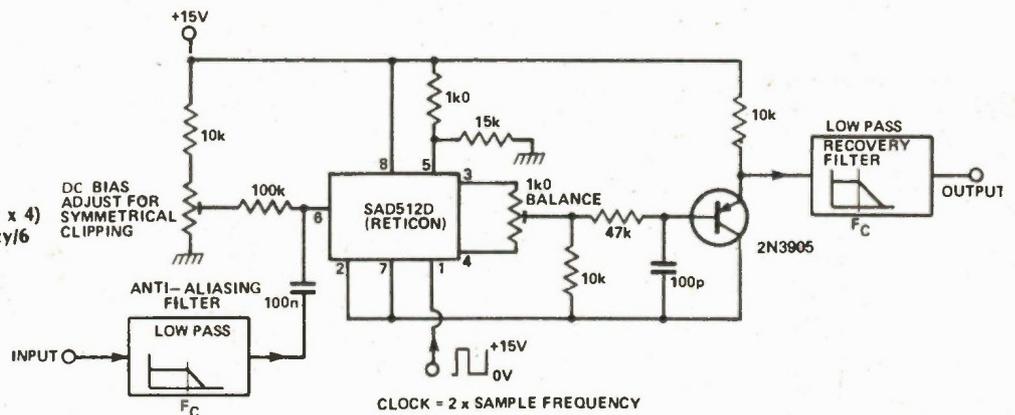


Oscillation frequency $F = 320/I C$ Hz, where I is in mA and C is in uF
 Maximum frequency = 1 MHz
 Best THD of sinewave = 0.5%
 When SW1 is open-circuit, the sinewave becomes a triangle
 Typical supply current for the XR2206 is 14 mA

28 Analogue Delay Line

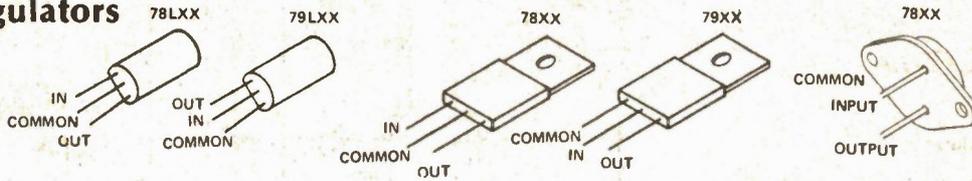
Delay time $\Delta T = 512 / (\text{clock frequency} \times 4)$
 Signal bandwidth (F_c) \leq clock frequency/6

If clock frequency = 60 kHz
 $\Delta T = 512 / (60,000 \times 4) = 2.13$ ms
 Bandwidth = 10 kHz



29

Voltage Regulators



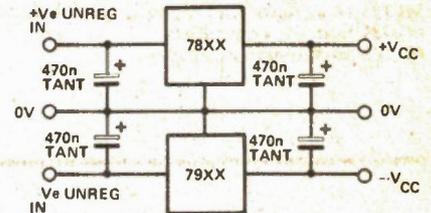
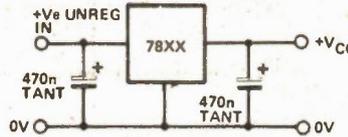
LOW POWER TYPES
TO92 CASE
100mA MAXIMUM

1A TYPES
TO220 CASE

TO3 CASE
Generally Available Output Voltages

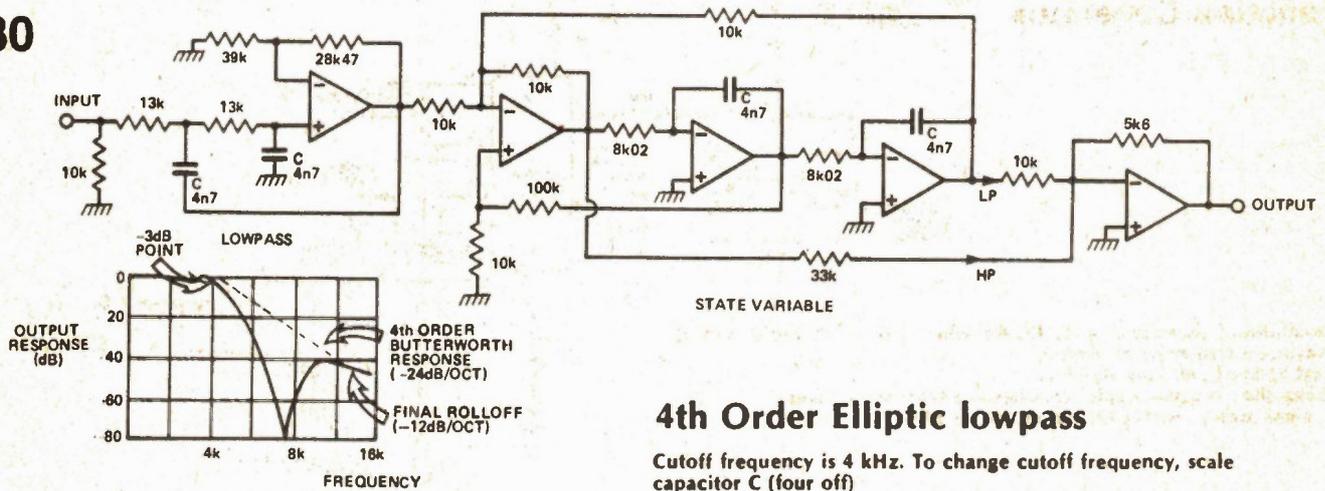
78XX series
+5V
+12V
+15V
+18V
+24V

79XX series
-5V
-12V
-15V
-18V
-24V



Refer to manufacturer's information for maximum input voltage. Typically this is 25 V for 5 V devices and 35 V for all others. Regulators need about 2 V difference between the unregulated rail and the output rail. Less than this, and the output rail will collapse. Note that the power dissipated in the regulator = $I_{OUT}(V_{UNREG} - V_{CC})$. This can be several watts, and so sufficient heatsinking must be used.

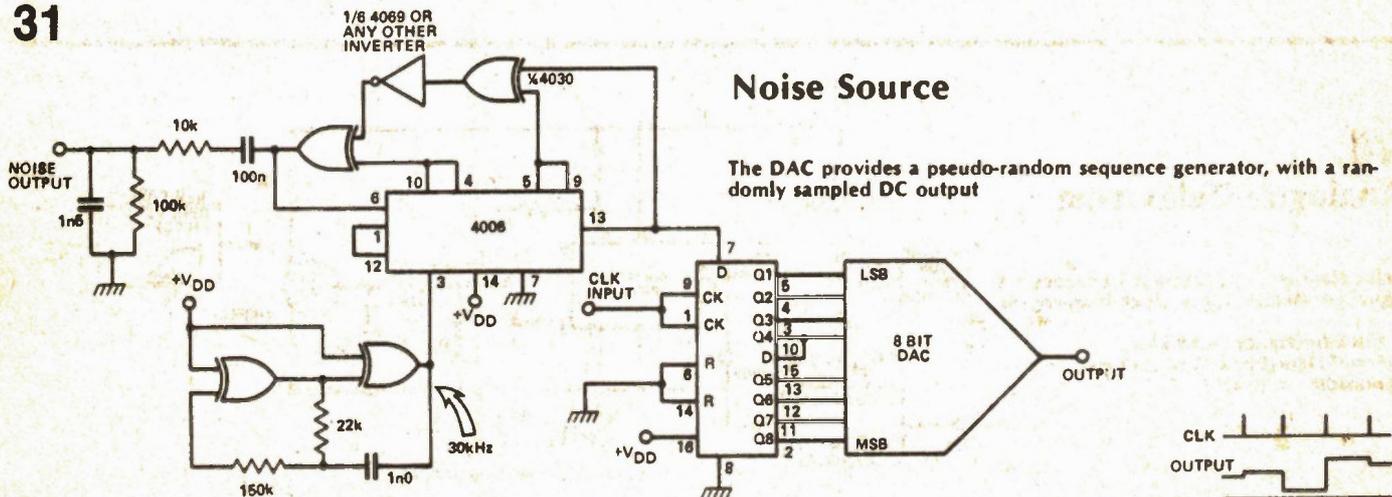
30



4th Order Elliptic lowpass

Cutoff frequency is 4 kHz. To change cutoff frequency, scale capacitor C (four off)

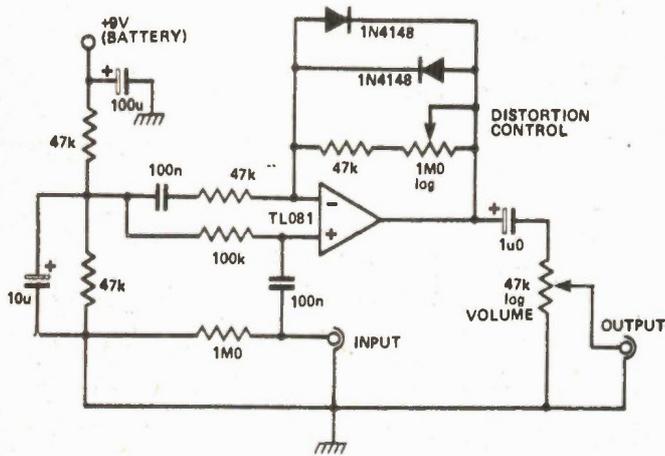
31



Noise Source

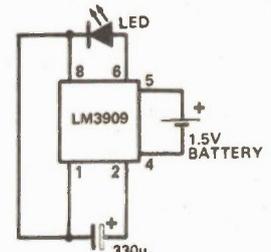
The DAC provides a pseudo-random sequence generator, with a randomly sampled DC output

32 Fuzz Unit For Guitar

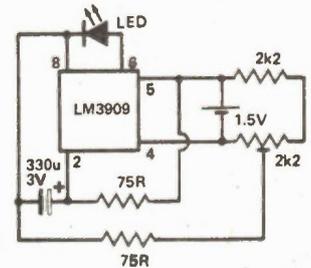


The battery can be switched on via the jack socket (a stereo jack can be used).

33 LED Flasher



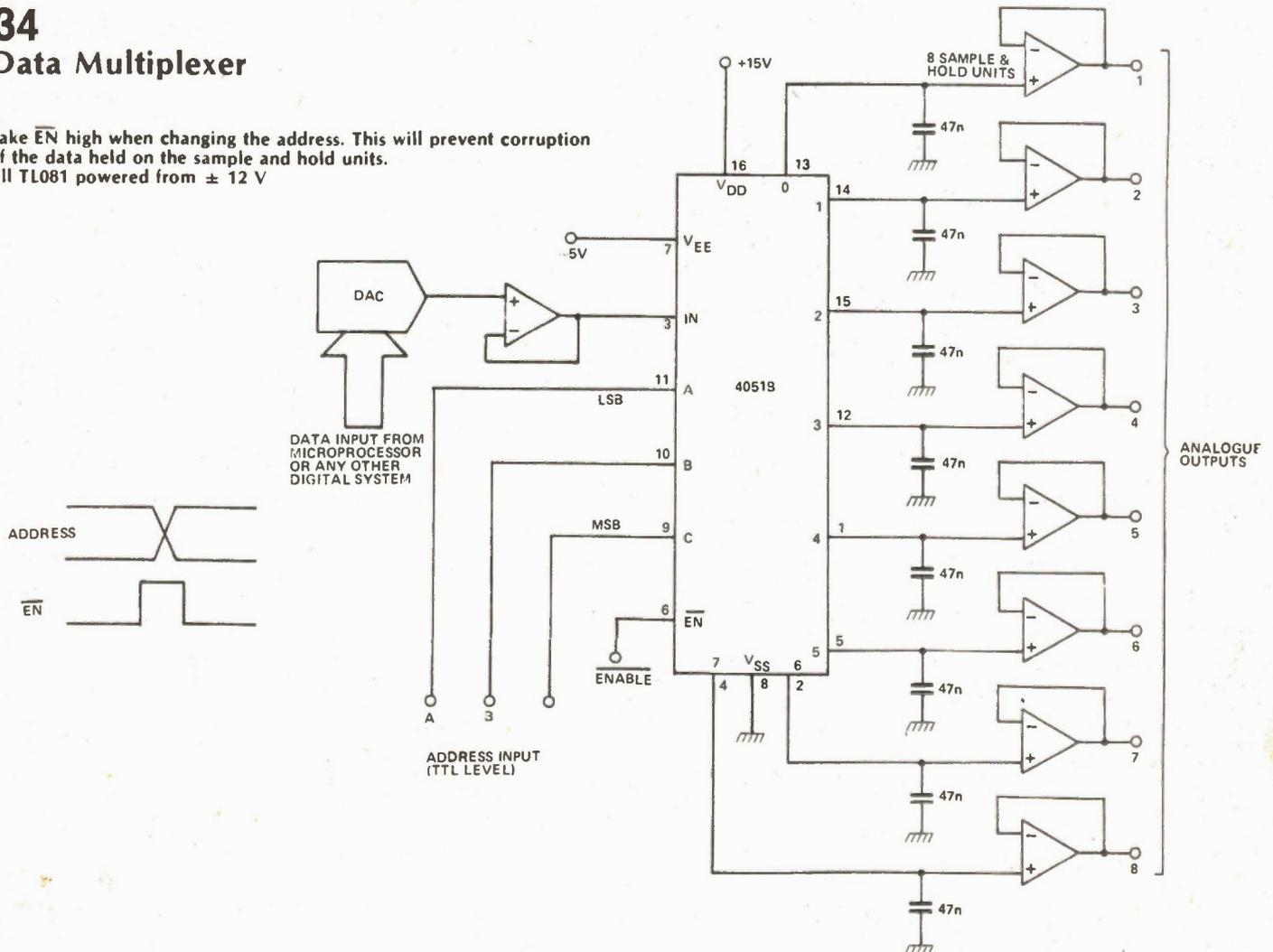
1 Hz flash rate
Average current drain = 0.32 mA
Circuit uses the timing capacitor to boost the output voltage



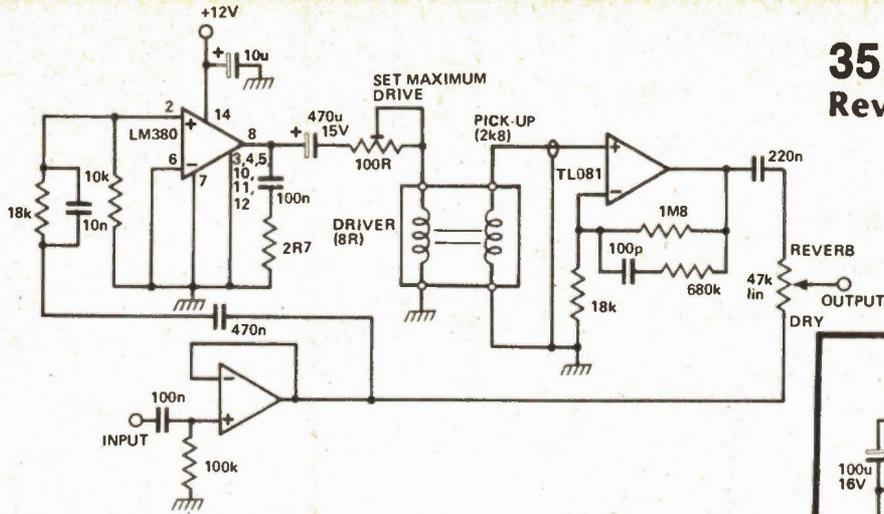
Variable flash rate 0 to 20 Hz

34 Data Multiplexer

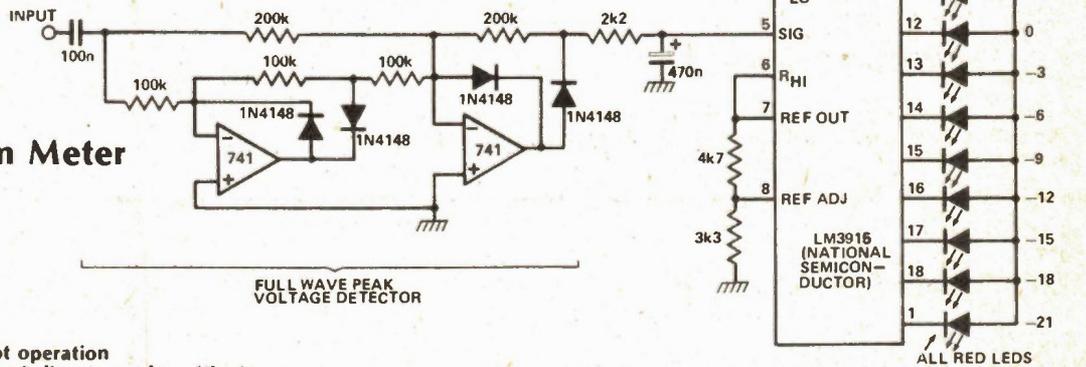
Take \overline{EN} high when changing the address. This will prevent corruption of the data held on the sample and hold units.
All TL081 powered from ± 12 V



35 Reverberation Unit

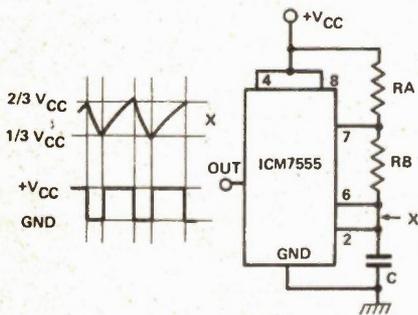


36 LED Peak Program Meter



Leave pin 9 open circuit for dot operation
If an LM3914 is used the display is linear, not logarithmic

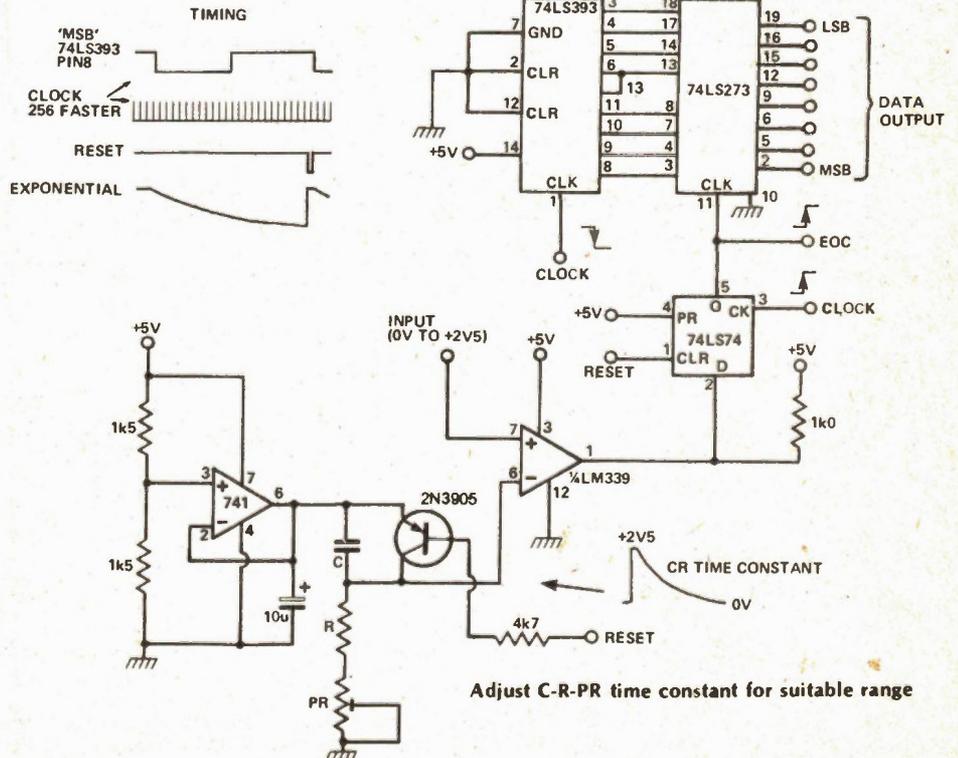
37 CMOS 555 Oscillator



Output frequency $F = 1.46/C(RA + RB)$
C in farads, R in ohms
Quiescent current $\sim 120 \mu A$
Input current $\sim 50 \text{ pA}$ (this allows the use of resistors up to 10M in value)
Frequency range 0.001 Hz to 500 kHz
Supply range 2 to 18 V
Rise and fall time (pin 3) = 40 ns

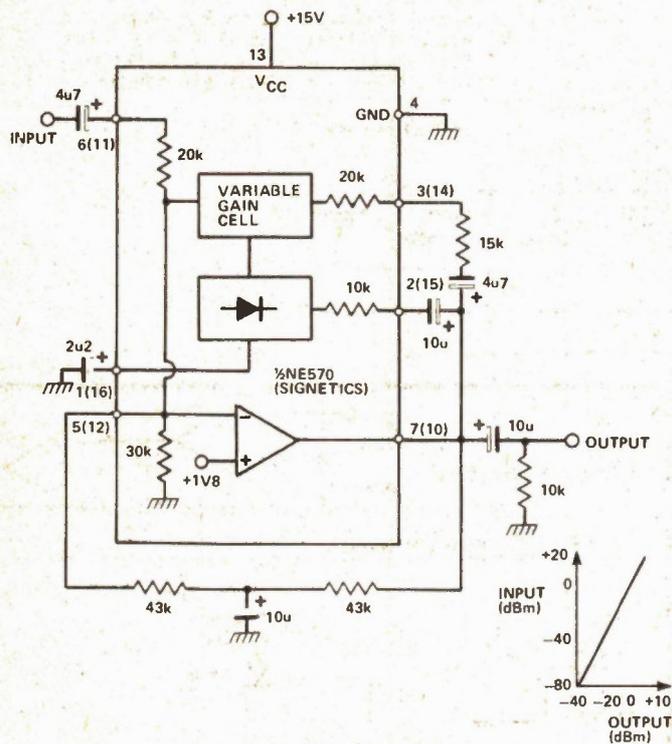
RA, RB	C	F
10M	10u TANT	7.3 mHz
1M0	1u0	0.73 Hz
100k	100n	73 Hz
10k	10n	7.3 kHz
10k	1n0	73 kHz

38 Logarithmic ADC



43

Two-to-one Compressor

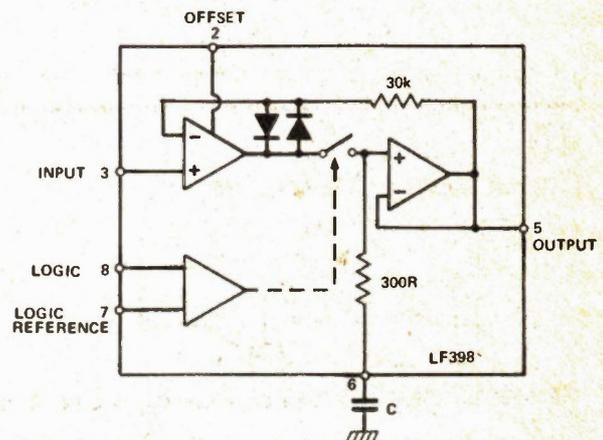


The pin numbers in brackets refer to the second circuit in the IC. Circuit can be used as a preconditioner in a noise reduction system.

45

Monolithic Sample And Hold

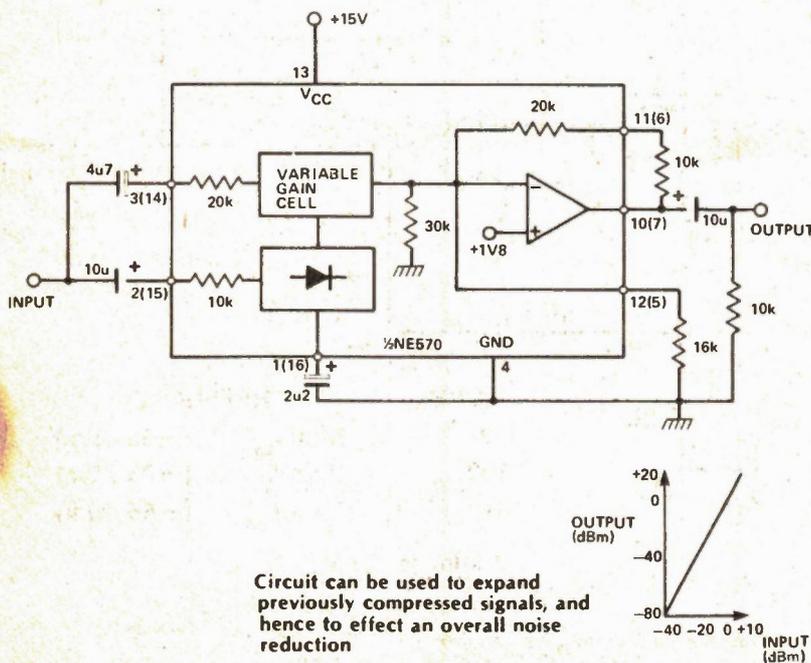
Logic high = sample
Logic low = hold
Logic reference = TTL or CMOS



Use a printed circuit guard ring (connected to the output voltage) around the hold capacitor

44

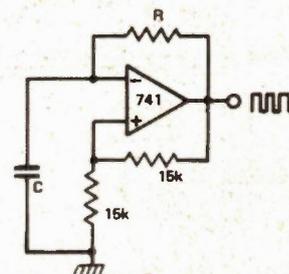
Two-to-one Expander



Circuit can be used to expand previously compressed signals, and hence to effect an overall noise reduction

46

Op-amp Oscillator



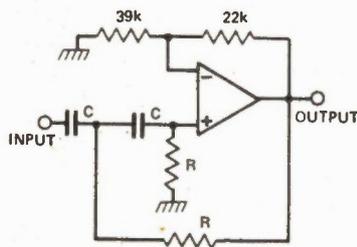
$F \sim \frac{1}{RC}$ (rule of thumb)

47 High Pass Active Filters

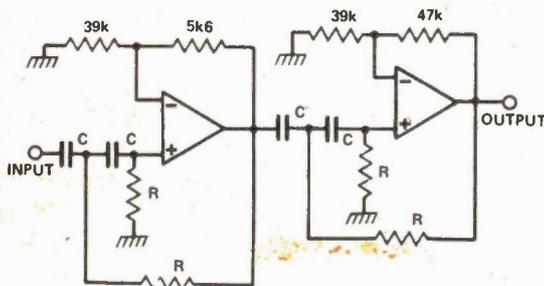
$$F_c = \frac{1}{2\pi RC} \text{ Hz}$$

2 pole roll-off = +12 dB/octave
 4 pole roll-off = +24 dB/octave

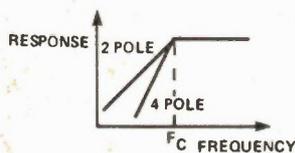
R	C	F _c
107k	15n	100 Hz
10k7	15n	1 kHz
10k7	1n5	10 kHz



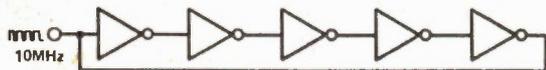
2 pole Butterworth



4 pole Butterworth



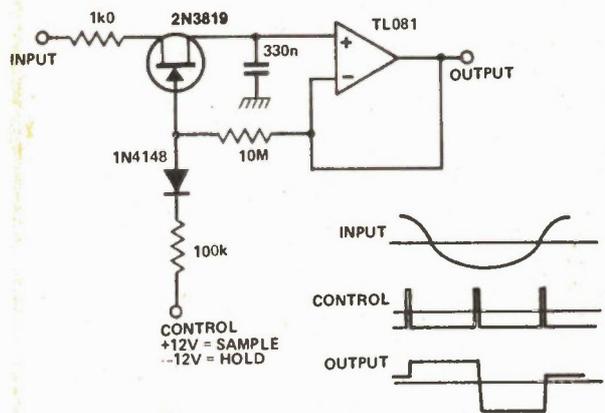
48 TTL Ring Oscillator



$F = 1/(5 \times \text{propagation delay})$
 For TTL inverters (74LS04) total propagation delay = 20 ns

49 FET Sample And Hold

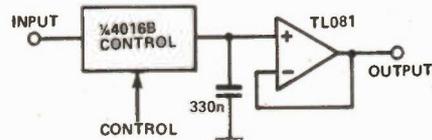
Control = +12 V; sample
 Control = -12 V; hold



Use a printed circuit guard ring (connected to the output voltage) around the hold capacitor

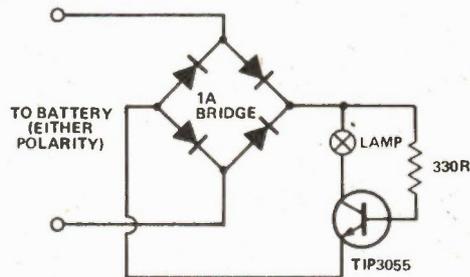
50 4016 Sample And Hold

Control = +V_{CC}; sample
 Control = -V_{CC}; hold
 -V_{CC} < signal voltage < +V_{CC}
 +V_{CC} - (-V_{CC}) ≤ 15 V



Use a printed circuit guard ring (connected to the output voltage) around the hold capacitor

51 Battery Eliminator



A free bonus!
 Lamp glows to show circuit is in operation
 Lamp goes out when battery has been eliminated
 Patent applied for

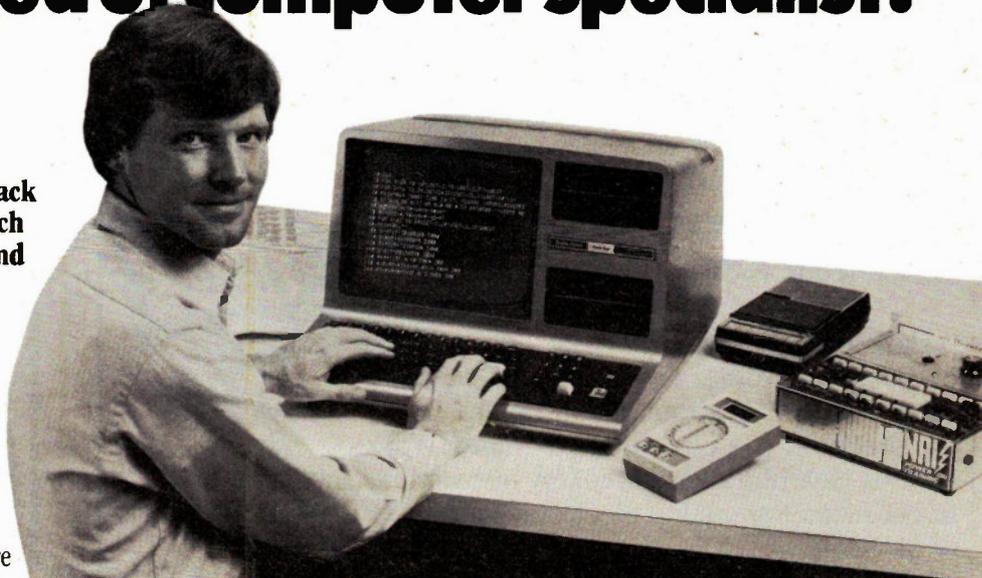
Now NRI takes you inside the new TRS-80 Model III microcomputer to train you at home as the new breed of computer specialist!

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and gain greater understanding of the information. Both microcomputer and equipment come as part of your training for you to use and keep.

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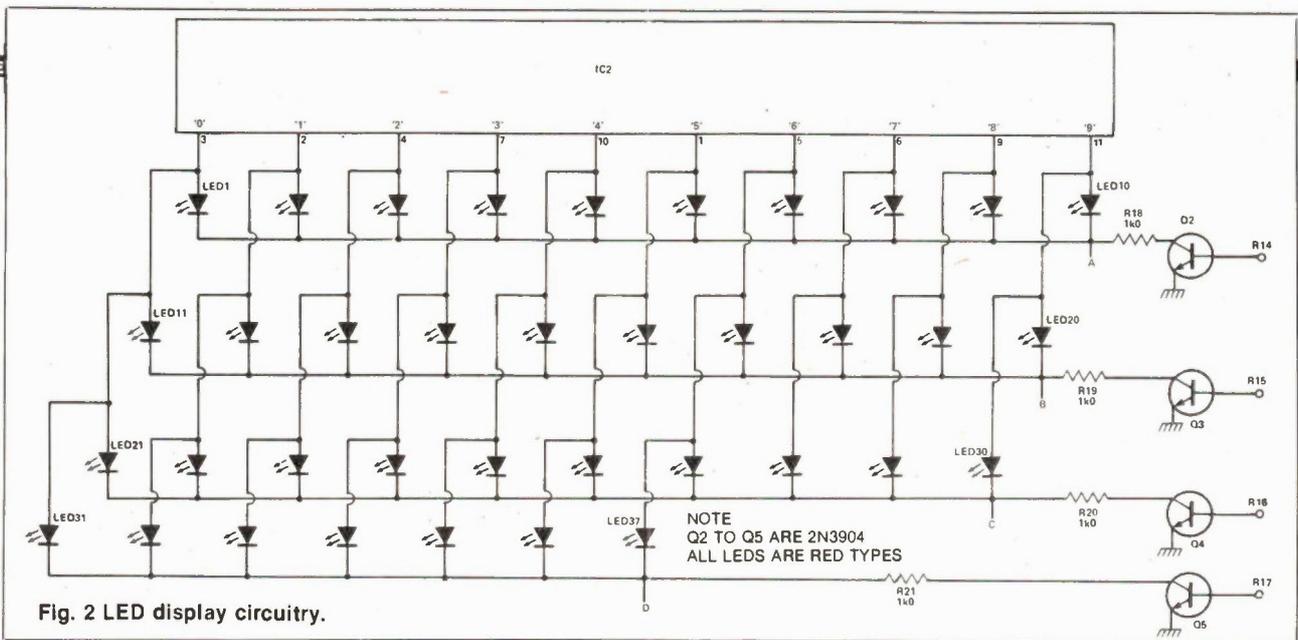


Fig. 2 LED display circuitry.

HOW IT WORKS

The circuit comprises a clock generator (IC1-Q1) and a multi-stage counter/decoder network (IC2-IC3-IC4) that drives a circle of up to 37 LEDs in the dot mode. The counter/decoder network is deceptively simple. CD4017 decade counter/decoders IC2 and IC3 are wired in series so that IC2 counts in units and IC3 counts in tens when the clock signal is fed to pin 14 of IC2. The '3' output of IC3 and the '6' or '7' output of IC2 are NANDed via IC4d and used to trigger monostable IC4b-IC4c, which generates a 16 μ s pulse and resets both counters to zero via IC4a each time that these two outputs go high simultaneously. The cascaded counters thus divide the clock signal by a fixed ratio of 36 or 37 (depending on the setting of SW1) and effectively produce 36 or 37 fully decoded outputs, which are used to sequentially turn on LEDs in the roulette ring or wheel.

The LED ring comprises three segments of 10 LEDs and one segment of seven LEDs. The anode drive to all LEDs is controlled by IC2 (the units counter), but the cathode paths of the LEDs are controlled by IC3 (the tens counter) via transistors Q2 to Q5. Thus, on the '15' count the '5' output of IC2 goes high and Q3 is driven on via the '1' output of IC3, so that only LED 15 illuminates. This multiplexing technique enables the 37 LEDs to be driven by fairly simple counter/decoder circuitry, which turns the LEDs on sequentially and produces an apparently-rotating ring of light.

The clock generator circuitry is delightfully cunning and is designed around the VCO section of a 4046 B phase-locked loop chip. The frequency of this oscillator is controlled by the value of C2, the resistance between pin 11 and ground and the voltage on pin 9. Slight bias is applied to the VCO by R7 to ensure that the VCO frequency falls to zero when the pin-9 voltage

is reduced to zero. The output of the VCO is available at pins 3-4 and is fed directly to the input of IC2 and by R10 to the transducer (Tx), which produces a click sound each time a clock transition is generated.

The VCO circuit operates as follows. When PB1 is closed, pin 9 of IC1 is pulled high via D1-R4 (thus charging C1 to maximum voltage) and Q1 is turned on by DR-R5, thus connecting R8 between pin 11 of IC1 and ground. Under this condition the VCO operates at a few tens of kilohertz and causes the LED display to appear to spin at a rate of several hundred revs per second,

so that the number of spins cannot be predicted by PB1.

When PB1 is released Q1 turns off, so that only R9 is connected between pin 11 and ground and C1 abruptly discharges to half-supply volts through D3-R2. Under this condition the wheel rotates at an initial visible rate of about two revs/sec. From this moment, C1 discharges exponentially through R3, so the pin-9 voltage and the wheel spin rate steadily decrease until, after about 15 s, the VCO stops generating and the wheel comes to rest. The operating sequence is then complete.

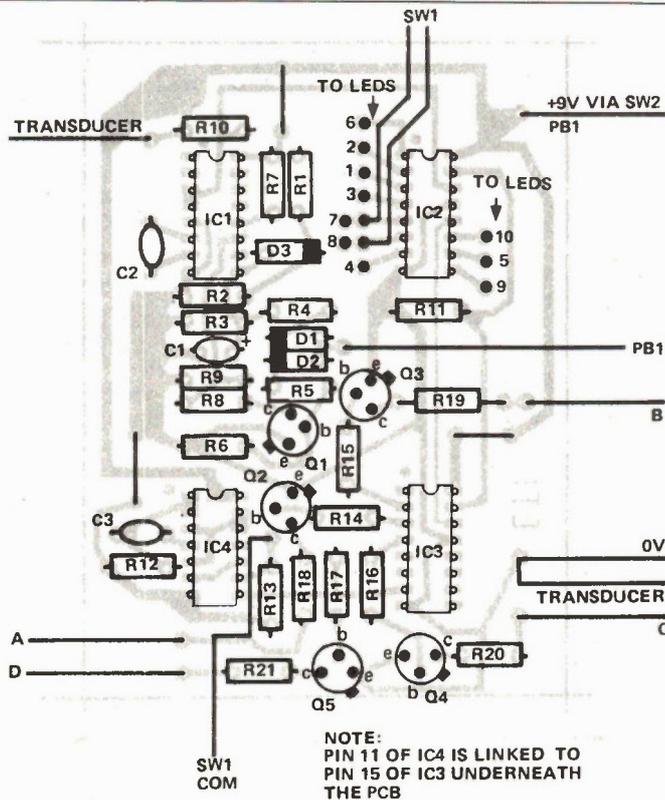


Fig. 3 Component overlay of the main circuit board. Don't forget the under-board link.

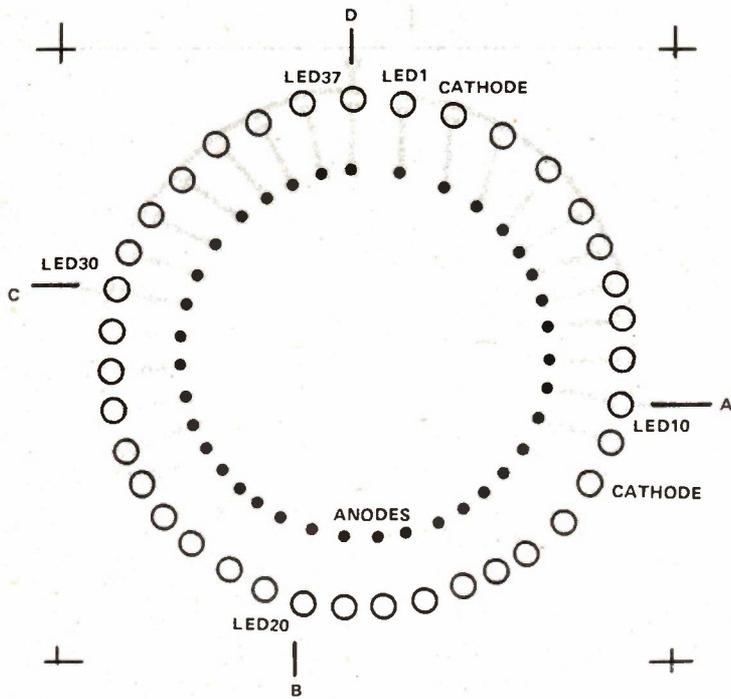


Fig. 4 Component overlay for the LED display.

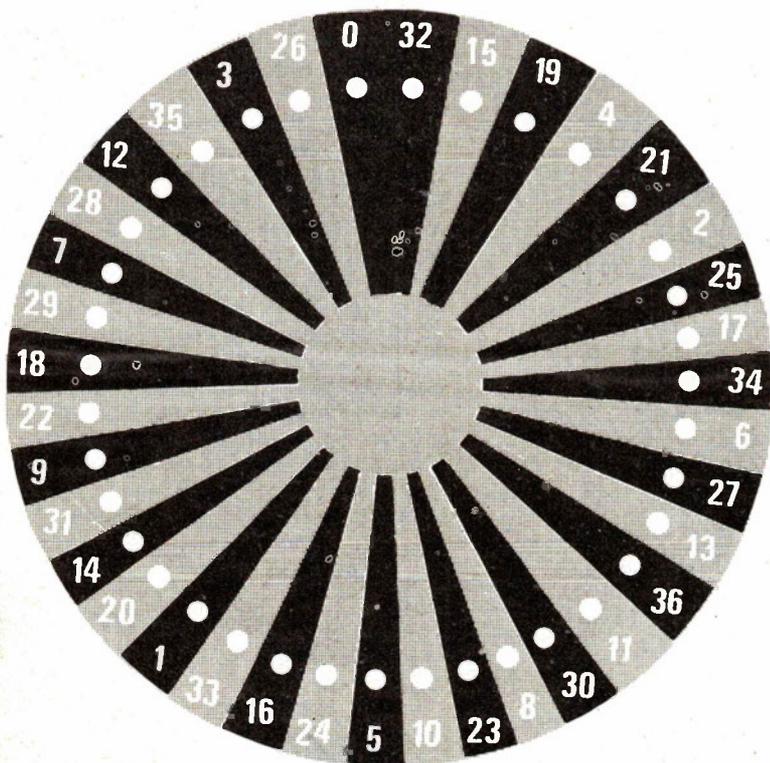
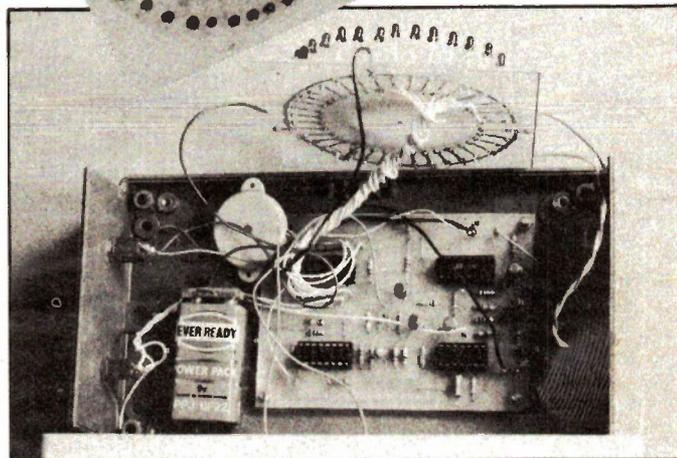
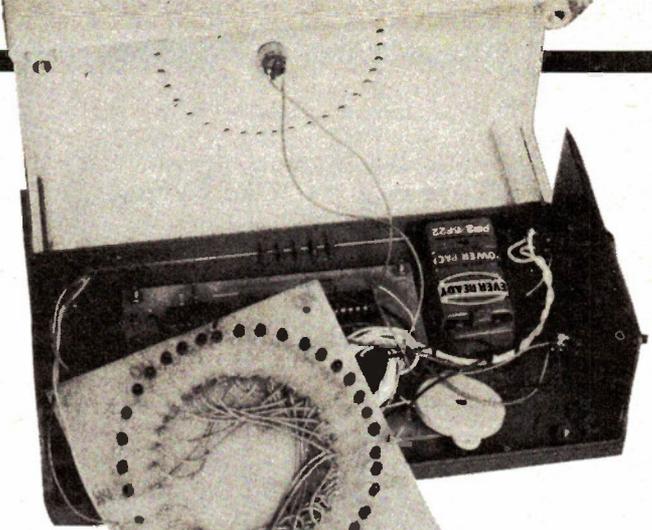


Fig. 5 Design for the 37 LED display.

PARTS LIST

Resistors all 1/2 W, 5%

R1,2	6k8
R3,9	1M0
R4	470R
R5,6	47k
R7	10M
R8	10k
R10	820R
R11	100k
R12	27k
R13	270k
R14,15,16,17	12k
R18,19,20,21	1k0

Capacitors

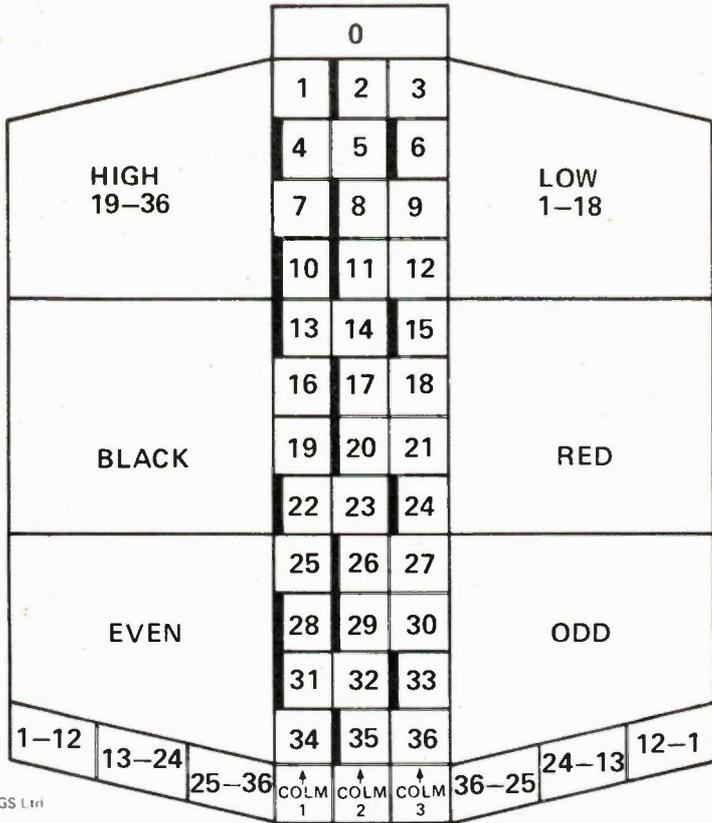
C1	10u 35V tantalum
C2	10n polycarbonate
C3	1n0 polycarbonate

Semiconductors

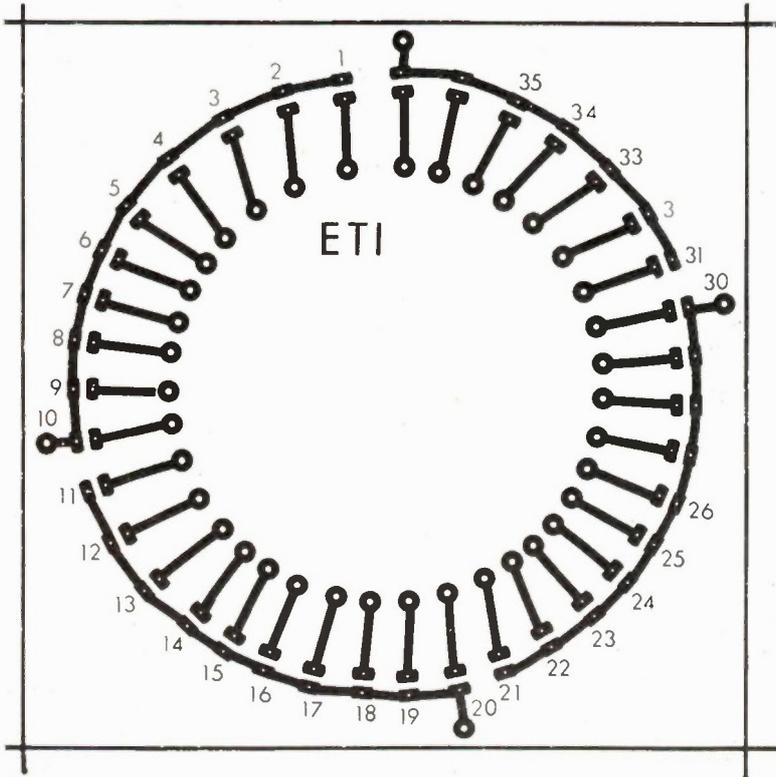
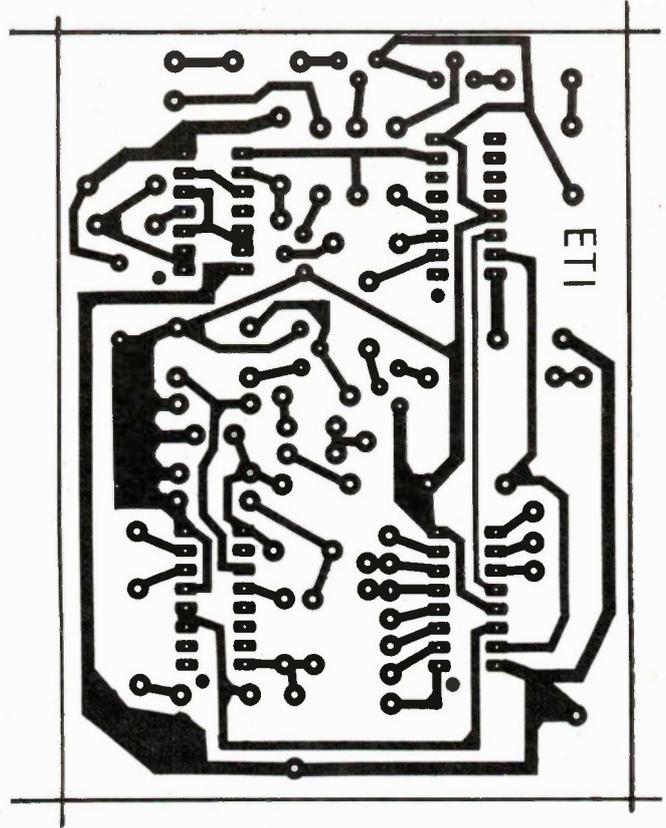
IC1	CD40468B
IC2,3	CD4017B
IC4	CD4011B
Q1,2,3,4,5	MPS6515
D1,2,3	1N4148
LED1-37	0.125" diameter (Red)

Miscellaneous

PB1	momentary push button Case
SW1,2	SPDT miniature toggle
1 9V battery	
Transducer	



GS Ltd



We've supplied the Roulette Game front panel construction and interwiring with this PCB (below).

tional test. If the LEDs fail to illuminate correctly, re-check your interwiring.

When all is well, you can fit the two PCBs, etc. into a suitable case. Drill a circle of 37 holes in the top of the case to coincide with the 37 LEDs and fit the push-button switch in the centre of the circle. The display board can be secured behind the case top by smearing drops of clear adhesive on the sides of the heads of a few of the LEDs and pushing them into the case holes. The project can be finished off by marking the roulette wheel artwork on top of the case. Note that the numbers marked on the roulette scale do not, in fact, have to coincide with any particular LED numbers.

ETI

If you liked this project, please circle Reader Service Card number 57. If you didn't, circle number 58.

Xerox Computer Review



Another big, cuddly computer to light up your life and figure pi to a thousand decimal places, it's the Xerox 820. Put it on wheels and it'll follow you wherever you go. By Steve Rimmer.

WELL, IT CERTAINLY doesn't play pac man worth spit, and there don't seem to be any provisions for either a joystick or a music interface. It doesn't fit in your pocket, and neither Bill Cosby *nor* William Shatner have endorsed it, and they should know. In other words, like, what earthly good is it? Listen, if your computer can't impress your friends when they're drunk, it is time to think about trading it in.

Well, yes, as game playing machines go, the Xerox 820 probably rates right up there with an Abacus. However, strange as it may seem, it does not actually appear to have been designed to do this. Gadzooks! No, what we have here is something of a business system, a computer that may spend eternity never knowing the pleasure of blasting a single alien, but can power up the massive data handling software required for word processing, file management, bookkeeping, and so forth. Beneath that quiet exterior lurks . . . RAM!

The Xerox 820 is, of course, built by the same folks that gave us plain paper copiers and occasionally sponsor television programs on the love life of dolphins. It is available in several configurations; our version has 64K of RAM, two eight inch single sided, single density drives and a daisy wheel printer. The price, of course, varies with the choice of options and wheel covers; ours goes for \$9495.00, which includes one software package (the word processor).

In all cases, the system consists of four major bits, each one enclosed in an appropriately shaped plastic case of about the same feel and colour as that of an Apple II. The first is the keyboard, which is separate from the rest of the computer. It has a numeric keypad which also holds the cursor control keys. The keytops are double shot moulded deals, and the action of the keyboard is very good. . . well, you wouldn't expect them to use surplus teletypes on a ten grand system, I suppose.

Next, there is the VDU, and computer proper. It's actually very small for what's in it. The screen is a full size 12 inch tube with white phosphor. The CPU is a friendly. . . and familiar. . . Z80 running at 2.5 megahertz, making it moderately speedy. The back of the case offers connectors to communicate with the disk and the printer, plus an RS232C port to interface with a modem or other serial doodad.

The disk drives come in a disk drive case, which seems logical, and come on and go off on

command. . . there isn't much to say about these, really. They didn't explode or mutate, so they've been pretty well uninteresting to date. They're worked fine, though.

Lastly, the model 630 printer we received is really nice. It produces very crisp type, and, of course, can accept multiple type faces. It has no buttons, but, rather, a number of membrane-type touch pads up front to do the usual printer things. It can print under control of the computer, or, if you aren't concerned about your print-outs meaning anything, can stand alone and generate a self test.

The type the 630 can produce is almost as good as that of our phototypesetter, which set this article, and is ideal for doing reports, letters and manuscripts.

Having had a protracted play with it, the Xerox computer is aesthetically very pleasing, which is no small concern if you intend staring at it for long periods. It's comfortable to work with, solidly built, and powerful. We've done a few casual fiddles with the IBM personal computer, and I think I prefer the Xerox for the functions it does: it is certainly not particularly expensive for what it is capable of. However, this, of course, only pertains to the hardware. The system's software is what makes the gears turn; let us, then, jam a disk in the drive and boogie.

Processors

The fact is, the Xerox 820, like most large systems, is nothing more than a big empty architecture with almost no intelligence on board, save for the boot ROM and suchlike workies. It craves an operating system, and, thereupon, something to operate. This sort of arrangement is intrinsically more flexible than a machine with a language (e.g., BASIC) in an onboard ROM, as, in this case, changing languages would require changing the hardware, and running software which does not require a language would forfeit however much of the memory bus real estate is tied up by the language ROM.

The Xerox 820 is supplied with CP/M, which is really rather nice. CP/M is Digital Research's disk operating system, which has become something of a *de facto* standard in medium size systems based on the 8080 or Z80 CPUs. It does all the disk manipulations, plus file management (moving, creating, editing, merging, killing, etc.). There is also a Microsoft MACRO-80 Assembler available on the disk, which provides the facility of creating ML programming without a lot of heavy thinking and reference to the relative branch tables. The assembler is fiendishly sophisticated, and a

decent look at it would easily encompass the rest of this article.

The CP/M manual is very well written, and gets into all aspects of the software, plus the basics of the 820 system. The last section deals with the printer connections, plus things like useful I/O routine locations, memory allocations, etc. There is certainly enough data available for anyone wishing to develop software on the system.

So, we turns on de computer. . . had a bit of a time finding the switch; it's hidden under the case. . . stick in de disk and, hmm, it says;

. . . XEROX 820 Version 2.0. . .

A — BOOT SYSTEM
T — TYPEWRITER

*

Now, this offers several possibilities. TYPEWRITER appears to be a resident routine, which echoes the keyboard onto the printer directly. It's not remarkably useful, except for testing the thing out upon first hooking things up, but it's fairly unobtrusive and rarely complains about being ignored. "A" refers to disk drive A; if you enter "B" it'll boot from the second drive instead.

With a disk bearing CP/M in the works, the system will, naturally, boot up CP/M and make available its library of commands. Real quick like, these are ERA, erase a file, DIR, produce a directory of the files on a disk, REN, rename a file, SAVE, store stuff on a disk and TYPE, display a file on the screen, plus the transient commands, STAT, provide disk file allocation, ASM, load the assembler, PIP, move files around, ED, edit files, SYSGEN, copy CP/M onto an initialized disk, SUBMIT, batch together CP/M commands, DUMP, do a hex dump of a file and MOVCPM, reconfigure CP/M for a given system size. If the disk has no other software on it, one can either (a) get one that does, (b) load the assembler and write some or (c) play with the file commands. This last, while neat, palls shortly.

Word Processor

The software we received with the Xerox probably offers as good a way as any of outlining the capabilities of the system. We got (slurp, drool, copy. . .) Word Processor, Analyst, QSort, Supercalc and CBASIC. We'll peer at each, in good time, beginning, as you might have gathered, with the word processor. It should be noted that this is not, by any means, the only software that can be run on this system.

The word processor is based on software written by MicroPro International, who brought you WordStar (this one is very similar). Its manual is quite huge. . . the thing is very powerful and very complicated. . . and even comes with a special training disk to help you get into it. Once again, we're going to have a real superficial scan of its capabilities.

The system is menu driven, a main menu selecting five secondaries. There are also multiple HELP levels to get in and out of the menu. This makes it a real challenge to actually butcher your text, or, better still, loose it. We're proud to say we never managed either.

Typing into the system is fairly straight up. There is, of course, automatic line ending plus. . . ex-

perience it. . . automatic on-screen right margin justification, which looks very neat. Text can be inserted, deleted, and blocks moved around. A FIND command locates strings. Margins and tabs are, of course, adjustable, and there are all sorts of formatting handles for doing tables, letters, and so forth. The software splits the text into pages for you, and numbers them, if you're in the mood. Then there's underlining, bold type, sub and super scripts, and all manner of embellishments. Much of what cannot be done with a typewriter can be achieved with this software, with the notable exception of milking cows. Sadly, too, no cow milking software is available or expected.

The word processor is a very sophisticated little devil; be prepared to take a week or two to learn it fully.

CBASIC (HearBASIC)

The BASIC is a bit unusual. It consists of two main routines, a compiler and a running package. The first takes the BASIC source text and compiles a Z80 machine code listing from it. The second one runs the resulting program. In none of this, however, does it explain where the text comes from. It's tricky; you generate it with the word processor.

This novel approach does, in fact, have some merit. The very sophisticated editing facilities of the word processor certainly rival the capabilities of many BASIC line editors, and, to the compiler, text is text. The procedure is not as clumsy as it might seem, although it is not the easiest way to write BASIC software. . . suffice it to say you get the hang of it after a while.

The facilities of the BASIC itself are not at all shabby; certainly it's as powerful as the TRS 80 Model II's we looked at a while ago. There are no programming utilities, such as AUTONUMBER, RENUMBER, and so forth, as these are the province of the editor. A dedicated editor would be a definite advantage for anyone contemplating the creation of a lot of BASIC programming.

The documentation for the BASIC isn't bad; you've certainly got to know BASIC well to use it, but, then, the Xerox 820 isn't a beginner's machine.

Analyst

No, if you type in your troubles it will not tell you that you hated your mother. The Structured Systems Group, Inc. Analyst package (plus QSORT) is a file management system that takes a whole mess of data and sorts it by whatever criteria you're interested in, producing printouts of whatever you're after. It can store great volumes of records on disk, retrieve and edit them, and, of course, digest them for specific information.

The Analyst is configured for whatever you are going to do with it. You define a number of categories under which the information you will enter will be stored, each of which can be one of numeric, interger, alpha and date. There can be as many categories as are required. Thus, for example, if one wished to create an Analyst configuration for ETI editorial, there would be a data item for the name of each feature, one for its type (project, review, news, Tech Tip, etc.), one for its length, its author, date of publication, its area of interest, and so on. It might look something like;

Xerox 820 Review
 review
 2.5 pages
 Steve Rimmer
 June '82
 Computers

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The Analyst could be stuffed full of references for all the material we've ever published. Then it could be instructed to locate specific articles, or all the reviews, or every audio project, or all the Tech Tips published in July, or whatever. It can handle huge volumes of data in minutes, print reports, tables, all manner of good stuff, all without a lot of paper shuffling and drudgery.

Supercalc (up, up, and a fraction)

Supercalc is very much like Visicalc, a number jumbling program for handling lots of computations. It consists of a huge virtual worksheet in the computer, with a raft of virtual boxes on it. Each box, or cell, can hold a literal, data, a formula, and so on. Each cell can be addressed by a cursor; at any given time, there is always one, and only one, cell being addressed, this being the active cell. The worksheet is much bigger than the screen, so the screen can scroll over the surface of the worksheet, producing what is called the window.

The software has incredibly sophisticated means for editing the data on the worksheet. Thus, information may be moved, replicated, inserted, deleted, its formats changed, and so on. It can also be displayed, such as in bar graph format. Disk commands can be used to save and retrieve work sheet information.

The whole purpose of this is to facilitate very complex interactive computation and analysis. If a whole raft of parameters and associated formulae are installed in the work sheet, their results can be observed while making individual changes to the data and/or formulae. Financial and scientific data can be observed and manipulated (great for fudging labs) without a lot of hammering upon the calculator and spilling of Liquid Paper. In fact, the uses of this kind of software do not even begin to fully unfold themselves until you've had it for a few months.

The End

It doesn't quite have the funkiness, the arcane familiarity of an 8K PET with a small keyboard, but it's close. Grudgingly, it's probably a lot more useful.

It combines flexibility with a lack of strangeness, and, if it lacks a lot of flashy extras, its decided lean towards off-the-shelf technology and software ensures that it won't become an orphan, even if its parent company comes out with a radically different system in the future. Being CP/M based, it has tons of available software just waiting for it, and it should be suitable for any application where a powerful small system is required. The software offered by Xerox is, on the whole, extremely good.

Yes, if I had ten G's hanging around, burning a hole in my pocket, I'd zip on down and buy one. Put it there, beside my PET, let 'em talk to each other, tell stories. . . play Microchess with each other. What a great pair of night lights.

Hey, Billy. . . I think I finally found a use for these things.



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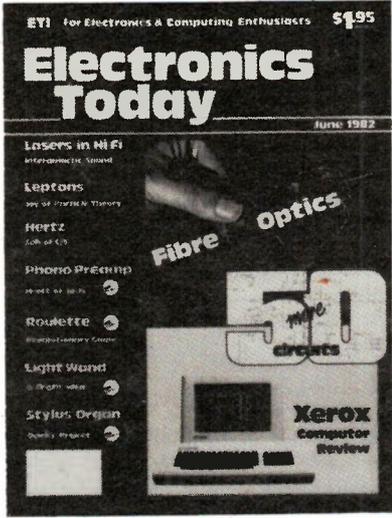
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Leptons

No, not more aliens for Captain Kirk to deal with, but a family of subatomic particles. Lepton means 'light particle', but some of them aren't, and they may not be made up of quarks either. Confused? So are the particle physicists. A.S. Lipton explains.

ONCE UPON A TIME, physics was simple (well, nearly ...). Subatomic physics especially seemed to be fairly clear cut. Around the turn of the century, J.J. Thomson had discovered the electron, which carried a negative electrical charge. A few years later, Max Planck had stated the existence of the photon, or 'particle of light'. There was one other particle; the proton, which was positively charged, and had a mass about 1836 times that of the electron. The proton and electron were known to exist within atoms. That was the entire list of subatomic particles, and it looked as though everyone would live happily ever after.

Then things got complicated. In the 1930s and 40s, more particles started turning up, and they have continued to do so to the present day. First there were the neutron and mu-meson. Then there were the p-mesons, or pions (three different ones!), the kaons, the positron, the anti-proton, the anti-neutron, the anti-muon, a few different particles called sigmas, and no less than four variations on a type of particle known as a neutrino (of which we will see more later) ... The list seemed endless.

Eventually, the physicists managed to start simplifying the situation. It became apparent that many particles, the proton and neutron, for example, might be made up of various combinations of a few even more basic particles, called quarks. Instead of having all those different particles, maybe everything could be explained in terms of just three or four quarks. There was a particular group of particles, however, collectively known as 'leptons', which did not seem to be made up of quarks. It's these particles which con-

cern us in this article.

Light Matter

The word lepton comes from the Greek word *lepto* meaning light, since the earliest leptons discovered were particles with relatively little mass. It is now known that not all leptons are light after all, but the name has stuck.

The first lepton to be discovered was the electron, which has a negative electric charge of 1.6×10^{-19} coulombs, and a mass of 9.1×10^{-31} kg. (It will be convenient for the purposes of this article to refer to particles as having a mass of so many times the mass of the electron, so for the moment we can say simply that an electron has mass 1. Using this scale, a hydrogen atom has a mass of nearly 2000). The next particle to enter our story is the neutron. The neutron is not a lepton, but its relationship with the electron leads us to the next important point; the neutrino.

The neutron is a fairly massive particle; on the electron's scale it has a mass of 1839. It carries no net electrical charge, hence its name. One important feature of the neutron is that, like many particles, it is unstable. An isolated neutron will tend, after an average time of 15 minutes or so, to disintegrate, producing a proton (mass 1836) and an electron. You will notice that, since the neutron carries no charge, when it turns into a positively charged proton, it is necessary that an equal and opposite charge, the electron, is created at the same time, so that the total charge remains zero. All well and good, then; sometimes a neutron spontaneously changes into a proton and an electron.

Particle	Mass (x electron mass)	Charge (in coulombs)	Lifetime	Lepton
Proton	1836	1.6×10^{-19}	Stable	No
Neutron	1839	Zero	About 15 min	No
Electron	1	-1.6×10^{-19}	Stable	Yes
Electron-neutrino	Very small	Zero	Stable	Yes
Muon	207	-1.6×10^{-19}	2.2×10^{-6} S	Yes
Muon-neutrino	Very small	Zero	Stable	Yes
Tau	About 3500	-1.6×10^{-19}	Less than 3×10^{-12} S	Yes
Tau-neutrino	Very small	Zero	Stable	Yes

Table 1. Particles discussed in the article (antiparticles left out for simplicity).

Think Of A Particle ...

Unfortunately, it isn't quite that simple. You see, when this reaction was first observed to happen, physicists weren't too happy with it. It seemed that certain physical laws which had always held before weren't holding any more. But then it was spotted that all the laws would be holding if only there was another particle taking part in the reaction. This particle, although it had never been observed, was christened the 'neutrino', from Italian words meaning 'little neutral one', since the neutrino, if it existed, would have little or no mass and be electrically neutral. The fact that the neutrino had never been detected was easily explained: all the methods used to detect subatomic particles depended on their having measurable masses and charges. The neutrino had neither. In fact, neutrinos react with other matter very rarely. If a beam of neutrinos was aimed at a concrete slab a light-year thick, by far the majority would get through easily!

You may think it a little bit far-fetched that scientists would actually invent a new particle, one that had never been found, just to explain why some physical laws didn't seem to work. Why not just change the laws? Well, all through the history of science, it has invariably turned out that the simplest explanation of a set of events is the correct one. In this case, it was simpler to keep the old, simple set of laws and invent a new particle, than it would have been to invent a whole new set of more complicated laws. This, at least, was how the physicists reasoned, and as it happened, they were right! In 1956, twenty-five years after its original in-

vention, the neutrino was discovered! In fact, it was found that the particle produced when a neutron turned into a proton and an electron was not a neutrino, but its *antiparticle*, the antineutrino. This, however, was a small point, and the discovery of the actual existence of the neutrino is regarded as a major triumph for theoretical physics, which had predicted its existence all those years before.

So now our family of leptons contains two particles; the electron and the neutrino (and their antiparticles, the 'positron' and the 'antineutrino' respectively). This wasn't the case for long, though. In the late 1930s another lepton was discovered in cosmic rays high up in the atmosphere. This particle was called the mu-meson, or muon for short. It was given the symbol μ , the Greek letter mu. There are only two real differences between the muon and the electron. Firstly, the muon has a much greater mass, about 207 times that of the electron and secondly, the muon, like the neutron, is unstable, although on average it has a much shorter lifetime. Under normal conditions, a muon will disintegrate after only about one five hundred thousandth of a second, turning into an electron and producing two neutrinos. Apart from these two differences, however, the electron and muon are strikingly similar. For instance, both carry the same charge, -1.6×10^{-19} coulombs. The anti-muon carries a positive charge of the same magnitude, just as does the anti-electron, or positron. The similarity between the two particles has been puzzling physicists ever since the discovery of the muon. But there's one more thing puzzling them, too...

Identical Twins?

It was found that many of the reactions involving electrons also involved neutrinos. Similarly, many reactions involving muons also involved neutrinos. The neutrinos that reacted along with electrons didn't seem to be the same as those which reacted along with muons. Apparently, there were two types of neutrinos. If you examined a neutrino from a reaction involving an electron, you would find that it could not be made to take part in a reaction involving a muon. Similarly, a neutrino from a muon reaction could not be made to react with an electron. Neutrinos, then, had to be divided into two groups; 'elec-

tron neutrinos' and 'muon neutrinos'. What is the difference between the two types of neutrino? The somewhat embarrassing answer (for a physicist) is that, even today, nobody really knows. They are different, but we don't know why. All we do know is that reactions involving electrons tend also to involve electron neutrinos, whereas reactions involving muons tend to involve muon neutrinos. When a reaction involves both electrons and muons, both types of neutrinos are involved. For instance, when a muon turns into an electron, a muon neutrino and an electron antineutrino are produced (see Fig. 1b). The two types of neutrinos are like almost-identical twins; you can't tell the difference just by looking at them, but only by looking at the different ways they behave. And, of course, each of the two types of neutrino has its own anti-neutrino, as well.

Three's A Crowd

As if the situation wasn't already complicated enough, experiments conducted in the last five years or so indicate (wait for it) that there's yet another lepton. This one, called the tau particle (and given the symbol τ — the Greek letter tau) is, again, just like the electron and muon, but with a still greater mass (about 3500 times the mass of an electron; nearly as massive as a molecule of hydrogen. As far as subatomic particles go, this is well into the heavyweight league), and with a still shorter average lifetime before it disintegrates into other particles. As yet, experiments are not conclusive, but it seems that the tau particle also has its own pair

of neutrinos; the tau neutrino and the tau antineutrino. Unsurprisingly, these neutrinos refuse to take part in electron or muon reactions unless a tau particle is also involved.

Any Answers?

So that is the situation at the moment. There are three known leptons which carry electric charge: the electron, the muon and the tau (each also having a positively charged antiparticle) and correspondingly, three sets of a pair of neutrinos: the electron-, muon- and tau-neutrinos, with their antiparticles. There a lot of questions still to be answered, though. Are there any more leptons, like the electron, muon and tau, but with still greater masses, and shorter average lifetimes? If there are, do they also have their own neutrinos? And for that matter, what is it that makes, say, a muon neutrino different from a tau neutrino? There's one more major problem too

A Massive Question

It has been known for several decades now that neutrinos have very little, or perhaps no mass at all. In fact, there has been a tendency among physicists to believe that the latter is the case, that the neutrino has no mass, although this has never been proven. Very recent experiments, however, make it look as though perhaps the neutrinos do have masses after all. If this is so, then physicists may have to rethink a lot of theories. Do neutrinos have mass? We shall just have to wait and see and maybe everyone will live happily ever after

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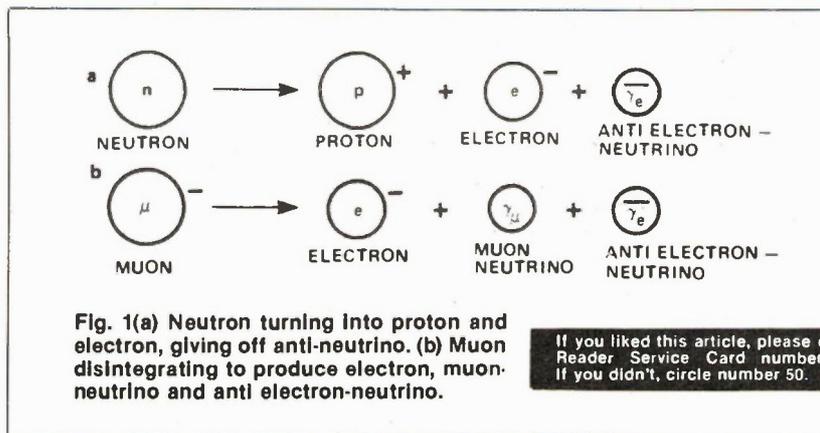


Fig. 1(a) Neutron turning into proton and electron, giving off anti-neutrino. (b) Muon disintegrating to produce electron, muon-neutrino and anti electron-neutrino.

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Hertz

Heinrich Hertz — you may think you know him as the father of stereo component specifications. However, his work was much more important; he discovered radio waves!

AFTER SO MANY years of calling the units of frequency cycles-per-second, it still takes old-timers a while to get accustomed to using the name Hertz. Surprisingly few people associate the name Heinrich Rudolf Hertz with the discovery of radio waves, but the use of Hertz (usually shortened to Hz) to denote frequency shows a deserving recognition of this fact.

Hertz was born in 1857 and after a distinguished school life, he entered Berlin University to study under the celebrated Helmholtz. Helmholtz was one of the last of the great Victorian scientists, one of those men who are equally happy in any branch of science. Two of his contributions to physics are still remembered in the textbooks: the Helmholtz coils and the Helmholtz resonator. A pair of Helmholtz coils consists of identical coils spaced one coil-radius apart, and their peculiarity is that the magnetic field between them varies only slightly from place to place between the coils. The Helmholtz pair is therefore the starting point for any TV deflection coil design. The Helmholtz resonator is a bottle with a narrow neck and its resonance to sound waves is decided by the volume of the bottle and the dimensions of the neck. If you happen to be in the business of designing cabinets for hi-fi loudspeakers, then the Helmholtz resonator is pretty important. All in all, young Hertz must have had a good grounding both in electromagnetism and in wave motion, and the success of his studies was recognised in the award of a doctorate by the University in 1880.

He started on a career of research in electromagnetism. In 1883 he became aware of Clark Maxwell's work on electromagnetic theory, a brilliant but neglected work which predicted the existence of waves which would be invisible, but which could travel at the speed of

light. Hertz was convinced that Maxwell's theory was correct, and that these waves existed in reality as well as in mathematical equations.

Hertz directed his very considerable experimental ability to the problem of generating and detecting electromagnetic waves. He reasoned that very high frequency oscillations should behave in a way similar to light waves, and decided that the resonant circuit around a spark-gap would probably provide the best conditions of generating suitable oscillations.

His apparatus, shown in Fig. 1, is now one of the famous landmarks in radio history. It consisted of an induction coil capable of generating about 30 kV of low-frequency AC, and a spark gap between two copper spheres. The inductance of the leads to the spheres plus the capacitance between the spheres constituted a resonant circuit. The resonant frequency was high, much higher than the frequencies which were to be used later by Marconi and others. Recreation of Hertz's experiment has, in fact, shown that the strongest transmitted frequencies were in the lower microwave range.

The receiver was equally simple, as can be seen from Fig. 1; a pair of copper spheres at the ends of short pieces of wire. This constitutes what we would now call a dipole aerial, and the principle on which Hertz was pinning his hopes was that electromagnetic waves picked up on the wires would create a sufficiently

large electrostatic field to ensure a high voltage across the gap between the spheres. Hertz's ideas worked out perfectly. When the transmitter was sparking away, sparks could also be seen between the spheres of the "receiver". There was no connection of any sort between the transmitter and the receiver. None, that is, apart from the electromagnetic waves which Maxwell had so confidently predicted in 1864. It was a perfect vindication of Maxwell's theory, but the evidence was not strong enough for Hertz.

Hertz felt that, in order to vindicate Maxwell's theory fully, he must show that there were waves passing from the transmitter to the receiver, and that these waves were physically similar to light waves. He started on a long and ambitious project of discovery using methods which were ideally suited to the short wavelengths which his equipment generated. Oddly enough, had he generated lower frequencies, his measurements would have failed: these are the sort of happy accidents which continually seem to occur in the history of science.

Practical Measurements

Measurement of the wavelength of the radio waves was the first objective. The standard method of measuring the wavelength of light makes use of wave interference. Light from a



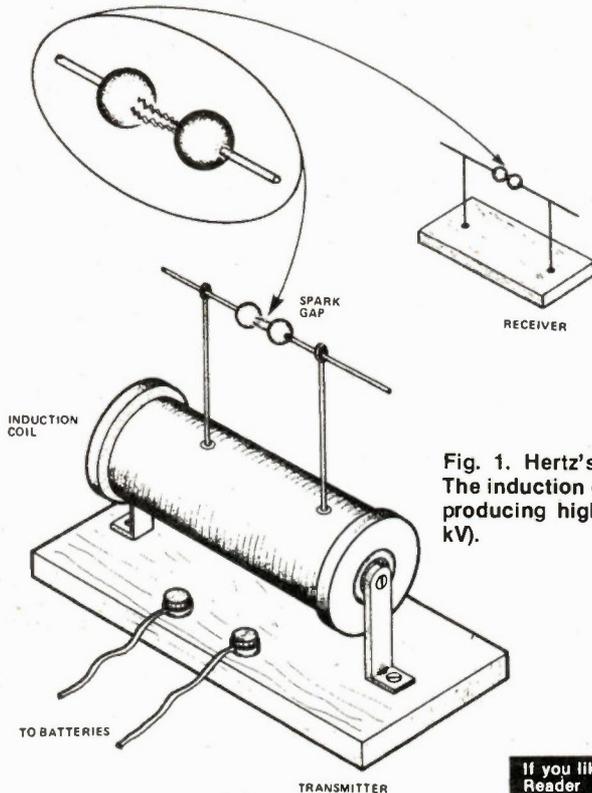


Fig. 1. Hertz's transmitter and receiver. The induction coil is a DC to AC converter producing high-voltage pulses (about 40 kV).

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source is split into two beams (Fig. 2) and these beams are aimed at a screen. Light rays which have travelled exactly the same distance will reinforce, causing a bright spot, but when the distance difference between the paths is half a wavelength, or any odd multiple (3,5,7,9, etc) of half a wavelength, the waves cancel, causing a shadow. By measuring the distances between these "fringes" of light and dark, the wavelength of light can be calculated.

Hertz used this technique, but since the waves could not be seen he had to use small spark-gap detectors instead of a screen. The wavelength of his apparatus turned out to be a few centimetres.

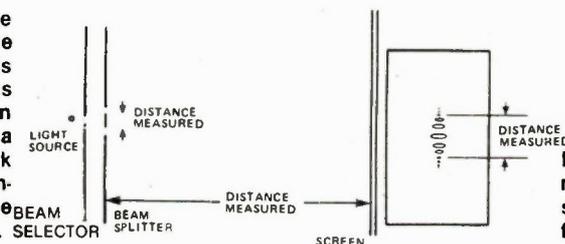
Hertz also measured the speed of the waves, using, once again, a version of the classic methods for measuring the speed of light. These make use of mirrors revolving so fast that a ray of light which has been delayed by travelling a long distance

to a reflector and back finds the mirror at a different angle when it returns, so shifting the reflection. The amount of the shift, together with the speed of rotation of the mirror and the path distance, can be used to calculate the speed of the light.

To make this measurement, Hertz had first to establish that radio waves were reflected, and he was delighted to find that the newly discovered waves reflected from metal sheets in exactly the same way as light waves do, with the angle of reflection equal to the angle of incidence (Fig. 3). He also found, incidentally, that radio waves were refracted; that is, they changed direction as they passed from one material to another exactly as do light waves.

Having made these points, Hertz succeeded in measuring the speed of the new waves. This speed turned out to be 300 million metres per second, the well established value for the speed of light. Hertz now felt that he

Fig. 2. The method Hertz used to measure wavelength of light: (a) a slit in an opaque sheet selects one ray of light, which is then split into two by close-spaced slits in another sheet. The image projected on the screen (b), when examined with a microscope, consists of alternate dark and light bands caused by wave interference. The wavelength can be calculated from the distances indicated.



had indeed discovered some of the waves which Maxwell had predicted. The work had taken him four years, from 1885 to 1889.

Road To Radio

In 1889, Hertz was appointed professor of physics at Bonn University. His work with electromagnetic waves was over for the time being, and his new line of research was to be on gas discharges, following the work of Geissler. His report, "Electric Waves", was not published until 1893, because his health was seriously declining; a lung infection which he had disregarded was now recurring.

He died in 1894, aged 37, with a brilliant career behind him, and a promise of much more to come. His "Miscellaneous Papers" was published in 1894, and his "Principles of Mechanics" in 1899. These works were not his epitaph, though they hinted at the remarkable discoveries which he might have made. There is little doubt that long-distance radio would have been established much earlier than 1910 had Hertz lived. As it was, his work started an immense frenzy of experimental activity, of which the work of Marconi is best known to us. We shall remember, though, that Hertz's work caused immense excitement, and practically every country can boast of a radio pioneer. Of these who disputed Marconi's claim to be first with long-distance radio transmission, Tesla in Czechoslovakia and Popov in Russia were both serious contenders.

There is no dispute about the source of the work, though. Maxwell blazed the trail, and Hertz built the road along which all the later radio experimenters travelled. Now that we no longer measure magnetic flux in maxwells, it seems entirely appropriate to measure frequency in hertz.

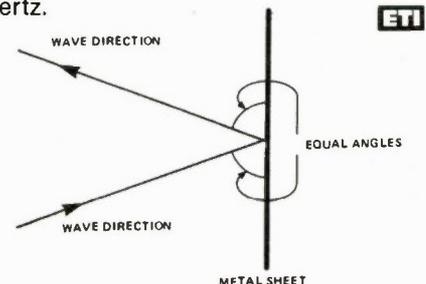


Fig. 3. Wave reflection. Radio waves are reflected from a metal sheet in just the same way as light waves are reflected from any mirror.

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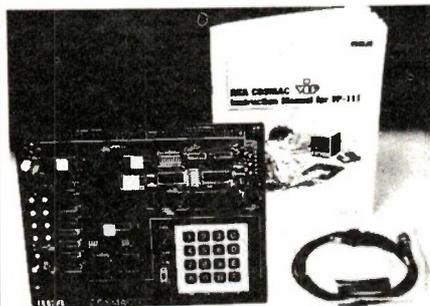
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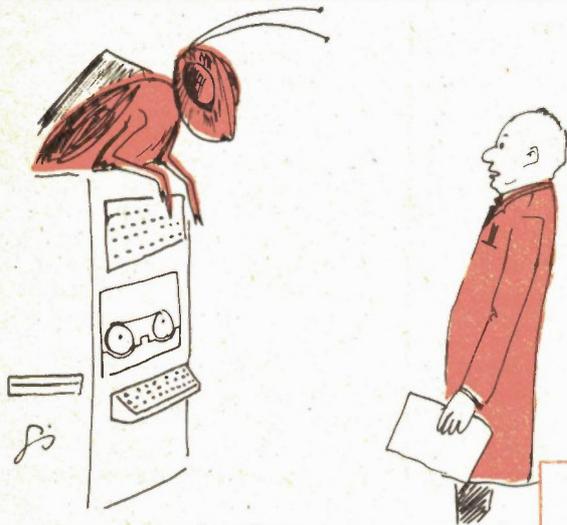
The Fun of Electronics



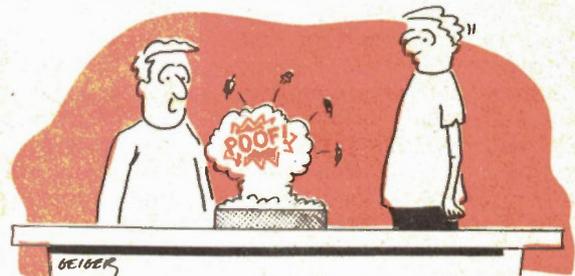
"Two wigwams plus one horse times five percent equals three buffalo."



This is the newest thing for the lab, a gold-fish electroscope.



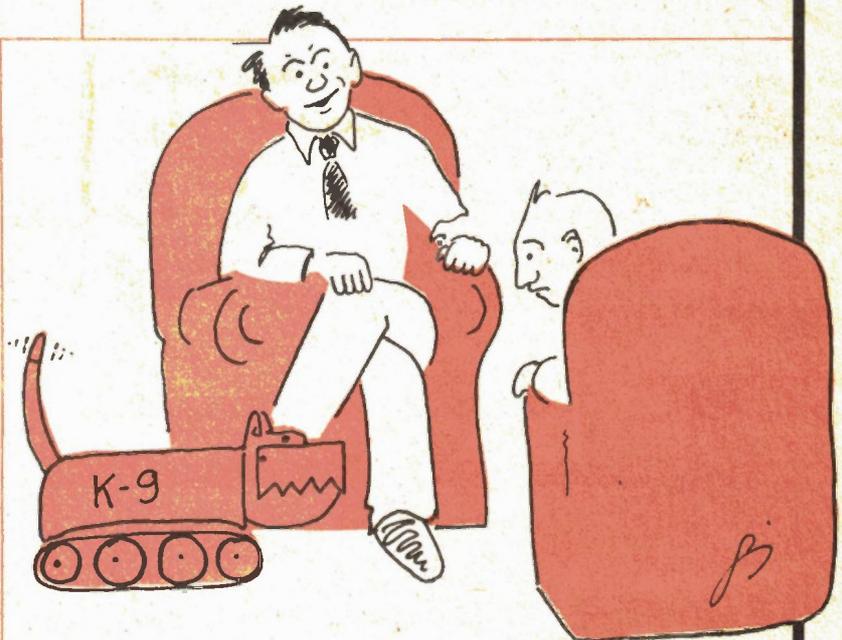
Harry, there's a bug in the system.



Y'know, I really wouldn't mind the fact that every single one of my projects blows up, if they'd at least wait until I turned on the power.

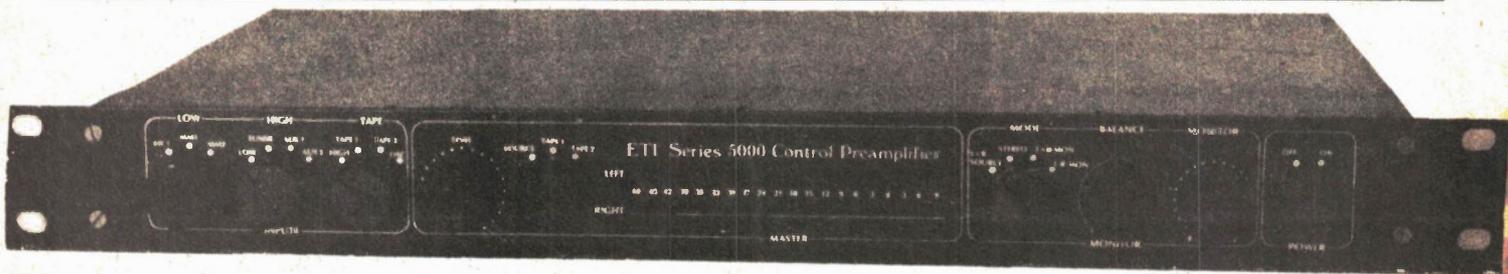


"John's home-made security system needs some work. We were broken into last week and not only didn't the alarm ring, but the safe opened automatically!"



The neighbours wouldn't dare complain.

Phono Preamp



Phono preamp design artistry set in silicon and fiberglass by David Tilbrook.

Phono preamplifier projects aren't new, but, in most cases, they are simple, one chip affairs with less than ideal performance. The pre-amp can, however, contribute a lot to the sound of a system, and this one is *the* last word in input stages.

The Series 5000 stereo control preamp has been designed specifically to overcome the problem of cartridge impedance interaction. This has been achieved by separating the moving magnet input stage into two separate active stages (see Figure 1). The first stage consists of a single NE5534AN configured as a linear amplifier with a closed loop gain of around 8.3. The large amount of overall negative feedback increases the input impedance of the stage so that the measured input impedance is simply that of the 470k resistor, R2. Since the 5534 has a small signal bandwidth of around 10 MHz without additional compensation, the input impedance will remain unchanged over a very wide frequency range. The high input impedance of this stage would usually allow the

input capacitor C2 to be conveniently small. However, for best noise performance the value must be increased substantially.

Capacitor C2 is necessary since it is not advisable to allow DC from the first stage to flow through the cartridge. The value of C2 used here is 100u, and this sets the lower -3 dB point well below 1 Hz. The upper -3 dB point of this stage is well above 100 kHz. An extended frequency response is necessary so that the accuracy of the RIAA equalisation is not affected by frequency response variations that might otherwise occur in the first stage.

RIAA Equalisation

In the development of the Series 5000 preamp several input stage configurations were tested for noise, distortion and cartridge impedance interaction. When a medium-priced moving magnet cartridge was connected to a stage like that in Fig. 3 (a typical input stage), severe cartridge impedance interaction was evident. The frequency response of the preamplifier peaked above 2 dB at 13 kHz. The same cartridge when connected to the Series 5000 MM amp exhibited quite a good frequency

response to beyond 20 kHz, and the frequency response graph obtained was identical to that when a FET buffer amp was placed between the cartridge and the input stage, indicating almost total lack of cartridge impedance interaction in the 5000 stage. This is a result of the use of the separate linear gain stage formed by IC1 (see Fig. 1) to isolate the cartridge from the RIAA equalisation.

The Series 5000 Preamp conforms to the proposed RIAA equalisation in Fig. 2. The 75 us and 7950 us time constants are obtained by passive RC filters at the output of the first stage. Resistors R5, R6 and capacitor C3 form a simple 6 dB/octave low-pass filter with a -3 dB point at 2122 Hz, and

$$t = \frac{1}{2\pi f} = \frac{1}{2\pi(2122)} \doteq 75 \mu s.$$

Capacitor C4, together with resistors R7 and R8, form a 6 dB/octave high-pass filter with a -3 dB point at 20 Hz, which is equivalent to a 7950 us time constant. The two remaining time constants are introduced into the negative feedback of IC2 and are formed by the values of resistors R9, R10, R11 and capacitor C6.

This method of generating the RIAA curve offers a number of advantages over the more conventional method.

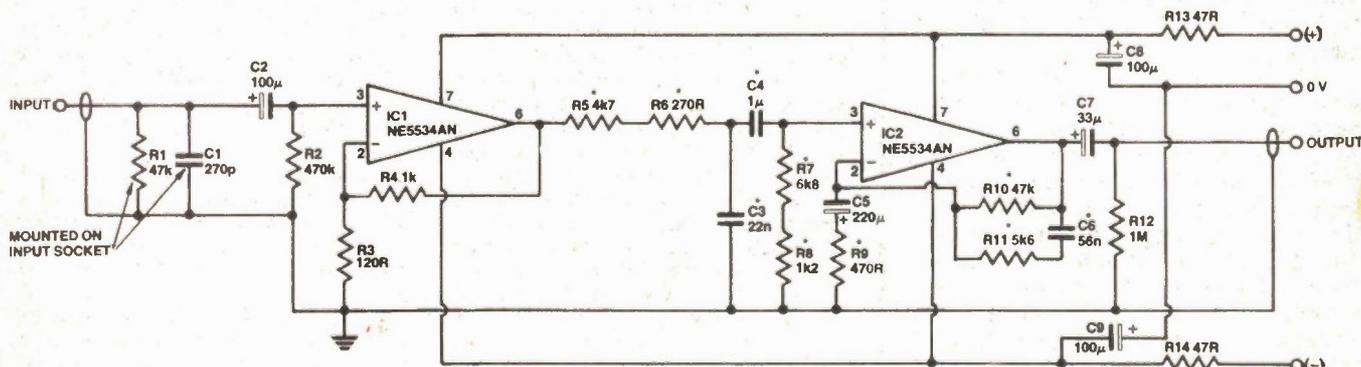
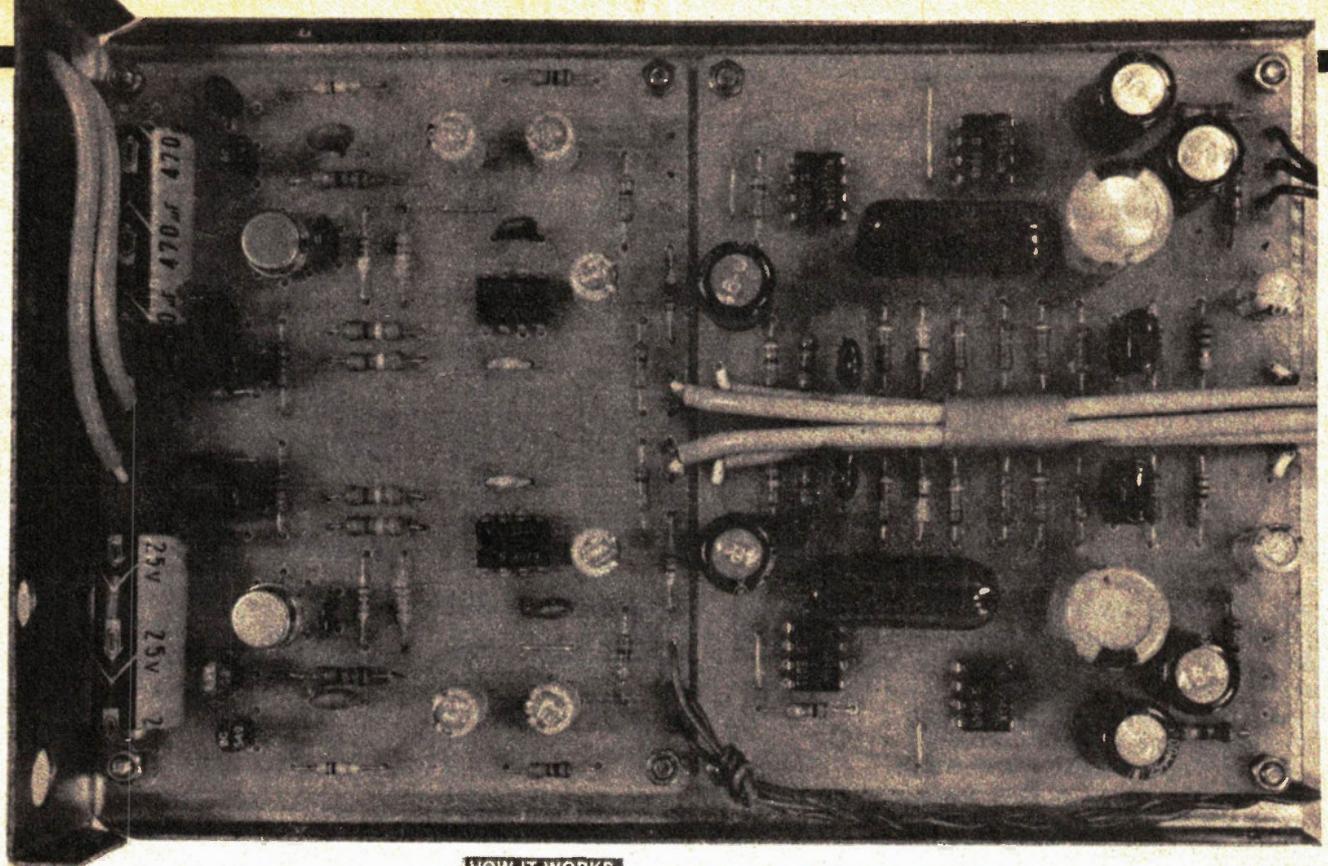


Fig. 1 Circuit of one channel of the moving magnet input stage. Note that the RIAA equalisation is incorporated in this stage. Components for the other channel are designated R101, C101, IC101, etc.

* DENOTES COMPONENTS ASSOCIATED WITH THE RIAA EQUALISATION



The low level Series 5000 Preamp Input stages. This is a view inside the enclosure; moving coil stage to the left, moving magnet stage at right.

Firstly there is low interaction between the different time constants, so that the RIAA curve can be optimised for a particular cartridge more easily by changing the resistor or capacitor values slightly. If the 75 us time constant is included in the negative feedback of a stage, the gain of the stage must decrease to unity at a suitably high frequency, so the stage must be compensated for unity gain to prevent instability. In the Series 5000 MM stage the gain of the second stage does not drop below 10; since the NE5534AN is internally compensated for gains of 3 or above, no additional compensation is required.

Another advantage of the two-stage approach is that the total gain necessary in the MM stage can be divided between the two stages, so more negative feedback is available for each stage. This will have the effect of decreasing non-linearities in the stages, provided the stages conform to the criteria for the avoidance of SID (slew-induced distortion) and amplitude overload. Fortunately, in the case of a phono input stage, both of these are limited by the recording medium. The RIAA standard sets a

HOW IT WORKS

The input from a moving magnet cartridge is connected to the non-inverting input of an NE5534AN via capacitor C2. R2 provides a dc current path to the input of the differential pair in the op-amp. The gain of this stage is determined by the ratio R4 to R3, which is around 8.3 in this case.

The resistor R1 provides a fixed resistive load necessary for best performance from an MM cartridge. Most cartridge manufacturers recommend that the input resistance be shunted by a certain amount of capacitance. This is the purpose of capacitor C1, the value of which should suit most cartridges. If you wish to optimise the value of this capacitor don't forget to allow several hundred picofarads for the shielded cable capacitance.

The best way to ensure that the cartridge is loaded correctly is with a test record containing a square wave track, and an oscilloscope. With the correct cartridge load and a good tonearm/cartridge combination, a good square wave can be obtained.

The value of resistor R1 at 47k is effectively in parallel with R2, giving an input resistance of 43k, slightly below the 47k normally used for MM input stages. This is unimportant, however, and will not affect performance of the cartridge. The important thing is that the value of this resistance remain constant over the full audio spectrum and beyond. In any case the value of the input resistance is easily changed by increasing the value of R1 to, say, 56k instead of 47k.

The output of the first stage is fed to two 6 dB/octave RC filters that provide one half of the RIAA equalisation.

Resistors R5, R6 and capacitor C3 form a first-order low-pass filter set at the 75 us time constant of the RIAA curve. At these frequencies (around 2122 Hz) the 1 uF capacitor appears as a short circuit connecting R7 and R8 in parallel with the capacitor C3. This must be compensated when choosing the value of C3 to ensure the correct RIAA equalisation. Similarly C4, R7 and R8 form a low frequency high-pass filter set at 20 Hz (the 7950 us time constant).

The output of these two filters is fed to the input of the second op-amp stage. The remaining RIAA equalisation is accomplished by the feedback loop around this stage. At frequencies below 500 Hz the 56nF capacitor C6 has a relatively high impedance. The voltage gain is therefore determined by resistors R9 and R10. At higher frequencies, however, where the impedance of C6 is less, both resistors R10 and R11 are in circuit. The capacitor C5 decreases the gain, at dc, of the second stage to unity, ensuring a low dc, of the second stage to unity, ensuring a low dc offset at the output and therefore symmetrical output stage clipping.

The 1M resistor R12 ensures that the dc voltage on the output remains at 0V. This is important so that operation of the selector switch following the stage will not cause thumps in the output.

Resistors R13, R14 and capacitors C8, C9 isolate the supply to the stage to decrease the effects of interactions between stages and to ensure freedom from 60 Hz ripple.

maximum recording velocity of 25 cm/sec, and most cartridges have output levels around the 1 mV/cm/sec figure. So maximum output levels from such a cartridge will be in the order of 20-30 mV. Even the highest output cartridge produces signal voltages usually in the 5 mV/cm/sec range. Combining a worst case of, say, 5 mV/cm/sec with the maximum allowable recording velocity of 25 cm/sec yields an output voltage of 125 mV. To ensure that the input stage cannot be overloaded we simply set the gain of these stages so that this maximum input signal cannot drive the output of the input stages into clipping. The NE5534AN is capable of driving to within 2V of the supply voltage, so a supply voltage of $\pm 15V$ gives the desired gain of around 75. We have divided this gain between the two input stages so that the first stage has a gain of 8.3 and the second stage a gain of 9 in the midband region (the actual gain of the second stage is, of course a function of frequency due to the RIAA equalisation).

As a result the total harmonic distortion of this MM input stage is well under 0.001%. The actual measured distortion using an HP3580A spectrum analyser was around 0.0005% at 1 kHz. (At these distortion levels even the best distortion analysers are practically useless, since the distortion is well below the level of noise.) Similarly, intermodulation distortion (IMD) was measured at well below the 0.001% figure.

The Moving Coil Input Stage

The subject of noise performance is particularly important for a moving coil input stage. The moving coil cartridge works on exactly the same principle as the moving magnet. The signal voltages produced are the result of relative motion between a coil of wire and a magnetic flux. In this case, however, the magnet assembly is mounted rigidly to the cartridge body and the coils are mounted on the cantilever assembly; hence the name 'moving coil'.

In order for the total mass and therefore the inertia of the stylus/cantilever system to be kept to a minimum, the coils are made with very fine wire and a small number of turns. Typical output voltages for moving coil cartridges vary widely from one manufacturer to another,

but a figure of 40 $\mu V/cm/sec$ is probably a reasonable compromise. A gain of 25 is therefore required to boost this voltage to that of a typical moving magnet cartridge.

The complete circuit diagram for the moving coil input stage is shown in Fig. 5. The collectors of the LM394 are connected to the input of an NE5534, which functions as a high-gain differential amplifier, providing adequate open loop gain to ensure low distortion and a flat frequency response when negative feedback is applied. The input choke is used to minimise the stage's susceptibility to RF noise.

The input impedance of the stage is determined by the parallel combination of R1 and R2, around 65 ohms for the values shown. This

should be suitable for most moving coil cartridges, but is easily changed if required. The DC operating point of the LM394 is determined by the constant current source formed by Q1, Q2, R3 and R6, so the current in resistor R2 is determined by this constant current source and the DC current gain of the LM394. Hence the value of R2 can be increased, in order to increase the input impedance, over a fairly wide range of values without affecting the operation of the circuit.

Once again the input coupling capacitor C4 is used to prevent DC current from flowing through the cartridge. Capacitor C4 is shunted by C3, a 10n capacitor, so that the base of the first transistor in the LM394 is decoupled for RF, through C2. Capacitor C2 represents a shunt

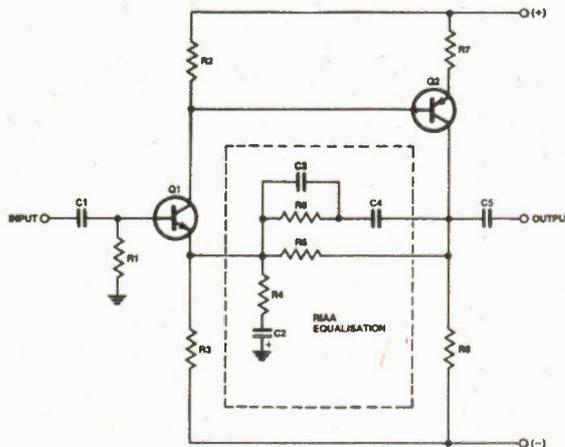


Fig. 3 Typical phono input stage.

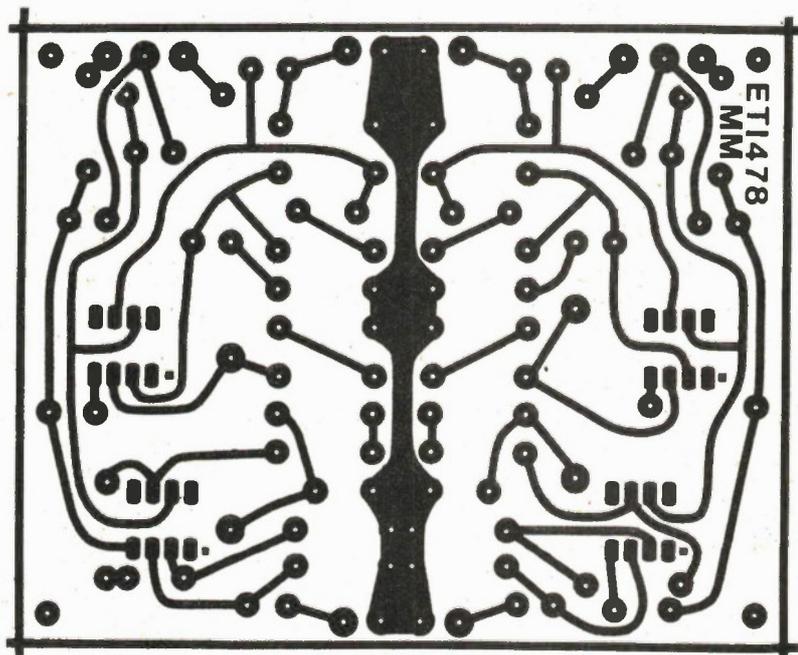


Fig. 4 PCB for moving magnet pre-amp.

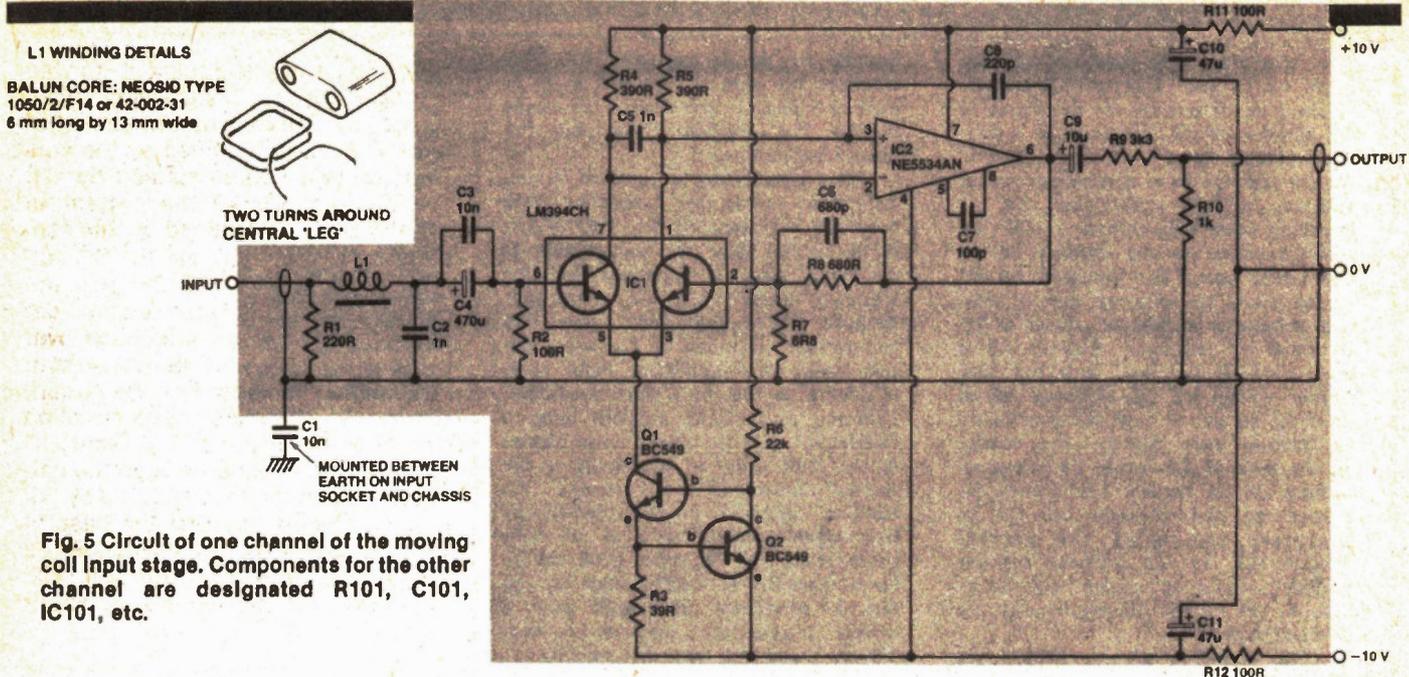


Fig. 5 Circuit of one channel of the moving coil input stage. Components for the other channel are designated R101, C101, IC101, etc.

capacitance to ensure correct loading of the moving coil cartridge. The value shown should be suitable for most cartridges, but can be changed for optimisation with any particular cartridge.

To prevent loading the 5534A, the feedback resistor R8 is kept above 600R, i.e., 680R. Resistor R7 effectively increases with the cartridge and must be kept as low as possible for best noise performance. The value of 6R8 chosen gives the stage a gain of around 100, which is too high. This is corrected, however, by a simple passive voltage divider at the output, formed by R9 and R10. Capacitor C9 doubles as a feedback isolation capacitor to ensure that reactive components in the load cannot cause a phase shift sufficient to cause oscillation.

The noise performance of the stage is extremely good. The total equivalent input noise was measured at 83 nV over a 20 kHz noise bandwidth. This is equivalent to 0.6 nV/(square root(Hz)) or a signal-to-noise ratio of 68 dB with respect to an input signal voltage of 200 uV. This might sound like only an average noise figure compared to that attainable with the moving magnet preamp, but it should be remembered that the noise generated by the cartridge itself is of this order of magnitude!

Construction

Construction of both boards is

PARTS LIST

Resistors all 1/2 W metal film

R1,101	47k
R3,103	120R
R4,104	1k
R5,105	4k7, 1%
R6,106	270R, 1%
R7,107	6k8, 1%
R8,108	1k2, 17
R9,109	470R, 1%
R10,110	47k, 1%
R11,111	5k6, 1%
R12,112	1M
R13,113,14,114	47R

Capacitors

C1,101	270p ceramic
--------	--------------

C2,102	100u, 16V electro
C3,103	22n greencap
C4,104	1u greencap
C5,105	220u, 16V electro
C6,106	56n greencap
C7,107	33u, 25V electro.
C8,109,9,109	100u,25V electro.

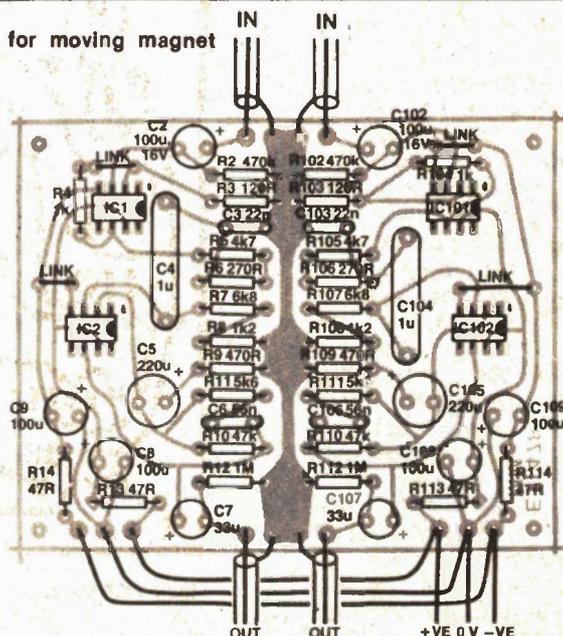
Integrated circuits

IC1,101	NE5534AN
IC2,102	NE5534AN

Miscellaneous

pc board; assorted mounting hardware; shielded cable.

Fig. 6 PCB overlay for moving magnet preamp.



HOW IT WORKS

The input from a moving coil cartridge is fed via L1 and capacitors C3 and C4 to the base of one of the transistors in the LM394, which functions as a differential input stage.

Q1 and Q2 form a constant current source, which stabilises the dc operating point and ensures a high impedance source to the emitters of the differential pair. The constant current source works by ensuring that a constant voltage is maintained across a fixed value of resistance. Resistor R3 is used for this purpose, with the base emitter voltage of Q2 expressed across it. If the current through R3 were to try to increase even slightly, the voltage on the base of Q2 would be increased, turning Q2 on harder. This causes the voltage on the collector of Q2 to decrease, decreasing the current through R3. So Q2 provides negative feedback acting to correct any deviations in the current flowing through the differential pair.

The collectors of the LM394 are

shunted by the 1n capacitor C5. This decreases the gain of the first stage at high frequencies and helps to ensure stability (i.e. freedom from high frequency oscillations).

The input stage is operated in full differential mode by connecting both collectors to inputs of the NE5534AN. If this is not done the voltage gain of the input stage is decreased and the signal-to-noise ratio is degraded. Because differential pairs have two base-emitter junctions in the input circuit, their total equivalent input noise is inferior to that of a single transistor. However, since it is possible using a differential pair to obtain noise figures of the same order of magnitude as the thermal noise of the cartridge, the marginal decrease in the theoretically best signal-to-noise ratio is of little consequence. On the other hand the inherent linearity of a differential pair offers a significant advantage over a single transistor, improving both distortion and high frequency stability.

Capacitor C7 ensures stability of the op-amp by providing adequate compensation for the increased gain around the stage due to the differential pair. C9 provides dc isolation of the stage. The resistors R9 and R10 form a potential divider to decrease the signal level to that suitable for the MM input. If the particular moving coil cartridge used requires a different amount of voltage gain than is provided, the value of R9 can be changed accordingly. Replacing R9 with a short circuit (i.e. a piece of tinned copper wire in place of the resistor on the circuit board) increases the voltage gain of the stage to slightly over 100.

The two RC networks R11, C10 and R12, C11 provide isolation of the supply voltage from other stages using the same power supply. This decreases interactions between stages, thereby improving crosstalk and the overall stability of the preamplifier.

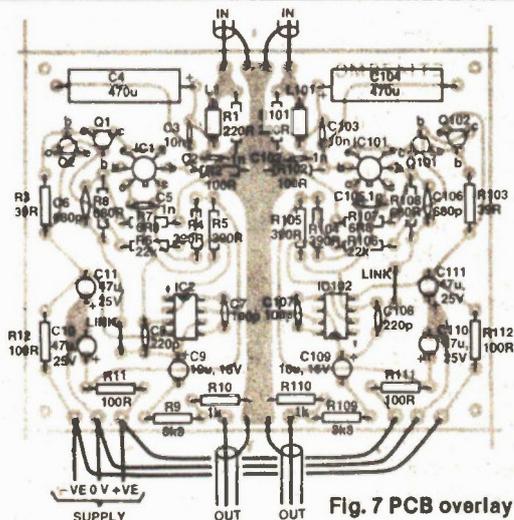
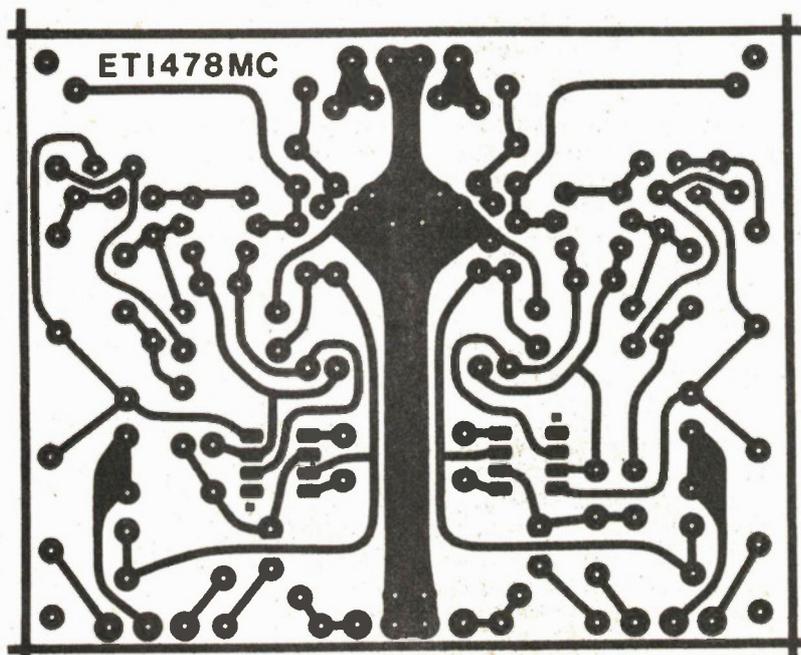


Fig. 7 PCB overlay for moving coil preamp.



Full-size artwork for the moving coil input stage.

PARTS LIST

Resistors all 1/2 W metal film, 5% unless noted otherwise.

R1,101	220R
R2,102,11,	
R111,12,112	100R
R3,103	39R
R4,104,5,105	390R
R6,106	22k
R7,107	6R8
R8,108	680R
R9,109	3k3
R10,110	1k

Capacitors

C1,101,3,103	10n greencap
C2,102,5,105	1n greencap
C4,104	470u 16V electrolytic
C6,106	680p ceramic
C7,107	100p ceramic
C8,108	220p ceramic
C9,109	10u 16V electrolytic
C10,110	
C11,111	47u 25V electrolytic

Semiconductors

Q1,101,	
Q2,102	MPS6515

Integrated circuits

IC1,101	LM394CH
IC2,102	NE5534AN

Miscellaneous

L1	Two turns on ferrite balun core, Neosid type 1050/2/F14 or 42-002-31
	pc board; shielded cable; assorted mounting hardware, etc.

Lasers in Hi-Fi

Laser technology is making a bid to replace the cartridge in your pickup arm, but it's already been in use for many years at the other end of the hi-fi, helping to develop better speakers. Peter Green takes a look at developments in the Wharfedale labs.

DESIGNING LOUDSPEAKERS is a complex business. Sound engineers trying to bridge the gap between theory and practice are faced with the tricky problem of investigating exactly how a speaker cone vibrates at frequencies across the audio band and at any point on the surface. Ten years ago the use of laser holography techniques was applied to speaker development by Wharfedale, techniques which provide a design team with a 'contour-line' map of the vibration of a speaker cone.

Typical holograms obtained with this technique are shown in the centre row of Fig. 1. The contours provide a typical guide to the manner and degree of vibration suffered by the cone at the moment the hologram was taken, but although this technique is a good one it has a number of disadvantages. Complicated vibration patterns give intricate contours which require much interpretation; furthermore, there are no helpful little numbers printed on the contours as in an ordinary map so it's not possible to tell whether the vibrations are convex or concave in nature. This makes it difficult to judge what remedy should be applied to counter the resulting sound distortion, so that the analysis becomes an art rather than a science. It also takes time, and in research and development time often means a great deal of money. What is needed is a quick way of producing a three-dimensional view of the actual 'hills' and 'dales' of the terrain, rather than a 2-D map.

To overcome these problems two new laser techniques have been developed by Wharfedale's senior acoustic engineer, Dr Peter Fryer. They are based on the laser doppler velocimeter concept pioneered at the British Atomic Energy Research Establishment, together with work

done at Southampton University. The equipment used was entirely designed and built by Wharfedale for a small fraction of the cost of commercially available sensors, using the excellent engineering rule of never re-inventing the wheel. The sensing circuit uses an ordinary FM radio set, and when you need a scanning mirror system, what else would a loudspeaker company build it from but loudspeaker voice coils?

Take A Scalp

The basic technique uses a Scanned Laser Probe, or SCALP, and in just 15 minutes it can provide an exact 3-D picture of the vibration of the whole surface of the speaker cone when a single frequency is fed into it. The signal from SCALP corresponds to both the amount and direction of the cone surface vibration at the point of reflection of the laser light, and thus gives a clearer and more accurate representation than holography, requiring a minimum of interpretation. Alternatively a Frequency Slice Plot (FRESP) can be made, which shows on one plot the 3-D behaviour of the speaker cone in one plane over the complete range of audio frequencies. Until now this complete vibration-frequency signature has been impossible to obtain.

The SCALP process is basically quite simple and is shown diagrammatically in Fig. 3. Laser light passes through a beam splitter and emerges as two equally bright beams travelling at right angles to one another. One of these, the reference beam, falls onto a rapidly rotating disc whose speed is such that the frequency of the reflected laser light is Doppler-shifted by 10.7 MHz, the in-

termediate frequency of the IF strip inside an FM radio. The other beam (the sensing beam) is reflected from two mirrors and then onto the speaker under test. The two reflected beams, reference and sensing, return back along their original paths and meet again at the beam splitter. Half of each of them is sent into a new beam which falls onto a photocell.

This output beam is composed of light, half of which is at the original frequency and half of which has been frequency-shifted by the disc. The two components beat together at the photocell and produce a steady 10.7 MHz electrical signal which is fed into the appropriate part of an FM radio just as if it had been picked up by an antenna. With no audio signal being fed to the test speaker the FM radio will output a steady DC level, showing the speaker to be stationary.

Light . . . Music . . . Action

Suppose now that a single frequency is fed to the speaker. During the first part of the vibration cycle the speaker is moving forwards and the reflected laser light is shifted upwards in frequency by an amount that depends on the velocity of the cone. Thus the beat frequency at the photocell is altered and the FM radio output increases by a corresponding amount. When the speaker is moving away from the beam splitter the frequency of the sensing beam is reduced and so the radio output drops. Thus the output of the radio indicates both the amount and the direction of the speaker cone movement, phase information that the hologram would have lost has been preserved.

The two mirrors in the path of the sensing beam are attached to

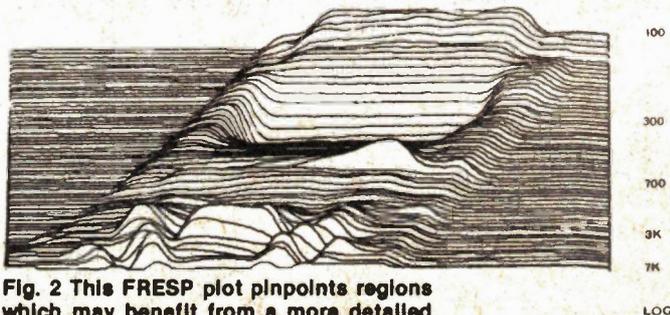


Fig. 2 This FRESP plot pinpoints regions which may benefit from a more detailed SCALP analysis. For example, the odd hump at about 500 Hz is probably worth investigating.

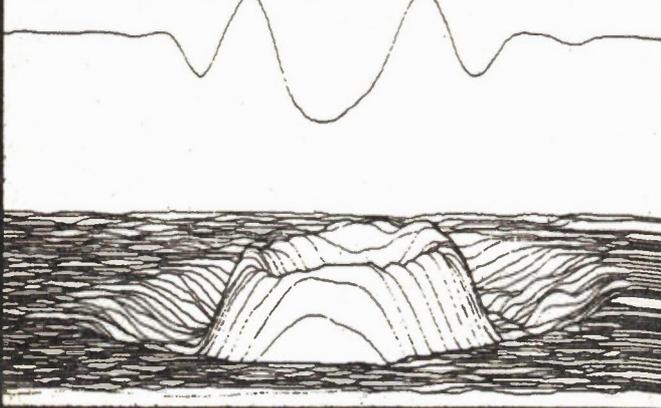
loudspeaker voice coils. One of these is connected to the voltage from the 3-D plotter which scans the X-Y plotter across the page, the other to the voltage which scans up the page.

Hence the sensing beam is scanned across the cone and at any point on the plot the movement of a corresponding point on the speaker is preserved in the form of a 3-D plot of the

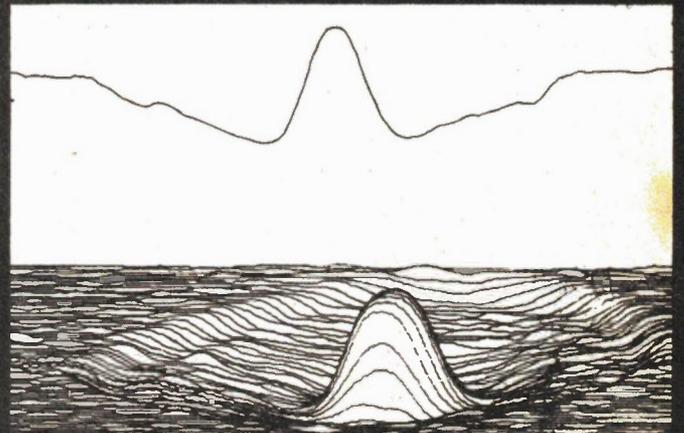
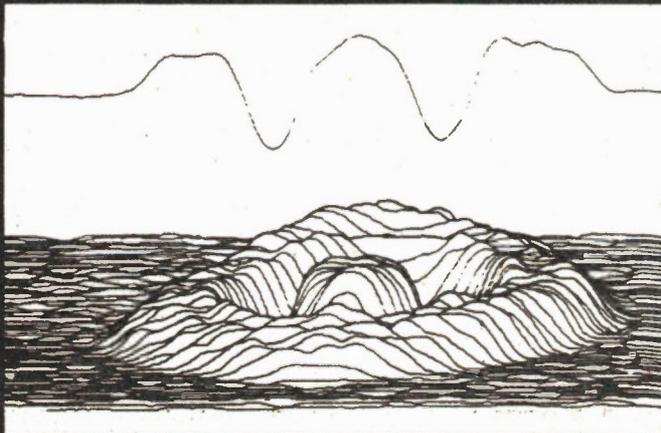
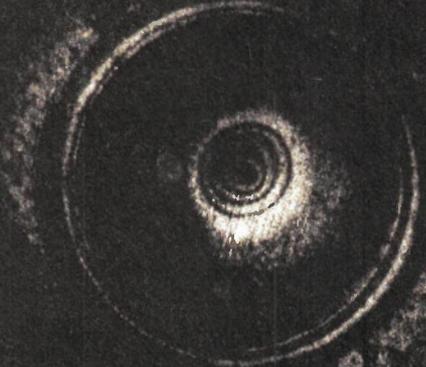
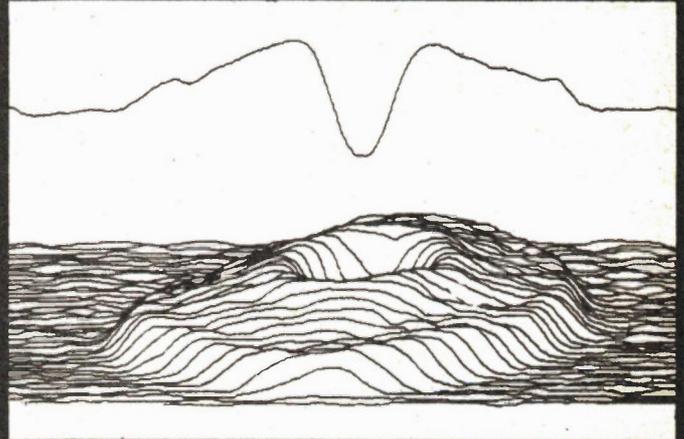
speaker vibration. Typical results of laser plotting are shown in the top row of Fig. 1.

BAD

Fig. 1 Laser studies of loudspeakers.



NOT SO BAD



FRESP — Son Of SCALP

FRESP is similar to SCALP, but in this case the vertical scanning mechanism is turned off. Thus each

curve plotted is of the same horizontal slice across the middle of the loudspeaker. Instead of moving the laser beam by a small amount vertically for each separate trace, the frequency being fed to the speaker is

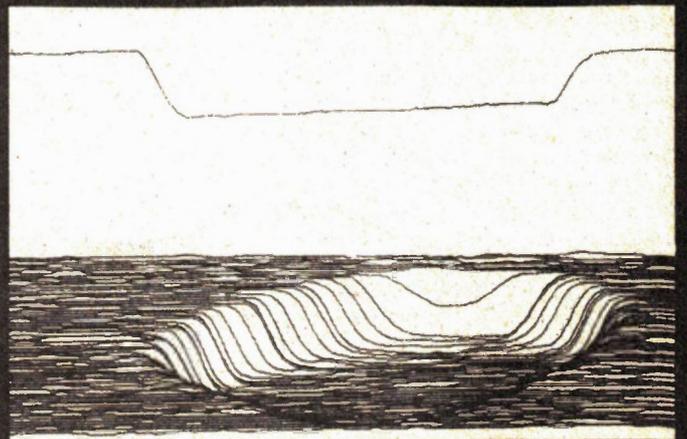
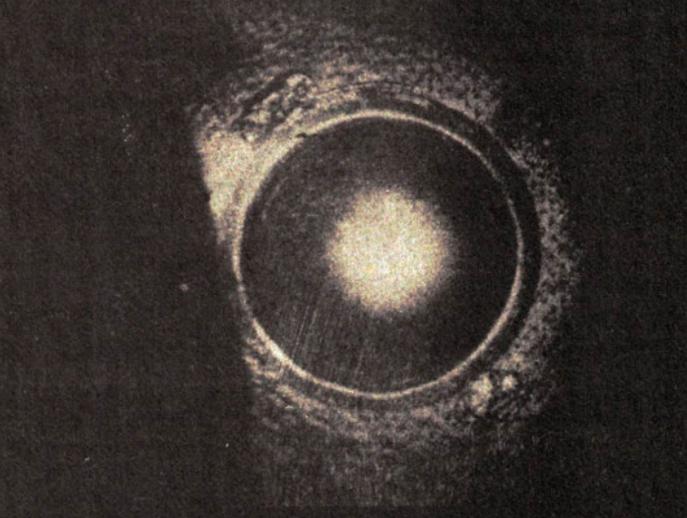
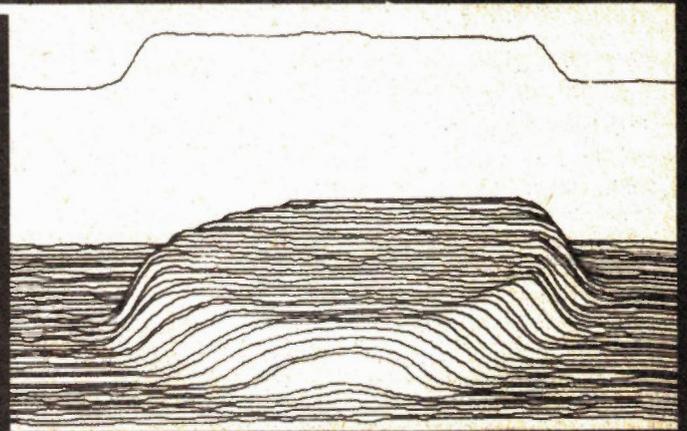
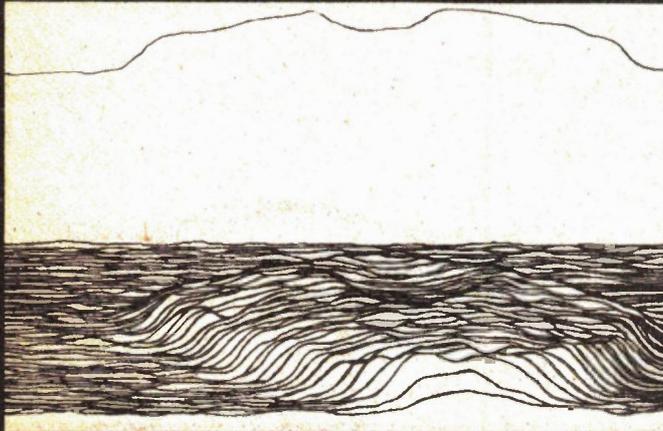
changed between traces starting at the highest frequency and moving down in small steps to the lowest frequency.

This results in a plot having the same width from top to bottom (the

Continued on page 70

BETTER

OK



Light Wand



A portable, battery-operated light has a thousand and one uses. Flashlights are fine, but their narrow beam limits their application. This project describes a highly practical, battery-operated fluorescent light which is highly efficient.

FLOURESCENT LAMPS, fluorescent lights on buses and trains, and battery backed-up fluorescent emergency lights have been with us for some time now. The original motivation for designing this particular circuit, however, was to produce the most light for the least weight. The design had to be compact, reliable, able to take a wide range of input voltages, but above all, be reliable.

Our basic model, the 8 W one, uses parts which are readily obtained. We built a 4W version similar to the 8W one simply by using the smaller tube. This is physically nicer, but inherently less efficient.

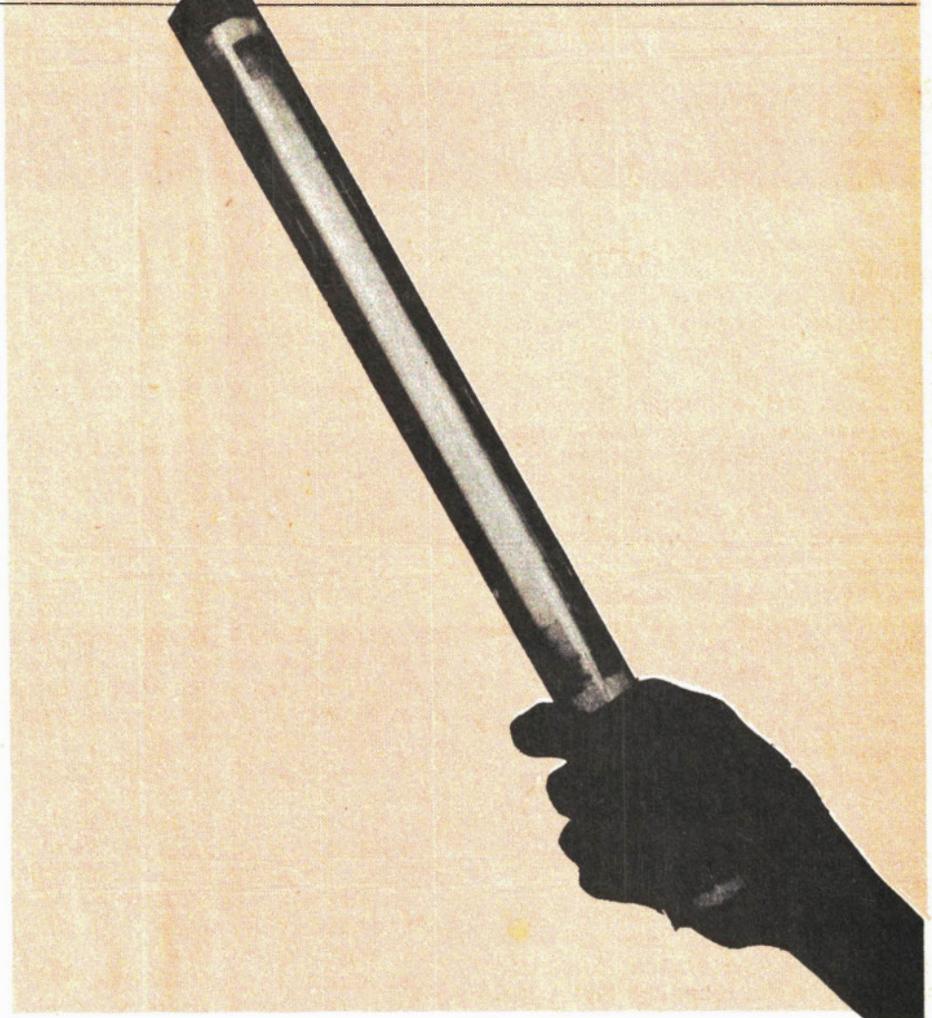
Neatness and care is important in this project, though construction is not difficult.

Construction

The first step is the most important and the most time consuming; winding T1. Ensure that you have adequate 26 swg, 32 swg and 40 swg wire; about 2m of the first and 10m each of the second and third will be required. Have a sharp blade, some ordinary clear sticky tape and about 90 minutes on hand.

Start with the secondary winding. Leaving about 3 cm of wire projecting, close wind the 32 swg wire on to the former; 150 turns is almost exactly 4 layers. When the first layer is complete, cut a strip of sticky tape the correct width and, without letting the turns unravel, insulate the layer with the tape. Repeat this procedure, layer by layer, until you have wound four layers.

Terminate the winding to the pins shown in Fig. 1. Next wind on the secondary and the feedback windings. The 30 turn primary is about 1½ layers and the feedback winding will go in the remaining ½ layer. Again terminate to the pins as shown



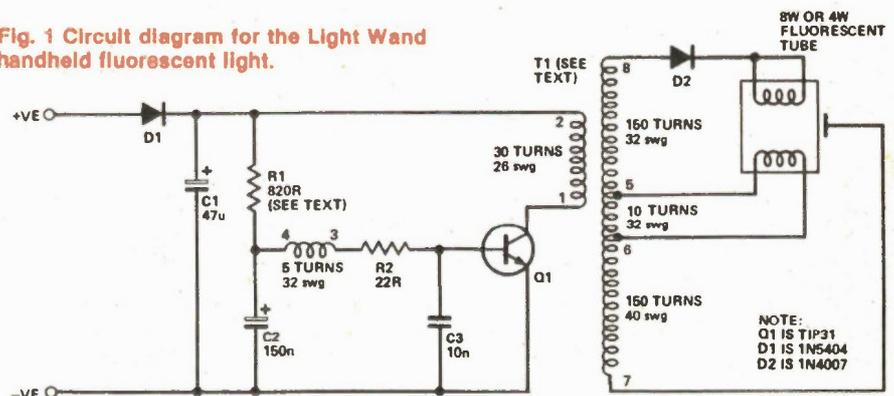
In Fig. 1. Put a layer of tape over the windings.

Now wind on the starter winding, 150 turns of 40 swg. This is very fine and must be handled with care. The winding must be as even as possible to avoid aging. If more than one layer

is needed, insulate with tape between them. Also put a layer of tape over the top. Terminate this winding to the proper pins.

Finally wind on the heater winding; 10 turns of 32 swg. Insulate and terminate.

Fig. 1 Circuit diagram for the Light Wand handheld fluorescent light.



The specified core is a gapped one. It is rather fragile and should be handled with care and reverence. Fit the cores into the former and secure with the clips provided. Under no circumstances should they be held tightly by the centre.

Circuit Notes

This converter circuit is actually much more complex in its operation than the circuit diagram appears! Hence the long *How It Works* section.

D1 is a protection diode. It can be used in either of the two positions indicated and will protect the circuit from damage in the event of reversed polarity being applied. In position, it blocks any flow of current in the reversed polarity condition but drops about 0V8 from the supply in normal operation. Where a car battery or rechargeable battery pack is used and efficiency is not at a premium, this is satisfactory. If, however, dry batteries are used or efficiency is at a premium, the supply can be connected to point A, but no polarity protection then operates.

Capacitor C1 is the supply bypass capacitor. Due to the high speed switching transients present, this capacitor needs to be a tantalum type.

Actual power consumption and apparent light output can vary from unit to unit. The amount of power delivered to the tube, and hence the power consumption overall, can be varied by adjusting R1 and R2. The values of 820 ohms and 22 ohms are given only as a guide. In order to have a current consumption of about 250 mA, which seems to be the best compromise, as little as 560 ohms or as much as 1k2 might be required for R1 and down to 2R2 for R2. Generally, if

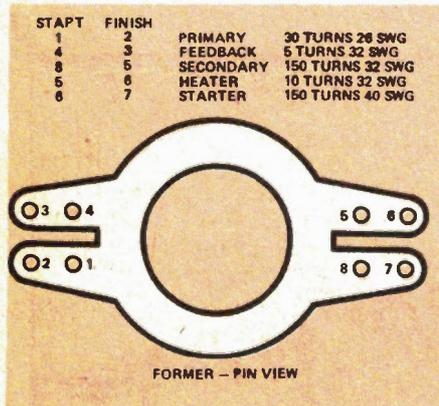


Fig. 2 T1 winding details

the supply current exceeds 400 mA, R1 should be increased and if starting is unreliable it should be decreased.

One final note; Q1 appears to be very overrated, being a 40 W device which can carry many amps; much more than necessary. However, we have found that transistor dissipation goes up (and efficiency down) if a transistor of smaller rating is used. This seems to be because the beta falls if the knee current is exceeded and the transistor dissipates power during switching as a direct result.

The next step is to assemble the PCB. The transformer should be inserted such that the secondary tags are nearest D2.

Initially it would be wise to connect the transformer to the board using short lengths of insulated wire until operation is verified.

Connect the tube to the board as shown in the overlay.

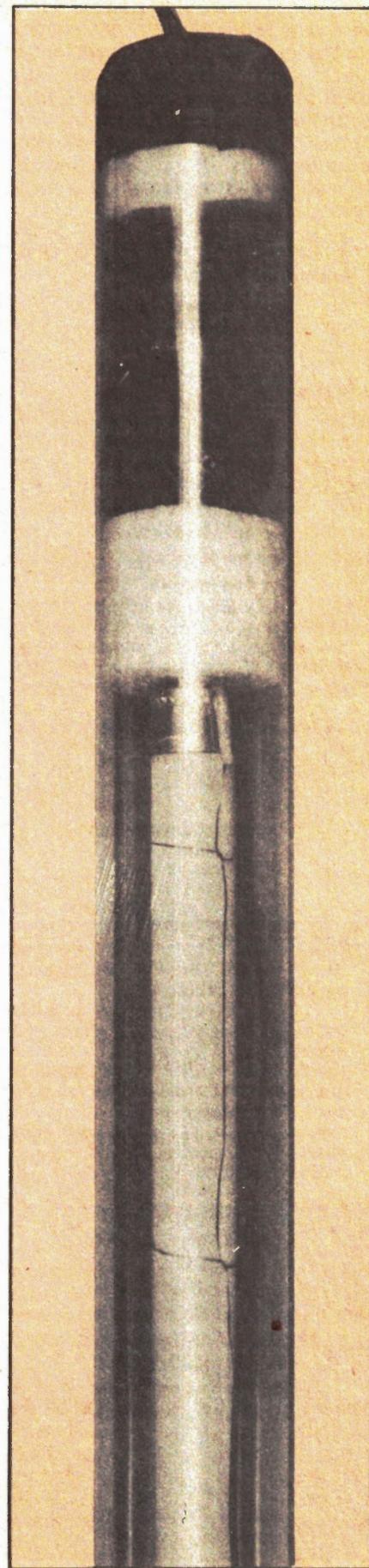
With some method of limiting current, such as a supply limited at about 200-500 mA or a 22 ohm resistor in series with a 12 V supply, apply power. Now, one of three conditions will exist:

1. No oscillation. If there is AC on the secondary, the device is oscillating. If you wish to check this without a multimeter, bridge the 1N4007 momentarily. Any flicker indicates oscillation. If there is none, reverse the phase of the feedback winding by swapping its wires. This should get you to condition (2) or (3).
2. Oscillation; but tube glows dimly or only with the 1N4007 bridged out. This means that the secondary sense is wrong. Swap both the primary and feedback wire pairs. This should get you to condition (3).
3. It works.

If necessary re-terminate the transformer windings and solder it into the PCB. Check the power consumption next. If it is more than 400 mA, or the transistor gets too hot to touch, increase R1 to 1k0 or 1k2. If the whole circuit draws less than 200 mA or is dim, increase it to 680 or 560 ohms.

If the lamp is still too dim, decrease R2 until it is satisfactory, while still not drawing excessive current or overheating.

The remaining construction is up to you, depending on how you have chosen to house the assembly. The following description pertains to our prototype. You will require a 400 mm length of acrylic tube; 32 mm I/D. The end pieces and spacer inside the tube



were made from polystyrene which is very easy to cut and provides support for the light tube. The ends are held in place and made waterproof with plastic tape. You may then fit a suitable connector on to the power cable; we built our device with alligator clips. A reflector may be formed by sliding some white paper behind the tube.

PARTS LIST

Resistors (All 1/4 W, 5%)

R1	820R
R2	22R

Capacitors

C1	47u 16V tantalum
C2	150n 35V tantalum
C3	10n polyester
D1	1N5404
D2	1N4007 or similar 1kV PIV diode

T1 Neosid RM10 with 0.3 mm gap.

F1 Fluorescent tube
Wire, 32 swg (0.2 mm) and 26 swg (0.4 mm) enamelled wire; Plexiglass tube, 32 mm I.D., length to suit; Alligator clips.

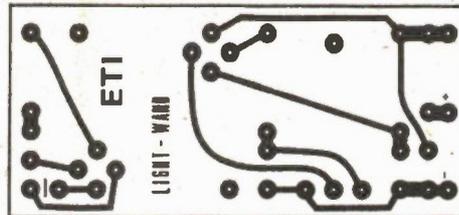
The only difficult part to acquire for the light wand is the pot core for T1. Neosid (Canada) Ltd. have kindly offered to supply this part to ETI readers. Contact:

Neosid (Canada) Ltd.
10 Vance Rd.
Toronto, Ontario.
M8Z 5J4
Telephone (416) 251-2831

HOW IT WORKS

R1, R2, C2, C3, Q1 and T1 comprise a self-oscillating DC-DC converter.

Initially, Q1 is turned off. At switch-on, current flows through R1, charging C2. Subsequently C3 charges up via the five-turn feedback winding and R2. When C3 reaches about 0.55 volts, Q1 begins to conduct. The feedback winding then forces more current into C3 via R2 because of the phase of its connection. Q1 is then turned hard on. During this positive feedback cycle



Above: the board for the Light Wand fluorescent lamp.

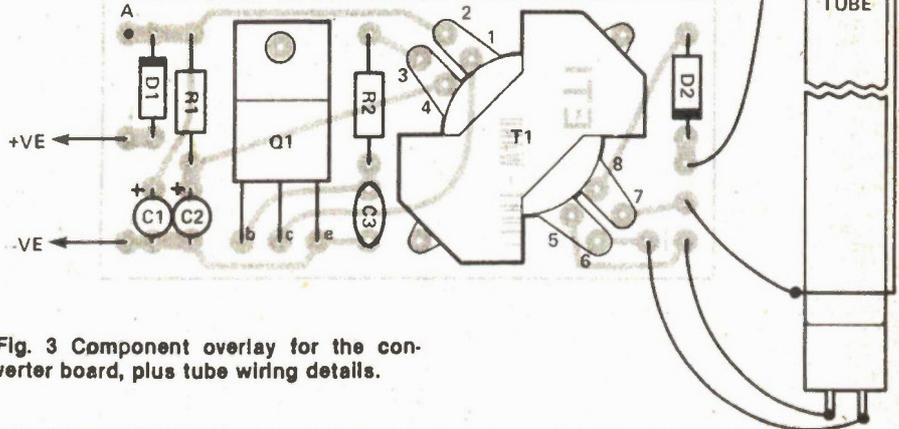


Fig. 3 Component overlay for the converter board, plus tube wiring details.

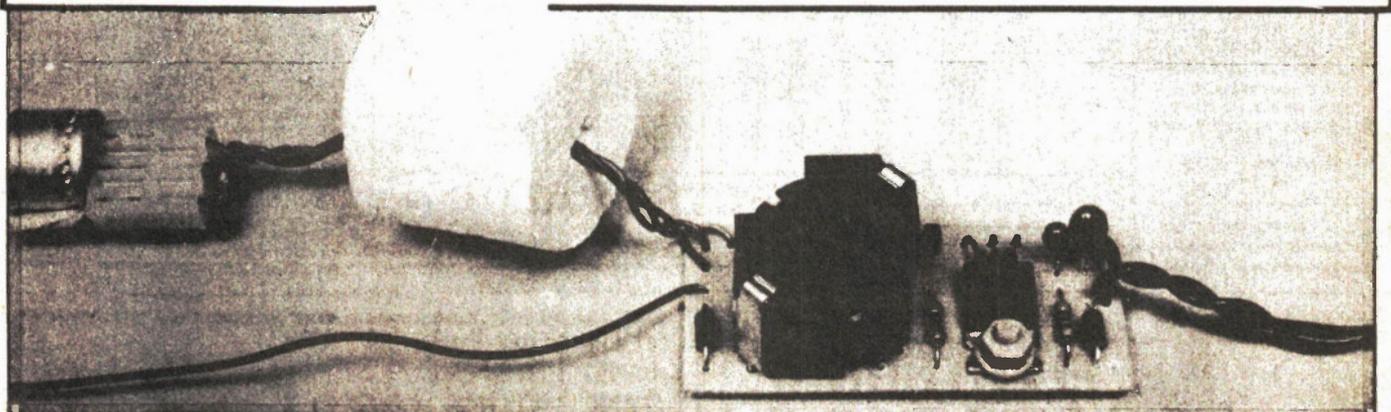
C2 is actually forced to discharge. R2 limits the maximum base current, and C3 removes fast spikes from the base circuit. These together serve to protect Q1's base.

Eventually, the magnetic field induced by the collector current of Q1 in the primary ceases to increase and the positive feedback ceases. Q1 then begins to turn off and the magnetic field in the core begins to collapse. This produces a negative voltage across the feedback winding which biases Q1 hard off. Then the cycle repeats, R1 and C2 defining the frequency and the power delivered to the tube, since a constant amount of energy (equal to $I^2 \text{ max times } L$) is transferred to the load each cycle.

The magnetic field collapsing in the core induces a very narrow high voltage spike in the secondary. When the unit is first turned on, the fluorescent tube will appear as an open circuit and a high positive potential will be present across it as a result of the secondary turn winding. Also, the negative (cathode) end of the tube is pulled negative by the starter winding. As these voltages add a very high potential exists from the anode to the external starter contact. This is enough to force some gas to ionize and the tube breaks down or

'strikes'; This occurs for a few cycles until the $10\frac{1}{2}$ turn winding heats the cathode filament and the tube conducts completely.

Once started, the increased temperature and traces of uncombined gas permit it to conduct quickly each cycle and the tube no longer relies on the ground electrode for breakdown. Once this condition is reached the secondary voltage is held low by the tube conducting, the inductance of the core and secondary limiting the current, as in a conventional 120 V ballast. Diode D2 prevents any conduction in the reverse phase which would upset the magnetic field buildup. If a high voltage is applied to the circuit and D2 is absent AC can flow in the tube and efficiency falls markedly. Hence the circuit in its correct mode acts in a magnetic pumping fashion rather than a pure transformer action. While the cathode is heated, tube life is reduced by the fact that the DC flow of current eventually strips the cathode. Theoretically, when the cathode is stripped to the point of failure the tube should be able to be physically reversed, since the anode end filament will not have been used at all. The tube does however have quite a long life.



EMM BOOKS

COMPUTERS (HARDWARE)

A BEGINNER'S GUIDE TO COMPUTERS AND MICROPROCESSORS — WITH PROJECTS.

TAB No.1015 \$13.45
Here's a plain English introduction to the world of microcomputers — It's capabilities, parts and functions... and how you can use one. Numerous projects demonstrate operating principles and lead to the construction of an actual working computer capable of performing many useful functions.

BP66: BEGINNERS GUIDE TO MICROPROCESSORS AND COMPUTING

E.F. SCOTT, M.Sc., C.Eng. \$7.55
As indicated by the title, this book is intended as an introduction to the basic theory and concepts of binary arithmetic, microprocessor operation and machine language programming.

There are occasions in the text where some background information might be helpful and a Glossary is included at the end of the book.

BP72: A MICROPROCESSOR PRIMER

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

BEGINNERS GUIDE TO MICROPROCESSORS

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

HOW TO BUILD YOUR OWN WORKING MICROCOMPUTER

TAB No.1200 \$16.45
An excellent reference or how-to manual on building your own microcomputer. All aspects of hardware and software are developed as well as many practical circuits.

BP78: PRACTICAL COMPUTER EXPERIMENTS

E.A. PARR, B.Sc., C.Eng., M.I.E.E. \$7.30
Curiously most published material on the microprocessor tends to be of two sorts, the first treats the microprocessor as a black box and deals at length with programming and using the "beast". The second type of book deals with the social impact. None of these books deal with the background to the chip, and this is a shame as the basic ideas are both interesting and simple.

This book aims to fill in the background to the microprocessor by constructing typical computer circuits in discrete logic and it is hoped that this will form a useful introduction to devices such as adders, memories, etc. as well as a general source book of logic circuits.

HANDBOOK OF MICROPROCESSOR APPLICATIONS

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

MICROPROCESSOR/MICROPROGRAMMING HANDBOOK

TAB No.785 \$14.45
A comprehensive guide to microprocessor hardware and programming. Techniques discussed include subroutines, handling interrupts and program loops.

DIGITAL INTERFACING WITH AN ANALOG WORLD

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

MICROPROCESSOR INTERFACING HANDBOOK: A/D & D/A

TAB No.1271 \$14.45
A useful handbook for computerists interested in using their machines in linear applications. Topics discussed include voltage references, op-amps for data conversion, analogue switching and multiplexing and more.

COMPUTER TECHNICIAN'S HANDBOOK

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

THE ESSENTIAL COMPUTER DICTIONARY AND SPELLER

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

HOW TO TROUBLESHOOT AND REPAIR MICROCOMPUTERS

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

TROUBLESHOOTING MICROPROCESSORS AND DIGITAL LOGIC

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

HOW TO DEBUG YOUR PERSONAL COMPUTER

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

THE COMPLETE HANDBOOK OF ROBOTICS

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

HOW TO BUILD YOUR OWN SELF PROGRAMMING ROBOT

TAB No.1241 \$13.45
A practical guide on how to build a robot capable of learning how to adapt to a changing environment. The creature developed in the book, Rodney, is fully self programming, can develop theories to deal with situations and apply those theories in future circumstances.

BUILD YOUR OWN WORKING ROBOT

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

COMPUTERS (SOFTWARE)

BEGINNER'S GUIDE TO COMPUTER PROGRAMMING

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

BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES

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

THE BASIC COOKBOOK.

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

PET BASIC — TRAINING YOUR PET COMPUTER

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

PROGRAMMING IN BASIC FOR PERSONAL COMPUTERS

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

COMPUTER PROGRAMS IN BASIC

AB001 \$14.45
A catalogue of over 1600 fully indexed BASIC computer programs with applications in Business, Math, Games and more. This book lists available software, what it does, where to get it, and how to adapt it to your machine.

PET GAMES AND RECREATION

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

BRAIN TICKLERS

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

PASCAL

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

PASCAL PROGRAMMING FOR THE APPLE

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

APPLE MACHINE LANGUAGE PROGRAMMING

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

Z80 USERS MANUAL

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

HOW TO PROGRAM YOUR PROGRAMMABLE CALCULATOR

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

BP33: ELECTRONIC CALCULATOR USERS HANDBOOK

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

PROJECTS

BP48: ELECTRONIC PROJECTS FOR BEGINNERS

F.G. RAYER, T.Eng.(CEI), Assoc.IERE \$5.90
Another book written by the very experienced author — Mr. F.G. Rayer — and in it the newcomer to electronics will find a wide range of easily made projects. Also, there are a considerable number of actual component and wiring layouts, to aid the beginner.

Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron.

Also, many of the later projects can be built along the lines as those in the 'No Soldering' section so this may considerably increase the scope of projects which the newcomer can build and use.

Z21: 28 TESTED TRANSISTOR PROJECTS

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

BP49: POPULAR ELECTRONIC PROJECTS

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

EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONIC PROJECTS

AB007 \$9.45
An ideal sourcebook of Solids State circuits and techniques with many practical circuits. Also included are many useful types of experimenter gear.

BP71: ELECTRONIC HOUSEHOLD PROJECTS

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

BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS

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

BP69: ELECTRONIC GAMES

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

BP95: MODEL RAILWAY PROJECTS

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



PROJECTS (CONTINUED)

BP76: POWER SUPPLY PROJECTS \$7.30 R.A. PENFOLD

Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unregulated types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits.

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

BP84: DIGITAL IC PROJECTS \$8.10

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

BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS \$7.55

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

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

213: ELECTRONIC CIRCUITS FOR MODEL RAILWAYS \$4.50

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

BP73: REMOTE CONTROL PROJECTS \$8.60

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

CIRCUITS

BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1 \$8.25

R.A. PENFOLD
Another book by the very popular author, Mr. R.A. Penfold, who has designed and developed a large number of various circuits. These are grouped under the following general headings: Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits.

THE GIANT HANDBOOK OF ELECTRONIC CIRCUITS

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

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS \$5.50

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

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

BP87: SIMPLE L.E.D. CIRCUITS \$5.90

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

BP42: 50 SIMPLE L.E.D. CIRCUITS \$3.55

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

BP82: ELECTRONIC PROJECTS USING SOLAR CELLS \$8.10

OWEN BISHOP
The book contains simple circuits, almost all of which operate at low voltage and low currents, making them suitable for being powered by a small array of silicon cells. The projects cover a wide range from a bicycle speedometer to a novelty "Duck Shoot", a number of power supply circuits are included.

BP37: 50 PROJECTS USING RELAYS, SCR'S & TRIACS \$5.50

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

BP44: IC 555 PROJECTS \$7.55

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

BP24: 50 PROJECTS USING IC741 \$4.25

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

BP83: VMOS PROJECTS

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

BP65: SINGLE IC PROJECTS \$6.55

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

BP 50: IC LM3900 PROJECTS \$5.90

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

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

223: 50 PROJECTS USING IC CA3130 \$5.50

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

224: 50 CMOS IC PROJECTS \$4.25

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

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

THE ACTIVE FILTER HANDBOOK TAB No.1133 \$11.45

Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the ideal reference for active filter design. The book introduces filters and their uses also presents many practical circuits including a graphic equalizer, computer tape interface and more.

DIGITAL ICs — HOW THEY WORK AND HOW TO USE THEM AB004 \$10.45

An excellent primer on the fundamentals of digital electronics. This book discusses the nature of gates and related concepts and also deals with the problems inherent to practical digital circuits.

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

THE MASTER IC COOKBOOK TAB No.1199 \$16.45

If you've ever tried to find specs for a so called "standard" chip, then you'll appreciate this book. C.L. Hallmark has compiled specs and pinouts for most types of ICs that you'd ever want to use.

ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS AB016 \$10.45

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

AUDIO

BP90: AUDIO PROJECTS \$8.1

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

HOW TO DESIGN, BUILD, AND TEST COMPLETE SPEAKER SYSTEMS. TAB No.1064 \$13.45

By far the greatest savings in assembling an audio system can be realized from the construction of speakers. This book contains information to build a variety of speakers as well as instructions on how to design your own.

205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES \$3.55

B.B. BABANI
This book gives data for building most types of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams for every construction showing the dimensions necessary.

BP35: HANDBOOK OF IC AUDIO PREAMPLIFIER AND POWER AMPLIFIER CONSTRUCTION \$5.50

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

BP47: MOBILE DISCOTHEQUE HANDBOOK COLIN CARSON \$5.90

The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Many people have wasted a "small fortune" on poor, unnecessary or badly matched apparatus.

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

HOW TO BUILD A SMALL BUDGET RECORDING STUDIO FROM SCRATCH... TAB No.1166 \$16.45

The author, F. Alton Everest, has gotten studios together several times, and presents twelve complete, tested designs for a wide variety of applications. If all you own is a mono cassette recorder, you don't need this book. If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING \$5.50

M.K. BERRY
Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator.

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

BP74: ELECTRONIC MUSIC PROJECTS \$7.70

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

P81: ELECTRONIC SYNTHESISER PROJECTS \$7.30

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

ELECTRONIC MUSIC SYNTHESIZERS TAB No.1167 \$10.45

If you're fascinated by the potential of electronics in the field of music, then this is the book for you. Included is data on synthesizers in general as well as particular models. There is also a chapter on the various accessories that are available.

See the order form on page 37

TEST EQUIPMENT

BP75: ELECTRONIC TEST EQUIPMENT CONSTRUCTION

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

99 TEST EQUIPMENT PROJECTS YOU CAN BUILD

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

HOW TO GET THE MOST OUT OF LOW COST TEST EQUIPMENT

AB017 \$9.45
Whether you want to get your vintage 1960 TestRite signal generator working, or you've got something to measure with nothing to measure it with, this is the book for you. The author discusses how to maximize the usefulness of cheap test gear, how to upgrade old equipment, and effective test set ups.

THE POWER SUPPLY HANDBOOK

TAB No.806 \$14.45
A complete one stop reference for hobbyists and engineers. Contains high and low voltage power supplies of every conceivable type as well mobile and portable units.

BP70: TRANSISTOR RADIO FAULT-FINDING CHART

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

ELECTRONIC TROUBLESHOOTING HANDBOOK

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

COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS

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

RADIO AND COMMUNICATIONS

BP79: RADIO CONTROL FOR BEGINNERS

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

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

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

BP91: AN INTRODUCTION TO RADIO DXing

\$8.10
This book is divided into two main sections one to amateur band reception, the other to broadcast bands. Advice is given to suitable equipment and techniques. A number of related constructional projects are described.

No. 215: Shortwave Circuits & Gear For Experimenters & Radio Hams

\$3.70
Covers constructional details of a number of projects for the shortwave enthusiast and radio "Ham". Included are: an add-in crystal filter, adding an "S" meter in your receiver; crystal locked H.F. Receiver; AM tuner using phase locked loop; converter for 2MHz, 40 to 800 MHz RF amplifier, Aerials for the 52, 144MHz bands, Solid State Crystal Frequency Calibrator, etc.

BP46: RADIO CIRCUITS USING IC's

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

BP1: FIRST BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES

B.B. BABANI \$2.80
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

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

TOWER'S INTERNATIONAL OP-AMP LINEAR IC SELECTOR

TAB No.1216 \$13.45
This book contains a wealth of useful data on over 5 000 Op-amps and linear ICs — both pinouts and essential characteristics. A comprehensive series of appendices contain information on specs, manufacturers, case outlines and so on.

CMOS DATABOOK

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

BP68: CHOOSING AND USING YOUR HI-FI

MAURICE L. JAY \$7.25
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.

REFERENCE

THE BEGINNER'S HANDBOOK OF ELECTRONICS

AB003 \$9.45
An excellent textbook for those interested in the fundamentals of Electronics. This book covers all major aspects of power supplies, amplifiers, oscillators, radio, television and more.

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

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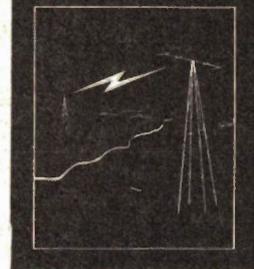
BOOK 5: A book covering the whole communication scene.

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ADRIAN MICHAELS \$12.25
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.

See the order form on page 37

An Introduction to Radio DXing



Book Of The Month

An Introduction to Radio DXingBP91\$8.10

The AM radio dial ends at 1600 KHz, and FM begins at 88 MHz. . . ever wonder what's in between? Well, for one thing, there's shortwave, a fascinating medium because its signals can bounce off the upper atmosphere and return to earth half a world away from where they originated. The art of tuning in these long distance transmissions, called DXing, is outlined in this book.

Covered are both amateur band and broadcast band DXing, and the receiver requirements thereof. Circuits are given for such things as a CW filter, and there are detailed explanations of the intricacies of single side band and multiple conversion, to name but a few. When you get through with this book, you will be able to listen to radio from around the world. . . not to mention viewing even the most sophisticated AM-FM tuner with complete contempt.

BP1, BP35 and BP51 are not in stock at present. These titles are due for reprinting in September 1982.

Into Linear ICs

Part 6

Ian Sinclair takes a long hard look at the world of the IC amplifier and suggests a few more practical circuits for you to experiment with.

THE 741 OPERATIONAL AMPLIFIER is useful, as we've seen, for several audio-frequency projects, but specially designed audio amplifier ICs are usually superior, particularly as far as noise is concerned. Amplifier noise is the rushing sound which you hear from the loudspeaker when the volume control of an amplifier is turned all the way up with no signal coming in. The noise comes from an unwanted electrical signal which is generated in all conductors, but particularly in transistors and ICs. The 741 was originally designed for uses (in computers) in which the electrical noise signals are not a serious problem, and it generates too much noise to be of much use at the input of a high-quality amplifier. Several ICs have therefore been designed to replace the 741 in audio amplifiers, so that in this part we're going to take a look at four preamplifier ICs, each with its own particular advantages.

The MC1303L Stereo Preamplifier

As the MC letters proclaim, this linear IC is manufactured by Motorola, and the package contains two identical preamplifiers on a single fourteen-pin chip, so making it ideal for stereo preamplifiers. Unlike most audio ICs, the MC1303 (the L means the package style) needs a dual power supply of +12V and -12V in addition to a common ground connection. In common with most modern audio amplifier ICs, the MC1303 has internal protection against short circuits at the outputs. Unusual for such an IC, loudspeakers can be driven directly at power levels.

The circuitry which is needed is shown in Fig. 1, assuming that the inputs are from a stereo magnetic cartridge which will be designed to feed into a resistance of around 47k. The capacitor C1 isolates this input from the bias at the input of the IC; this bias comes from R2. Feedback is applied at pin 8 through the network consisting of R4, C3, R5, C4 and C2, R3. Some explanation of this little lot is needed if you're not familiar with preamplifier circuits.

When discs are recorded, we find that we can't just record the signals from the microphone by amplifying them and using them to drive the disc cutter. There are two problems. One is that the low bass frequencies cause excessive cutting width, so that one groove cuts through into the next. The other problem is that the uncut groove will still cause a signal, a noise signal, if it's played and this noise signal can be louder than some of the high notes that we're trying to record.

Recording engineers get round these problems by a technique called pre-emphasis and equalisation. Before recording, the signal is deliberately distorted, so

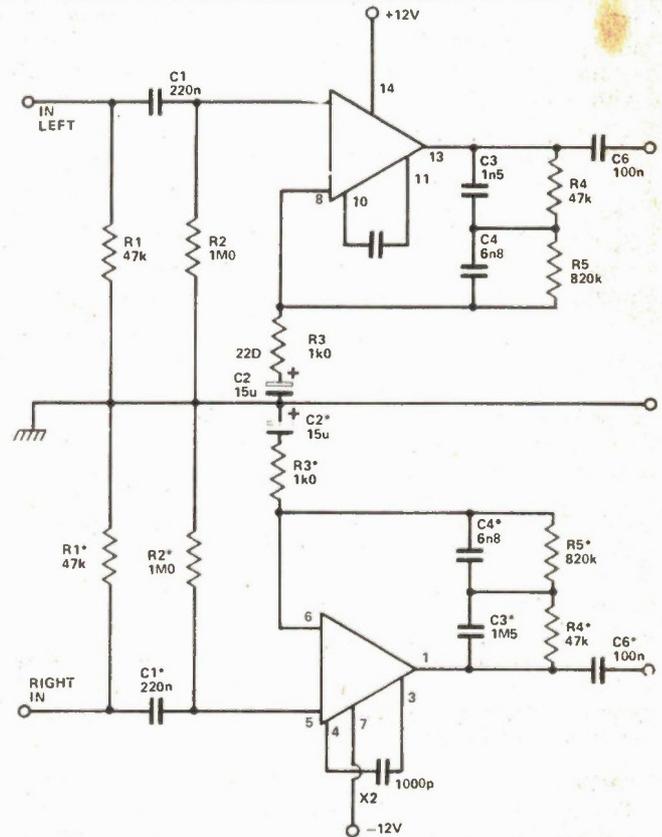


Fig. 1 MC1303L stereo preamplifier circuit.

that the low frequencies are attenuated (their amplitudes reduced) and the high frequencies boosted (amplitudes increased) leaving the middle frequencies unaffected. This isn't done any old how, but by using filter networks whose values are internationally specified. To recover the original signal, then, we must reverse this process, using an equalising network.

C4 and R5 in parallel ensure that the gain is very high at low frequencies around 30 Hz, but the gain decreases at higher frequencies because C4 offers less impedance to feedback signal than does R5. The gain at a frequency of around 500 Hz is the "normal" gain of the amplifier; but at higher frequencies the combination of C3 and R4 causes the gain to decrease. The combined effect of the network is to reverse the attenuation and boosting processes that were carried out during recording, so restoring the signal to the correct amplitude at each frequency. . . we hope. The values which are shown in the circuit are those used for the signals from magnetic pick-up cartridges, since other types of cartridges are much less common, even on low-quality equipment. No values for tape or cassette signals have been given because the equalising values have to be matched to the type of replay head which is used, and there is much less international agreement about the amounts of boost and the frequencies at which they

start.

C6 has been included in case the preamplifier is to be used to drive an amplifying stage which has a DC bias voltage present at the input. The voltage at the output of the MC1303, as used in this circuit, will normally be ground voltage, so that this preamplifier can be directly coupled to most of the output stages illustrated later in this part. There aren't many components needed to try out the MC1303, so it doesn't take very long to knock up the circuit on a breadboard, and it will operate with +9V and -9V supplies.

The LM381 Stereo Preamplifier

The letters LM reveal that this chip is made by National Semiconductors, and this particular one is another dual preamplifier which is intended for stereo use. Once again, the circuit arrangements for a magnetic pickup

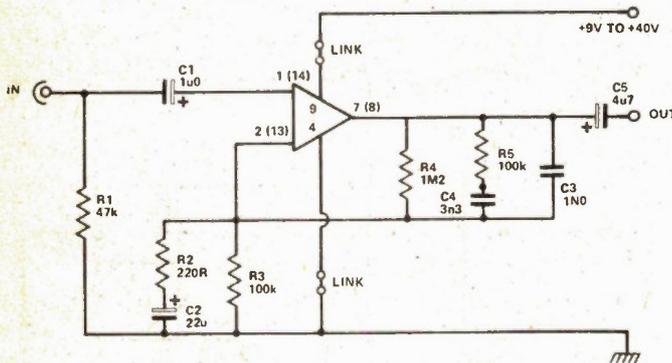


Fig. 2 Circuit for the LM381 preamp. The layout is shown mainly for one channel.

cartridge have been illustrated (Fig. 2), with R1 set at 47k to match most popular types of magnetic cartridges. This particular IC, however, differs from the Motorola one in several ways, not least in using a single supply which may be of anything from 9V to 40V, making battery or AC use simple. The bias is set by R3 and R4 applied to the input on pin 2 (pin 13 on the other part of the circuit), and the equalisation is carried out by R5, C3, C4 feeding back a fraction of the output signal across R2. Note that R2 does not affect the bias, since C2 is connected in series so as not to block DC though it passes signals. The circuit, incidentally, needs twice as many components as are shown if it's going to be used for stereo. Since the two parts are identical, there isn't much point in showing both parts. The output signal from each section is taken through a capacitor (C5) which has to be used because the output pins (7 and 8) are not at ground voltage.

This chip has a low-noise input stage, claimed as the equivalent of 0.5 uV of noise signal, as compared to about 1 mV of normal signal from the cartridge, so that its noise performance is a lot better than that of the 741. The 381 is not sensitive to hum on the supply, so that AC supplies which are not too well-filtered can still be used.

The LM382 Preamplifier

This IC is a design which is intended for simple record-players, using the smallest possible number of components. Like its stable-companion, the LM381, it uses a single power supply line which may be anything from 9V

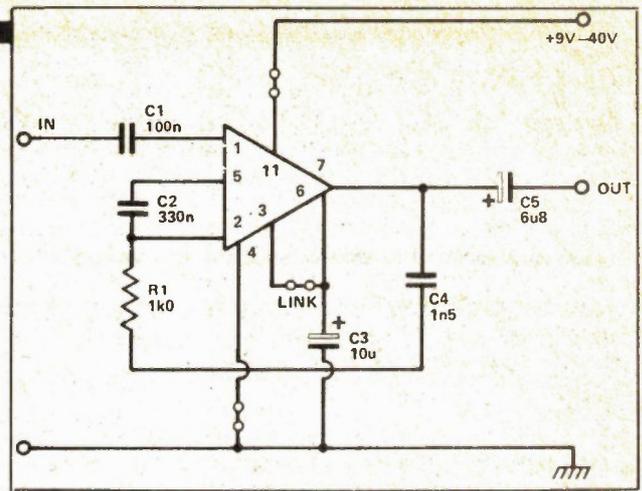


Fig. 3 Circuit and layout for one half of the LM382 stereo preamplifier.

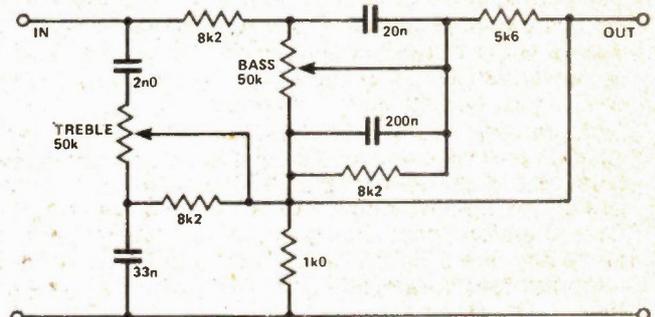


Fig. 4 One form of a passive tone-control circuit.

to 40V. The simplicity of the circuit makes it particularly suitable for low voltage operation from a single 9V battery. No external bias components are needed, so that the circuit shows only the equalising and coupling components. C1 is the input coupling capacitor and C5 the output coupling capacitor.

Equalisation is carried out by C2, R1 and C4, with C3 used to decouple unwanted signals from the internal circuits. The claimed noise signal at the input is slightly higher than that of the 381 at 0.8 uV, but the same excellent standard of AC hum rejection allows the chip to be used with poorly-filtered line supplies. Like its companion, the 382 is internally protected against short-circuits at its output, so that it isn't easy to burn out the IC because of such accidental short-circuits.

Treble Trouble and Bass Base?

Amplifiers and loudspeakers which might sound good out in a field somewhere often sound a bit peculiar in your own room. The reason is the way that sound waves bounce off the hard surfaces, like walls and windows, inside a room, and are absorbed by curtains and soft furnishings (no, not her!). To restore things back to something which pleases us more, though not necessarily like the original sound, we use tone controls.

A tone control reduces (cuts) or increases (boosts) the gain of the amplifier for a chosen range of frequencies. Most tone controls leave the "mid-range" frequencies of 400 Hz to around 1.5 kHz alone, and boost or cut the bass frequencies below 200 Hz or the treble frequencies above about 4 kHz. What about the ones in between, I hear you ask? They are affected to some extent

Continued from page 50

relatively straightforward, since almost all the components are mounted on the pc boards. Resistor R1 and capacitor C1 on the moving magnet board are intended to be mounted directly across the back of the input socket. Order of construction is not critical, although it is probably easier to mount small components first, followed by the larger components such as the electrolytic capacitors and IC1. Be careful to watch the orientation of the electrolytic capacitors, ICs and transistors; these components will be damaged if the unit is powered up with them inserted incorrectly. Shielded cable should be used on all inputs and outputs. We have used mono shielded cable rather than the stereo type for ease of soldering.

Each of the pc boards is a stereo input amplifier, with each channel sharing a common input ground track running down the centre of the board.

The power supply wiring from each channel on the MC board can be connected in parallel, so only three wires (+, 0, -) need to be brought out for power to the MC amp. The MM board is similar, but the power supply wiring for the two boards should be kept separate, since they run from slightly different supply voltages.

The input ground is not connected to the 0v line from the power supply at any place on the pc boards. This means that without a separate 0v connection added to the input stage they will not work. This has been done deliberately to ensure that hum present on the ground line, due to supply bypass capacitors for example, cannot modulate the signal ground, producing hum in the output. The 0v line on the pc boards is in fact a separate supply bypass ground line and is not equivalent to the signal ground. For the purpose of testing the stage, a separate wire should be run

from the centre point (0V point) of the power supply used to the signal ground at the input sockets.

Both boards should be mounted in a steel box. This greatly improves the rejection of 60 Hz magnetic fields generated by nearby power transformers or 120V cables.

Powering up

No setting-up procedure is required for either stage, but make a final check of all components before applying power to the unit. After a few minutes operation the LM394s should be reasonably warm. These devices dissipate around 160 mW, so some heating should be expected. Similarly the NE5534s run slightly above ambient temperature.

SPECIFICATIONS

ETI-478MM MOVING MAGNET INPUT STAGE

Gain: 74, 1 kHz
 Frequency response: Conforms to RIAA Equalisation ± 0.2 dB. (This is the performance of the prototype. The actual figure obtained will be determined by the accuracy and long-term stability of the components used.)
 Total harmonic distortion: $< 0.001\%$, 1 kHz, 10 mV RMS input
 Headroom: > 28 dB with respect to 5 mV RMS input signal, i.e: 135 mV RMS max.
 Noise: Total equivalent input noise, 122 nV 'A', input shorted, 216 nV flat, input shorted.

S/N ratio:

	1 mV	5 mV	10 mV
Flat	73 dB	87 dB	93 dB
A-weighted	78 dB	92 dB	98 dB

IDEAL RIAA		MEASURED - SERIES 5000
Hz	dB	dB
2	-0.2	-0.2
4	+5.7	+5.7
8	+11.2	+11.2
16	+15.4	+15.4
20	+16.3	+16.2
30	+17.0	+17.0
40	+16.8	+16.8
50	+16.3	+16.2
80	+14.2	+14.2
100	+12.9	+12.8
150	+10.3	+10.2
200	+8.2	+8.1
300	+5.5	+5.4
400	+3.8	+3.7
500	+2.6	+2.6
800	+0.7	+0.7
1k	0.0	0.0
1k5	-1.4	-1.3
2k	-2.6	-2.4
3k	-4.8	-4.7
4k	-6.6	-6.6
5k	-8.2	-8.1
6k	-9.6	-9.6
8k	-11.9	-11.9
10k	-13.7	-13.8
15k	-17.2	-17.1
20k	-19.6	-19.5

SPECIFICATIONS

ETI-478MC MOVING COIL INPUT STAGE

Gain: 24
 Frequency response: 7 Hz-135 kHz $+0, -1$ dB
 Total harmonic distortion: $< 0.003\%$, 1 kHz, 30 mV input
 Noise: Total equivalent input noise: 83 nV flat, input shorted. 42 nV 'A', input shorted. 56 nV flat, after RIAA Eq., input shorted. 34 nV 'A', after RIAA Eq., input shorted.

S/N ratio of MC Input stage after RIAA Equalisation:

	60 μ V	200 μ V	500 μ V
Flat	61 dB	71 dB	79 dB
A-weighted	65 dB	75 dB	83 dB



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Fig. 2 gives details on how to build and wire up the project. We leave probe and keyboard details up to the builder; we used an old multimeter probe and a piece of Veroboard into which the presets were positioned as the keyboard, but readers may like to use their own ingenuity at this stage.

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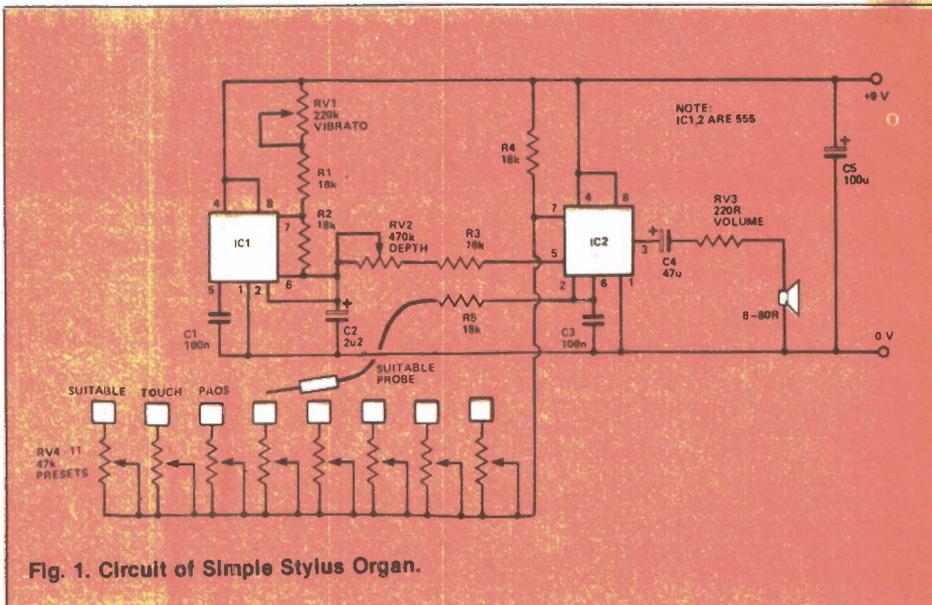
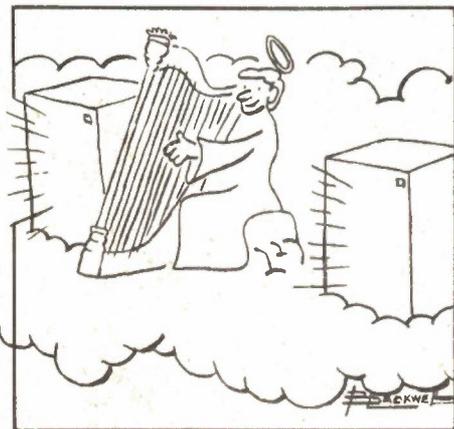


Fig. 1. Circuit of Simple Stylus Organ.

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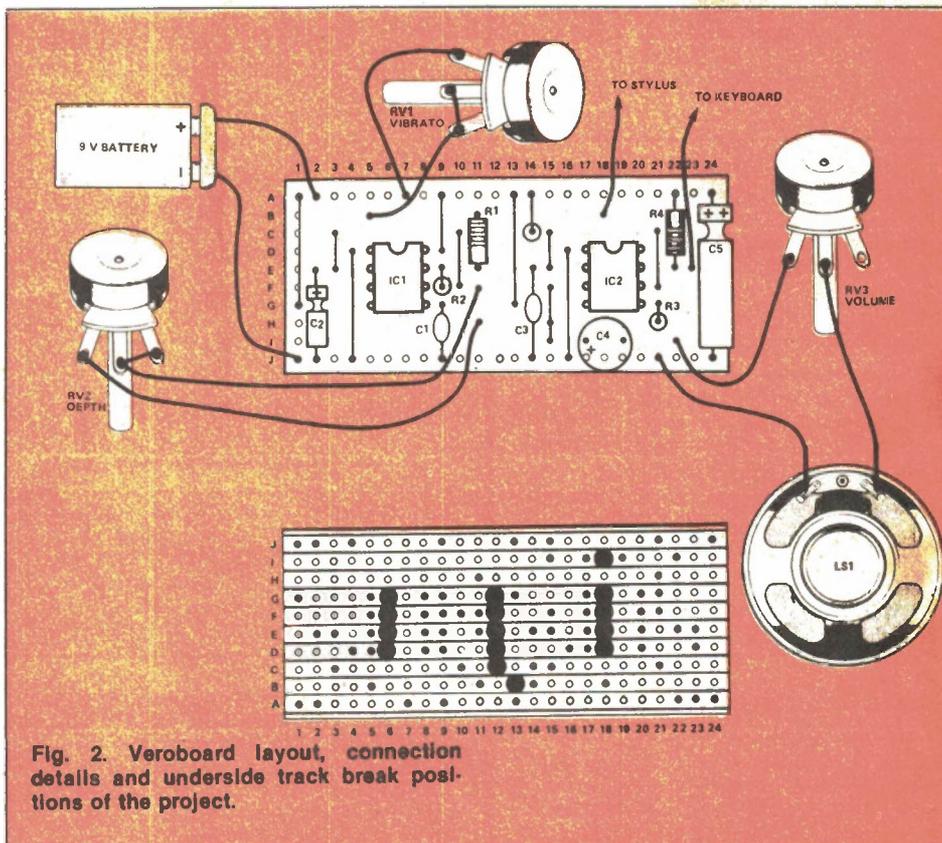
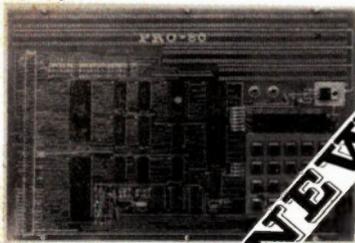


Fig. 2. Veroboard layout, connection details and underside track break positions of the project.

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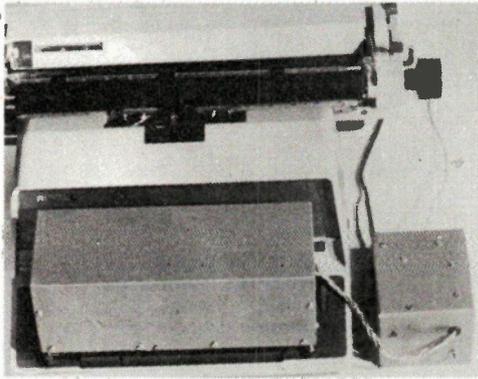
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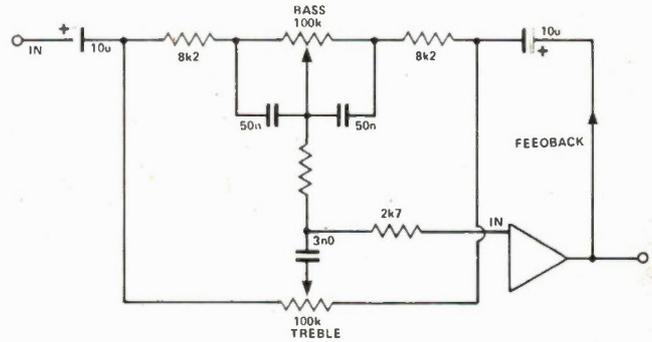


Fig. 5 The Baxendall tone-control circuit.

by the tone controls, but not so much as the intended frequencies.

Tone controls come in two basic types, active or passive. Passive tone controls can never increase the amplitude of a signal, and are best suited to a part of a circuit where you have a fairly large signal voltage, a volt or so, to play with. Fig. 4 shows an example which uses four capacitors, five resistors and two potentiometers — the reason for the complicated circuit is to try to ensure that the controls don't affect each other. It's a bit of a nuisance if twiddling the bass control changes the treble, just to take one example.

Fig. 5 shows the most famous of active tone control, the Baxendall circuit. This little lot is always operated as a feedback network, and can permit amplification, unlike the passive type of circuit.

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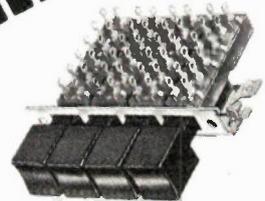
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THIS MONTH'S PROGRAM is a random text generator. It's uses are numberless (unless you regard zero as a number), but it's fun to watch, and can impress your friends. Run with a printer, it will generate interesting reports or memos, which can be circulated to collect signatures. If you just let it run onto the screen, you can tell people it's a news wire feed from the Mesopotamian outback in ancient Ladino, and thereupon read off the highlights (translating/concocting as you go). It will run on most any BASIC equipped system with a few changes, to be discussed shortly, although it is written for the Commodore PET. Being essentially functionless, it's effective social comment increases in proportion to the size of the system tied up in running it.

Program 1 is the essence of the work. It should be observed that the printer on which the listing was rendered elected to display the CBM graphics set in place of the character set, hence a few lines look a bit weird. To wit, the literals in line 140 are "a", "e", "i", "o" and "u". Line 150 is "Pet Random Text Generator rev. 2.3" with a reverse on flag before it and a reverse off flag after it. The club in line 250 is "x". Line 260's mysteries are "q", "y", "j", "k" and "z". 270 is "q" and "qu". In 280 we find "c", "s" and "t". Lastly... I think that's all... the upper left hand box corner in 430 is "o". All these are, of course, lower case letters.

The Works

Generating random text is quite tricky, at least, if it's to look like actual words, rather than just a string of random characters. Assuming that the vowels and consonants of the alphabet still make the same sounds in the random language, there are certain rules that must be followed to make everything seem grammatically correct. The arrangement here is ac-

tually quite simple; everything is more or less pronounceable, and the overall feel of the text seems to read like it could mean something. You can increase the complexity of the filtering process to make the text actually read like a specific linguistic group, if you want to confuse things.

The program consists of a number of nested loops which generate (from the inside out) characters, words, sentences and paragraphs, with each loop calling the one immediately inside it. We'll look at the character generator first.

Random lower case characters are generated in line 190. Line 200 sets VF, vowel flag, to zero, and then scans through the V\$ matrix, which holds the vowels, setting VF to 1 if the random character, A\$, turns out to be a vowel. Lines 210 and 220 adjust the vowel count, VC, and consonant count, CC, depending upon what A\$ turns out to be. Obviously, the vowel flag also tells the program if a consonant has been found by indicating the absence of a vowel, since A\$ can only hold characters from "a" to "z".

program 1

```

100 REM ...RANDOM TEXT & WISDOM GENERATOR...
110 REM COPYRIGHT (C) 1982 STEVE RIMMER
120 REM COPYRIGHT EXTENDS TO ANY USEFUL WISDOM PRODUCED.
130 PRINT "Q"; :POKE59468,14
140 V$(0)="a":V$(1)="e":V$(2)="i":V$(3)="o":V$(4)="u"
150 PRINTSPC(4)"Pet Random Text Generator rev. 2.3";
160 GOSUB550:GOTO160
170 END
180 REM GENERATE CHARACTER...
190 A$=CHR$(INT(26*RND(1))+193)
200 VF=0:FORX=0TO4:IFV$(X)=A$THENVF=1
210 NEXTX:IFVF=1THENVC=VC+1:CC=0
220 IFVF=0THENVC=0:CC=CC+1
230 IFVC>2THEN190
240 IFCC>2THENA$=V$(INT(4*RND(1))):CC=0:VC=1
250 IFL<>LWANDR$="*"THEN190
260 IFCA$="*"ORR$="*"ORQ$="*"ORW$="*"ORX$="*"ANDINT(7*RND(1))>2THEN190
270 IFA$="*"THENR$="*"A$=V$(INT(RND(1)*4)):L=L+2
280 IFR$="*"ORR$="*"ORR$="*"ANDINT(RND(1)*9)=1THENR$=A$+" ":L=L+1
290 IFB$=A$ANDINT(10*RND(1))>2THEN190
300 B$=A$
310 RETURN
320 REM GENERATE WORDS
330 LW=INT(8*RND(1))+1:IFLW=1THENW$=V$(INT(4*RND(1))):GOTO360
340 IFLW>5ANDINT(RND(1)*5)<>1THEN330
350 FORL=1TOLW:GOSUB180:W$=W$+A$:NEXTL
360 IF37-POS(I)<LEN(W$)THENPRINTCHR$(13);
370 IFS>1THEN400
380 IFL<LEN(W$)=1THENW$=CHR$(ASC(W$)-128):GOTO400
390 T$=LEFT$(W$,1):R$=RIGHT$(W$,LEN(W$)-1):T$=CHR$(ASC(T$)-128):W$=T$+R$
400 IFL<LEN(W$)<>2THEN420
410 W$=LEFT$(W$,1)+V$(INT(4*RND(1)))
420 IFL<LEN(W$)<4ANDLEN(W$)=WLTHENW$="":GOTO330
430 IFW$="*"THENW$=CHR$(ASC(W$)-128)
440 IFL<LEN(W$)=2ANDLEFT$(W$,1)=RIGHT$(W$,1)THENW$="":GOTO330
450 PRINTW$ " ";:WL=LEN(W$):W$=" "
460 RETURN
470 REM GENERATE SENTENCES...
480 PT=2:SL=INT(8*RND(1))+2
490 IFSL>5THENFORT=1TO(SL-2):F(T)=INT(RND(1)*2):NEXTT
500 FORS=1TOSL
510 GOSUB320:IFF(S)=1ANDS<<(SL-2)ANDPT>-1THENPRINT"!!! ";:PT=PT-1
520 NEXTS:PRINT"!!! ";:IFINT(RND(1)*10)=1THENPRINT"!!!! ";
530 IFINT(RND(1)*15)=1THENPRINT"!!!! ";
540 RETURN
550 REM GENERATE PARAGRAPHS...
560 PRINTCHR$(13)" ";:FORZ=1TOINT(RND(1)*10):GOSUB470:NEXTZ:RETURN

```

The VC and CC registers are set up such that the routine won't generate great strings of just vowels or just consonants. When a vowel is produced, VC is incremented and CC is set to zero. . . and likewise in reverse for consonants. If VC increases past 2, the routine returns to line 190 to try again, via line 230. Because the odds of producing a vowel are rather small (5 in 26), when CC gets over 2, line 240, the program randomly gets a vowel from the V\$ matrix, rather than hacking away at the character generator 'til one turns up.

Line 250 begins the rudimentary character filter. L is the position in the current word that the character being generated will fill, and LW is the final length of the word. 250 prevents the last character from being "x". Line 260 returns to get a new character if one of the more infrequently used characters turns up. . . six out of seven times. Line 270 trolls for "q", and, upon finding one, adds "u" plus a random vowel. In order to prevent this from swelling the word, L is incremented by two. 280 looks for "c", "s" and "t", and adds "h" to them one time in nine, again, incrementing L. Line 290 compares B\$, the last character produced, with A\$ to find double letters, and, nine times out of ten, returns to 190 to get a different character.

Further provisos and traps can, of course, be added in this area. These lines represent the most useful forms.

The word generator strings the random characters together to form meaningfulness. Line 330 insures that one character words be vowels. 340 reduces the likelihood of words longer than five characters. 350 does all the actual word building, loading the word into W\$.

360 provides automatic line ending by printing a carriage return if the cursor position, given by the POS(x) function, doesn't leave enough room for the word.

The S in 370 is the position of the word in the sentence under construction. If the word is not the first word, the routine jumps over lines 380 and 390, which would otherwise capitalize the first character of the word by subtracting 128 from its ASC value. Line 410 makes sure that the second character of a two character word is a vowel.

Line 420 compares W\$ to WL, the length of the previous word, and trashes words of less than four

characters should the previous word have been of the same length. . . which looks much nicer on the screen. 430 converts one character words that are "o" to "O", which is the first person singular in this language.

Line 440 trashes two letter words having the same character for both letters, and, after all that, line 450 actually prints the poor word, or what's left of it, plus a space.

Life Sentence

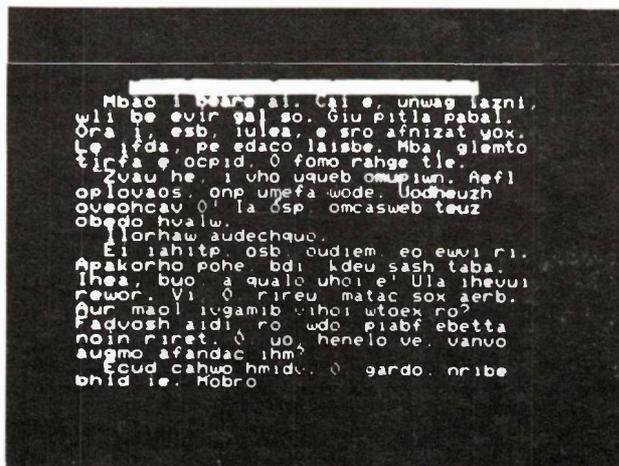
The sentence generator is simpler. The SL variable in 480 is the sentence length. The P matrix is the random punctuation matrix, which will place a comma after every word in which the corresponding P matrix element is 1, up to a maximum of three per sentence. Because the word generator prints a space after each word, it is necessary to backspace one before putting in the comma. Likewise, the end of a sentence gets a backspace and a period. Lines 520 and 530 replace the period by either a question mark or an exclamation point on infrequent occasions. These must have two backspaces before them to kill off the period.

The paragraph generator, which is what the program mainframe actually calls, resides at line 560, and simply does a carriage return, a two space indent, and calls the sentence generator a random number of times.

Fun, wasn't it?

Conversion

Running this thing on a PET or CBM



should be no hassle. You may want to modify the POKE59468,14 in line 130: it selects the lower case character set in the PET. The line length value in line 370 will want changing to something like 75 for an 80 column machine, and 19 or 20 for a VIC. The control characters used are the reversed heart in line 130, clear the screen, the reversed "R" and reversed horizontal line in 150, reverse on and off respectively and the reversed vertical lines in lines 510 to 530, backspace one.

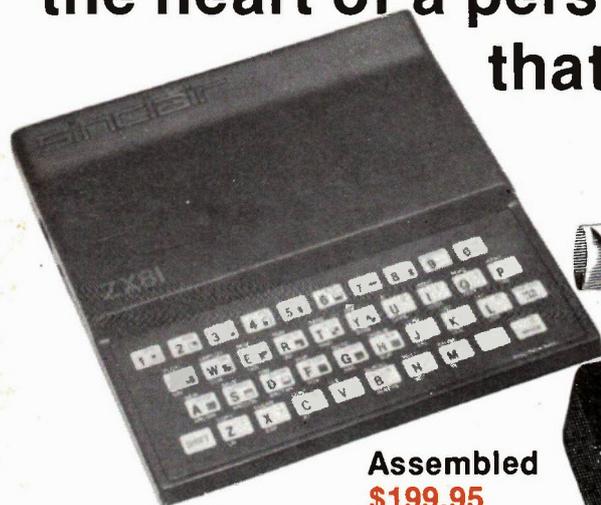
Other than that, like, go forth unto all mankind and generate wisdom, my children, that the Earth may be verdant and green. . . or white, if you have a screen with the old style phosphor.

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Programs. . . we want programs. Hardware ideas are neat too. Tricks, innovations, fine. No more "12 innovative uses for Univac vacuum tube flip-flops", though. And, though we enjoyed the llama we received in the mail, and liked the idea of tattooing a listing on its side it was postage due and we had trouble getting it to lie down on the repro camera. Please don't do this again, either. Other than that, if you have a clever bit of software, a simple peripheral circuit, tips, obscure memory locations, anything you'd like to share, send it along to *Computing Today*. We'll publish the best stuff, and send you either a generous payment or a pair of tickets good for a free ride on the next space shuttle (our choice).

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Continued from page 53

width of the central slice through the speaker) instead of the circular representation of SCALP. Each separate curve now represents the behaviour of this slice at a different frequency. FRESF gives a complete resonant history of vibration of the cone slice between any two frequency limits, the curves being plotted in 3-D and with added horizontal and vertical perspective to aid visibility.

The Plot Thickens

FRESF may also be plotted in a different manner. Instead of each curve being a slice across the middle of the speaker for a single frequency, the axes are both turned through 90°. Each curve is then a complete frequency sweep at a single point on a line across the middle of the speaker, each curve representing the behaviour of the cone at all frequencies, albeit at slightly different points across the width. This change in vision angle can often allow faults to be more clearly seen which could have been hidden behind other features in the normal FRESF.

Furthermore, both FRESF and SCALP can easily be drawn with the phase of the display changed. Peaks in the original display become troughs and vice versa, especially useful where the true depth of very deep 'holes' are masked by the 'foreground' of the plot, as in the 'BAD' example of Fig. 1. The out-of-phase plots along the bottom of Fig. 1 show how this reversal makes holes into peaks and allows their true 'depth' in relation to the rest of the curve to be judged.

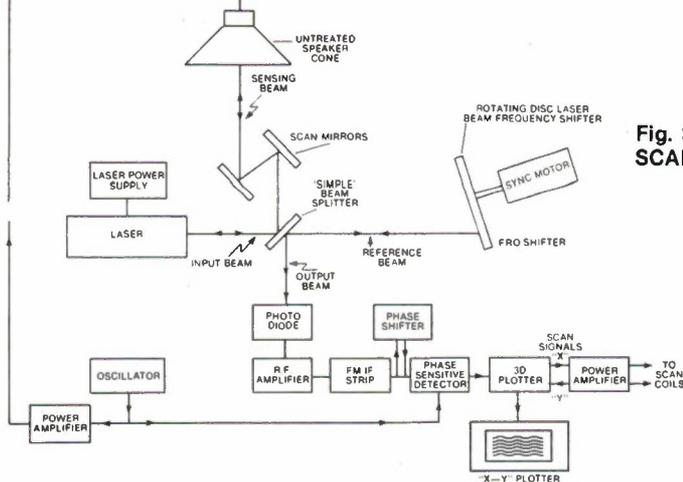
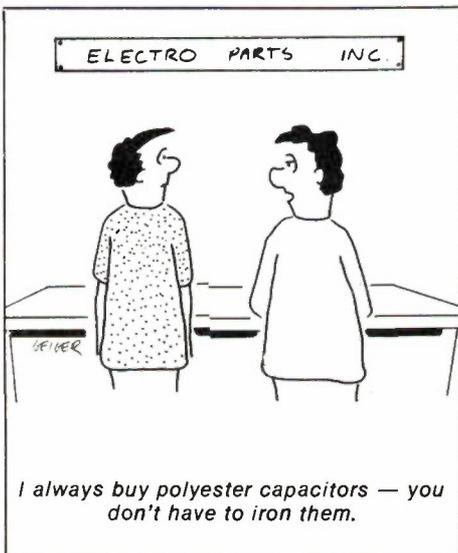


Fig. 3 Block diagram of the SCALP equipment.

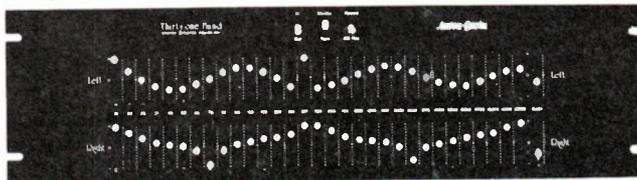
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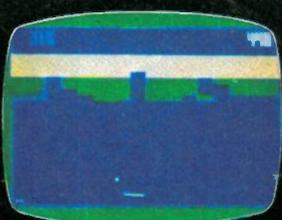
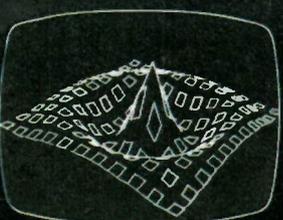
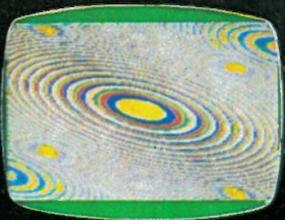
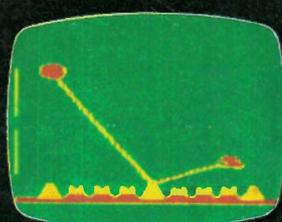
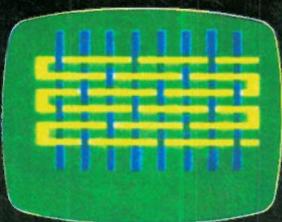
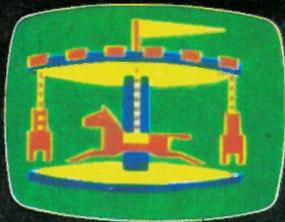
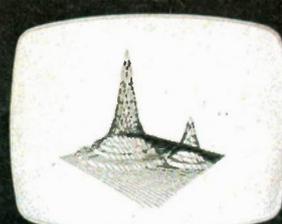
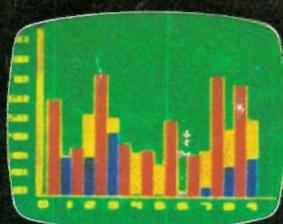
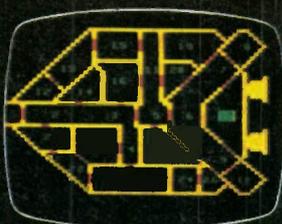
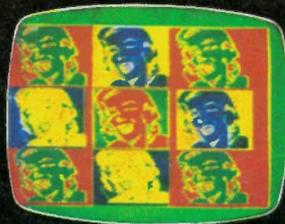
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