Australia $1.60 New Zealand $1.75 Malaysia $4.95

PRACTICAL SEPTEMBER 1984 · 90p

ELECTRONICS

ROBOTICS · MICROS · ELECTRONICS · INTERFACING

NEPTUNE ROBOTS

THROUGH THE MAINS CONTROLLER

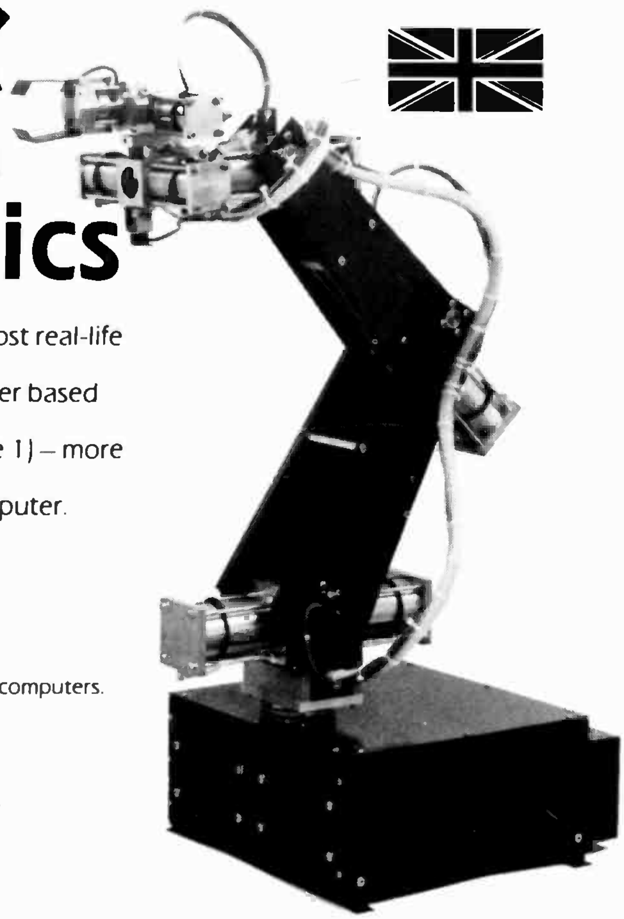
MONO/STEREO ECHO AND REVERB

DISC DRIVES EXPLAINED

neptune

for low-cost training in

real-life robotics



The advanced design of the Neptune 2 makes it the lowest cost real-life industrial robot.
It is electro-hydraulically powered, using a revolutionary water based system (no messy hydraulic oil!)
It performs 7 servo-controlled axis movements (6 on Neptune 1) – more than any other robot under £10,000.
Its program length is limited only by the memory of your computer.
Think what that can do for your BASIC programming skills!

And it's British designed, British made.

Other features include:

- Leakproof, frictionless rolling diaphragm seals.
- Buffered and latched versatile interface for BBC VIC 20 and Spectrum computers.
- 12 bit control system (8 on Nuptune 1).
- Special circuitry for initial compensation.
- Rack and pinion cylinder couplings for wide angular movements.
- Automatic triple speed control on Neptune 2 for accurate 'homing in'.
- Easy access for servicing and viewing of working parts.
- Powerful – lifts 2.5 kg. with ease.
- Hand held simulator for processing (requires ADC option).

Neptune robots are sold in kit form as follows:

Neptune 1 robot kit (inc. power supply)	£1250.00
Neptune 1 control electronics (ready built)	£295.00
Neptune 1 simulator	£45.00
Neptune 2 robot kit (inc. power supply)	£1725.00
Neptune 2 control electronics (ready built)	£475.00
Neptune 2 simulator	£52.00
ADC option (components fit to main control board)	£95.00
Hydraulic power pack (ready assembled)	£435.00
Gripper sensor	£37.50
Optional extra three fingered gripper	£75.00
BBC connector lead	£12.50
Commodore VIC 20 connector lead and plug-in board	£14.50
Sinclair ZX Spectrum connector lead	£15.00

All prices exclusive of VAT and valid until the end of 1984.

mentor

desk-top robot

This compact, electrically powered training robot has 6 axes of movement, simultaneously servo-controlled. It gives smooth operation, and its rugged construction makes it ideal for use in educational establishments. Other features include long-life bronze and nylon bearings, integral control electronics and power supply, special circuitry for inertial compensation, optional on-board ADC, and hand-held simulator as the teaching pendant. Like Neptune, Mentor's program length is limited only by your computer's memory. Programming is in BASIC.

Mentor is all-British in design and manufacture and comes in kit form at an astonishingly low price:

Mentor robot kit (inc. power supply)	£345.00
Mentor Control electronics (ready built)	£135.00
Mentor Simulator (requires ADC option)	£42.00
ADC option (Components fit to control electronics board)	£19.50
BBC connector lead	£12.50
Commodore VIC 20 connector lead and plug-in board	£14.50
Sinclar ZX Spectrum connector lead	£15.00

All prices exclusive of VAT and valid until the end of 1984.

Cybernetic Applications

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PRACTICAL
ELECTRONICS

VOLUME 20 No. 9 SEPTEMBER 1984

CONSTRUCTIONAL PROJECTS

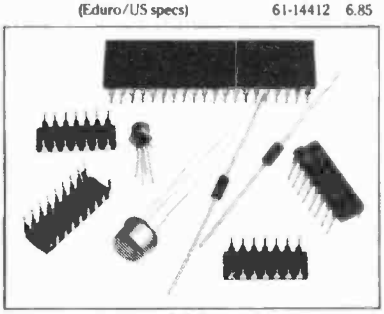
GENERAL FEATURES

NEWS AND COMMENT

OUR OCTOBER ISSUE WILL BE ON SALE FRIDAY, SEPTEMBER 7th, 1984
(for details of contents see page 16)

for a better service.

NE556N	Dual version of the 555	61-05560	0.50
uA741CN	DIL low cost op amp	61-07411	0.22
uA747CN	Dual 741 op amp	61-07470	0.70
uA748CN	741 with external frequency comp	61-04780	0.40
HA1388	18W PA from 14V	61-01388	2.75
TDA2002	8W into 2 ohms power amp	61-02002	1.25
ULN2283	1W max. 3-12V power amp	61-02283	1.00
MC3357	Low power NBFM IF system and detector	61-03357	2.85
ULN3859	Low current dual conversion NBFM IF and detector	61-03859	2.95
LM3900	Quad norton amp	61-39000	0.60
LM3909N	8-pin DIL LED flasher	61-39090	0.68
KB4445	Radio control 4 channel encoder and RF	61-04445	1.29
KB4446	Radio control 4 channel receiver and decoder	61-04446	2.75
ICM7555	Low power CMOS version of timer	61-75550	0.98
ICL8038CC	Versatile AF signal generator with sine/square/triangle OPs	61-08038	9.50
TK10170	5 channel version of KB4445	61-10170	1.87
HA12002	Protection monitor system for amps, PSUx, TXs etc	61-12002	1.22
HA12017	83dB S/N phono preamp 0.001% THD	61-12017	0.80
MC14412	300 baud MODEM controller (Eduro/US specs)	61-14412	6.85



Microprocessor & Memories

Z80A	Popular and powerful 8-bit CPU	26-18400	3.40
Z80AP10	2 port parallel input/output	26-18420	2.95
Z80A CTC	4 channel counter/timer	26-18430	2.90
Z8671	Z8 Micro comp. and Basic	26-08671	17.50
6116-3	16K (2kx8) CMOS RAM 200nS	26-36116	6.68
Z6132-6	32K (4kx8) quasi RAM 350nS	26-06132	15.00
4116-2	16K (16kx1) 150nS	26-24116	1.59
2764	64K (8kx8) 450nS	26-02764	9.50
2732	32K (4kx8) 450nS	26-02732	5.70

Voltage Regulators

7805	5V 1A positive	27-78052	0.40
7812	12V 1A positive	27-78122	0.40
7815	15V 1A positive	27-78152	0.40
7905	5V 1A negative	27-79052	0.49
7912	12V 1A negative	27-79122	0.49
7915	15V 1A negative	27-79152	0.49

Transitors

BC182	General purpose	58-00182	0.10
BC212	General purpose	58-00212	0.10
BC237	Plastic BC107	58-00237	0.08
BC238	Plastic BC108	58-00238	0.08
BC239	Plastic BC109	58-00239	0.08
BC307	Complement to BC237	58-00307	0.08
BC308	Complement to BC238	58-00308	0.08
BC309	Complement to BC239	58-00309	0.08
BC327	Driver/power stage	58-00327	0.13
BC337	Driver/power stage	58-00337	0.13
MPSA13	NPN Darlington	58-04013	0.30
MPSA63	PNP Complement to MPSA13	58-04063	0.30
J310	JFET for HF-VHF	59-02310	0.69
J176	JFET analogue switch	59-02176	0.65
3SK51	Dual gate MOSFET-VHF amp	60-04051	0.60
3SK88	Dual gate MOSFET-Ultra lo noise	60-04088	0.99
TIP31A	Output stage	58-15031	0.35
TIP32A	Complement to TIP31A	58-15032	0.35
VN66AF	VMOS Power FET	60-02066	0.95
IN4001	Rectifier diode	12-40016	0.06
IN4002	Rectifier diode	12-40026	0.07
IN4148	General purpose silicon	12-41486	0.05

Silicon Controlled Rectifiers

BRY55-100	100V .8A	52-55100	0.50
C106DI	400V 4.0A	52-00106	0.70
C122DI	400V 8.0A	52-00122	1.45

3mm Diameter LEDs

V178P	Red	15-01780	0.15
V179P	Green	15-01790	0.16
V180P	Yellow	15-01800	0.18

5mm Diameter LEDs

CQY40L	Red	15-10400	0.12
CQY72L	Green	15-10720	0.15
CQY74L	Yellow	15-10740	0.15

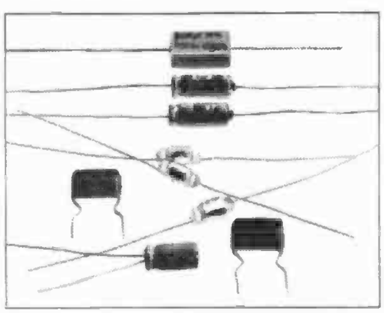
Infra-Red LEDs

CQY99	Emitter	15-10990	0.56
BPW41	Detector	15-30410	1.51

Tri Colour LED

V518	Orange-Green-Yellow	15-05180	0.60

Capacitors



Aluminium Electrolytics Radial PCB Mounting

			Pack of 4
10u	16V	05-10606	0.24
47u	16V	05-47606	0.28
47u	25V	05-47607	0.28
470u	6.3V	05-47705	0.36
470u	16V	05-47706	0.48

Tantalum Beads

			Each
1uf	35V	05-10501	0.18
10uf	16V	05-10601	0.28
47uf	6.3V	05-47601	0.45
47uf	16V	05-47602	0.92

Monolithic Capacitors

		Pack of 3
1n	04-10204	0.39
10n	04-10304	0.42
100n	04-10404	0.45

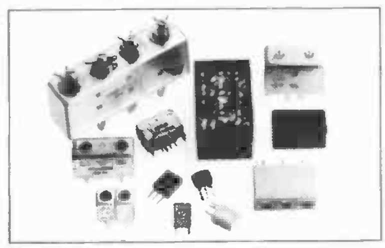
Low Voltage Disc Cermaic

		Pack of 5
1n	04-10203	0.20
10n	04-10303	0.20

Polyester (C280)

		Pack of 3
10n	04-10305	0.18
47n	04-47305	0.24
100n	04-10405	0.24
470n	04-47405	0.51
1uF	04-10505	0.66

R F Components



Filters

CFU/LFB CFW/LFH SERIES

Miniature 455kHz filters. I/P and O/P impedance 2K.

	−6dBW	−40dBW		
LFB6/CFU455H	6kHz	18kHz	16-45512	1.95
LFB12/CFU455F	12kHz	26kHz	16-45515	1.95
LFH6S/CFW455HT	6kHz	14kHz	16-45525	2.45
LFG12S/CFW455FT	12kHz	22kHz	16-45528	2.45
CFM2455A Mechanical IF Filters for 455kHz			19-45530	0.77

Crystal Filters 2 Pole Types

10M15A	10.7 Centre Freq.	20-10152	2.10
10MO8AA	10.695 Centre Freq.	20-11152	3.49

Inductors

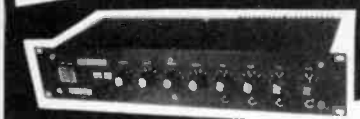
We offer the complete Toko range of fixed and variable inductors. Over 500 coils from audio to V.H.F. See catalogue for details.

Soldering Irons (Antex)

CS240	Iron 240VAC 17 Watts	54-22300	5.20
XS-240	Iron 25W 240V High heat capacity	54-22500	5.40
SK6	Presentation pack of one XS-240 with ST4 stand	54-22510	7.20
MLXS	Handy 12V 15W soldering iron complete with crocodile clips and solder	54-20004	5.60

Please add 15% to all advertised prices and 60p post and packing. Minimum order value £2 please. We reserve the right to vary prices in accordance with market fluctuation. *Items in stock despatched within 48 hours.

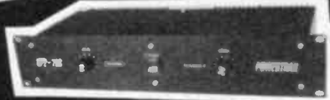
TOP QUALITY KITS AT LOW-BUDGET PRICES



MPA 200
100w Mixer/Amplifier

A rugged mixer amp designed for adaptability, stability and easy assembly. The MPA 200 has four inputs (sensitivities can be easily changed), 3 separate tone controls and a master volume control. Steel cabinet to suit 19" rack systems.

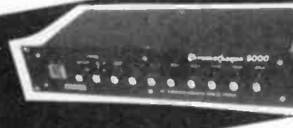
Complete kit **£79.50 + VAT**



SP2 200 2-Channel
100 watt Amplifier

An ingeniously designed power amp. The SP2 200 can deliver over 100w rms into 8 ohms on each channel. Separate volume control and a sensitivity of 0.775 mV (0dBm) make this unit suitable for virtually all pre amps or mixers. Construction is very simple, with minimal wiring and the steel cabinet is suitable for 19" rack mounting.

Complete kit **£99.50 + VAT**



Chromatheque 5000
5 Channel
Lighting Effects System

Versatility is the key aspect of the Chromatheque. Musical input can perform switching or modulation of the light output. 5 banks of lamps of up to 500w each can be controlled in either analogue or ditigal mode. Variable light level controls provide scope for "mood" lighting. The kit's single-board concept makes for straightforward assembly.

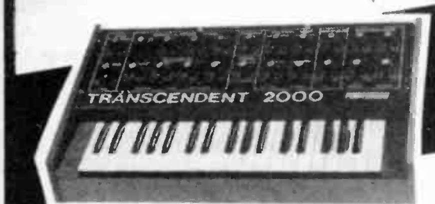
Complete kit **£79.50 + VAT**

Digital Delay Line

Digital quality at an Analogue price! With this unit you can have Phasing, Flanging, ADT, Chorus, Echo and Vibrato at the touch of a button. In a steel cabinet suitable for 19" rack mounting.

Complete kit (400ms delay) **£179.00 + VAT**

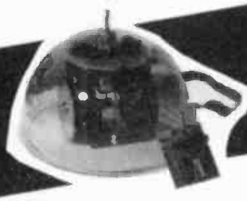
Parts for Extra 400ms delay (up to 3 can be added) **£19.50 + VAT**



Transcendent 2000

This professional quality, single board 3-octave synth is transposable 2 octaves up or down giving an effective 7-octave range. There is portemento, pitch bending, VCO with shape and pitch modulation, VCF with high and low pass outputs and separate dynamic sweep control; noise generator and an ADSR envelope generator.

Complete kit **£150.00 + VAT**

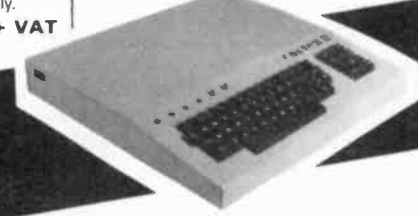


Hebot II Robot Turtle

At a price that makes even a TV look expensive, Hebot provides an exciting introduction to computer control. Independent drive of the two weels, flashing "eyes", two-tone horn and a retractable pen are directed by your microcomputer while four collision detectors relay information about the robot's environment.

Complete kit **£95.00 + VAT**

Universal computer interface board kit **£11.00 + VAT**



Cortex II
16-bit 16-colour Computer

The new slimline Cortex offers constructors the speed and power of 16-bit computing for the same price as an 8-bit games machine. The standard kit has TV, cassette and RS232C interfaces – others are available as optional extras. Add disc drives, printer and monitor for a fully-fledged business system.

Complete kit **£299.00 + VAT**

Optional extras **Phone for Illustrated brochure**

Genesis P101
Hydraulic Robot Arm

With its own dedicated microprocessor or under the control of an external computer, the Genesis P101 simulates the operation of industrial robots at a mere fraction of their cost. With this robot, practical robotics experience is available without tying up valuable capital.

***6-axis robot system kit** **£1050.00 + VAT**

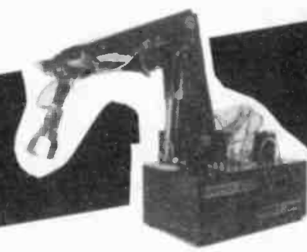
6 axis robot kit **£750 + VAT**

MicroGrasp Electric Robot Arm

A real programmable robot arm at an affordable price. Five motors – four with servo control – are mounted directly on the axes they drive (no fiddly strings and pulleys!). The robot can be controlled by any microcomputer with an expansion bus.

Robot kit with power supply **£215.00 + VAT**

Universal computer interface board kit **£57.00 + VAT**



Genesis P102
Hydraulic Robot Arm

A sophisticated robot system with microprocessor control, two speed, double acting hydraulic operation and the option of external computer control.

The P102 offers "hands-on" experience for robotics training, at a fraction of the cost of an industrial robot.

***6-axis robot system kit** **£1476.00 + VAT**

*System includes Robot, Processor Box and Teach Pendant

NEW PROJECT

DOPPLER RADAR INTRUDER ALARM

See October's Practical Electronics

All kits are complete down to the last nut and bolt and are supplied with an easy-to-follow assembly handbook.
Write or phone for further details, stating which product(s) interest you.
Access/Visa cardholders may order by telephone to avoid delays.

Prices apply to UK only and are correct at time of going to press. Overseas customers – please contact our Export Department for the name and address of your local dealer. Allow 21 days for delivery. Offers subject to availability.

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PE

VOLUME 20 No. 9 SEPTEMBER 1984

PROBLEMS

AT the time of writing the country is in the grip of what seem to be politically motivated strikes. While the miners' disaster does not affect PE, the dock strike could have, had it continued. A few more weeks' strike and the country would have been virtually devoid of publications due to lack of paper!

Unfortunately we have had our own problems with a journalists' dispute, thankfully now over. During the IPC dispute, issues of some magazines were lost and many retailers informed readers that issues would not be published. I must point out that we have published all issues of PE and (dockers willing) will continue to do so. This brings us to a question of supply which arises even in good times and is heightened when there are problems.

With so many magazines on the market not many retailers can keep them all; it is therefore necessary to order your issue of PE in advance to make sure you secure a copy. If you do miss out we can supply a limited number of back issues but the cost is £1 each. So please ensure your supply with a regular order—so far PE has published every month since November 1964 and we hope to continue this tradition for many years to come.

FUTURE

Changing the subject completely I was interested to hear Sir Clive Sinclair saying on TV that his only real ambition now was to live to see intelligent machines. Apparently Sir Clive is not a materialistic man and has everything he needs in life—as a multimillionaire, I suppose it would hardly matter if he were materialistic!

Anyway, the race for fifth generation computing is on and chips like the Transputer (featured in PE in the April 84 issue) are showing the way. Of course the fifth generation, thinking computer is a massive jump from the dumb data crunchers of today.

Interestingly, Sir Clive, whose company is of course taking part in this race, sees the eventual intelligent machine as only differing from the human brain if one considers humans to have a soul. This leads to some interesting thoughts. Perhaps what is most worrying about the next generation computer systems is the immense power such units will bring to the industrialised world, which is precisely why we need to be at the forefront of such development.

Can you imagine the cost savings possible when the computer can quickly design a new product from basic parameters, can go on to plan production and program the robotic production line? It may all sound like science fiction but it may not be that far away in terms of human lifespan.

With the Japanese setting out to dominate the next generation market it is essential that we stay ahead of the game. Fortunately we have some UK masterminds that hopefully will stand us in good stead—Sinclair and Iann Barron (father of the Transputer) being among them.

Keep reading our pages for further instalments—the future looks exciting.

KEEPING UP

In our own small way we hope to keep up with developments in the projects we publish. At the present time robotics is catching people's imagination and we now present details on some more designs for your interest. This issue also carries what we believe is one of the best articles ever published on Disc Drives. If you want to understand these peripherals turn to page 22.

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Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Back Numbers and Binders

Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at £1 each including Inland/Overseas p&p. Please state month and year of issue required.

Binders for PE are available from the same address as back numbers at £5·50 each to UK or overseas addresses, including postage, packing and VAT where appropriate. State year and volume required.

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Copies of Practical Electronics are available by post, inland for £13, overseas for £14 per 12 issues, from: Practical Electronics, Subscription Department, IPC Magazines Ltd., Room 2816, King's Reach Tower, Stamford Street, London SE1 9LS. Cheques, postal orders and international money orders should be made payable to IPC Magazines Limited. Payment for subscriptions can also be made using a credit card.

BIG SQUEEZE ON PLANTS

If plants could talk, they might tell us that they need water, that cigarette smoke bothers them or that there are too many pollutants around. But since they lack verbal communication skills, botanists and others have spent years trying to develop methods of detecting and measuring plant responses to environmental conditions. At Battelle's Pacific Northwest Laboratories in America, researchers have come up with just such a device.

Named after the Roman goddess of agriculture, the Ceres device makes it possible to determine the severity of environmental stress or change on vegetation within minutes depending on the type of exposure. Ceres is a simple, fundamental instrument that records the effects of environmental stress on plants by measuring minute changes in stem diameter.

Promising uses for the device include predicting irrigation schedules, evaluating the effectiveness of fertilizers or determining the impact of pollutants in order to recommend immediate preventative or remedial measures.

"Ceres is a completely portable field unit that is capable of detecting short- and long-term responses to stress to woody or herbaceous plants," said research scientist Dr. Peter A. Beedlow, one of the inventors, who works in Battelle's Environmental Sciences Department.

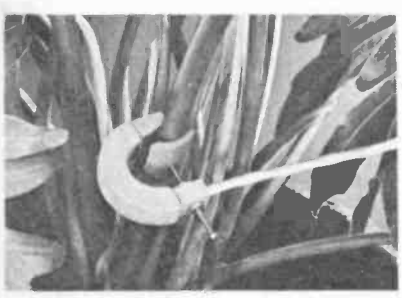
"It is sensitive enough to detect when a cloud momentarily passes over a plant on a sunny day," Beedlow said. He added that the device can measure a plant's stress due to lack of water up to five days before signs such as drooping leaves are observed.

The invention is based on the physiological principle that as plants are stressed, tiny pores on their leaves, called stomates, open or close. Opening or closing of the stomates causes a slight change in the stem diameter as water is retained or expelled by the plant. The diameter change is immediately detected by the device.

The unit comprises a transducer and an adjustable attachment mechanism which is connected to a microprocessor and recording system. The entire system is small enough to be taken into the field to record changes in stem diameter and to monitor the influence on plants of environmental factors such as air temperature, wind speed, solar radiation, rainfall, soil temperature and soil moisture.

Under laboratory tests, Battelle researchers demonstrated that Ceres can detect changes in soil water availability, often in minutes. They have also documented the response of sunflowers to vehicle exhaust and cigarette smoke within two minutes of exposure.

"These and other test results indicate that the device is practical and cost-effective for a broad range of applications that include determining the effects of air pollutants, increasing crop production and providing bioassays for environmental studies," said Beedlow. Battelle has filed patent applications for the device.



NEW MICRO LAUNCH DUE

It has just been announced that the Ericsson Group intend to launch an advanced new personal computer. The Ericsson Personal Computer will be marketed by Ericsson Information Systems in the UK through a national network of dealers.

Aimed at the professional user, the new machine has full operational compatibility with the IBM Personal Computer, both PC and the PCXT models. Operational compatibility means that any software available for the IBM will run without change on the Ericsson PC. It is available in both floppy and hard disk models, with monochrome or colour monitors.

"Discussions with a number of major distributors and dealers are now well advanced," said Ron Parkin, Ericsson's PC Marketing Manager, based at the company's Birmingham Headquarters. *"We will be offering dealers a comprehensive support package. This will include a wide range of software packages, training, a hot-line and troubleshooting service, maintenance and software support, and a wide range of co-operative marketing support programmes."*

Eye-strain relieved

With the continuing increase in the purchase of Home Computers, especially for use by children under 16 years old, the apparent possible health hazards have not been widely publicised. These problems have been known to exist in the business computer user world for over 5 years. The main health hazards being vision problems and headaches.

These vision problems are caused by continually staring at the bright images on the TV monitor with reflected ambient light causing the eye muscles to work overtime. Specular reflections from the screen face leads to fatigue because the eye enters a 'hunt' or 'seek' mode where it focuses first on the display, receives out of focus information from the specular image, refocuses on that image, receives out of focus information from the display, ad infinitum. This continued fatiguing of the eye muscles can in some cases cause permanent changes in eyesight.

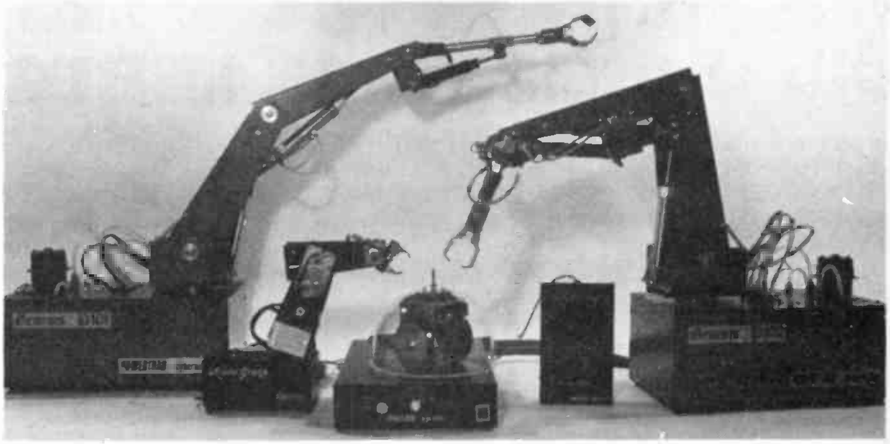
The solution to the problems experienced is to stop the glare from reflected light and also from the TV/Monitor display. This can be achieved by fitting a contrast enhancement anti-glare filter. Romag, the UK based glass specialists, have now produced such a screen called the CEAF, it consists of a special laminated filter to enhance the TV/Monitor colours and stop glare combined with a diffused etched aspherically curved face which dissipates the unwanted specular reflections, so stopping the need for the eye to have to continually re-focus. Romag's CEAF is profiled to fit the curvature of the screen and is fixed in position with velcro fasteners for easy removal.

Similar screens have been available in the business computer user market but have always been rather expensive, also technically, being flat, have not performed that well.

The CEAF will be stocked by many retail outlets like W. H. Smith, John Menzies etc. and will also be available by mail order, priced at £19.95, inc VAT and P & P. From ROMAG, Patterson Street, Blaydon on Tyne, Tyne & Wear NE21 5SG. (091 4145511).

MARKET PLACE

ROBOT RANGE



Hands on experience of robotic equipment, particularly in the field of computer control, is now a real possibility.

A complete range of robotic products is available from Powertran Cybernetics. The range is designed to provide an introduction to the whole field of Cybernetics with systems which can be reprogrammed and even physically modified to suit individual projects, prices for this equipment range from £95 to £1476.

The top of the range Genesis P102 is a hydraulically powered revolute arm with 6 degrees of freedom. Double acting cylinders and two speed operation make for a smooth, powerful action while a dedicated microprocessor and control box make the whole system totally independent and readily transportable. The Genesis P102 can be connected to an external microcomputer via its RS232C interface, thus enabling more complex algorithms to be programmed.

The Genesis P101 is a slightly simplified version of the P102. Single acting cylinders and reduced memory capacity are among the economies that bring the P101's price down to £1050.

Lower down the scale, Micrograsp is an electrically operated arm with 5 degrees of freedom. Powertran's custom-built interface board enables the robot to be controlled by virtually any microcomputer. A Micrograsp system (robot and interface) costs just £272.

Hebot II, a turtle-type robot, offers an excellent introduction to computer control at just £95. Features include independent two-wheel drive, collision detectors, a retractable pen, flashing eyes and a horn. Hebot's universal interface board enables the turtle to be connected to most micro computers.

Powertran's robots are all supplied in kit form, complete with assembly instructions and programming tips. Ready-made robots can be supplied by special arrangement.

Further information can be obtained from Powertran Cybernetics Limited, Portway Industrial Estate, Andover, Hants, SP10 3DF. Telephone (0264 64455).

Briefly...

GEC Computers through their associated company GEC Australia Ltd. has won the prestige videotex contract for Australia. The contract is for the supply of its 4100 series computers equipped with Prestel software, which GEC Computers markets worldwide.

The initial value of the contract is over £2m though Telecom Australia have further enhancements in mind. Viatel, Australia's name for their videotex service, will be similar to the UK's Prestel service and will include the latest generation of facilities now being implemented or planned by BT, other PTT users of Prestel and GEC Computers own videotex development programme.

Countdown ...

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.

Concerned Technology (for disabled) Aug. 2–4. Eldon Square Rec. Cntr. Newcastle. **Y3**
Acorn User Aug. 16–19. Olympia. **J3**
Electron & BBC Micro User Aug. 31–Sept. 2. Renold Building, UMIST, Manchester. **L**
Video Software Show Sept. 2–4. Earls Court. **G3**
IBM System User Show Sept. 3–5. Olympia 2. **Q2**
Concerned Technology (for disabled) Sept. 3–7. Meadowbank Sports Cntr. Edinburgh. **Y3**
Laboratory Sept. 4–6. Barbican, London. **E**
Amplifiers & Speakers (meeting) Sept. 8. Electronic Organ Constructors Society. **Y4**
Testmex Sept. 11–13. Grosvenor Ho. Pk. Lane, London. **E**
Leeds Energy Manager Sept. 12–13. **W3**
What Peripherals Sept. 13–16. Barbican. **J3**
Personal Computer World Show Sept. 19–23. Olympia 2, London. **M**
Semiconductor International Sept. 25–27. NEC. **T1**
Pemec (British Robot Assn.) Sept. 25–28. NEC. **G2**
Building & Home Improvement Sept. 25–30. Earls Court, London. **M**
Computer Fair Sept. 29. Prestatyn High School. See the I.T. mobile exhibition, armed forces and Microelectronics Education Programme Centre. Competition, clubs, hardware/software. **Z9**
Computer Graphics Oct. 9–11. Wembley Conf. Cntr., London. **O**
Software Expo Oct. 16–18. Wembley Conf. Cntr., London. **O**
Drives, Motors & Controls Oct. 24–26. Harrogate Exhibition Cntr. **E**
Leisuretronics Nov. 8–11. Royal Horticultural Hall, London. **T**
P.c.b. Manufacture & UV Box Construction (meeting) Nov. 17. Electronic Organ Constructors Society. **Y4**
Computers In The City Nov. 20–22. Barbican, London. **O**

E	Evan Steadman ✆ 0799 26699
G2	✆ 01-747 3131
G3	Link House Magazines
J3	Computer Marketplace ✆ 01-930 1612
L	Database ✆ 061-456 8383
M	Montbuild ✆ 01-486 1951
O	Online ✆ 01-868 4466
Q2	EMAP ✆ 01-837 3699
T1	Cahners ✆ 0483 38085
W3	MCM ✆ 01-231 1481
Y3	Expoman ✆ 01-788 7755
Y4	Percy Vickery ✆ 0202 423863
Z9	Mr. Carson ✆ 0244 535606

MONO·STEREO ECHO & REVERB

JOHN M.H. BECKER

THIS mono-stereo echo and reverb unit features delay times from 22ms up to 200ms in three electronically gated ranges, with reverberation variable from zero to infinity. Greater echo delay times may be achieved by the use of additional extension boards. A block diagram is shown in Fig. 1.

DELAY FACTORS

The circuit is based upon the recently introduced TDA1097 "bucket brigade delay line" chip which utilises MOS technology to provide 1536 stages of delay at 0dB insertion loss, at a low noise level of typically 0·3mV, and with a maximum input voltage of 1·5V r.m.s. Using the hitherto popular TDA1022 employing 512 stages three would be needed to achieve the same delay length with a typical noise level of 0·75mV and a 12dB insertion loss. The TDA1097 offers a total delay range of 7·68ms to 153·6ms with a clock frequency range of 100kHz to 5kHz. However, as the clock frequency should be around three times the required signal frequency, the longest delay range would limit the maximum processed frequency to about 1·5kHz. This would be adequate for speech, but too low for musical purposes. Consequently the unit has been designed to give a good compromise between signal delay and frequency response, the latter being nominally around 3·5kHz and more than adequate for most musical applications. The bandpass frequency of the unprocessed original signal is barely affected, and frequencies between 1Hz and well over 30kHz pass through with virtually no insertion loss. In nature, echo and reverb signals are largely multidirectional so it is only necessary to mix a composite delay signal with the stereo original to achieve realistic results.

INPUT PROCESSING

Stereo signals are brought in to the identical buffer stages IC1a and IC1b. Mono signals are brought into IC1a only. IC1a and IC1b feed directly to IC1c and IC1d respectively and can go to any normal amplifier system. The signals are also mixed in the low pass filter stage IC2a, where VR1 varies the bandpass gain from unity to x10. This allows the signal level reaching the delay stage to be altered without affecting the bypass level. The filtering as set by C5 and C6 restricts the maximum frequency reaching the delay to minimise distortion at lower clock frequencies. Echo signals achieve greater clarity with less bass content to them, so VR2 is included to vary the bass cut to between about 100Hz and 400Hz. IC2b is a mixer stage where the original signal can be combined with the delayed ones for reverberation feedback. The signal level here is monitoried by driving the l.e.d. D6 via TR1. Illumination will start at about 0·6V and rise in proportion to the signal strength, full illumination indicating a signal in excess of the preferred maximum of 1·5V. D5 limits the polarity seen by TR1.

DELAY STAGES

From IC2b signals proceed to the first of the chips in the delay series IC5–IC7. Signals pass through at a rate determined by the controlling clock frequency. The slower the clock, the longer the delay time. The bias required for minimum waveform distortion is preset by VR6, and applied equally to each stage via R40, R42 and R44. The outputs of

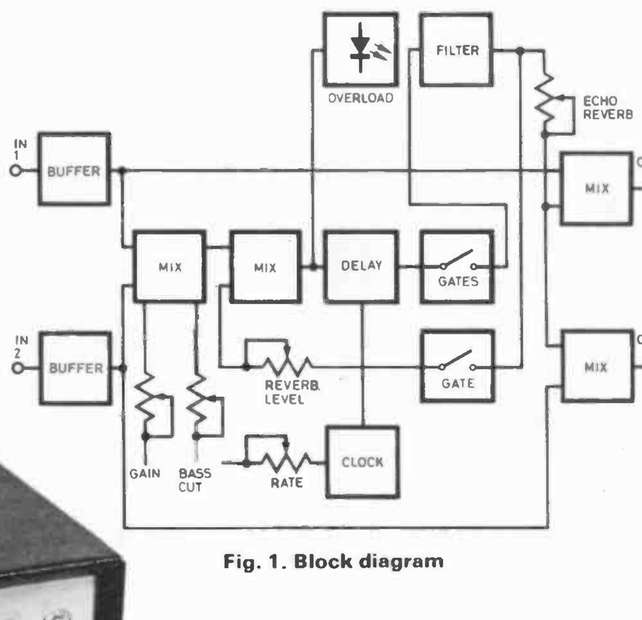


Fig. 1. Block diagram

AUDIO EFFECTS PROJECT

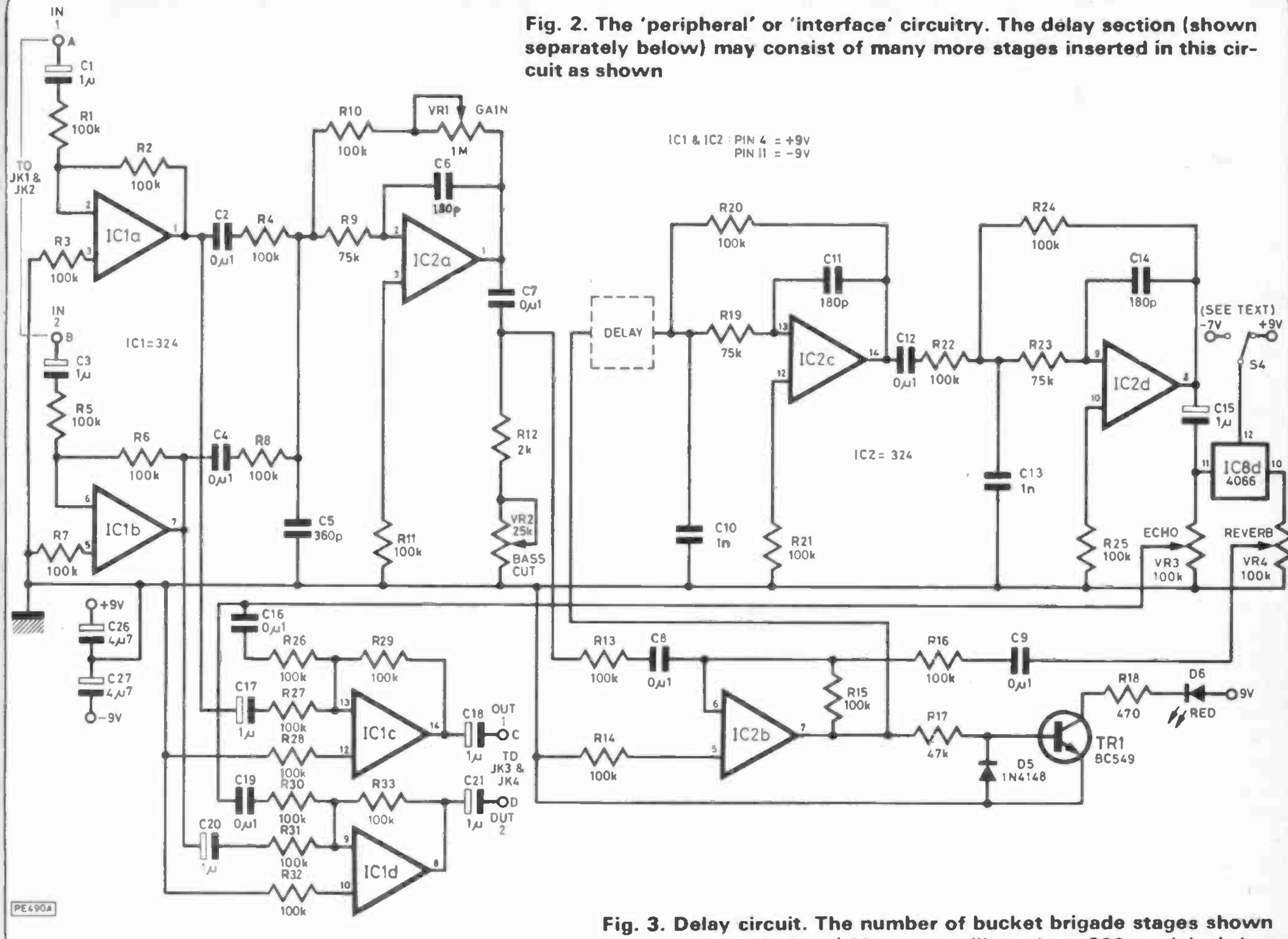


Fig. 2. The 'peripheral' or 'interface' circuitry. The delay section (shown separately below) may consist of many more stages inserted in this circuit as shown

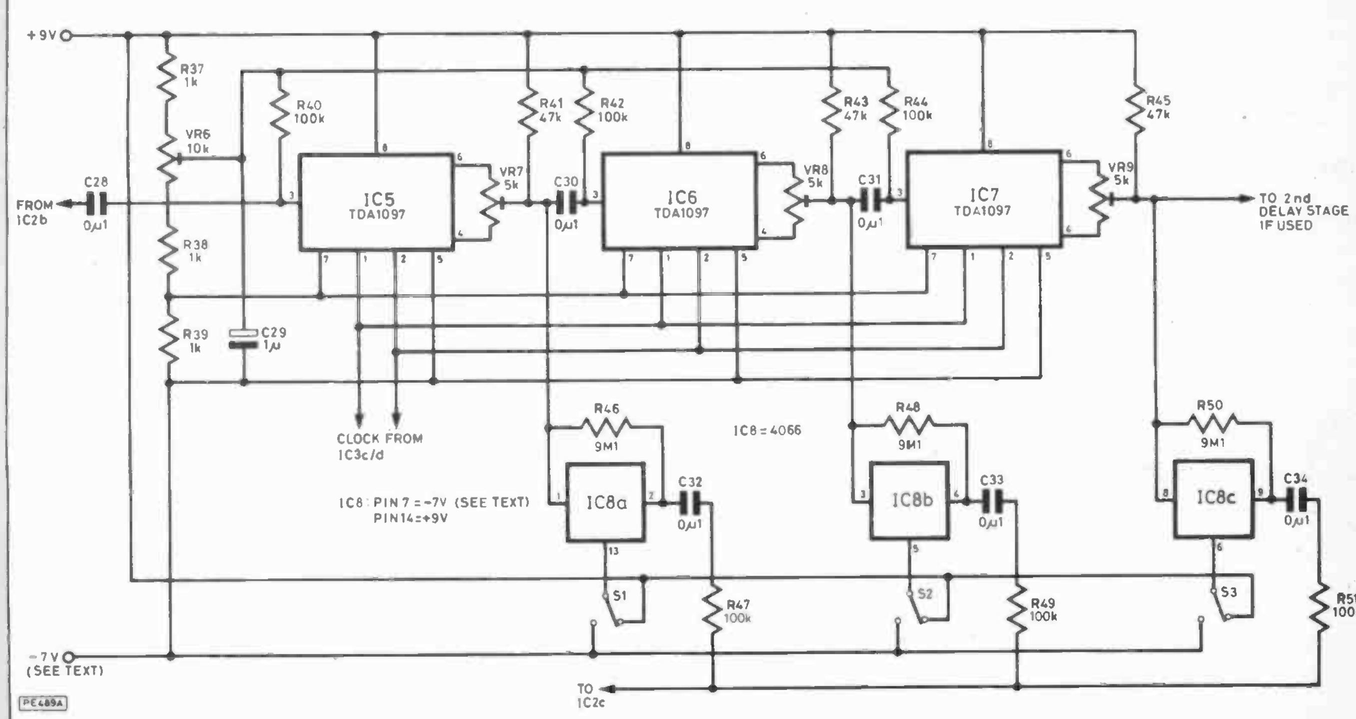


Fig. 3. Delay circuit. The number of bucket brigade stages shown here can be added to (this many will produce 200ms delay), but must be used with the peripheral circuitry shown above

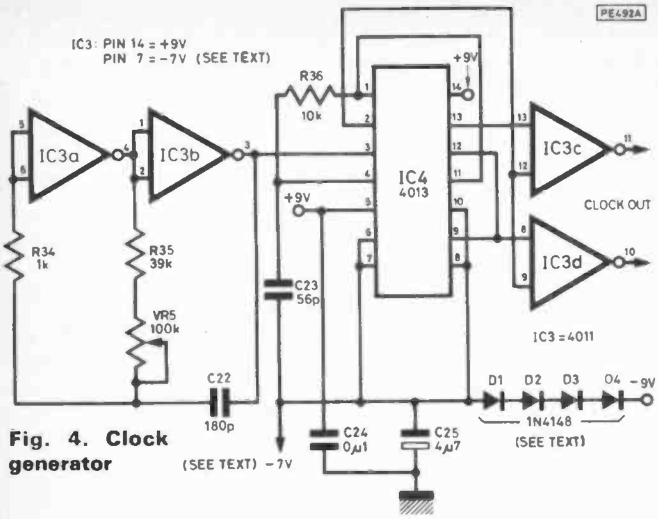


Fig. 4. Clock generator

the last two internal stages of each chip are summed at the respective presets VR7–VR9. The signal at these points also contains some processing clock frequency which can be partially cancelled out by balancing with the presets. Each chip feeds to the next in the series, the delay becoming longer at each stage. At each output the signal can be tapped with the gates IC8a/b/c performing the switching virtually silently. Normally each gate is held closed by a negative voltage from the respective switch S1–S3. On switching to a positive voltage, the gate opens permitting the analogue signal to pass through. Any or all of these gates can be selected so that different combinations of delays can be switched in. Resistors R46, R48 and R50 maintain a d.c. potential on the output of each gate to further reduce switching noise. As their resistance is high in proportion to that of the mixer stage, signal leak through is insignificant. Each gate output is combined onto a common bus line via the series C32–R47, C33–R49, C34/R51. The output of IC7 can also be fed to further delays in an identical fashion. Fig. 3 shows the full circuit for a chain of three delays. The author has used 6 TDA1097 in series, and it is probable that more could be chained.

CLOCK GENERATOR

The controlling clock frequency is generated by the network around IC3a and IC3b, and determined by C22 in conjunction with the total resistance across R35 and the panel control VR5. To reduce interference from the clock frequency, overlap between opposing phases of the square wave output is eliminated by taking the clock through the dual flip flop IC4 and the twin gates IC3a and IC3d. In my model the frequency range is approximately 12kHz to 36kHz, so that IC5 has a controllable delay range of about 22ms to 67ms, IC6 44ms to 134ms, and IC7 66ms to 201ms. Normal component tolerances may slightly vary these times between individual units.

FILTER AND MIXING

Further attenuation of the residual clock content of the delayed signal is performed by the two filter stages around IC2c and IC2d, where the effective frequency limit is set by C10/C11 and C13/C14 at about 3·5kHz with unity gain to the bandpass signal. The output from IC2d can now be mixed with the original signals at IC1c and IC1d via the level control VR3. Double tracking occurs with one delay stage, triple with two, and quadruple with three together. Further multiples will result with more delay stages introduced. From IC2d the delayed signal can also be fed back on itself for repeating echo and reverb. Reverb essentially refers to short repetition rates, and echo to longer delay repeats, in each case each repeat normally at a lower level than the preceding one. Silent switching of the feedback is achieved by taking the signal through the gate IC8d, activated by S4. The level of the feedback, and thus the repetition decay rate, is set by VR4. The basic feedback level as seen on the output of IC2d will relate to the original signal strength entering the delay chain, and also the number of delay tappings switched in. As a composite delay mix will be summed at IC2c this can result in a perpetual feedback loop occurring. Interesting effects can thus be produced by judicious manual control of VR4 in conjunction with the clock control VR5.

POWER SUPPLY

The unit has been designed basically for use with two 9 volt batteries, drawing only 7mA on each line. However, the voltage limit of the TDA1097 is 16V whereas two 9 volt batteries in series can actually deliver in excess of 18 volts when new. Consequently all controlling voltages seen by IC5–7 must be restricted to no more than the 16V maximum. As the current drawn is so low, this is readily achieved by using the voltage drop across the four silicon diodes D1–D4. The voltage seen at D1/C25 is nominally referred to as −7V, and is used as the negative supply rail feeding IC3–7 and S1–4. If it is preferred to power the unit from a stabilised power supply, this secondary negative level can be ignored, and the relevant connection made to the main negative line. The restrictions are that the total voltage seen by the TDA1097 lies between 9V and 16V, with an optimum range of 12V to 16V. IC1 and IC2 are not fussy about power line voltages provided they lie between 3V and 30V.

ASSEMBLY

Perform each step of assembly methodically and follow the normal ritual of examining solder joints with a magnifying glass. Short link wires on the delay p.c.b. may be formed from resistor offcut leads. With the battery operated unit, screening of internal leads was not found necessary as all stages except IC2a are effectively at unity gain, and any stray clock frequency is largely taken care of by the filter circuits. It is advisable though that the leads to VR5 should be kept separate from the signal leads, and that the case should be earthed to the common 0V point, either by soldering a short lead from the body of one of the panel pots to the nearest 0V connection line (point 2), or alternatively a tag screwed to the back of the case could be wired to the jack socket 0V bus line. If a mains power supply is used the signal leads of VR1/3/4 and the connection between p.c.b. points 17 and 32 may need screening. Signal leads on the jack sockets are too short to bother with. It is inadvisable to screen the leads to VR5 as the induced capacitance may upset the clock response. Remember that IC3–7 are MOS devices and the usual handling precautions should be observed.

SETTING UP

VR1 min, VR2 max (no bass cut), VR3/VR4 min, VR5 max, VR6–VR9 midway, S1–S4 off. With unit connected to main amplifier, apply an input signal. This should be already pre-amplified, but less than the maximum of 1·5V r.m.s. required by IC5–7. It is preferable not to use the unit with low level signals as this will degrade the signal to noise ratio. Check that the input signal reaches the amplifier. At this stage it is more dramatic to use a "click" type signal as the input, though any other signal source can be used such as

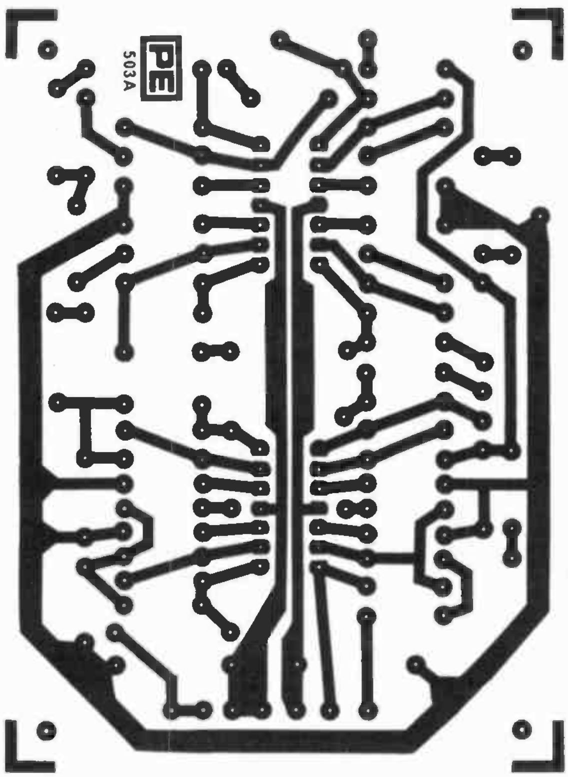


Fig. 5. Peripheral circuit p.c.b. (actual size)

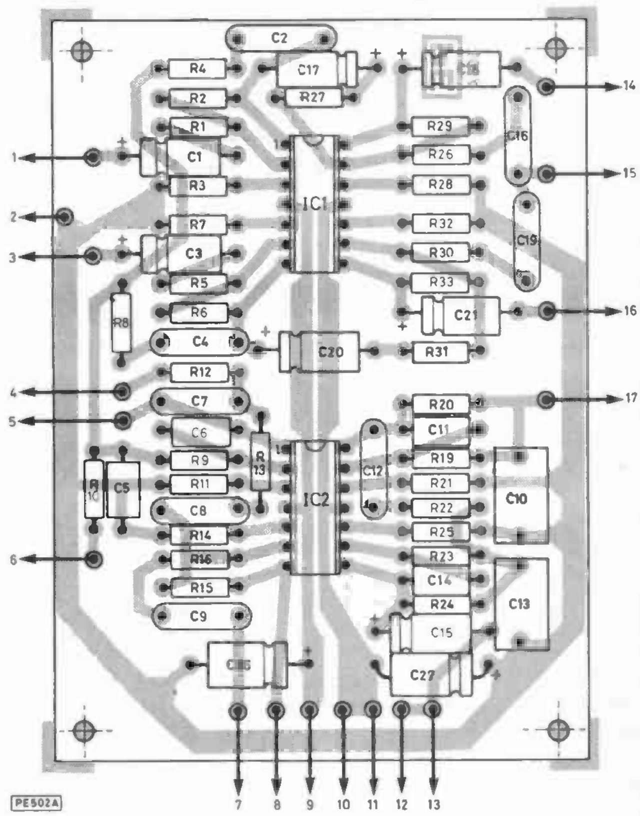
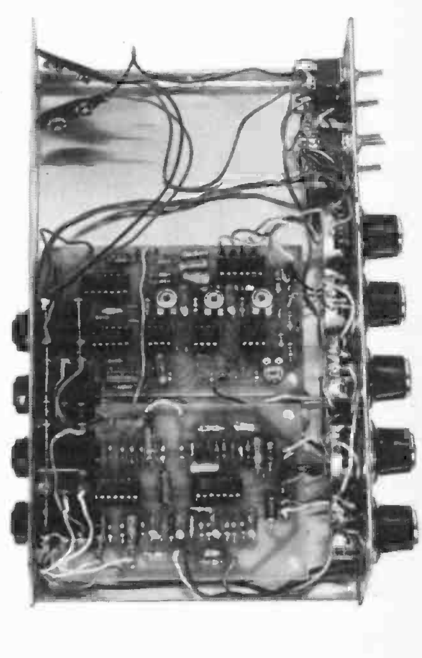


Fig. 6. Peripheral circuit component layout



ECHO TO 200ms
REVERBERATION TO INFINITY (or mind-bending crescendo)
STEREO OR MONO COMPATIBILITY
"BUCKET-BRIGADE" TECHNOLOGY

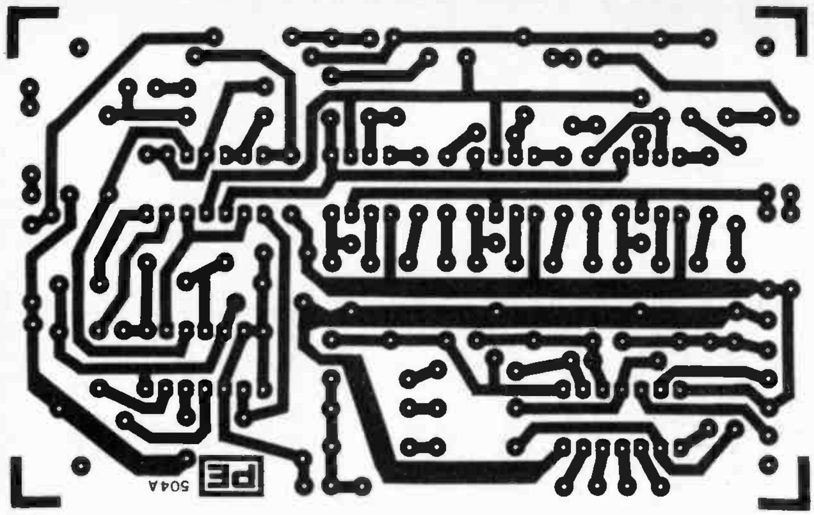


Fig. 7. Delay circuit p.c.b. (actual size)

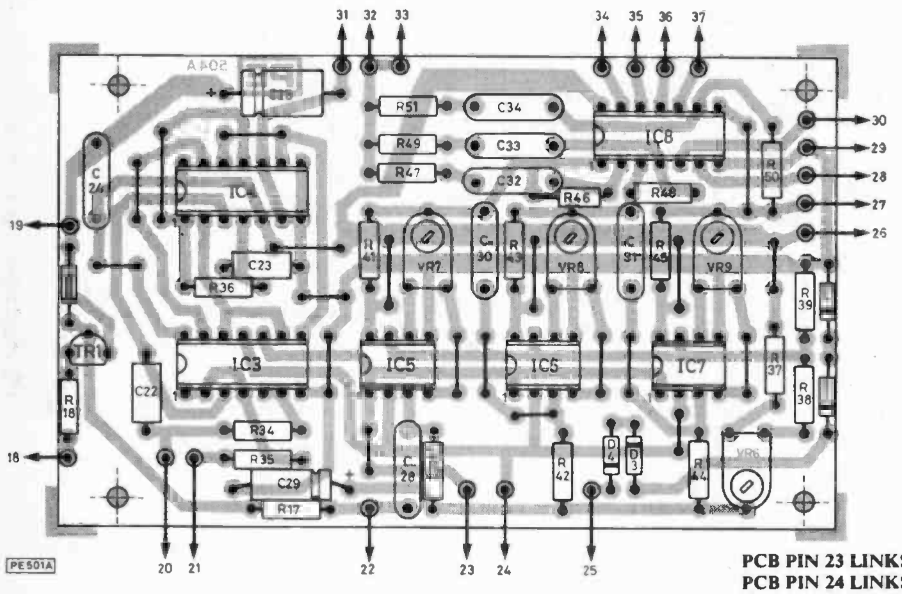


Fig. 8. Delay circuit component layout

PCB PIN 8 LINKS TO PCB PIN 22
PCB PIN 11 LINKS TO PCB PIN 25
PCB PIN 13 LINKS TO PCB PIN 36
PCB PIN 17 LINKS TO PCB PIN 32
PCB PIN 23 LINKS TO PCB PIN 23 OF 2ND DELAY BOARD IF USED
PCB PIN 24 LINKS TO PCB PIN 24 OF 2ND DELAY BOARD IF USED
PCB PIN 27 LINKS TO PCB PIN 22 OF 2ND DELAY BOARD IF USED
PCB PIN 31 LINKS TO PCB PIN 29 OF 2ND DELAY BOARD IF USED
PCB PIN 33 LINKS TO PCB PIN 32 OF 2ND DELAY BOARD IF USED
(OTHERWISE THESE PINS ARE NOT USED)

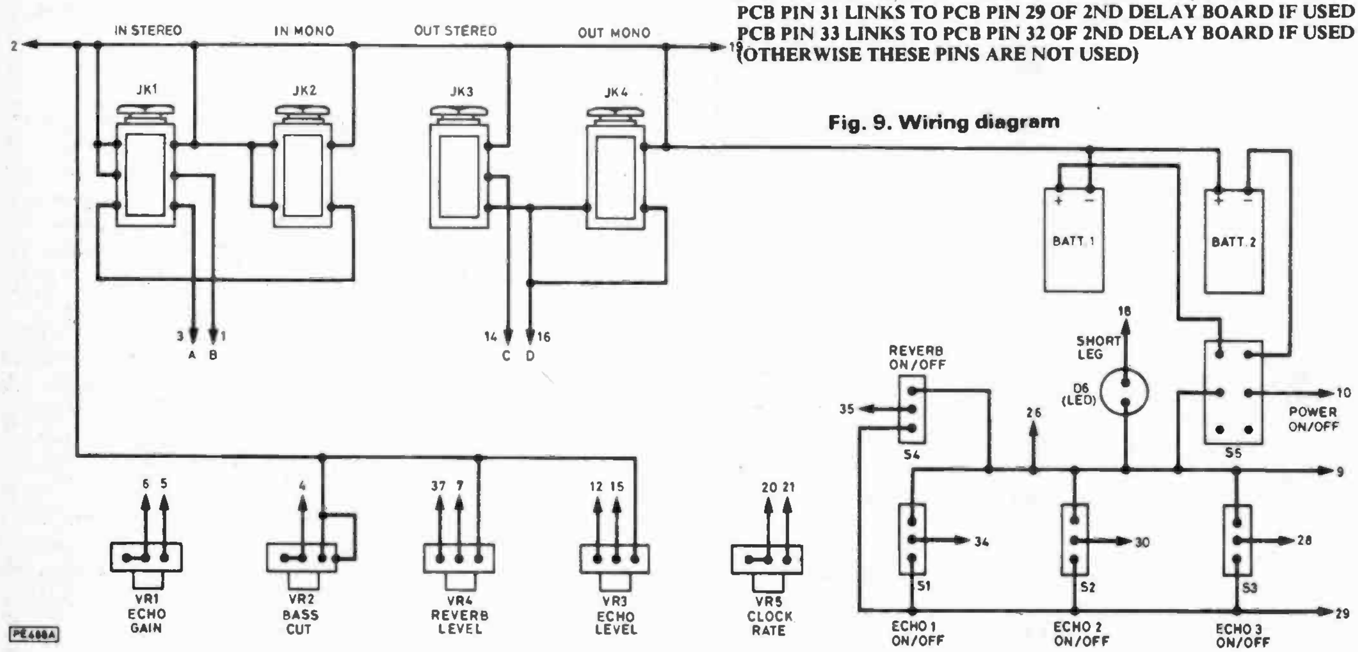


Fig. 9. Wiring diagram

COMPONENTS . . .

Resistors

R1–8, 10, 11, 13–16, 20–22, 24–33, 40, 42, 44, 47, 49, 51	100k (33 off)
R9, 19, 23	75k (3 off)
R12	2k
R17, 41, 43, 45	47k (4 off)
R18	470
R34, 37–39	1k (4 off)
R35	39k
R36	10k
R46, 48, 50	9M1 (3 off)

Potentiometers

VR1	1M lin. Mono Rota
VR2	25k lin. (can be 22k) Mono Rota
VR3, VR4	100k log. Mono Rota (2 off)
VR5	100k lin. Mono Rota
VR6	10k skeleton
VR7–9	5k skeleton (can be 4k7) (3 off)

Capacitors

C1, 3, 15, 17, 18, 20, 21, 29	1µ/63V elect. (8 off)
C2, 4, 7–9, 12, 16, 19, 24, 28, 30–34	100n poly (15 off)
C5	360p polystyrene
C23	56p polystyrene
C6–11, 14, 22	180p polystyrene (4 off)
C10, 13	1000p polystyrene (2 off)
C25–27	4µ7/63V elect. (3 off)

Semiconductors

D1–5	1N4148 (5 off)
D6	Red l.e.d.
TR1	BC549
IC1, 2	324 (2 off)
IC3	4011
IC4	4013
IC5–7	TDA 1097 * (3 off)

Miscellaneous

S5	DPDT switch (ON/OFF)
S1–4	SPDT switch (4 off)
SK1, 2	Stereo jack socket (2 off)
SK3, 4	Mono jack socket (2 off)
14-pin d.i.l. socket	(5 off)
8-pin d.i.l. socket	(3 off)

P.c.b. No. 218B and p.c.b. No. 218A
Knobs round (5 off)
P.c.b. clip (8 off)
PP3 batteries (2 off)
PP3 battery clips (2 off)
Case 9 x 5 x 2½in. (Phonosonics type BK3)
Wire and solder
4 stick-on rubber feet
L.e.d. clip

* **CAUTION**—MOS devices are liable to sudden death from static electricity and are subject to special handling precautions and restrictions. To comply with the guarantee, the d.i.l. sockets must be used. Note that semiconductors may have prefix and suffix codes.

Constructors' Note

Complete kit of parts available from: **PHONOSONICS**, 8 Finucane Drive, Orpington, Kent BR5 4ED. Price: £65 inclusive of VAT & UK p&p.

music or speech, but a constant amplitude from a signal generator will not adequately confirm the delay settings. Maximise VR3, and check that S1 to S3 select different delay combinations, and that VR5 varies the delay spread. Check that VR1 increases the echo level, that VR2 discretely attenuates the bass response, and that the l.e.d. responds to varying signal levels. Next, VR1 min, VR2 max, S1/S2 off, S3/S4 on.

Bringing up VR4 observe that feedback occurs and that multiple echoes die away. Maximising VR4 may result in self-perpetuating feedback, certainly if more than one delay stage is used, particularly stages 1 and 3 together. This will cease on reducing VR4 or switching off S4. Half-way rotation of VR4 is the maximum preferable for multiple delay selection unless bass cut is employed. Lower frequencies are more inclined to produce perpetual feedback than higher ones. Next, S2–S4 off, S1 on, VR3 max, VR5 min (slowest clock), disconnect input signal, turn up amplifier volume. Carefully adjust VR7 around its central point until the minimum system hiss from the delay chip is audible at which point the opposing clock phases are balanced. If an oscilloscope is used the midway balance point will be clearly seen. Switch off S1 and repeat for S2/VR8, and S3/VR9. Reduce amplifier to normal volume and apply a music signal or sine wave between about 400Hz and 2kHz. Bring up the signal volume either at source or with VR1 until a little distortion is just heard. Adjust VR6 around its central point until this is minimal. (Beware that the distortion is not due to overloading the amplifier). If using an oscilloscope the adjustment should be made so that any distortion is symmetrical to both sides of the sinewave trace. Upon completion the box may be painted and control legends applied with letraset or similar, covering them with a clear varnish or plastic film.

USE

The input jack sockets are wired to give priority to stereo signals, the mono input automatically being switched off during stereo use. Both output sockets may be used simultaneously. The input signal should be close to the maximum of 1·5V r.m.s. to maintain a good signal to noise ratio in respect of the delay stages. Using VR1 can help maximise the ratio, and will certainly be of value when using VR2 for bass cutting. Any of S1–S3 can be selected at any time, though adjusting VR5 should preferably be made with these switches off otherwise phase shifting of the delayed signal will be heard as the delay rate changes, sounding similar to varying the speed of a record player. VR4 should be below the self-sustaining level when S4 is switched in then bring it up as required. In most cases the best setting of VR3 is about three-quarters rotation so that the echo level is below that of the original signal, though depending on the settings of VR1 and VR2. Using the unit with any music or speech signal will greatly enhance the acoustic spaciousness, and this will be especially apparent with solo or rhythmic sources, but even orchestral tracks can benefit. ★

all in the

OCTOBER

issue!

New Series...

Sequential Logic Techniques

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OCTOBER ISSUE ON SALE FRIDAY, SEPTEMBER 7

Parallel to Serial Converter

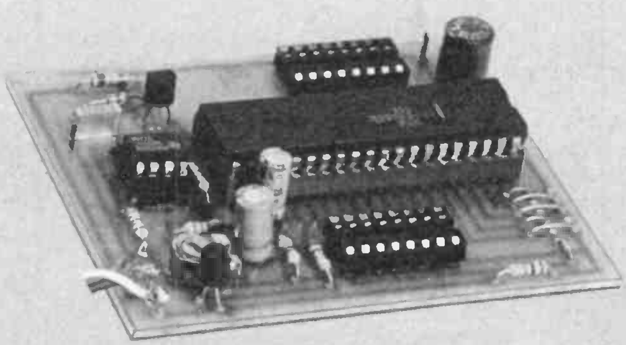
R.A.Penfold

MANY home computers have an RS232C or RS423 port, either as a standard feature or as an optional extra. This type of interface is primarily intended for use with peripherals such as printers and modems, and due to the serial nature of the data it is not possible to directly drive such things as relays and digital to analogue converters, or to directly read switches, analogue to digital converters, and similar devices. However, with the aid of the simple converter described in this article it is possible to use an RS232C or RS423 port as a parallel port having eight input and eight output lines.

This unit represents a very convenient way of getting parallel data into and out of a suitable computer in that it is very simple to connect the interface to the computer, with only three or four connecting wires being required. Even if the computer has a built-in user port or parallel port of some kind, it is often necessary to have extra lines, and this is an easy way of obtaining them. There is one drawback to this system which must be borne in mind, and that is simply the relatively slow rate at which data is sent and received when using a serial interface. This is not a major drawback since a serial interface can keep up with BASIC programs even when only a modest baud rate is used, and it is only in high speed applications where machine code is used that the interface would be unsuitable.

SERIAL SYSTEMS

Serial data is transmitted in a number of different word formats, but these are really just variations on one basic system. The line on which the data is transmitted is normally low, but at the beginning of a word it goes high for a certain period of time to indicate to the receiving equipment that a word has commenced. This is known as the start bit, and all standard serial systems use just one start bit. The following 5 to 8 bits are the data bits, and the receiving equipment examines the data line at suitable intervals to determine the correct logic state for each data bit. These bits are transmitted with the least significant bit first and the most significant bit last. Finally, 1, 2, or 1·5 stop bits are transmitted at the end of each word to indicate that the word has been completed. Fig. 1 shows the standard system of serial transmission.



In this context the word format will use either 7 or 8 bits, with 8 bits being the most common. Of course, if you use a 7 bit word format with this interface only 7 input and 7 output lines will be usable. The number of stop bits will be 1 or 2. Some serial systems use parity checking, and this is where either an even number or an odd number of bits are always transmitted, with the parity bit being added where necessary to give an appropriate number of bits. This enables a simple (but not totally reliable) system of error checking to be implemented at the receiving equipment. It is obviously essential to use the same word format at both ends of the system if satisfactory results are to be obtained. With some computers there is only one word format available, such as the 8 data bits and one stop bit of the BBC model B, or the 8 data bits and two stop bits of the Dragon 64. This interface has therefore been designed so that it can be programmed (via five link wires) to handle any standard word format.

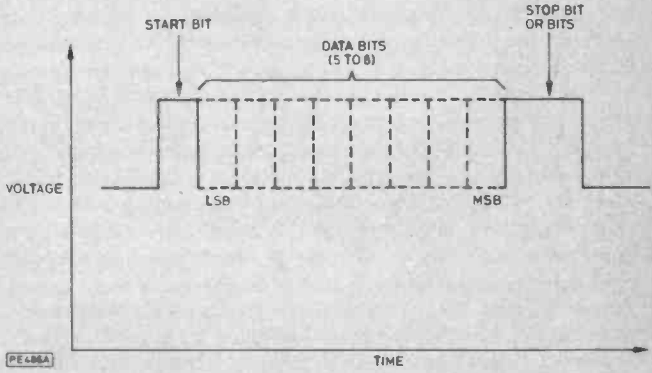


Fig. 1. The system of serial data transmission

HOW IT WORKS

A block diagram of the interface is shown in Fig. 2. Most of the work is done by a UART (Universal Asynchronous Transmitter/Receiver) which is represented by the area within the broken lines. On the input side, an inverter is used to convert the incoming positive pulses into the negative pulses required by the UART. This stage also provides level shifting, giving a standard 0 to 5 volt output from the nominal −12 to +12 volt input. A timing and control circuit, in conjunction with an external clock oscillator, clocks the incoming data bits into an 8 bit receiver register, which is a form of serial shift register. Stop, start, and any parity bits are automatically stripped from the data bits by the timing and control circuit. When all the data bits have been received they are transferred into the receiver buffer register so that the receiver register is almost immediately ready to receive the next word. The receiver buffer provides what are effectively eight latching outputs which can be used to drive l.e.d.s, a digital to analogue converter, or any other suitable equipment.

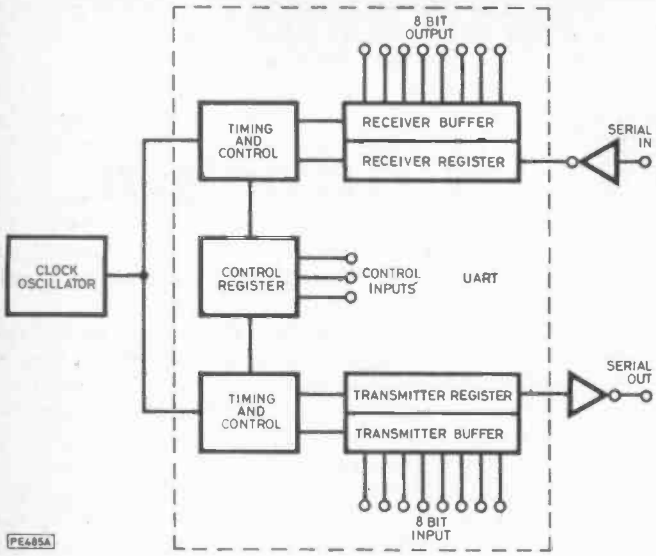


Fig. 2. Block diagram of the converter

The transmitter operates in the reverse fashion with the 8 bit input being transferred from the transmitter buffer to the transmitter register, and then clocked out in serial form with stop, start, and any parity bits being automatically added by the transmitter timing and control circuit. An inverter converts the negative output pulses of the UART into the required positive ones, but in this circuit it does not provide level shifting. In practice, computer RS232C and RS423 inputs seem to operate properly with ordinary 0 to 5 volt logic signals provided only a short connecting cable is used.

When a serial interface is being used to (say) send text to a printer, a handshake line is normally used to control the flow of data and ensure that no characters are missed. In an application such as this the use of handshaking is not really necessary, and the circuit is designed to simply send a constant stream of data. The fact that much of the data that is transmitted may not be read and used by the computer is irrelevant in this case. One point that should be kept in mind though, is that the serial interface device in the computer will, like the receiver section of this interface, use a receiver buffer. However, with most devices the contents of the receiver buffer are not allowed to be updated until the buffer has been read by the computer. This is perfectly satisfactory if readings are being taken with only brief intervals between each reading, but it may not be acceptable if there are long delays between readings. What happens then, is that when the receiver register is read, the next word received is fed into the receiver buffer and remains there until the next reading is taken. It is this non-current data that is fed to the computer when the next reading is taken. Fortunately there is an easy way around this problem, and this is to simply take a reading from the receiver register, but discard the data (which is old), and then immediately take a second reading which will give current data.

CIRCUIT DESCRIPTION

The full circuit diagram is shown in Fig. 3. The circuit is built around the industry standard UART, the 6402 (IC1). The clock signal is provided by IC2, which is a 555 timer device used in the standard astable configuration. The 6402 has separate transmitter and receiver clock inputs (pins 40 and 17 respectively), and it can operate with different transmit and receive baud rates. The baud rate is simply the number of bits per second with a continuous stream of data, but the baud rate is only one sixteenth of the clock frequency due to an internal divider and synchronisation circuit of the 6402. Using the specified values for timing components R4, VR1, R5 and C1 the clock oscillator has a nominal operating frequency of 4·8kHz, giving a baud rate of 300. VR1 is used to trim the clock frequency to the correct figure. Other baud rates can be obtained by using suitable timing component values. For example, changing C1 from 1nF to 220pF would allow VR1 to be adjusted for operation at 1200 baud.

The received data is fed via current limiting resistor R1 to clipping diode D1 and the simple inverter comprised of Tr1 and R2. The level shifted and inverted signal is applied to the serial input of IC1. The serial output of IC1 is inverted by Tr2 and then taken to the input/output socket, SK1.

The 6402 requires a long positive reset pulse at switch on, but this can be provided by a simple CR circuit. In this case the reset pulse is generated by C2 and R6. In normal operation the TBRL (Transmitter Buffer Register Load) input at pin 23 is held high, and is pulsed low to load data from the 8 inputs into the transmitter buffer register. The data is

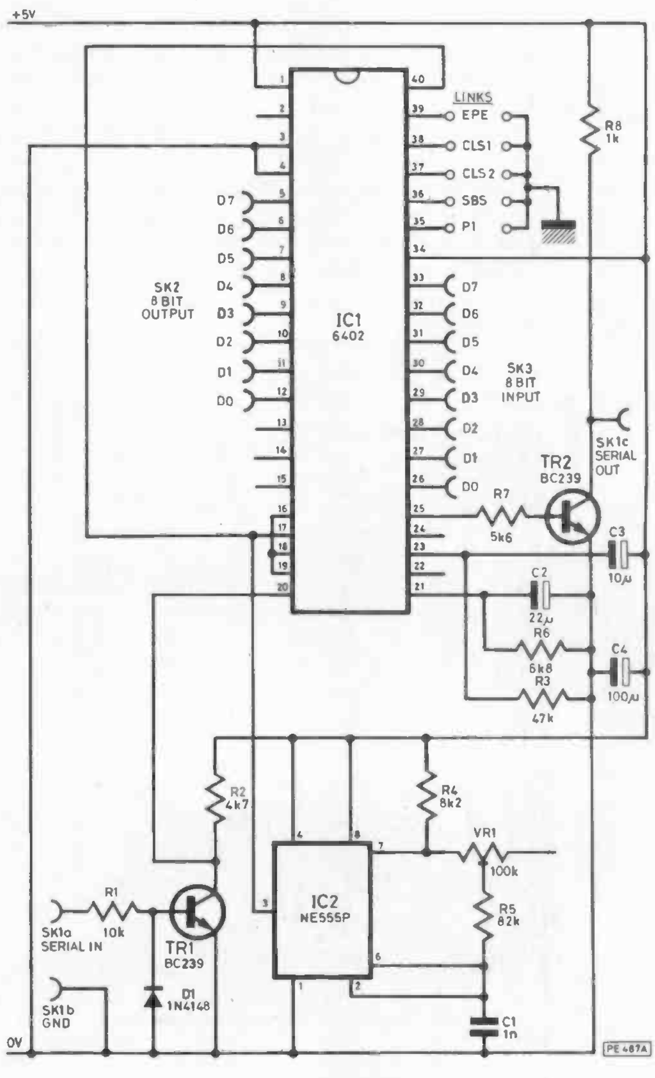


Fig. 3. Circuit diagram of the converter

CLS2 (3)	CLS1 (2)	PI (5)	EPE (1)	SBS (4)	DATA BITS	PARITY BIT	STOP BITS
L	L	L	L	L	5	ODD	1
L	L	L	L	H	5	ODD	1·5
L	L	L	H	L	5	EVEN	1
L	L	L	H	H	5	EVEN	1·5
L	L	H	*	L	5	NONE	1
L	L	H	*	H	5	NONE	1·5
L	H	L	L	L	6	ODD	1
L	H	L	L	H	6	ODD	2
L	H	L	H	L	6	EVEN	1
L	H	L	H	H	6	EVEN	2
L	H	H	*	L	6	NONE	1
L	H	H	*	H	6	NONE	2
H	L	L	L	L	7	ODD	1
H	L	L	L	H	7	ODD	2
H	L	L	H	L	7	EVEN	1
H	L	L	H	H	7	EVEN	2
H	L	H	*	L	7	NONE	1
H	L	H	*	H	7	NONE	2
H	H	L	L	L	8	ODD	1
H	H	L	L	H	8	ODD	2
H	H	L	H	L	8	EVEN	1
H	H	L	H	H	8	EVEN	2
H	H	H	*	L	8	NONE	1
H	H	H	*	H	8	NONE	2

* indicates that this state is irrelevant. The numbers in brackets correspond to link wires on the printed circuit board that are used to program IC1.

Table 1. Program links for IC1

then loaded into the transmitter register and transmitted as soon as this register is free. In this case continuous data transmission is required, and the most simple way of achieving this is to provide a high to low transition on pin 23 after the reset pulse has finished, and then hold this pin low. This is achieved using the CR circuit, C3–R3.

Pins 35 to 39 of IC1 are used to program the required word format, and some 24 of these are available. The required format is obtained by taking each of these pins high or low, and Table 1 gives details of all the formats available and how to program the unit for them.

The receiver buffer outputs are three state types, but in this application the three state facility is not required, and pin 4 is tied to ground so that the outputs are permanently enabled. There are a number of unused pins, some of which have no internal connection to the chip, but these are mainly unused handshake lines or status outputs. As the 6402 is a CMOS device the two unused inputs at pins 16 and 18 are connected to an unused output at pin 19, and are not simply left floating.

A single 5 volt supply is needed for the unit. As the total current consumption is only about 7 to 8 milliamps there should be no difficulty in powering the circuit from the computer, and most machines have a suitable supply output. The current consumption is much lower than one might expect, since serial interface adaptors usually have quite high current consumptions of around 100 milliamps or more. However, as IC1 is a CMOS device and is not operating at a very high clock frequency it actually consumes less than a milliamp.

CONSTRUCTION

Details of the printed circuit board are shown in Fig. 4. The main point to note here is that IC1 is a CMOS device, and as it is also not one of the cheapest integrated circuits, the normal MOS handling precautions should be scrupulously observed. Fit IC1 in a 40 pin d.i.l. socket, but do not plug it in place until all the other components and the link wires have been mounted on the board. Leave it in its anti-static packaging until this time, and handle it as little as possible.

Table 1 shows the appropriate logic states for the five pins that control the word format. Connect these in the ap-

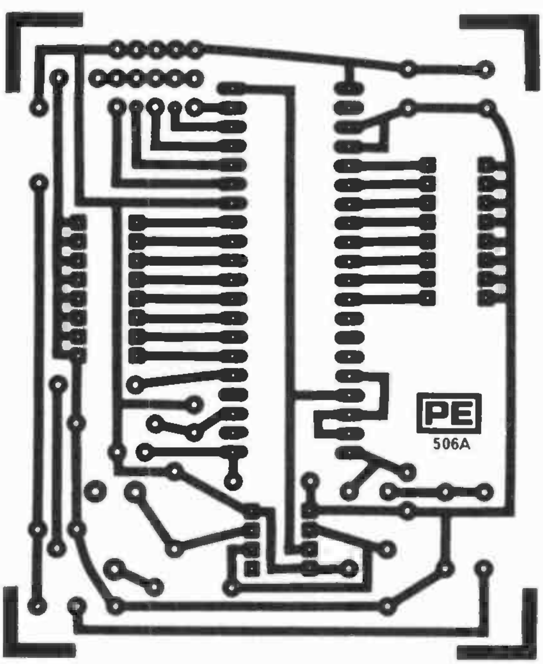


Fig. 4. PCB layout of the unit

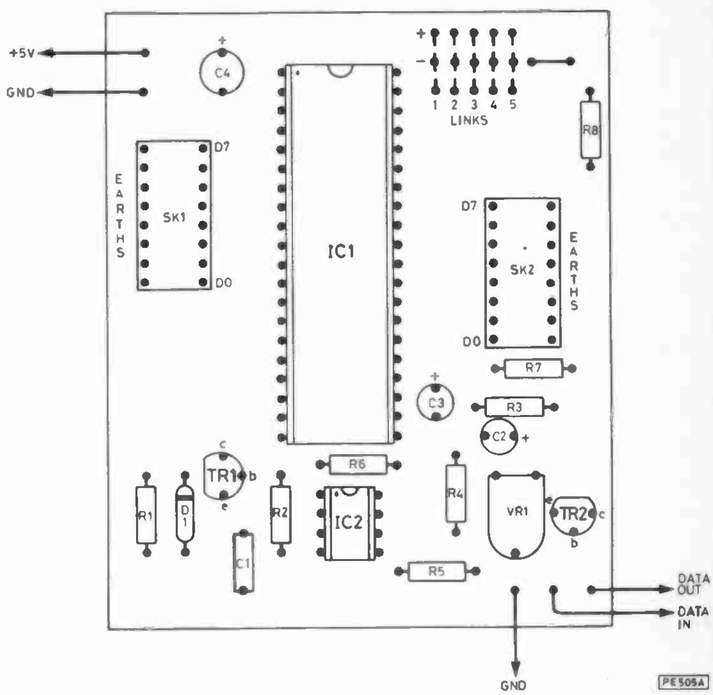


Fig. 5. Component layout of the unit

propriate fashion using the programming link wires. Where the state of an input is irrelevant it should still be connected to one or other of the supply rails, and should not be left floating. The inputs and outputs are taken to 16 pin d.i.l. sockets and connections can be made to these via 16 pin d.i.p. plugs. When the inputs are not in use it is advisable to fit a shorting plug in SK2 to protect the inputs.

Connection to the computer should not be difficult, and it is just a matter of crossing over the data input and output terminals of the converter with those of the computer, and providing a ground connection between the two pieces of equipment. It is unlikely that the serial interface will include a 5 volt supply output, but one of these is likely to be available at the user port or some other port of the computer.

The way in which the unit is accessed will vary somewhat from one computer to another, but if possible it is probably best to directly address the serial interface of the computer. For example, in the BBC model B computer the transmit and receive registers of its 6850 serial interface are at address &FE01. Reading from or writing to this address therefore reads data from or sends data to the converter. The transmit and receive baud rates of the computer's serial interface must be set correctly, and for the BBC machine this is achieved using the commands:—

```
*FX7,3
*FX8,3
```

VR1 must be adjusted to give a suitable clock frequency at the converter, and this should be done with the aid of a digital frequency meter if possible. As explained earlier, the clock frequency is sixteen times the baud rate, or 4·8kHZ for a baud rate of 300. If a frequency meter is not available VR1 can simply be given the correct setting by trial and error. ★

COMPONENTS . . .

Resistors

R1	10k
R2	4k7
R3	47k
R4	8k2
R5	82k
R6	6k8
R7	5k6
R8	1k

All resistors $\frac{1}{4}$W 5% carbon film

Potentiometer

VR1	100k 0·1W horizontal preset

Capacitors

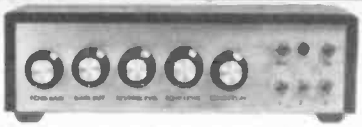
C1	1nF carbonate
C2	22μF 25V radial elect
C3	10μF 25V radial elect
C4	100μF 10V radial elect

Semiconductors

D1	1N4148
Tr1,2	BC239 (2 off)
IC1	6402
IC2	NE555

Miscellaneous

Printed circuit board
40 pin d.i.l. i.c. socket
Wire, solder, etc.



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DISC DRIVES Explained!

MICHAEL TOOLEY BA **DAVID WHITFIELD** MA MSc CEng MIEE **PART 1**

THE arrival of a Home Computer brings with it the inevitable "Wish List" for the new home computer owner. Indeed, once the basic system has been installed and set to work, the "need" for further extensions begin to make themselves felt almost at once. Perhaps the most popular major addition at this stage is a printer. This is the peripheral which transforms most systems from a sophisticated toy, to being an invaluable and highly versatile tool of real practical value. It also usually costs rather more than the original computer!

The next major item on the wish list is often tentatively pencilled in as "Floppy Discs (?)". By marked contrast with the printer, where there is usually little difficulty about what is meant by a printer and what it can do for us, considerable confusion often surrounds floppy discs. The difficulties can start with the simple fact that what is referred to as a disc, actually turns out to be square rather than circular. This confusion is then compounded by the bewildering array of new jargon, and the wide range of choice offered (in seemingly similar boxes) by the floppy disc manufacturers and suppliers.

In this article we look at the most popular of today's floppy disc systems, as used in many small business and home computer systems. We examine the nature and operating principles of floppy discs, and explain the significance of some of the important points to consider when buying a floppy disc system.

WHY USE DISCS?

Before we look in detail at floppy discs and what they can do for us, it is useful to be clear about what we mean when we talk about a disc-based system. To start with, therefore, we will look at a basic small computer system, since this will allow us to identify what we must add to upgrade our system to include floppy discs. Fig. 1 shows a schematic representation of a typical small computer system before its upgrade. We will be looking again at the details of this arrangement later, but for the time being this figure allows us to identify the major components involved.

The heart of the system is the basic computer; typically this is a Spectrum, BBC, Apple, Commodore, Atari, or similar model. The basic forms of these machines include a central processor, some memory, a keyboard, and facilities for driving a television and/or a video monitor. The memory usually contains software in permanent memory (ROM) for BASIC, and for the operating system which supports the general 'housekeeping' tasks. An interface to a cassette recorder is usually also included, and specific machines may also provide additional facilities, e.g. a printer interface. The basic elements, however, are common to all computer systems of this type.

One disadvantage that we soon encounter with such a system is that the loading and storing of information involves the use of cassette tapes. Whilst cassettes are cheap and physically robust, they are also slow, cumbersome to use, error prone, and capable of storing only limited amounts of information. Tape as a storage medium also involves a significant amount of user involvement in order to be able to store (SAVE) and retrieve (LOAD) programs and data. Programs may take minutes to load, with the user being required to rewind the tape if a loading error occurs. This is a consequence of the fact that tape is a serial access storage medium, whereby it is necessary to wind through a tape to locate the required information, even if the intervening tape contains nothing of current interest. Overall, however, it must be said that cassette tapes represent an ingenious technical compromise, giving a very low cost information storage system. Nevertheless tapes do have some serious drawbacks if the user is contemplating any significant amount of program loading or data manipulation.

One solution to the limitations of cassettes is to use discs for storing programs and data. A disc storage system gives fast parallel access to large amounts of stored data, and thereby brings us a quick and convenient way of storing information. In practice, disc systems come in a number of

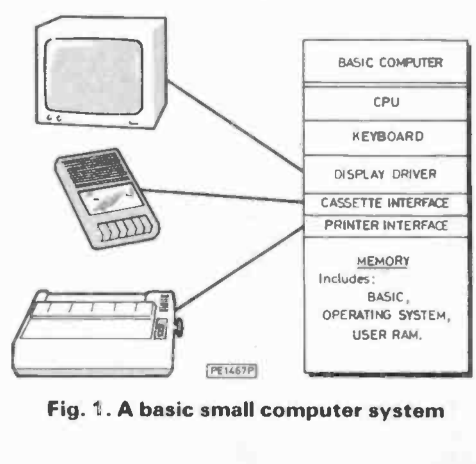


Fig. 1. A basic small computer system

different forms, depending on the type of disc used, and the underlying technology involved.

DISC UPGRADE

Now that we have seen some of what a floppy disc system can do for us, we are in a position to look at the effect of upgrading a system to include floppy disc storage facilities. Fig. 2 shows how the basic system from Fig. 1

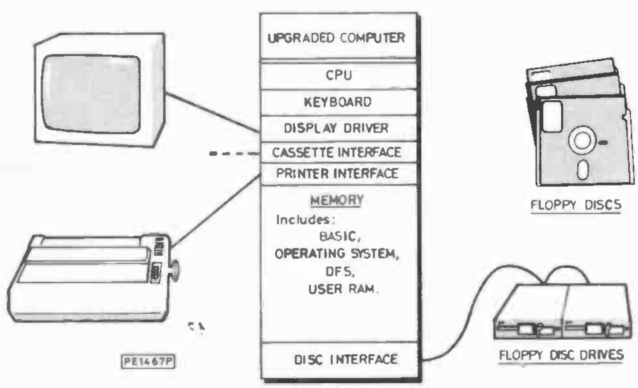


Fig. 2. Small computer system after floppy disc upgrade

must be extended to include floppy discs. From this figure we can see that there are four major additions necessary:

Floppy Disc(s)
Disc Drive(s)
Disc Interface
Software

We will now go on to look in turn at each of these components in more detail. The advantage of understanding the physical nature of the discs, the drives and the interface to the computer, is that we will then be in a much better position to understand the significance of the facilities offered. We will also be in a better position to understand the likely nature of the problem when the system fails to behave properly or quite as expected.

HARD vs FLOPPY DISCS

Large computers, most mini-computers, and some top-of-the-range small computers use what are known as hard discs. Such discs use a rigid aluminium platter covered in recording oxide for storing information. They rotate continuously at high speed (typically 2400 or 3600r.p.m.), and require a very precise drive mechanism, as well as very clean air in which to operate. The read/write heads are aerodynamically designed and literally fly over, but hopefully never touching, the disc surface. Storage capacities per drive vary from useful (1·25 Mbyte for example) to simply vast (300 Mbyte or more). However, and despite the advances in disc and manufacturing technology over the last decade, the cheapest hard disc units (based on the Winchester technology) still cost upwards of around £1000. Hard discs, therefore, while offering almost unbelievable increases in speed of access, reliability and storage capacity, are still beyond the budget of the majority of small computer systems.

Instead of hard discs, most micros use flexible (or 'floppy') discs. In place of the aluminium platter used to support the recording oxide in hard disc units, floppy discs have their recording oxide deposited on a thin flexible plastic base of

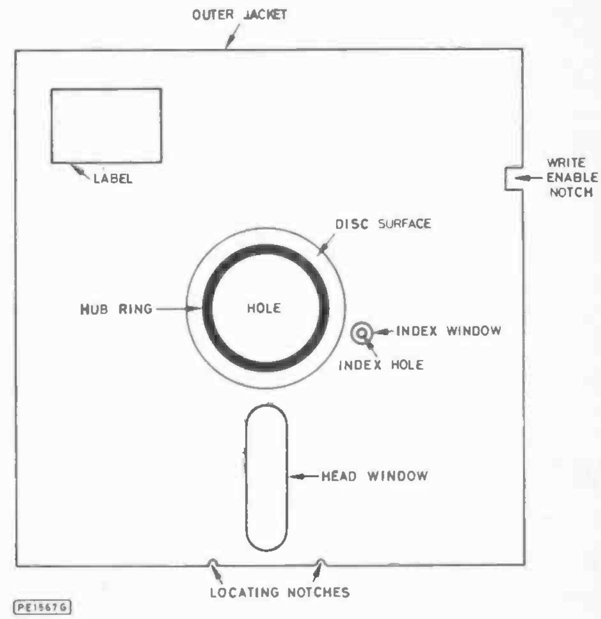


Fig. 3. External appearance of a 5·25in. mini-floppy disc

mylar. The read/write heads actually touch the recording surface, but the discs only rotate when reading or writing is taking place. The discs themselves generally have a much smaller storage capacity than hard discs (typically measured in 100's of Kbytes), and are rotated more slowly (usually at 300r.p.m.). Even so, floppy discs represent a dramatic improvement over cassette tapes in performance terms, and are vastly more convenient to use. The cost of a floppy disc drive is also significantly less; current prices range from around £100 up to £300 or more, depending on the storage capacity. Floppy disc units are much less particular about their operating conditions than hard discs, and overall they provide a cost effective solution to the problem of information storage on many small computers.

FLOPPY DISCS

Floppy discs come in a number of sizes, the most common being 8in. and 5·25in. in diameter. The standard for small computer systems is currently 5·25in, and the outward appearance of a 5·25in. (mini-floppy) disc is shown in Fig. 3.

As mentioned earlier, the first thing that strikes a newcomer when looking at a floppy disc is the fact that it is actually square, whereas a circular shape may quite naturally have been expected. The stiff square jacket we see actually serves to protect the circular disc which is hidden from view inside. The disc itself is never removed from the jacket (indeed the jacket is often welded shut), and rotates within it in normal use. The disc is made from a circular piece of plastic (mylar) film which is coated with a layer of magnetic recording oxide. This coating is similar to the one used on recording tapes, but floppy discs are thicker than tapes, and they are usually coated on both sides rather than on just one.

An important point to bear in mind when handling a floppy disc is never to touch the recording surface which is exposed through the various apertures in the protective jacket. Similarly, replacing the disc in its storage sleeve when not in use is an important habit to practise. Finger prints (and the dust and grit that they attract) ruin more discs than any other cause. Another thing which must be avoided when storing a disc is any form of strong magnetic field (e.g. loudspeakers, mains transformer, moving coil meter, or similar), which could corrupt the information stored on the disc.

The disc drive rotates the disc within the jacket by gripping it in the centre. Some discs have an additional thin plastic reinforcing ring at the centre (as shown in Fig. 3) in order to improve the grip and to give longer disc life. This is a point to bear in mind when considering cut-price discs, which often have no such reinforcing rings. When the disc is spinning, the drive's read/write head moves across the disc surface as exposed through the head window. The point to note here is that the head is actually brought into contact with the disc when reading or writing, rather than 'flying' over the surface as with hard discs.

The write enable notch on the jacket allows the information on the disc to be protected against accidental erasure. By covering the notch with a suitable tab, write operations will be prevented. The write enable notch thus works in the opposite sense to the tab on a cassette tape.

The index window in the jacket near the centre allows the drive electronics to detect whenever the index hole in the disc (provided during manufacture) passes this known point. An index mark pulse, which occurs whenever the index hole in the disc and the index window in the jacket coincide, provides essential timing and positioning information to the drive's control circuits.

The locating notches on the front edge of the jacket are to assist in positioning the disc correctly in the drive. When correctly inserted in a horizontally mounted drive, we should find that the disc label is uppermost and adjacent to the open edge of the drive's slot. The disc label should be used for recording disc identification information, but care should be taken not to press too hard when writing on the label. A soft-tipped felt tip pen is recommended for writing on floppy disc labels, and one well-known pen manufacturer even produces a special floppy disc pen solely for this purpose.

DISC FORMATS

So far we have looked only at the physical structure of the basic floppy disc. In order to be able to store (and perhaps more importantly, retrieve!) information on a floppy disc, we need to know where to find any data stored on the recording surface. For this purpose we organise the initially blank surface of the disc into a number of concentric magnetic tracks or rings. Each track is arranged to be a known distance from the centre of the disc. Thus, the drive can easily locate a track for reading or writing, provided that its position is known, and the drive mechanics are capable of the necessary precision of movement. In practice, this mechanical precision accounts for much of the cost of a typical floppy disc drive.

In order for discs to be interchangeable between drives and systems, it is important that we use a standardised arrangement of tracks. Most flexible discs use a standard which is based on the 77-track standard established by IBM for the original 8in. floppy discs. There are two current standards in common use with 5·25in. floppy discs, allowing either 40 or 80 magnetic tracks. The number of tracks which can be used on a particular disc is actually determined by the drive on which it can be used (see later), and to some extent by the quality of the disc itself. The higher the quality of the recording oxide, the greater the number of tracks it is capable of reliably supporting on a given size of disc (and the higher the price!).

On a 40-track disc, the tracks are laid down on a pitch of 48 tracks per inch (t.p.i.). The storage area of the disc is thus a band just under 1in. wide, and this band is positioned as close to the outer edge of the disc as possible. All of the tracks are usually arranged to hold the same amount of information, despite the fact that the outer tracks are longer than the inner ones. The same recording area is used by 80-track discs, but in this case the tracks are on a pitch of 96 t.p.i., giving tracks which are half the width of those on a 40-track disc. The relationship between the tracks on 40- and 80-track discs is illustrated in Fig. 4.

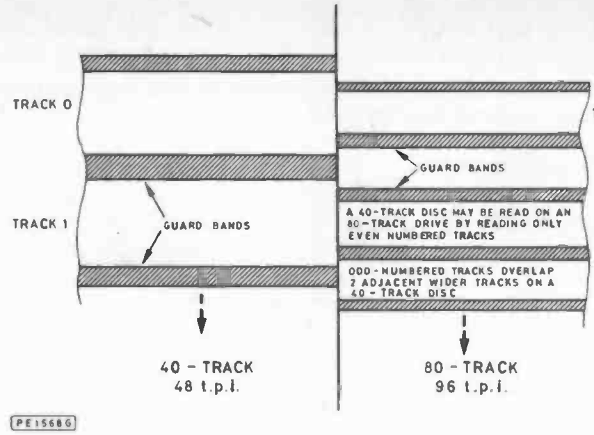


Fig. 4. Relationship between tracks on 40- and 80-track discs

Each floppy disc track is capable of storing a significant amount of information. However, in order to make best use of the capacity of the disc, we usually divide each track into an equal number of sectors. A sector is then used as the smallest unit of information ever written to or read from a disc. The standard capacity chosen for a disc sector is 256 bytes. Typically a track is divided up into 10 sectors when using single-density recording (see later), but the number may be more or less than 10 in some systems. A 40-track disc will thus usually contain 400 sectors, each capable of storing 256 bytes of information, i.e. a total of 102,400 bytes. On an 80-track disc, the capacity is exactly doubled to 204,800 bytes.

THE FORMATTING PROCESS

So far we have looked at what a floppy disc is, its storage capabilities, and how it is organised. However, the question remains as to how the structure of the disc just described is imposed on the initially blank oxide of a new floppy disc? The answer is by a process known as formatting.

Before a floppy disc can be used for the first time, it must be formatted using a special program known as a formatter. During formatting, the concentric magnetic tracks are laid down, and the sectors are marked out and numbered. The tracks are numbered from outermost (0) to innermost (39 or 79), and the sectors on each track are numbered from 0 to 9. This and other information is actually written onto the disc by the formatter. The detailed layout of part of a standard mini-floppy track is illustrated in Fig. 5; the reader hopefully need never be concerned with the structure in this much detail!

In addition to the functions just described, the formatting program has one further task to perform. It is all very well to be able to store such vast amounts of information on a disc, but how do we know what we have put where? The answer is that a number of sectors are reserved on each disc to act as a catalogue. This catalogue is then used by the computer to record (on the disc) the names, locations, and related status information for all of the files on that disc. If a file is not described in the catalogue, then for all practical pur-

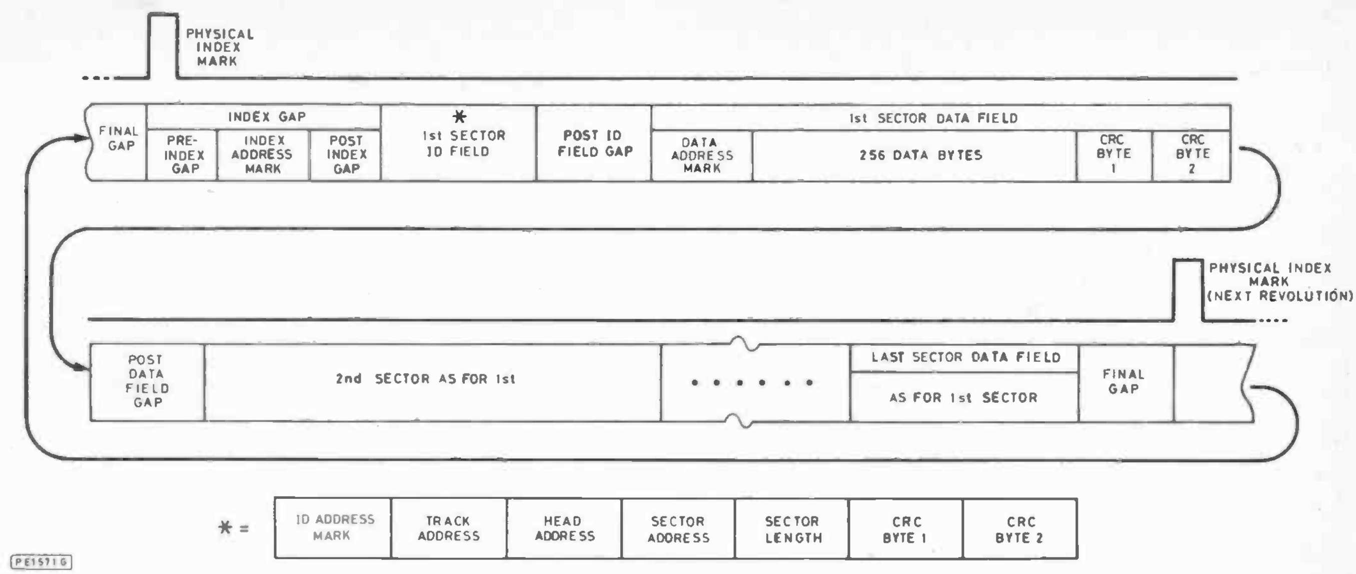


Fig. 5. Detailed organisation of part of a disc track

poses, the computer will consider that it does not exist. As one of its final tasks, therefore, the formatter must set up an empty catalogue for later use by the system. The actual sectors reserved for the catalogue, and the internal structure, will vary from system to system. The BBC Micro, for example, uses the first two sectors of the outermost track (sectors 0 and 1 of track 0), while the TRS80 uses the middle two tracks.

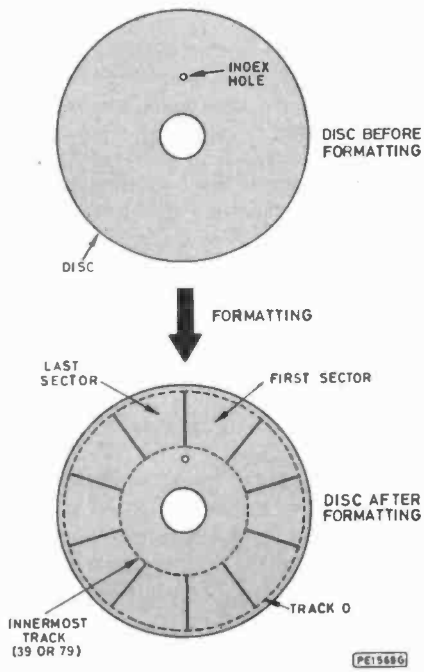


Fig. 6. The formatting process

The process of formatting a disc thus has the effect (illustrated in Fig. 6) of converting a blank disc into one which is mapped out in tracks and sectors. The number of tracks is essentially chosen for us by the type of drive in which we are going to use the disc. The number of sectors per track, on the other hand, depends on the interface and the software in the computer. We should also remember that a number of sectors will be reserved for the disc catalogue, depending on the system for which the disc is being formatted. The usable storage capacity of a disc will thus be slightly less than we might otherwise expect from a simple consideration of the numbers of tracks and sectors involved.

DO NOT

- **Touch the disc surface**
- **Use solutions like thinners to clean the disc surface**
- **Use magnets or magnetised objects near the disc**
- **Bend or fold the disc**
- **Place heavy objects on the disc**
- **Use paper clips on the disc**
- **Write on the disc label in ball-point pen**
- **Leave the disc on top of the computer or monitor**
- **Expose the disc to excessive heat or sunlight**
- **Smoke near the disc or drive**
- **Eat or drink near the disc or drive**

DO

- **Put the disc label in the correct place**
- **Keep the disc in the protective envelope**
- **Store the disc in an upright box**
- **Insert the disc in the drive carefully**

Table 1. Do's and Don'ts of floppy disc care

Our discussion so far has confined itself to the 'top' surface of a floppy disc. It is also possible, however, to use both top and bottom surfaces of a suitable floppy disc for storing information, so long as an appropriate double-sided disc drive is available. We should note in passing that, unlike cassette tapes, it is not possible to use the reverse side of a disc by simply turning it over; the two sides would need to be mirror images of each other, and they are not.

Double-sided discs are identical in format to the single-sided types, but the recording oxide is manufactured and tested to the same high standard on both sides of the disc. Whether both sides of a double-sided floppy disc can actually be used depends on the disc drives themselves. All mini-floppy discs are currently manufactured with read/write and index windows on both sides of the protective jacket. Single-sided discs can thus be read/written on double-sided drives, and vice versa, but the number of sides which can actually be used depends on the drive and disc combination. To be able to use both sides of a disc, we need a combination of a double-sided disc in a double-sided drive.

Before we leave the subject of the discs themselves, we offer a few Do's and Don'ts in Table 1 which should help to prolong disc life and to ensure that problems with data corruption are avoided, or at least the risk kept to a minimum. With careful handling, a floppy disc should give many years of faithful service.

FLOPPY DISC DRIVES

A floppy disc drive consists basically of a drive motor which rotates the disc within its jacket, and a read/write head to store/retrieve data. Behind this simple description, however, lies a sophisticated piece of electro-mechanical engineering coupled with precision control circuitry. The mechanical components of the drive fall into two main categories: those concerned with disc rotation, and those concerned with head movement. The general mechanical arrangement of a typical drive is shown in Fig. 7. The precise details of any particular will vary in different manufacturers' products.

Disc rotation

The rotation mechanism is a little more than just a motor, in that it must first of all allow us to clamp the disc to the spindle. The clamping action is achieved by 'closing the door' after the disc has been inserted in the drive's slot. This action may actually involve us closing some sort of door arrangement, or it may more usually be by turning some form of lever. Whatever the detailed arrangement, the object is to cause the hub to clamp the centre of the disc to the motor spindle. This spindle is now usually directly coupled to a d.c. brushless motor, although a number of alternative designs have been used in the past. The motor then rotates the disc at exactly 300r.p.m., as and when required by the drive's control circuits.

A figure often quoted in relation to the rotational motor is the time to run up to full speed: the motor start time. A typical figure for a current half-height drive is around 250 msec. The motor start time is significant because, when not being accessed by the computer, the disc drive stops rotating the disc. This substantially reduces disc and head wear, and is in contrast to hard disc systems where the discs rotate continuously, but where the heads are not actually in physical contact with the disc.

Head movement

The other major part of the mechanical system looks after the movement and positioning of the read/write head(s). In double-sided drives there are two read/write heads, one for each side of the disc. However, both of these heads always move together, and they are mounted on a common carriage. The selection of which head is active at any time is controlled by the drive electronics, in response to commands from the computer. A positioning actuator is used to move the head assembly to the desired track on the disc. This movement is done initially without the head(s) in contact with the disc. The head load solenoid then moves the head(s) into contact with the recording medium: a process known as head loading. Data may only be read or written from/to the disc when the heads are loaded.

The movement of the head assembly is controlled by a stepping motor. In such a motor, the spindle rotates a fixed amount in response to each electrical step. The amount of rotation may vary between drive designs, but the result is always the same because a mechanical gearing arrangement converts the rotational movement into a lateral movement equal to the spacing of a track. Thus, the head assembly moves across the disc by a distance equal to: (the number of pulses × the track spacing). In an 80-track drive, for example, 40 pulses will cause the head assembly to move 40/96 inches, while on a 40-track drive the movement would be 40/48 inches. The direction of movement is controlled by the computer.

One of the commonly quoted figures for a disc drive is known as step time (or sometimes the track-to-track seek time). The step time is the time taken for the head assembly to move from one track to the next adjacent track, and is usually a figure in the range 2 to 30msecs. Clearly, the time taken to access a particular file on a disc is greatly affected by this figure. Starting from the outer edge of the disc, for example, the heads of a fast half-height 80-track drive with a 3msec step time would take only 120msec to access the start of a file in the centre of the disc. On the other hand, a

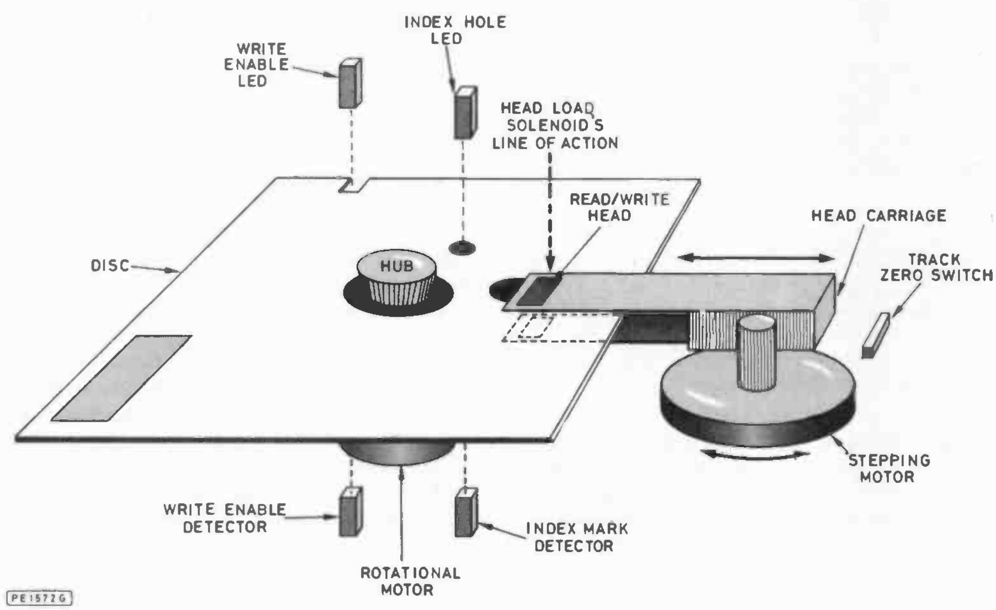


Fig. 7. General mechanical drive layout

slower unit with a 24msec step time would take almost 1 second to complete the same operation. The step time is thus important when we are considering uses which involve a significant amount of head movement.

Following the movement of the head assembly, a further interval must be allowed to permit the head to settle down, before we attempt to read or write data. This period is known as the settling time, and is typically around 15msec.

Track-0 detection

The head actuator arrangement allows the head assembly to be moved with precision over the surface of the disc. At switch-on, however, the heads could be in any position, so we must have some method of telling the computer where the carriage is located. This is done by providing a sensor to detect whenever the head assembly is over track zero (the outermost track). At start-up, or even during the normal operation of the system, the computer will issue a series of pulses to move the head assembly outwards one track at a time until the track-zero detector is tripped. This process is known as restoring the heads, and allows us to establish the position of the read/write heads. From then on, the computer can keep a record of the current head position, since the head assembly only ever moves in response to commands from the computer.

Index mark signal

As we have seen, the track zero detector allows us to establish the initial position of the read/write head(s). The head movement actuator then lets us position the head assembly over any desired track. In order for the computer to find where it is within any given track, however, further information is required. This is provided by a signal at a fixed point on every disc rotation. The index hole near the centre of the disc (see Fig. 3) coincides with the index window in the jacket once for each revolution of the disc. A beam of light from an l.e.d. is detected by a photoelectric detector whenever this occurs, and an index mark signal is sent back to the computer to indicate the start of a track.

Write enable notch

There is a further detector mounted inside the disc drive. This detects whether the write enable notch is covered or uncovered. The drive returns a signal to inform the computer whether or not the notch is covered, and the computer should always check whether a write operation is allowed before attempting to write to the disc. Data should only ever be written when the notch is uncovered; this should be checked by the disc interface/software.

Reading/writing

The read/write heads in the drive usually contain three ferrite cores. These consist of a read/write core in the centre, and an erase core on either side, i.e. one closer to the centre of the disc than the read/write core, and one further away. This arrangement provides erasure of the space between the tracks, shown previously in Fig. 4, and provides good isolation between data recorded on adjacent tracks.

The data written onto the surface of the disc is written one bit at a time (i.e. serially). The conversion from parallel to serial data is looked after in disc interface of the computer. The serial information (1's and 0's) is then converted by the computer interface into an encoded stream of pulses, synchronised to a clock. This stream is then supplied directly to the disc drive by the computer, and these pulses are then recorded onto the disc as magnetic flux reversals.

There are currently two forms of encoding used to represent serial data on the disc. The first is known as FM, and an example of FM-encoded bits is shown in Fig. 8 (a). Each bit cell contains a clock pulse at the leading edge of the cell, while the data bit (0 or 1) is located at the centre of the cell. FM encoding is used for what is known as single-density recording. The capacity of a typical disc track using single-density recording is 2560 bytes (10 sectors of 256 bytes). All currently available disc drives will support single-density recording. We can actually use any method of data encoding we like with a disc drive, so long as the speed of flux change is within the capability of the drive. It is also necessary that the encoding conforms to a recognised standard if the discs produced are to be interchanged with other systems. FM is the current single-density standard for 5·25in. floppy discs.

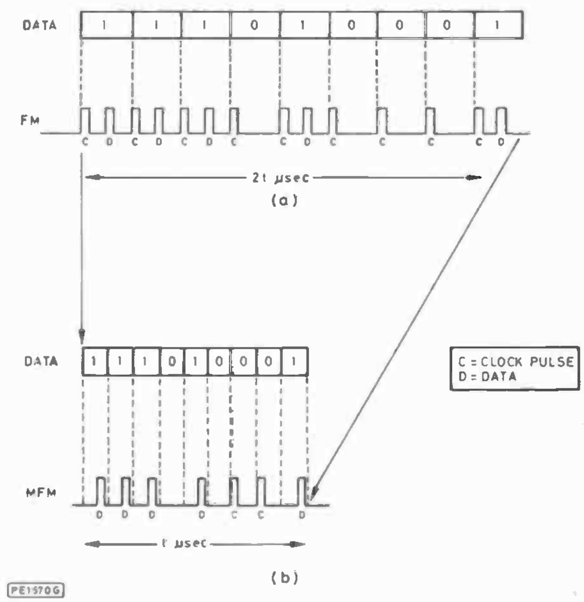


Fig. 8 (a). Data encoded in FM
(b). Data encoded in MFM

A development on FM recording is MFM (modified FM), where the data bits are again written at the centre of the bit cell, see Fig. 8 (b). However, a clock pulse is only written at the leading edge of the bit cell if no '1' bit was written in the previous bit cell, and no '1' bit will be written in the present cell.

The use of MFM recording allows a greater recording density (bits per inch of disc track) to be achieved. Double-density recording on floppy discs uses a combination of a higher clock rate and MFM recording to allow the amount of data stored on a disc track to be doubled to 5120 bytes. Disc drives are now often able to handle the higher frequency flux changes required by double-density recording. Such drives are then able to support either single- or double-density recording. The actual read or write signal generated then depends on the computer interface and software; the drive does not need to know the recording mode being used.

The capability of supporting double-density recording can be an important consideration when choosing a floppy disc drive. If not required immediately, the possibility of MFM recording will mean that the drives will be suitable for future upgrade to double-density.

Half-height drives

Recent developments in motor technology, and improvements in overall design, have allowed the height of floppy disc drives to be reduced, giving rise to the so-called half-height drives. These, as their name might suggest, are exactly half of the height of the original units. Typically such a drive is around 42mm high. In addition to reduction in physical size, which in itself is useful, the half-height drives usually also offer us greater performance and lower power dissipation.

Drive electronics

We have looked in detail so far at the mechanical operation of the disc drive. A floppy disc drive also contains a considerable amount of electronic circuitry, although this is getting progressively physically smaller due to the increasing use of special purpose integrated circuits of ever greater complexity.

The drive electronics contain circuits to convert the TTL-compatible command signals from the computer into electro-mechanical operations, e.g. head movement. In addition the circuits sense and report back to the computer the status of the drive, e.g. write protect. The drive electronics also contain analogue components to sense, amplify and shape pulses read from, or written to, the disc surface by the read/write head(s).

COMPUTER/DRIVE INTERFACE

The disc drive electronics communicate with the computer using a standard disc interface bus. This bus carries all of the command and status signals mentioned above. Most drives now adopt a standard arrangement of signals on the drive connector. This means that we can buy a drive from any manufacturer, knowing that it will be compatible with a unit from another source.

Pin	Signal
2	Spare
4	Spare
6	Drive Select 3
8	Index Pulse
10	Drive Select 0
12	Drive Select 1
14	Drive Select 2
16	Motor On
18	Direction Select
20	Step
22	Write Data
24	Write Gate
26	Track Zero
28	Write Protect
30	Read Data
32	Side Select
34	Spare

Table 2. Standard disc interface connections

The standard bus has 34 connections, and is summarised in Table 2. Only the even-numbered connectors are listed in the table because all of the odd-numbered ones are connected to signal ground. The signals on the bus are sent using high-current line drivers, and received using Schmitt-triggered receivers, and flat or twisted pair cables are used to connect the disc drive(s) to the computer.

The disc cable can be connected simultaneously to a number of different drives. Usually the cable goes from the computer to the first drive, with the second drive connected to the first, the third to the second, and so forth. The last drive in the chain contains the line termination resistors which are required by the bus. Commands to all of the drives are sent down the same cable, and the drive to which a particular command is addressed is determined by the signals on pins 10/12/14. The side selected on a double-sided drive is decided by the signal on pin 32.

In order to make the disc bus work in practice, it is necessary for each disc to have its own identity to be able to decide when it is being addressed. This identification is achieved by setting appropriate links inside the drive.

Needless to say, no two drives on the same cable should ever have the same identity! Fortunately, twin disc units usually come already set-up with the appropriate links. Full details are usually contained in the manual provided with the drives.

DISC INTERFACE

The disc interface is at the computer end of the bus, and is responsible for converting the high-level disc commands (issued by the disc operating system software) into disc drive commands on the bus. The heart of the interface circuitry is invariably a highly complex LSI disc controller chip, which is supported by ancillary SSI chips, e.g. the line drivers already mentioned. The floppy disc controller (FDC) chip is usually connected to the main processor bus inside the computer, and receives its commands directly from the CPU. It accepts command numbers and generates the appropriate sequences of pulses to instruct the drive to carry out the required operations. FDC i.c.s are usually capable of controlling more than one drive, although the structure of the bus means that only one is ever active at a time.

We will now look briefly at some of the functions performed by the disc interface in the computer. The majority of these functions are now usually performed by the FDC chip.

Drive selection

The controller allows the computer to specify which drive is to be used for a particular operation.

Track selection

The FDC issues a timed sequence of step pulses to move the head assembly from its current position to the proper track. The FDC usually stores the current track number for each drive, and computes the stepping distance and direction to move from the current track to the required track. The head select signal is also controlled to select the appropriate side of the disc.

Sector selection

The FDC monitors the data being read from the selected track until the requested sector is sensed. As we have mentioned, all disc transfers relate to complete disc sectors. The controller makes use of the index mark pulse in this operation.

Head loading

The disc controller determines the times at which the head assembly is to be brought into contact with the disc surface (loaded) in order to read or write data. The FDC is also responsible for waiting until the head assembly has settled before reading or writing. Often the controller will keep the head(s) loaded for up to 16 disc revolutions (approximately 3 seconds) after a disc access has been completed. This helps to avoid the overhead which is otherwise imposed by the head load time during periods of heavy disc usage.

Data separation

The signal recorded on the disc is, as we have seen, a combination of data and timing information. The signal actually recorded on the disc (as a series of magnetic flux reversals) is a combination of timing information (clock pulses) and data. The serial stream read from the disc must therefore be separated into two streams: clock and data. The serial data stream must then be assembled into 8-bit bytes for transfer to the computer's memory.

Data separation is not usually accomplished within the FDC chip itself, but usually uses external circuitry. In a single-density system this may be a simple monostable arrangement. In a double-density system, however, a phase-locked loop (PLL) arrangement is usual.

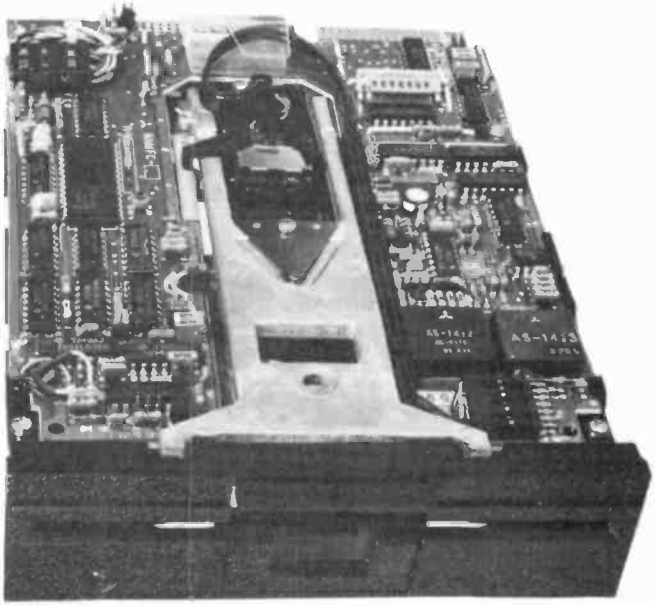
Error checking

The data recorded on the disc may by subjected to errors, usually classified as hard or soft errors. A hard error is caused by a disc defect, whereas soft errors are temporary errors caused by electro-mechanical noise or mechanical interference. Disc controllers use a standard error checking technique known as a Cyclic Redundancy Check (CRC) in order to detect such errors. When data is written to the disc, a 16-bit CRC value is also calculated, and this is saved with the data on the disc. When the data is subsequently read back, the controller re-computes the CRC for the data, and compares this new CRC value result with the one stored on the disc. If a CRC error is detected, the software in the computer usually re-tries the read operation a number of times to attempt to recover from a soft error. If the data cannot be reliably read after a number of attempts, the software usually reports it to the user as a hard error.

When a disc if verified by the user, this usually involves the computer checking the CRC value for each disc sector with the one it calculates during the check. Hopefully all of the CRC values will agree, but if not a number of retries will be made. If the CRC values still do not agree, then the sector is likely to contain a hard error.

SOFTWARE

We have seen so far what a floppy disc is, how a floppy disc drive works, and what the disc interface in the computer does. The missing link which remains between the user and the disc is the software to drive the disc interface. Depending on the computer, this may be supplied included



A Mitsubishi M4855 2 Mbyte disc drive (Altek Microcomponents)

in the computer's operating system from the start (unusual), or is more usually supplied (at extra cost) on disc/tape or in ROM.

As we have seen, the disc interface is responsible for converting the high-level commands from the software into disc drive commands. What then does the disc operating system (often abbreviated to DOS) software do for us? The simplest answer to this question is to look at the situation as it would be without a DOS.

It is obviously very cumbersome, but without a DOS it would be necessary, to refer to disc files in terms of their track and sector numbers. This would require us to remember where each file started and which sectors it used. Similarly, it would be tedious to have to instruct the drive to move the heads to the appropriate track in order to be able to read the file, to read the first sector, check the CRC result, . . . and so on. Add this to the frustration of having to start again if ever the order of operations is incorrectly specified, and all of a sudden discs are maybe not quite so wonderful.

The answer to this problem on small computer systems is known as a disc filing system (DFS), and is one version of a true DOS. The DFS makes use of the disc catalogue described earlier, and provides us with a number of commands to allow manipulation of files simply by name. The filing system software is then responsible for looking after where the file starts, for issuing the appropriate series of commands to the disc interface, error re-tries, reporting completion, updating the catalogues, etc. Instead of the horror picture previously painted, therefore, we can issue a simple keyboard or program command, and then sit back while the DFS does the rest of the work for us. As we mentioned, the DFS will in turn rely upon the FDC chip in the disc interface to do a lot of its work. The number, names and power of the commands provided vary from system to system. Typically, however, a user is able to: save a file, delete a file, load a file into memory, display the catalogue of a disc, rename a file, verify a disc, select a different drive, and many more.

When extending a computer system to include discs, therefore, a disc interface and filing system are required inside the computer. There may not be any choice of filing system for a particular computer, in which case there is little practical alternative but to use the one supplied. In other cases, such as with the BBC Micro, there is a choice of filing systems and of disc interfaces. In such a situation it is important to choose a combination which is compatible, and which provides the facilities required. Particular points to note in this respect are the ability to support the number of drives to be fitted now or in the future, the ability to support double-density recording if this is required, and software compatibility.

FINALLY

In this first article we have looked at the floppy discs, disc drives, interfaces, and disc filing system software which is usually involved in a disc-based small computer system. These four items are the essential ingredients which must be included in any small business or home computer system to upgrade it to floppy discs. However, these components must all be compatible if the system is to work at all. This month's article should help readers to make sense of the current floppy disc drive literature, and to determine the questions which need answering before embarking on a disc drive purchase for probably the most expensive of computer upgrades.

NEXT MONTH: we shall be looking at the range of floppy disc drives which is currently available.

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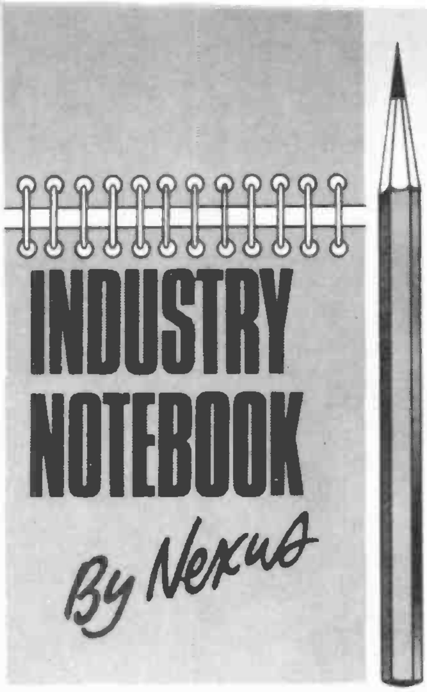


Overseas Aid?

Government support (or taxpayers cash) for new industrial projects has the objective of providing work for British people and a return on the capital provided.

Recent monumental flops suggest that much, if not most, of the cash finds its way overseas to the benefit of our competitors. The ill-fated, now extinct, electronic office company Nexos costing the taxpayer £31 million spent heavily on Japanese facsimile equipment. Also, there is still controversey over where the deLorean millions went.

The Lear Fan aircraft project is virtually at a standstill awaiting an airworthiness certificate. Lear Fan and deLorean were two great hopes for Ulster employment. Lear Fan may yet be resurrected next year but deLorean is dead. These three projects provided only a few hundred jobs, now lost, at a cost of perhaps £150 million with virtually nil return.

A brighter note can be struck with Inmos. It was just six years ago that I was welcoming the birth of Inmos with its promise of 4,000 jobs in four UK factories from technical leadership in the then new field of Very Large Scale Integration (VLSI).

Three years ago (July 1981 issue) I was noting that although Inmos now had some products to sell, nearly all the investment and subsequent employment had been in Colorado Springs, USA. I received some frosty letters after my assertion that it would take a good deal of imagination to believe that Inmos would ever employ 4,000 people in the UK.

By May this year, after spending over £100 million, Inmos employed 584 people in the UK compared with 850 people in the USA. Forward projections are for about 1,100 in both locations by the year end. The promised 4,000 jobs in the UK is now admitted to be unrealistic.

On the plus side Inmos is now making a trading profit and the three founders who made a modest investment stand to emerge vastly enriched, a figure of £18 million having been mentioned. The fact remains, however, that of the £100 million or so provided, about £75 million has been spent enriching the US economy at no cost to the US Treasury while £36 million has been spent in the UK at great cost to ourselves.

The Inmos Transputer, which may yet prove to be a runaway success, is not available. Prototypes should be ready by the end of the year and first production in the early months of 1985. Market price is expected to be about £300 initially, falling to £50 or less when production speeds up in 1986.

No Future In Investment!

The Government is reluctant to invest further in Inmos believing that private investment should take the strain. American Telephone and Telegraph Corporation are interested in buying Inmos.

Rumours are rife. A depressed area in Holland is said to be offering attractive terms for an Inmos production plant. Another story is that AT & T would transfer Inmos designers to ICL thus opening the door to Japan's Fujitsu who have a technology exchange agreement with ICL.

The whole matter may be resolved by the time this comment appears on the bookstalls. The lesson to be drawn is that publicly funded enterprises need far more day-to-day scrutiny and tighter financial control. Best of all that Government should keep out of business altogether.

Gracious Living

I recall it was the late Sir Alan Clark of Plessey who had a fondness for having his research laboratories in fine old mansions with spacious grounds. It was said that he disliked hotels and as a guest at some of the Plessey stately houses I can testify that they are well above average hotels in comfort, elegance and the pleasures of the table.

When IBM set up a UK research centre they, too, chose an imposing manor. The trend continues with a new generation of entrepreneurial boffins, mainly in computers, who have chosen rural tranquility rather than urban chaos as of benefit to creative endeavour.

Conversion costs have soared since Sir Alan's day. Sir Clive Sinclair, for example, is reported to be spending £2 million on his prestigious Milton Hall, eighteenth century homes of his MetaLab research company.

Even without the oak beams and panelled walls the better lifestyle is a feature of today's employment come-on. British Aerospace is opening a new design and development facility at Plymouth offering "a breath of fresh air for high-tech engineers".

Plymouth, too, is to be the home of Plessey's £50 million investment in a new microchip factory which will employ some 250 people by 1986, ultimately 600. Sir John Clark, announcing the new plant, stuck strictly to business. Why Plymouth? Because it has development area status (meaning hand-outs), good communications and skilled labour, the latter being presently employed at similar plants in the area although he didn't say that.

I note, too, that Monsanto has chosen Milton Keynes as the site for a £35 million investment on wafer production. MK is perhaps the most attractive of all inland locations for those inclined towards modernity and claims to have created 50,000 new jobs.

For the R & D man, however, what could be better than the mansion in parklands? The civilised academic atmosphere and, after tea, who's for tennis?

Prejudice

Few people other than those directly involved are aware of the submerged obstacles that bedevil our exporters, not least political prejudice. I will confine myself to two recent examples.

The first resolved itself in our favour when Short Bros of Belfast won a 165 million dollar order from the US Air Force for Sherpa transport aircraft. Opposition came from competing manufacturers in the normal course of trade but added to it was noisy protest from the powerful Irish Republican lobby in the USA alleging that Shorts discriminated against Roman Catholics, an allegation unproven. In the end Shorts not only won the intial order for 18 aircraft but also an option for the supply of an additional 48.

My other example is the decision by Spain to buy the French Roland air defence missile system despite the fact that British Aerospace offered Rapier at a substantially lower price. One is left with the suspicion that the decision may have been more to do with Spanish sympathy for the Argentine over the Falklands and Spain's own claim to Gibraltar rather than on price and technical merit. Well, you can't win 'em all.

China

The last remaining huge market now opening to industry is China, still engaged in hot debate on the type of communism best suited to expansion. Among the models elsewhere are the Soviet Union and the less rigid Yugoslavian and Hungarian.

The model now unanimously rejected is that of Mao Tse-tung who died in 1976. Mao was an out-and-out idealist who insisted that workers didn't need extra money to work harder. The new leaders realise that incentives are required. And, of course, the introduction of more technology.

Racal has not waited for a final resolution of the China debate, preferring to get in and sell. I have already reported Racal's joint ventures with the China National Offshore Corporation.

Since then Racal has supplied a harbour surveillance radar system worth nearly £1 million. Also, Racal Marine Radar has just concluded a £3.25 million joint manufacturing agreement whereby the 4th Shanghai Radio Factory will make ships radars including the latest Automatic Radar Plotting Aid (ARPA).

David Elsbury, Racal's deputy chief executive, has revealed that more then 20 cooperative and technology transfer projects are under negotiation but competition is fierce.

neptune ROBOTS

RICHARD B. H. BECKER, SYSTEM DESIGN AND MECHANICAL ENGINEERING.
TIM ORR, COMPUTER INTERFACE AND CONTROL ELECTRONICS. **PART ONE**

PREVIOUS articles in this magazine have introduced a number of robots which have found considerable use in educational establishments and industrial research and development laboratories. The Micrograsp was the first miniature robot to have servo control of each axis and the Genesis family of robots were the first to use low pressure hydraulics. Over 1,000 of these self-assembly kit robots have now been produced.

Low pressure hydraulics are used also in the NEPTUNE robots but instead of using hydraulic oil, which makes experimentation and operation rather messy, NEPTUNE uses ordinary tap water. Special techniques were developed to make this possible and will be described later. The NEPTUNES are substantial machines suitable for industrial as well as instructional use. MENTOR is a sturdy little desk-top all-electric robot with full servo control over each axis and it is configured to move in a manner similar to the Unimation Puma robots which although market leaders in industry carry a £20k+ price tag precluding their use for training purposes.

Also to be covered is a new means of robot programming using a simulator teaching pendant. All three robots are available as self-assembly kits and interface with the Commodore VIC 20, Sinclair ZX Spectrum and BBC computers. The interfaces to these computers include data-out as well as data-in facilities enabling considerable computer interaction with the robots.

ROBOT POPULATION

The robot population of this country is rising at a higher percentage rate than that of any other industrialised nation. During 1983 the number of industrial robots rose from 1152 to 1753—a 52% increase! Good news though this increase is, we do however still lag far behind West Germany (4800 robots) and even further behind Japan (16,500). The Americans have 8000. The Japanese, although not noted for innovation, are first class production engineers and their realisation of the significance of robots in automation has greatly facilitated their domination of world markets for an ever-increasing number of consumer products. Gone are the days of their exporting the product of cheap labour.

Japanese success now relies on efficiency of manufacture. With the increasing ease of transporting goods around the world we too must achieve a high degree of efficiency using high levels of technology to assist us. Using the same machinery, companies in countries like Taiwan or Sri Lanka could readily beat us on price on account of their low labour rates. Success on equal terms with them can result only in our becoming a third world country too. Our future success depends upon our ability to purchase high technology automatic manufacturing equipment and also upon our ability to understand and fully utilise it. This country still has capital available and automation we can and must afford. Our educational establishments have the ability to provide the background understanding and familiarity with robotic automation if we invest in equipment for education as well as industry. Familiarity with robotic technology is also essential if this country is to be significant in manufacturing as well as using robotic equipment. Are we to allow the Japanese to dominate the industrial robot market too?

INDUSTRIAL ROBOTS

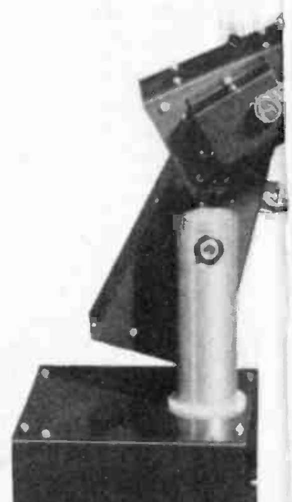
The industrial robot is not to be confused with the androids of science fiction. Whilst there is little doubt that androids will

NEPTUNE I

Robot kit including Power Supply: £1250

NEPTUNE II

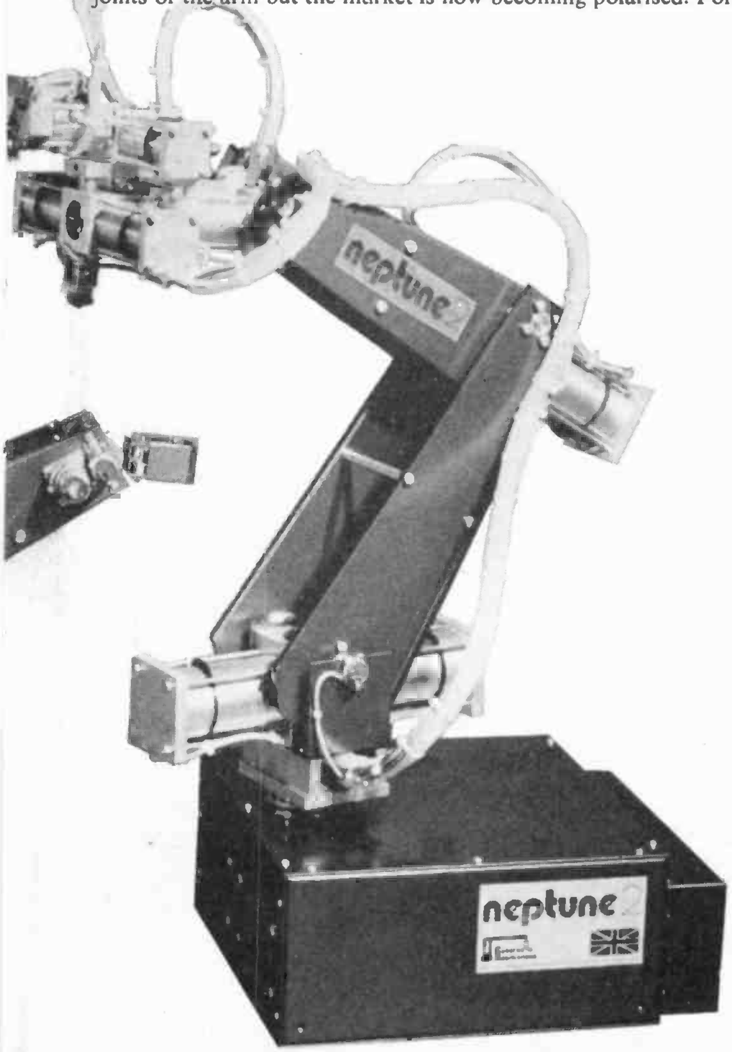
Robot kit including Power Supply: £1725



eventually become reality, at present the robots in industry are mostly fixed position, single arm mechanisms at the end of which is a tool or gripper which can then be moved in a programmable manner. The program is the sequence of movements which will be carried out repeatedly until an external stimulus such as a signal from a parts detector or vision system occurs. The program is handled by a microprocessor based control system and can be readily changed to enable the robot to perform a new task.

The tasks for which most industrial robots are currently used include spot welding, arc welding, surface coating (e.g. paint spraying), handling of components between machining operations and assembly operations. Currently the automobile industry is the major user of robotic equipment: 94 robots have been installed on the new Maestro/Montego production line at Cowley. Car production is a particularly competitive business and following the Japanese lead, robotic automation was inevitable for it and must now spread rapidly throughout the rest of the industry. This will be aided by the steadily falling costs of the computing power which is necessary for intelligent interaction of robots with their environment.

The tool or gripper of an industrial robot is moved through three dimensions by a single jointed arm, usually of two sections, providing the major movements, and a complex wrist at the end of it for rotational and final close positioning movements. There are a number of possible ways of producing the motion of the joints of the arm but the market is now becoming polarised. For simple movements in situations where little program change is required, pneumatics is used. These are non-servo robots. A servo controlled robot is one where there is a continuous feedback of data from the joint, indicating its position and thus enabling the control system to correct any error. With pneumatics, fixed stops are used and intermediate positions are not possible.



Many such machines fall outside current definitions of robots. The British Robot Association includes in its figures for industrial robots only those machines which have four or more axes of movement and are programmable. More complex tasks require versatile programmability and in the smaller sizes of servo controlled robots electric motors dominate. Although stepper motors are used extensively on machine tools, only a small proportion of industrial robots employ them and d.c. servo motors are the norm. For high power applications hydraulics are the most cost-effective technique despite the high cost of controlling the oil flow with the servo valves which are usually used.

THE PROBLEMS OF FRICTION

The NEPTUNES are hydraulic robots using a new technique offering a number of important advantages over previous designs. The author, having had considerable experience on hydraulic robots, has cursed frequently the characteristic of hydraulic cylinders of adding the feature of "self lubrication" to robots. Seepage past seals is inevitable. Seepage can be reduced by tightening up the fit of the seal: however this leads to increased friction and stiction—which is the static friction which occurs after the piston has stopped moving. An extra large force is then required to start motion again and jerkiness at low speeds can occur. Furthermore some fluid spillage is bound to occur during commissioning, resulting not infrequently in the lubrication of the commissioner too! Water would be a much more pleasant hydraulic fluid, but unfortunately would not work in a conventional hydraulic system. This is because water is a very poor lubricant and the cylinders would seize up and destroy their seals. Water-oil emulsion is usable and sometimes is used on very large hydraulic installations for reasons of economy but it is little more pleasant a material.

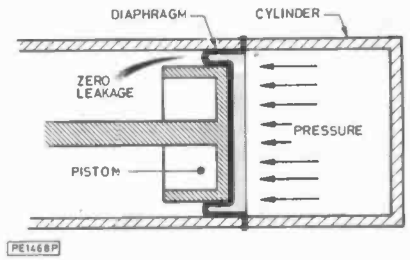


Fig. 1.1. Rolling diaphragm installed in cylinder

The problem of friction in hydraulic cylinders can however be totally bypassed by use of rolling diaphragm seals which are inherently frictionless. The use of water then becomes possible. Rolling diaphragm seals (Fig. 1.1) are inherently leak-free too, though with water as the working fluid this feature is less important. Formed in the shape of a truncated cone or top hat, the diaphragm is turned in on itself when installed so that during the stroke, it rolls and unrolls alternately on the piston skirt and on the cylinder wall. The rolling action is smooth and effortless, completely eliminating sliding contact and break-away friction. With its outer flange clamped to the cylinder and its centre fastened to the piston head the diaphragm forms a perfect barrier. Unlike "O" rings, cup seals and other conventional sealing devices the diaphragms require no lubrication.

A rolling diaphragm is constructed from a layer of specially woven Dacron fabric impregnated with a layer of nitrile elastomer. The fabric which provides the high tensile strength of the diaphragm is designed to permit free circumferential elongation (allowing free rolling action) whilst preventing axial distortion eliminating stretching or ballooning during the stroke. These diaphragm seals can withstand pressures up to 200 bar (2900psi).

WATER-POWERED ROBOTS

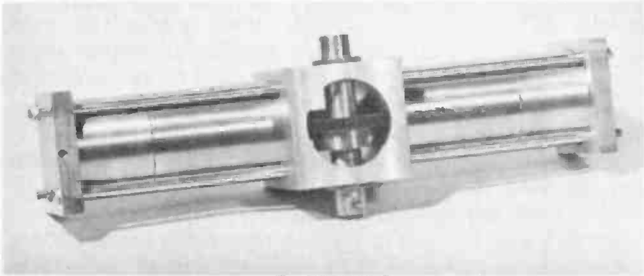
Water, being partially ionised, has the drawback of inducing electrolyte corrosion so great care is required in the design of a water-containing system. Corrosion will occur wherever there is contact between dissimilar metals which have a difference in electrolyte potential of more than 600mV. This problem has been avoided in the NEPTUNES by extensive use of plastics where there is a contact with water.

Another characteristic of water to be considered is its viscosity. The viscosity of water is substantially less than that of hydraulic oils which makes the pump design more demanding; but it does mean that much smaller pipes can be used and even with the low operating pressure of 8 bar (116psi), only 4 and 5mm bore pipes are required. The pipework can then be treated like wiring and the kits are supplied with pipework already made up into a wiring (plumbing?) loom. The viscosity of all fluids changes with temperature and hydraulic oil thins down considerably as it warms up, affecting robots' speed of operation. This makes them a bit human-like in being slower first thing in the morning! In Japan, robots are given warming-up exercises at the same time as the workforce are subjected to massed physical training! Interestingly water has a viscosity change with temperature of less than half of that of hydraulic oil, further justifying the design efforts to use it as a working fluid.

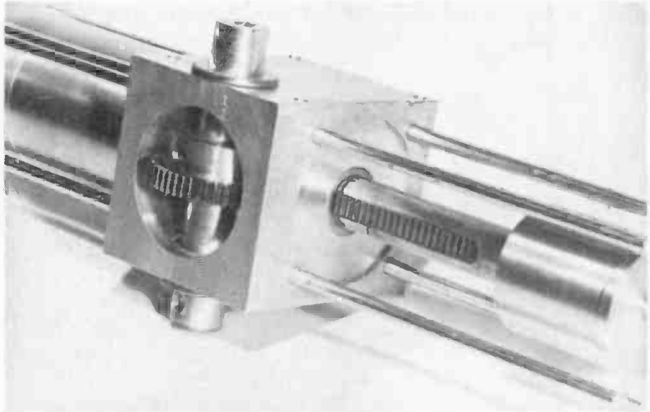
Hydraulic cylinders can be used to act directly upon the arms of a robot (Fig. 1.2), but on the NEPTUNES power is applied via a rack and pinion driven by a cylinder at each end (Figs. 1.3, 1.6). Whereas a directly acting system has a limit of about 90° to its movement there is no limit for a rack and pinion and movements between 150° and 270° are used for the various axes (Fig. 1.4). Furthermore the torque from a directly-acting system falls off at the ends of its travel whereas torque is constant during the travel of a rack and pinion. Having a cylinder at each end of the rack means that it is not necessary to rely on gravity for the return of the arms from their lifted position.

THE HYDRAULIC SYSTEM

Early school electricity is sometimes taught using water as an analogy, with pressure representing voltage and water flow representing current etc. For those with the familiarity with electricity and electronics to be readers of *Practical Electronics*, it is probably easier to use the analogy the other way round and the circuit diagrams are shown with electrical symbols. B.S.I./I.S.O. fluid power symbols are rather less than obvious to the uninitiated. See Fig. 1.5.



Complete hydraulic cylinder assembly



Detail of the rack and pinion mechanism

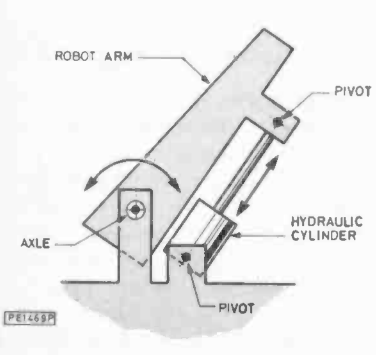


Fig. 1.2. Using a hydraulic cylinder to directly move a robot arm

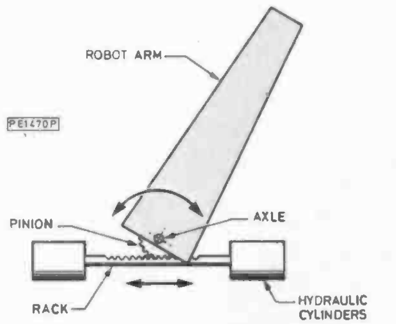


Fig. 1.3. Using a rack and pinion to transfer power from hydraulic cylinders to a robot arm

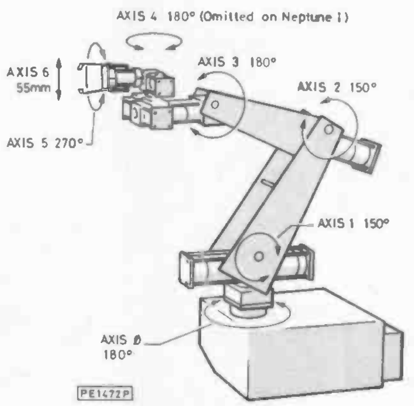


Fig. 1.4. NEPTUNE's degrees of freedom

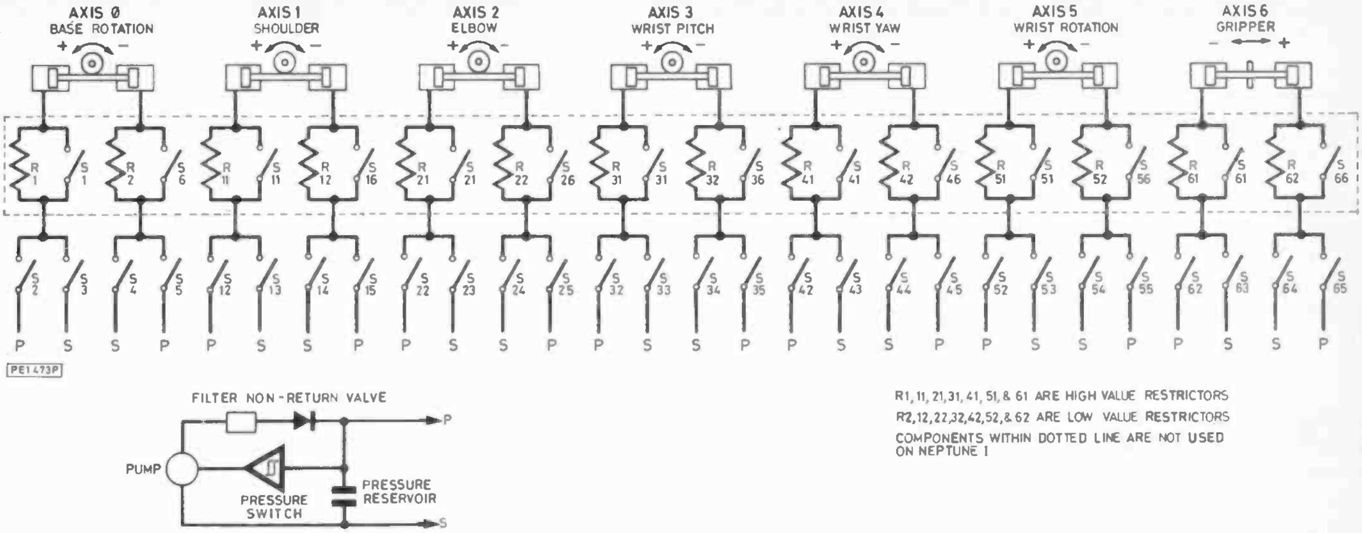
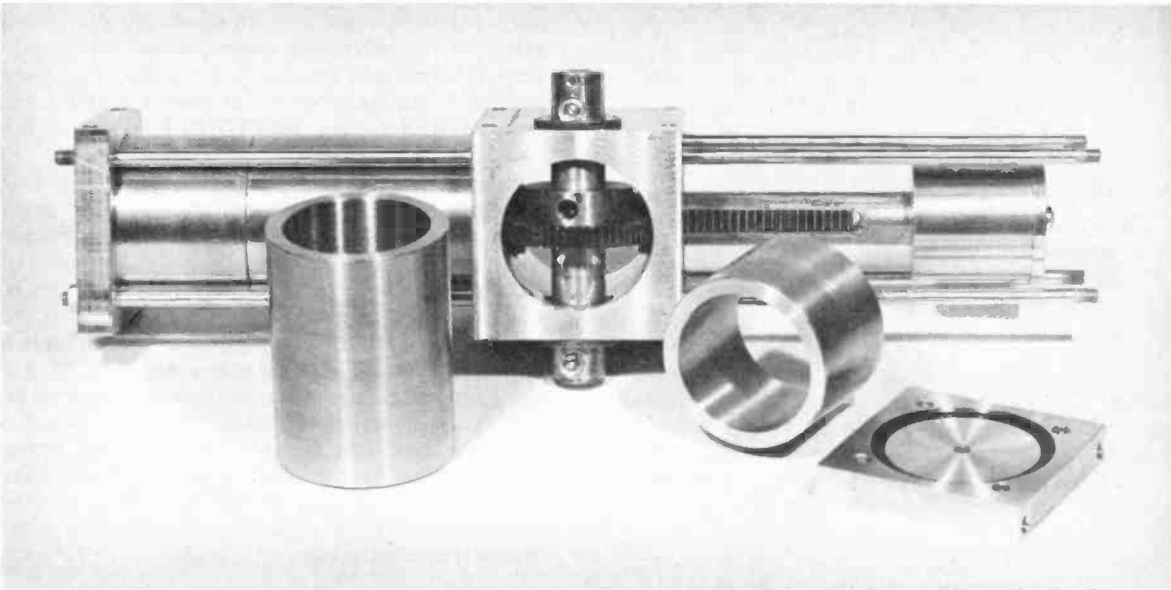


Fig. 1.5. The hydraulic system of NEPTUNE



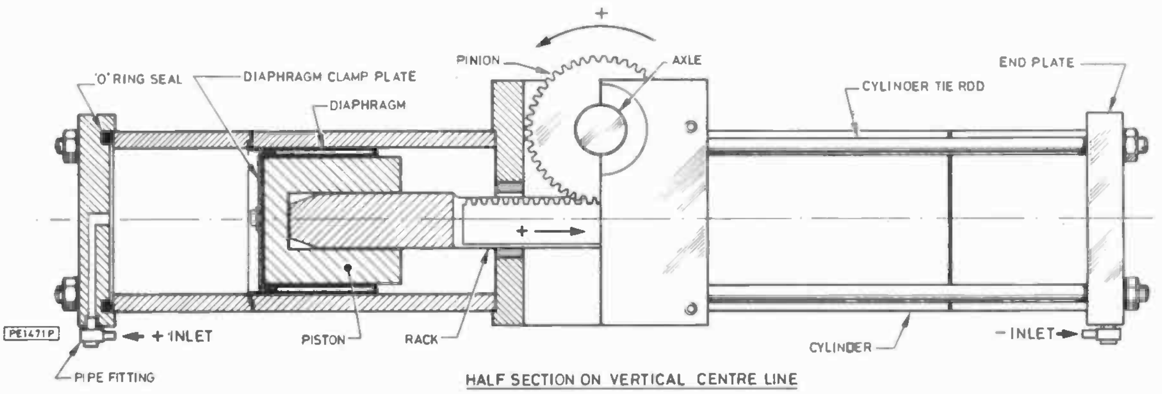


Fig. 1.6 and photo. Hydraulic cylinder assembly of NEPTUNE

The power source is a mains-driven peripheral motor pump (voltage source P) in which the water is hurled from the ends of the rapidly rotating blades (Fig. 1.7) through the outlet orifice, through a filter to remove any particles that have fallen into the sump and then through a non-return valve (diode) into a pressure reservoir (capacitor). A pressure switch with hysteresis (Schmitt trigger) controls the pump so that the pump only turns on after a large amount of movement of the robot has occurred. The motor is rated at $\frac{3}{4}$h.p. and on starting it takes considerable current. To ensure a long life for the switch, a triac is used in series with the motor and only the triac gate current passes through the switch contacts. The pressure reservoir (Fig. 1.8) is a heavy aluminium casting with a spherical chamber enclosing a bladder full of compressed air. When the water is pumped in, the air is compressed further and after the pressure has risen to the limit set by the pressure switch and the pumping has ceased, the compressed air provides a reserve of energy expelling pressurised water to operate the robot. Separation of the air from the water by a bladder is necessary to prevent it from dissolving in the water thereby disappearing from the system. The pressure reservoir is fitted inside the sump beneath the pump.

For portability of the system and to keep mains-borne transients away from the control circuitry the hydraulic power supply is a separate unit. The pressurised water is taken from the pressure reservoir through a flexible hose via self-sealing plug-in connectors. Water is returned from the robot to the sump with a similar hose. The hose plugs into the manifold in the base of the robot.

The manifold acts like a printed circuit board (Fig. 1.9) making the connections to the solenoid-operated valves which control the water flow. Each axis of the robot is powered by an opposing pair of hydraulic cylinders driving a rack and pinion with a position-sensing feedback potentiometer connected to it. The potentiometers used are of a new design using conductive polymer which has excellent linearity and smoothness. They also feature continuous rotation so there is no possibility of their being torn apart if incorrectly fitted. The potentiometers measure directly the angle of the axis movement and, being fed by a precision voltage source, this system ensures reliable positioning with excellent temperature stability.

SERVO SYSTEM

The servo electronics compares the position of the axis with the target position generated by the computer. In NEPTUNE II if there is a large difference between these two positions then the axis moves rapidly. When there is a "medium" difference the axis moves at a medium pace. When the difference is small the axis then moves at a slow pace. When the difference reaches zero the axis stops. Thus the axis servos itself in such a way as to attain the position dictated by the computer. The position data from the computer can be changed at any time and the spread would then change automatically to suit the new difference. The slow and medium speeds prevent "hunting" of the axis as it approaches the target position whilst still being sensitive to very small changes in the target. This allows the arm position to approach the 12 bit resolution of the electronically generated target value. NEPTUNE I, having an 8 bit control system, does not have the additional speeds.

Solenoids are used to open and close the hydraulic valves (switches) and those which connect to the pump or sump are fitted to the manifold. S2 and S5 connect to the pressure reservoir whilst S3 and S4 connect to the pressure sump. The other end of each of the valves is fitted to a connector bar (one per axis) on which the speed control valves S1 and S6 are also fitted together with the bypass restrictors (resistors). The restrictors consist of a polyacetal block (Fig. 1.10) with a hole through it which links the input to the output. Into the hole fits a tapered peg which is threaded, making them in effect pre-set resistors. A simple fine bore hole could have been used instead of this arrangement but the hole would have then been less than 0·3mm diameter. Holes of this size are not only difficult to drill but very awkward to clean in the event of a blockage. The dynamic response of the system is detailed in Figs. 1.11, 1.12.

NEXT MONTH: The electronic control system for NEPTUNE and the computer interfacing requirements.

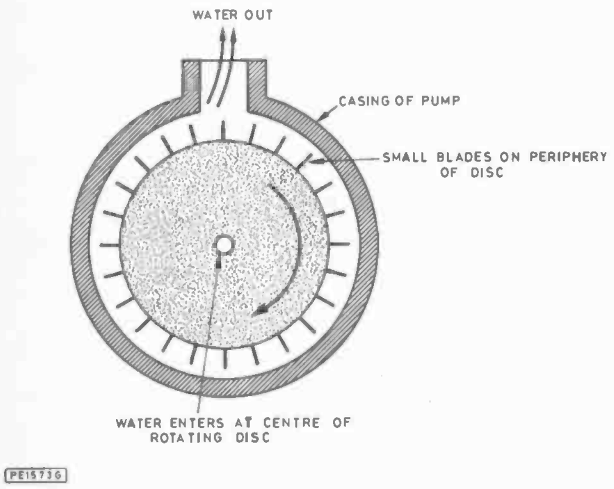


Fig. 1.7. Operation of peripheral motor pump

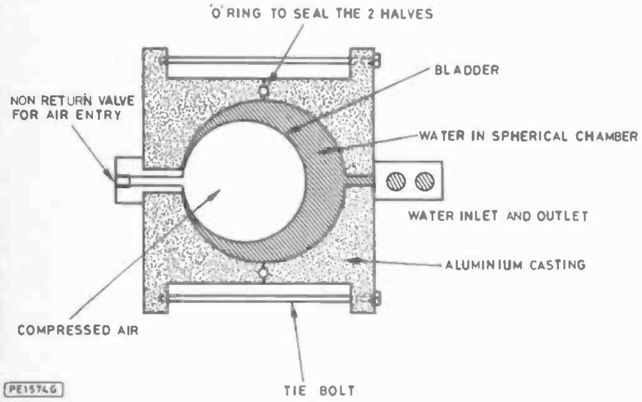


Fig. 1.8. Construction of pressure reservoir

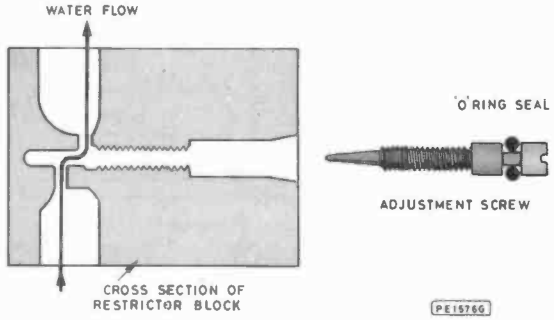


Fig. 1.10. Hydraulic restrictor

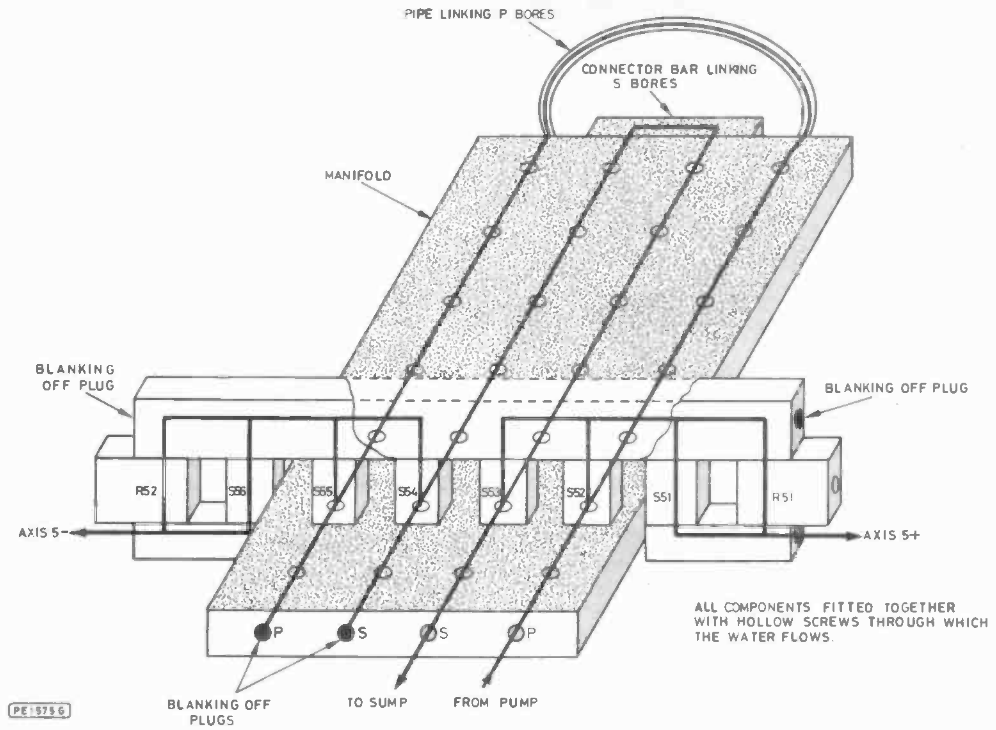
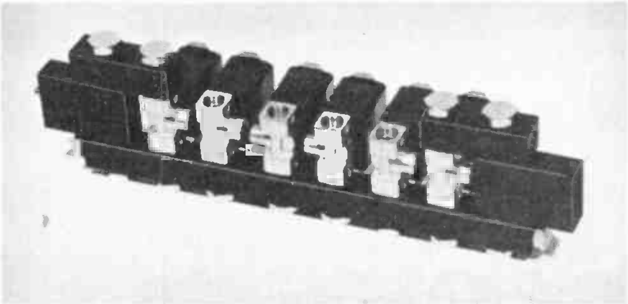


Fig. 1.9. The manifold showing the valves and restrictors of axis 5



The solenoid-operated valve subsystem

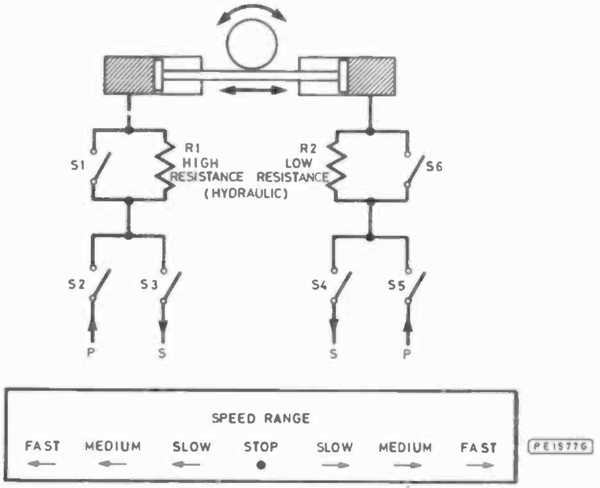
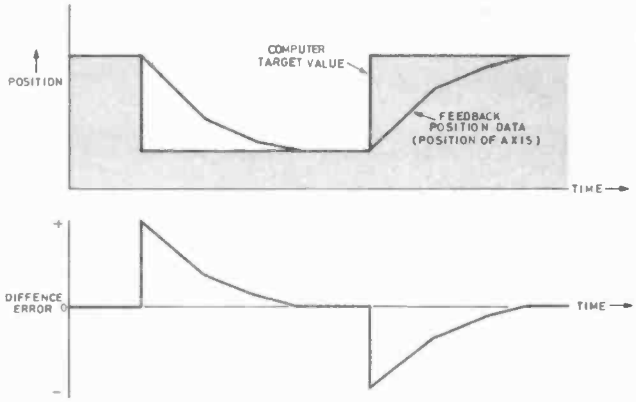


Fig. 1.11. Operation of the hydraulic system



MODE	STOP	FAST ↓	MEDIUM ↓	SLOW ↓	STOP	FAST ↑	MEDIUM ↑	SLOW ↑	STOP	
S1	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF	SPEED
S2	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	DIRECTION
S3	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	DIRECTION
S4	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	DIRECTION
S5	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	DIRECTION
S6	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	SPEED

↑ SOLENOIDS

PE1578G

Fig. 1.12. Axis response to a change in position data

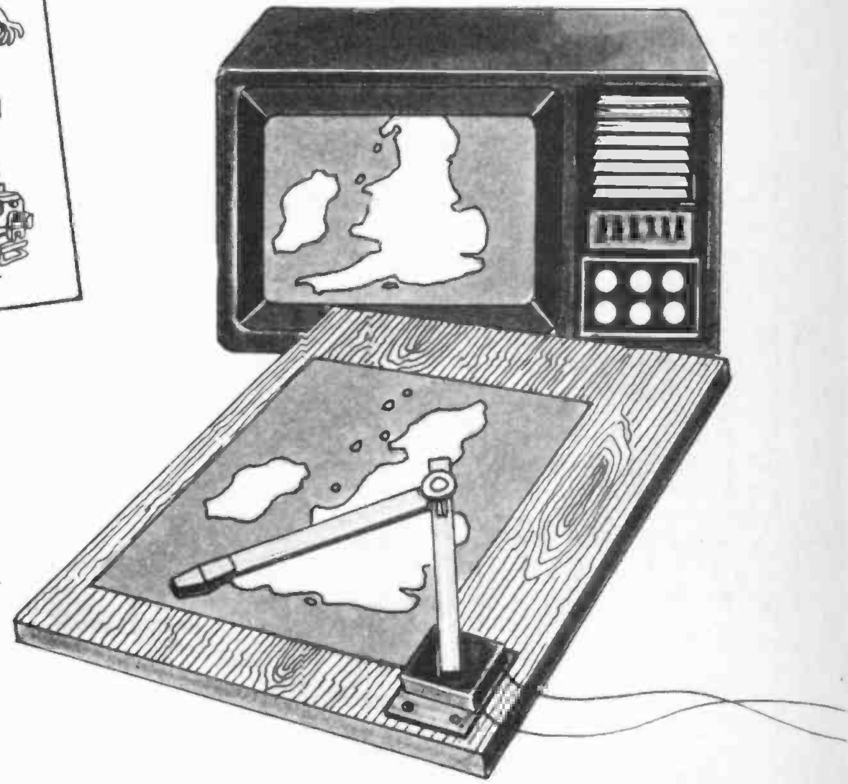
Solenoids S2, S3, S4, S5 control direction. With S2 and S4 ON, the axis advances. With S3 and S5 ON, the axis retracts. Solenoids S1 and S6 are speed controls.

When the arm is a long way from its final position, both S1 and S6 are ON. Therefore both restrictors are shorted out and the motion of the arm is rapid. When the arm is close to its final position, S6 turns off and so a low resistance is presented. The arm then moves at a medium speed. When the arm is *very* close to its final position, S1 also turns off. Now a high resistance is presented to the system. The arm then moves slowly to the final position. When it reaches this position, *all* the solenoids turn off, and the arm stops.

SEPTEMBER FEATURES...

MICROCOMPUTER DIGITISER

Producing complex images such as maps on a computer screen can be a difficult task but using our digitiser to trace over an existing drawing, passing its co-ordinates onto the computer, makes it simple.



GUITAR HEADPHONE AMPLIFIER

Very low cost guitar practice amp for use with headphones. Will also keep the neighbours happy . . .

EVERYDAY ELECTRONICS and computer PROJECTS

SEPTEMBER 1984 ISSUE ON SALE FRIDAY, AUGUST 17

Through the Mains Controller

R.A. PENFOLD

THIS project is primarily designed for use with a home computer to enable it to control pieces of mains powered electrical or electronic equipment. It operates by sending a signal through the mains supply so that no connecting wires from the controller unit to the receivers are necessary. The system should work well between any two rooms of a house, or between a house and an outbuilding provided they are on the same mains circuit. Systems of this type are not suitable for long distance use though. The controller can be used with up to four receivers, and each receiver has a relay that can control mains loads of up to 10 amps (or some 2400 watts with the 240 volt UK mains voltage).

Although the circuits used in the system are quite simple and the equipment is fairly inexpensive to construct, the system has good reliability and operates well in practice. The use of a phase locked loop tone decoder device in each receiver largely accounts for this combination of simplicity and good reliability. The controller can be driven directly from any computer that has a built-in digital output port, and the prototype equipment has been used successfully with a VIC–20, Commodore 64, Atari 600XL, Atari 800, and BBC model B. It should also operate perfectly well with any computer having an add-on output port, such as the units that are popular for use with the Sinclair ZX81 and Spectrum computers. The unit could easily be modified to give manual control (from a central point) of up to four items of digital timing or control circuit.

THE SYSTEM

The block diagram of the system is shown in Fig. 1, but only a single receiver unit is included here. However, the receivers all use the same circuit.

The transmitter is little more than an oscillator operating at a frequency in the region of 200kHz. The oscillator is normally switched off, but it can be brought into action by operating one of four electronic switches. These are actually operated via an opto-isolator which ensures that the computer providing the control signals is totally isolated from the mains supply. Apart from bringing the oscillator into operation, the electronic switches also provide control for the output frequency of the oscillator. Each switch gives a different output frequency so that by tuning one receiver to each frequency four receivers can be independently controlled.

The receiver circuits are designed to respond to short bursts of signal from the transmitter, and each time a burst of signal is received the relay changes state. The alternative of having a relay switched on when the relevant frequency from the transmitter is present would be more difficult as the transmitter would have to be capable of providing up to four frequencies simultaneously.

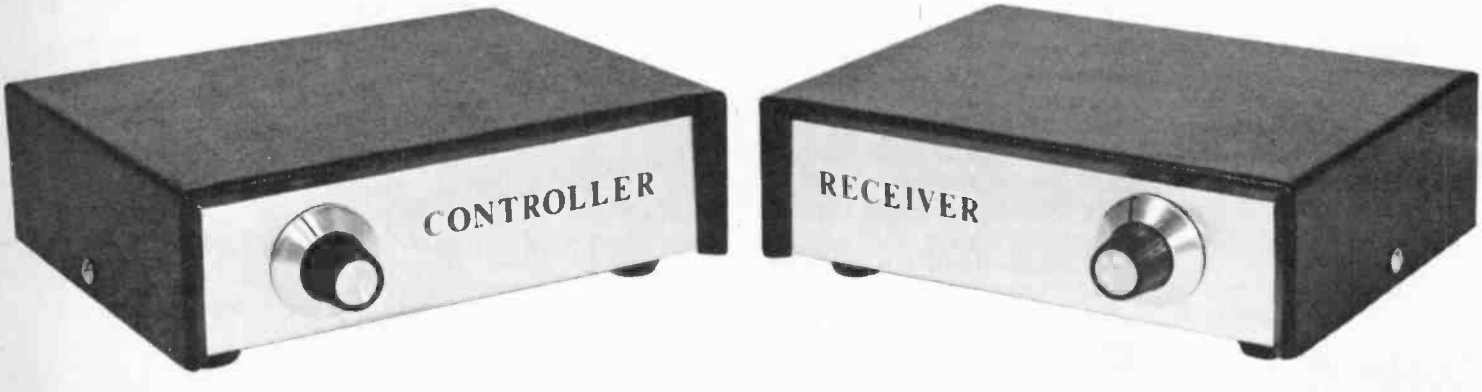
There could also be difficulties with the signals interacting with one another and preventing the system from operating properly. This successive switching system is probably the most simple solution and can be designed to give very reliable results.

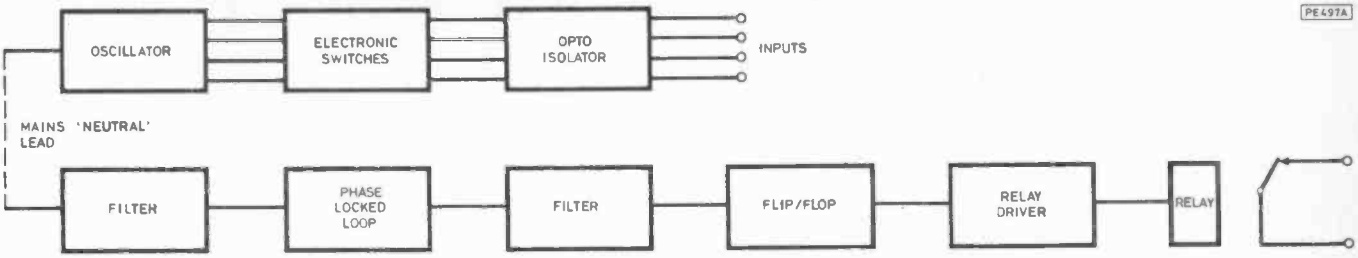
The transmitted signal is carried by the "Neutral" mains lead. A filter is used at the input of the receiver to reduce out-of-band noise, and this is also a step-up transformer which gives a higher level, higher impedance signal that is well matched to the next stage.

PHASE LOCKED LOOP

The next stage is the phase locked loop tone decoder, and this is actually a fairly complex piece of electronics, as can be seen from Fig. 2, which shows the phase locked loop in block diagram form. The particular device used in this design is the NE567 incidentally.

The NE567 is specifically designed for use as a tone decoder, and it includes some additional stages not normally found in phase locked loop integrated circuits. The phase detector, lowpass filter, and current controlled oscillator (CCO) form a conventional phase locked loop. The phase comparator is used to compare the output of the CCO with the input signal. If the CCO is at a lower frequency than the input signal, or even just lagging it in phase, the phase comparator produces an increased output current that boosts the frequency of the CCO. If the CCO is at a higher frequency than the input signal, or leading it in phase, the phase comparator produces a lower output current that reduces the frequency of the CCO. This results in the CCO accurately tracking the input signal in terms of both phase and frequency, provided the input signal frequency remains within the lock-





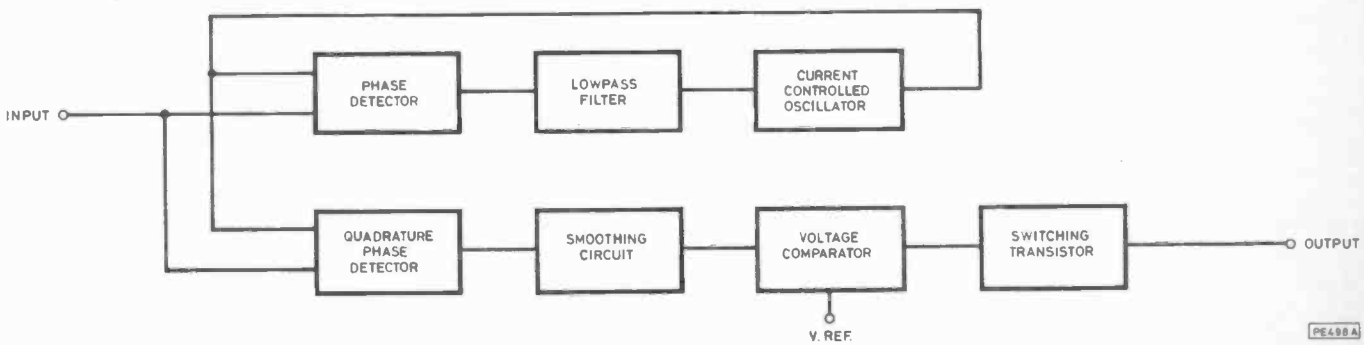


Fig. 2. Block diagram of the NE567 phase locked loop

ing range of the loop. The NE567 purposely has a narrow locking range of typically only about plus and minus 5 per cent. This narrow locking range helps to give good noise immunity, and it also enables several tone decoders to operate at closely spaced frequencies. The purpose of the lowpass filter is to smooth the output of the phase comparator to produce a reasonably stable control current for the CCO.

The input and CCO signals are compared by another stage of the device, the quadrature phase comparator. This can be regarded as a sort of electronic switch that enables the input signal to pass when the output of the CCO is positive going. If the loop has locked onto the input signal, the latter will be positive going at the same time as the CCO, and only positive input half cycles will appear at the output of the quadrature phase comparator. In other words, the input signal will have been halfwave rectified. If lock is not achieved, the input and CCO signals will be randomly phased, giving a mixture of positive and negative output half cycles from the quadrature phase comparator.

The output of the comparator is smoothed, and provided lock has been achieved a strong positive bias will be produced. If it has not, the mixture of positive and negative signals cancel out one another and give zero volts at the output of the smoothing circuit. A voltage comparator is used to detect the positive signal when lock has been achieved, and it then switches on an npn switching transistor. This transistor is therefore switched on whenever there is an input signal within the locking range of the circuit.

If we now return to Fig. 1, the output of the phase locked loop is fed to a divide-by-two flip/flop circuit via a lowpass filter. The latter is needed to eliminate spurious output signals from the phase locked loop caused by strong noise spikes on the mains supply. Each time a burst of signal is applied to the phase locked loop it generates a negative output pulse which toggles the output of the flip/flop to the opposite state. The output of the flip/flop drives a relay via a simple relay driver stage, and the relay in turn controls the load via a set of normally closed contacts. Successive bursts of signal from the transmitter therefore switch the load off, then on, then off again, and so on.

TRANSMITTER CIRCUIT

The full circuit diagram of the transmitter is shown in Fig. 3.

The circuit is powered from a straightforward non-stabilised mains power supply which gives a loaded output voltage of about 7·5 volts. The VCO is a standard 555 astable circuit which has its output loosely coupled to the "Neutral" mains lead by way of C12. The timing resistance for IC4 is formed by R6 and one of four electronically switched resistors (R7, R9, R11 and R13). This gives four switched output frequencies, with the desired frequency being selected by activating the appropriate transistor (TR2 to TR5). Each of these transistors is activated by another switching transistor (TR6 to TR9), and the reason for using this high level of gain is to ensure that the output frequency is almost totally independent of the input drive current. This is certainly achieved, and there is no significant change in output frequency using any drive current from a few tens of microamps to several milliamps. IC5 is the opto-isolator, and this has four infra-red l.e.d.s with each one driving a separate phototransistor. By driving one of the l.e.d.s the corresponding phototransistor can be made to switch on and activate the transmitter. There is no direct connection from the computer to the main circuit, and the computer is left totally isolated from the mains supply.

The cathodes of the l.e.d.s are wired together and connect to the ground terminal of the computer port. The anodes are then taken high (but only one at a time) to activate the circuit. There are no current limiting resistors in series with the l.e.d.s as most computer ports can only provide a very limited output current (typically about 1 milliamp). Current

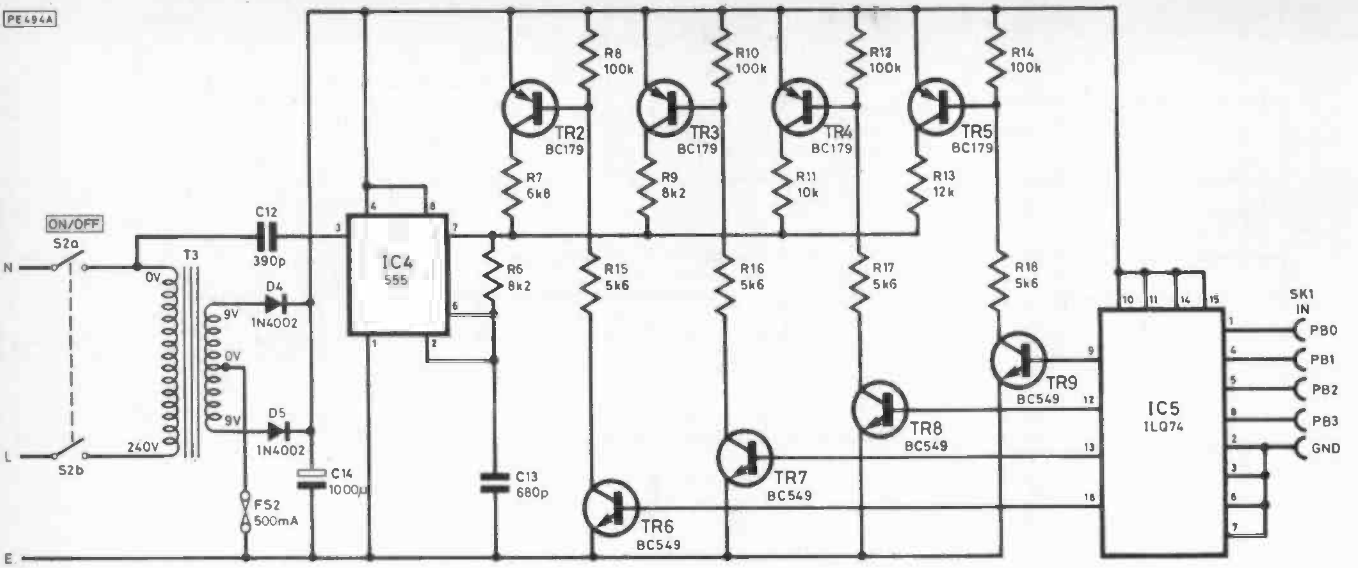


Fig. 3. Circuit diagram of the Controller

limiting resistors of about 4k7 in value should be added if the circuit is driven from outputs that will provide a drive current of more than a few milliamps.

RECEIVER CIRCUIT

The receiver circuit is shown in Fig. 4. This has a non-stabilised supply for all the stages apart from the phase locked loop, and the supply potential is about 12 volts. IC1 gives a stabilised 5 volt supply for the NE567 (IC2), which has a maximum supply voltage rating of just 10 volts. Apart from preventing IC2 from receiving an excessive supply potential the use of a regulated supply aids good long term stability and reliability.

C1 couples the signal from the "Neutral" mains lead to the primary winding of input filter and transformer T2. This is actually a 455kHz last i.f. transformer, but it works well in this application even though it is used in reverse with the input signal applied to what would normally be the secondary winding. C5 is used in parallel with the internal tuning capacitor of T2 to reduce the resonant frequency to about 200kHz.

C6 couples the output of the filter to the input of IC2. IC2 requires a minimum input level of about 20 millivolts r.m.s., and as the output of the filter is about ten times this figure no preamplification is needed. VR1, R1, and C7 are the frequency determining components of the current controlled oscillator. VR1 is adjusted to bring the receiver onto the same frequency as its corresponding transmitter channel. C8 is the filter capacitor in the lowpass filter, and C9 is the smoothing capacitor in the switching circuit. R2 is the load resistor for the output transistor of IC2.

Although the phase locked loop has good immunity to noise spikes on the input, and the high value for C9 also helps to suppress noise spikes, it was still found that spurious operation of the circuit could be produced by the inevitable noise signals on the mains supply. However, adding the lowpass filter comprised of R3 and C10 completely cured the problem, and deliberate attempts to produce spurious operation all proved to be fruitless.

IC3 is the flip/flop, and this is actually a 14 stage CMOS binary divider. Only the first stage is used in this application. C11 and R4 produce a positive reset pulse for IC3 at switch-on. TR1 is the relay driver and D3 is the usual protection diode. A pair of normally closed relay contacts are used to control the "Live" output to the load. The use of normally

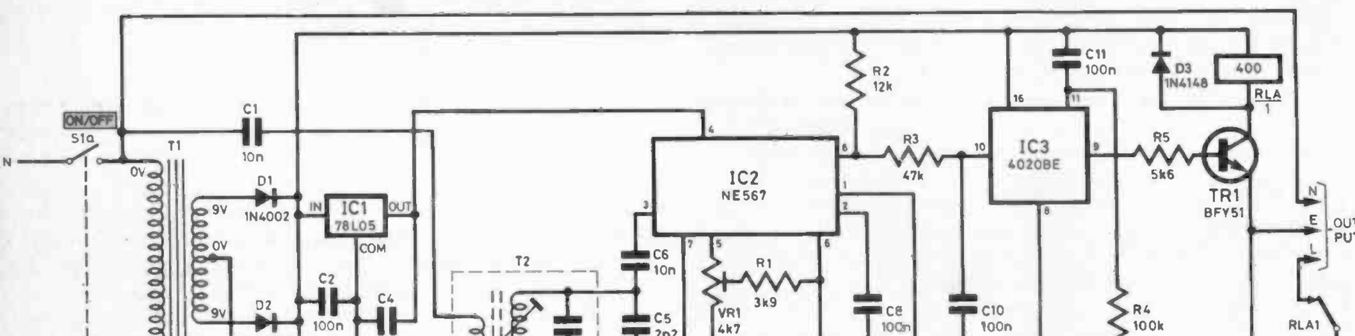
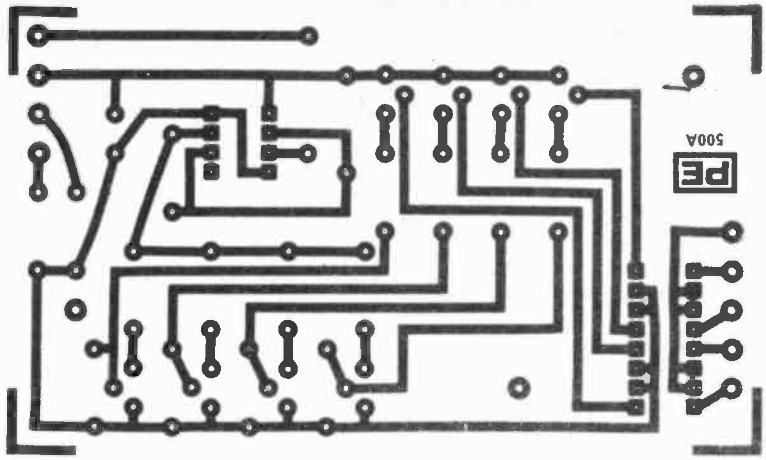
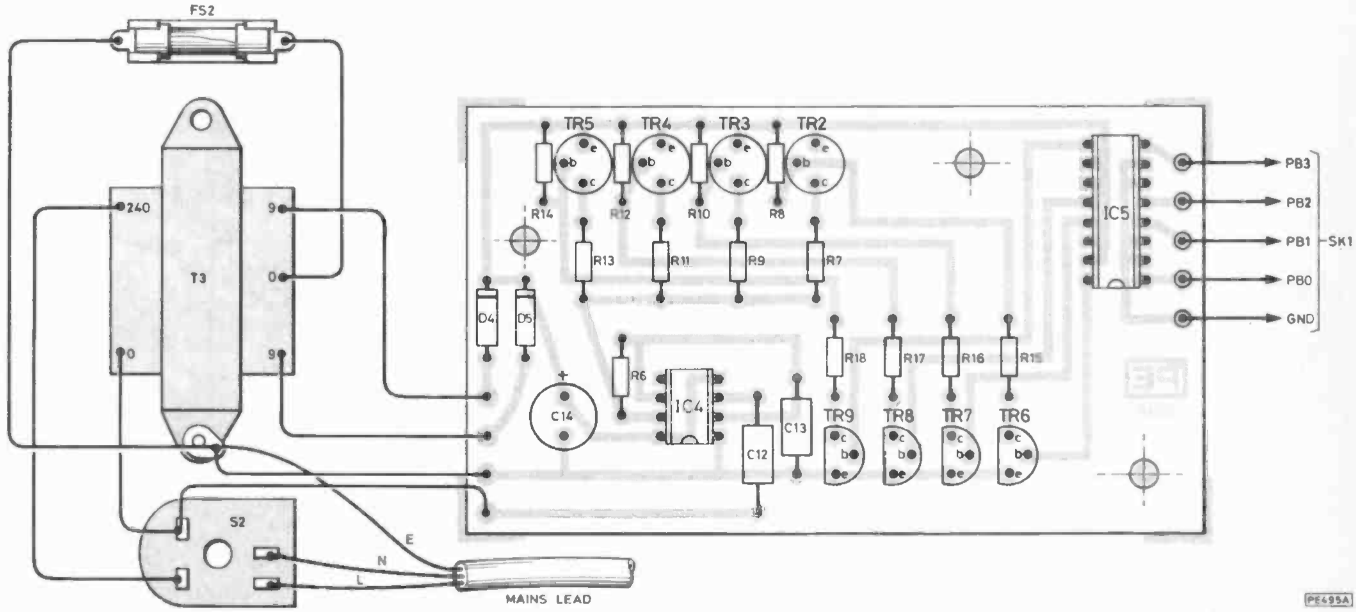


Fig. 4. Circuit diagram of the Receiver

Fig. 5. P.c.b. design for the Controller

Fig. 6. Component layout and wiring diagram





closed contacts is convenient as the unit is effectively bypassed when it is switched off.

CONSTRUCTION

The controller and the receiver units are housed in metal instrument cases that have approximate outside dimensions of 152 x 114 x 44mm. Taking the controller unit first, the on/off switch is mounted at the left hand end of the front panel, and T3 is bolted to the base panel immediately behind this. A soldertag is fitted on one of the mounting bolts of T3 to provide a chassis connection point. The fuseholder for FS2 is mounted just to the rear of T3. An entry hole for the mains lead is drilled in the rear panel, and this should be fitted with a grommet to protect the cable. SK1 is mounted on the rear panel, and a 5 way DIN type is utilised here on the prototype, but any socket having at least 5 ways can be used here.

COMPONENTS . . .

CONTROLLER

Resistors

R6	8k2
R7	6k8 1%
R8,R10, R12,R14	100k (4 off)
R9	8k2 1%
R11	10k 1%
R13	12k 1%
R15,R16, R17,R18	5k6 (4 off)

All $\frac{1}{4}$W carbon 5% unless otherwise stated

Capacitors

C12	390p polystyrene
C13	680p polystyrene
C14	1000µ 10V radial elect

Semiconductors

D4,D5	1N4002 100V 1A rectifier (2 off)
IC4	555 timer
IC5	ILQ74 quad opto-isolator
TR2,TR3, TR4,TR5	BC179 silicon pnp (4 off)
TR6,TR7, TR8,TR9	BC549 silicon npn (4 off)

Miscellaneous

T3	Mains primary, 9–0–9 volt 100mA secondary
FS2	500mA quick blow 20mm
SK1	5 way DIN socket
S1	Rotary mains switch

152 x 114 x 44mm instrument case
Printed circuit board
20mm chassis mounting fuseholder
Control knob
Mains lead, Veropins, wire, etc.

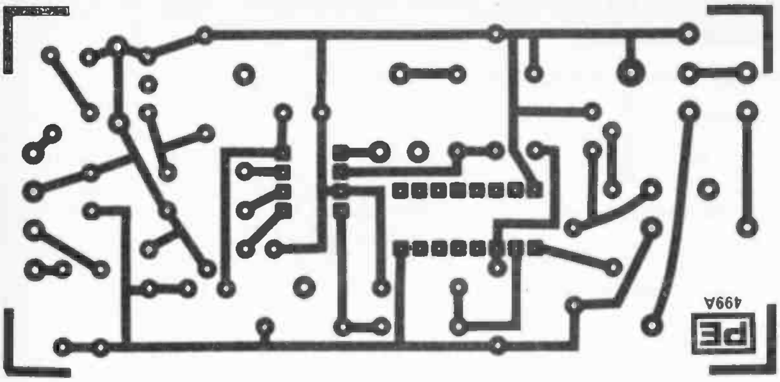
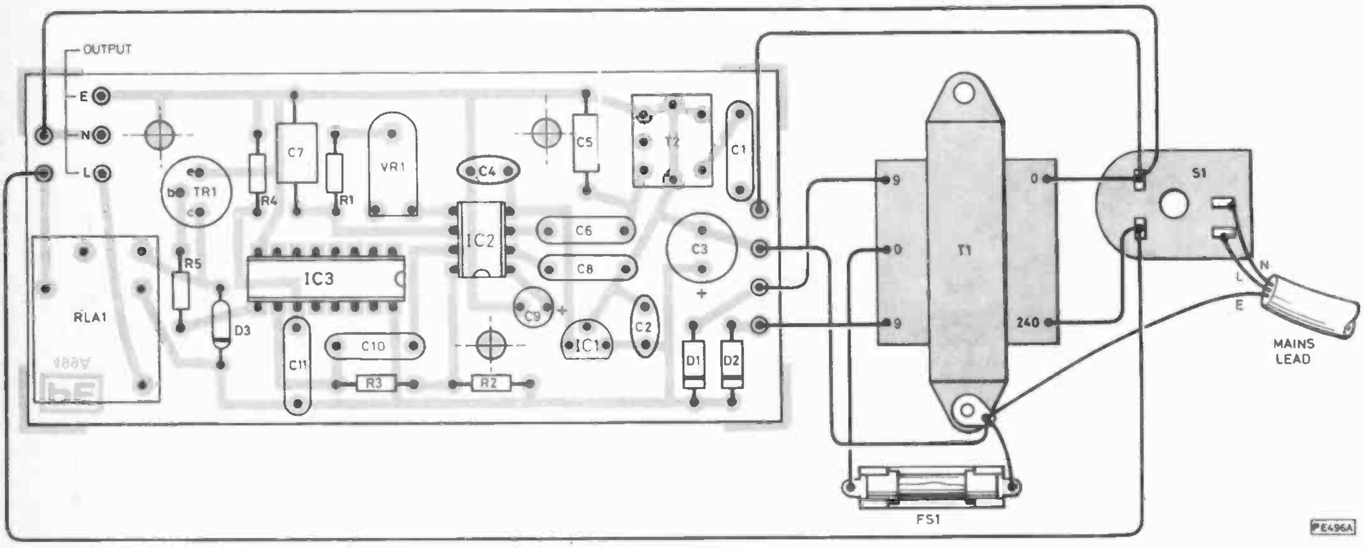


Fig. 7. P.c.b. design for the Receiver

Fig. 8. Component layout and wiring diagram



The printed circuit board, component layout and wiring are shown in Figs. 5 and 6. This is all quite straightforward, but as the mains supply is involved be very careful not to make any wiring errors, and thoroughly check all the wiring once the unit has been completed. The printed circuit board fits onto the base panel in the vacant area on the right hand side of the case. It is mounted using M3 or 6BA fixings, including spacers to keep the underside of the board clear of the metal case.

RECEIVER CONSTRUCTION

Construction of the receiver is along the same general lines as for the controller, but the on/off switch, mains transformer and fuse are on the right hand side, with the printed circuit fitted at the left end of the unit. A hole for the mains output lead is needed in the rear panel, and if the receiver is only to be used with one piece of equipment this can be connected direct to the receiver. If it is to be used with several pieces of equipment it is better to take the out-

COMPONENTS . . .

RECEIVER

Resistors

R1	3k9
R2	12k
R3	47k
R4	100k
R5	5k6

All ¼W carbon 5%

Potentiometer

VR1	4k7 0·1W horizontal preset

Capacitors

C1,C6	10n polyester (2 off)
C2,C4	100n ceramic (2 off)
C3	1000µ 16V radial elect
C5	2n2 polystyrene
C7	1n polystyrene
C8,C10, C11	100n polyester (3 off)
C9	10µ 25V radial elect

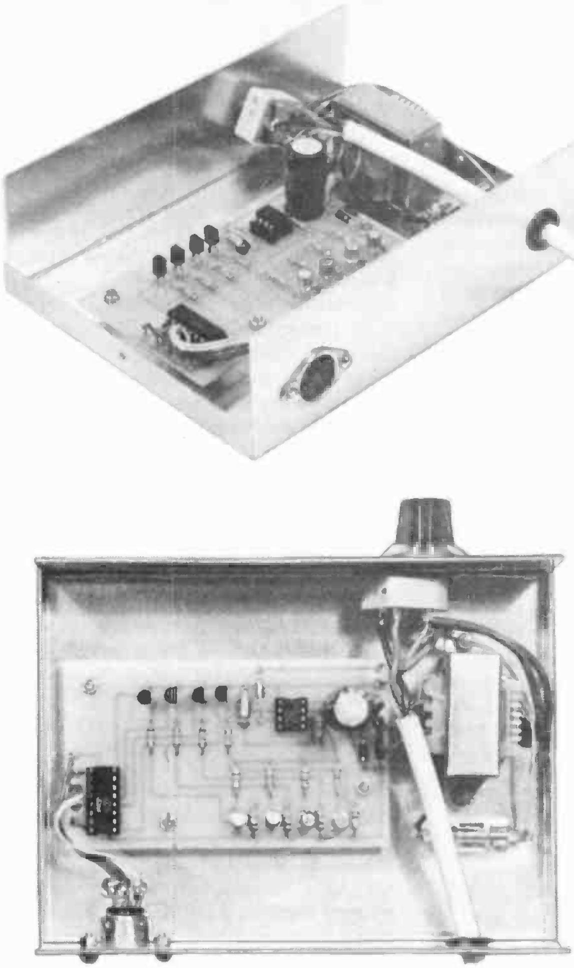
Semiconductors

D1,D2	1N4002 100V 1A rectifier (2 off)
D3	1N4148 silicon diode
TR1	BFY51
IC1	78L05 5V 100mA regulator
IC2	NE567 phase locked loop
IC3	4020BE 14 stage binary divider

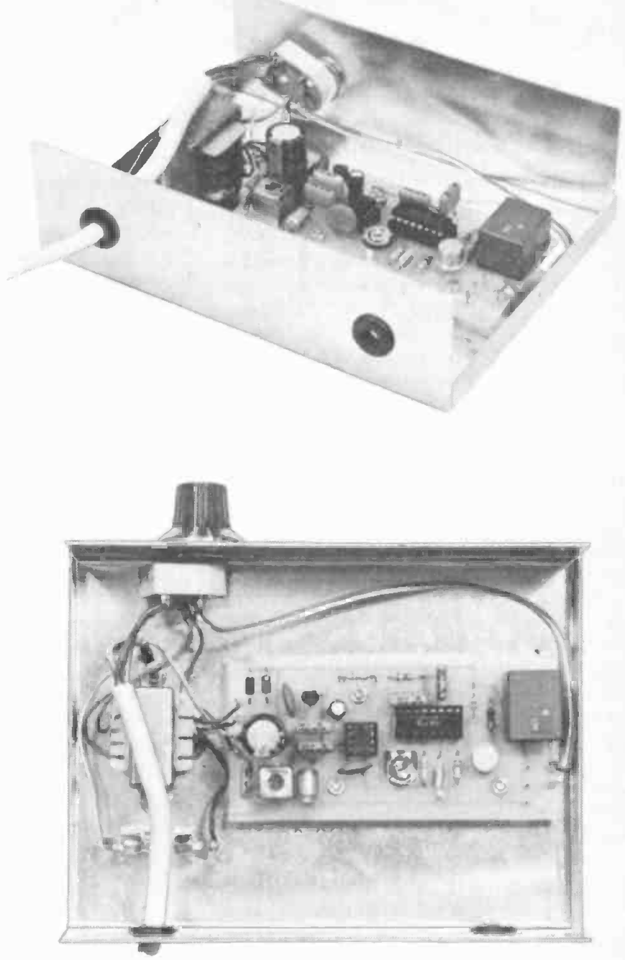
Miscellaneous

T1	Mains primary, 9–0–9 volt 100mA secondary
T2	Toko YHCS11100
S1	Rotary mains switch
FS1	500mA quick-blow 20mm
RLA	12 volt 400Ω coil, 10A changeover contacts, PCM

Case about 152 x 114 x 44mm
Printed circuit board
20mm chassis mounting fuseholder
Control knob
16 pin d.i.l. i.c. socket
8 pin d.i.l. i.c. socket
Mains lead, Veropins, etc.



Internal views of the Controller



Internal views of the Receiver

put via a short piece of mains cable to a trailing 13 amp mains socket, so that any desired piece of equipment can be plugged into the unit. Make sure that you use mains cables of adequate rating for the items of equipment that will be used with the unit. Figs. 7 and 8 provide details of the printed circuit board, component layout and wiring for the receiver. Of course, you must build a receiver for each channel of the transmitter that you intend to utilise.

ADJUSTMENT AND USE

The correct method of connection to the computer obviously depends on the particular machine used, but the identification markings shown in Fig. 6 are correct for the user ports of the VIC–20, Commodore 64, and BBC model B computers. The manuals for these give connection details for the ports. Of course, any output port can be used to drive the unit, with the "GND" input being connected to the ground terminal of the port, and "PB0" to "PB3" each being connected to a latching output of the port.

Here we will only consider the setting up and use of the controller with the three computers mentioned above, but the general technique is the same for any others. First, lines PB0 to PB3 must be set up as outputs, and this is achieved by POKEing 15 to the data direction register for the port. This is at addresses 37138, 56579, and &FE62 for the VIC–20, Commodore 64, and BBC model B respectively. The four outputs are then controlled by POKEing the appropriate number to the peripheral register (i.e. the port itself) at addresses 37136, 56577, and &FE60. 1, 2, 4, and 8 respectively set PB0, PB1, PB2, and PB3 high, while 0 sets all the outputs low.

When initially setting up a receiver it is probably best to have the computer sending a continuous stream of signal bursts from the appropriate channel of the controller. For example, this program could be used with the VIC–20 and channel 0 (PB0).

```
10 POKE 37138,15
20 POKE 37136,1
30 FOR X=1 TO 1000: NEXT X
40 POKE 37136,0
50 FOR X=1 TO 1000: NEXT X
60 GOTO 20
```

Do not use very short signal bursts or the receiver may well fail to respond to them (about 0·5 to 1 second is suitable). Also note that the controller can only transmit one channel at a time. With the controller sending a series of suitable signal bursts, VR1 at the receiver is adjusted slowly from one end of its track to the other until a point is reached where the relay pulses on and off in sympathy with the signal from the controller. It is unlikely that the core of T2 will need any adjustment, but if necessary this can be tried at various settings until satisfactory results are obtained. If an a.c. millivoltmeter is available, with the aid of this T2's core can be adjusted to peak the signal level across the tuned winding. ★

THE LEADING EDGE

BARRY FOX

ELECTRONIC MAIL

The first company, that I know of, to set up an electronic mail newsroom is 3M. Anyone with a home computer, a telecom program and modem can call up the 3M newsroom and access press releases and background information on the company.

To be strictly accurate, you first have to call up 3M and persuade the company that you are a *bona fide* journalist. Then they give you the necessary code words to log on. This is a necessary precaution because there is a fast growing clique of computer owners who hook up their computers by telephone and talk by keyboard.

There are several data banks, like Compuserve and Dow Jones in America, to which computer users can subscribe. Because it's pricey to use these systems computer buffs are always looking for free services. A few universities, and computer magazines, offer free data by telephone but it is often pretty worthless material.

For many people the real value of computer phone linking is electronic mail, like the Telecom Gold service in Britain. This gives subscribers an electronic pigeon hole, into which correspondents can drop messages to be picked up at any time.

The advantage of course is that both parties do not have to hook their computers onto a phone line at the same time. The disadvantage is that it can be expensive, around 10p a minute computer time on top of telephone charges.

LACK OF MODEM

The computer phone hook-up craze has been slower to catch on in Britain than in America. This is largely because the Tandy TRS-100 machine as sold in Britain misses a vital part incorporated in the US version.

Both the British and American TRS-100 machines have telecommunication software burned into the chips. But only the American version has a modem built in as well. You can plug it direct into a phone line and even use the memory file as a high capacity auto dialler. The British version does not have the modem circuitry.

This odd situation has its origins in the confusion over the schemes for certifying equipment as fit for connection to the British phone system. At the time when the British TRS-100 was launched the certification system was not yet up and running smoothly, so Tandy just stripped out the modem. This also kills the TRS-100 as an auto dialler.

Now Tandy is doing very nicely thank you out of selling add-on modems at over £250 a time so there's little or no incentive to modify the TRS-100 to include a modem now that certification is easier.

HYBRID FLOPPY

While still on the subject of computers, I'll report on a fascinating development which 3M showed me in their laboratories. It's best described as a hybrid cross between a floppy magnetic disc and a hard Winchester. It could well speed the three cornered marriage between audio, video and computer technology.

The aim is to provide Winchester capacity storage at something approaching floppy price, with the added bonus that the new "hard floppy" will be suitable for vertical magnetic recording as well as conventional longitudinal.

For vertical recording the magnetic particles stand upright rather than lie down along the coating surface. Storage density is increased by a factor of at least five, just as you can get more people in a room standing up than if they were lying down.

The snag is that for vertical recording you need very close contact between head and disc. This is difficult to achieve with a hard Winchester.

SECRET CODE

The Winchester disc is now just over 10 years old. It was an idea dreamed up by IBM and the word Winchester was a secret code name, derived from the 30-megabyte capacity of early large discs. IBM used two 30-megabyte drives side by side, and 3030 is the bore of a Winchester repeater rifle.

Small Winchesters have a storage capacity of 10 or 12 megabytes, depending on formatting. The read-write head skims over the thin magnetic coating on an air cushion. If there is any dirt in the disc the head crashes into the coating surface and immediately destroys both head and disc. Data is lost as well, of course.

Floppy magnetic discs, on the other hand, work by physical contact between the head and disc magnetic coating. It's why cheap discs start to look worn and dirty after heavy use.

The recording capacity of a floppy disc is limited by the way it is made. Large sheets of extruded polyester are coated with magnetic oxide and then discs are cut from the sheet. This means that the disc is stretched in two directions. So if the temperature rises the disc warps in two directions at once.

If the recording and read head is servo controlled a floppy can pack 200 tracks to an inch. An unservoed floppy can muster only around 100. But of course floppies are cheap, much less than half the price of a hard Winchester.

RIGID PERFORMANCE

The 3M laboratory at St. Paul has been trying to get rigid disc performance from floppy technology. They now think they have done the trick. A blank former is moulded from very tough plastic, with rims around the inside and outside.

Polyester film coated with magnetic oxide is then stretched tight as a drum over the rimmed surface to form a very narrow air gap. A small hole is cut in the stretched skin to let atmospheric pressure of the trapped air even out (otherwise the skin would burst at low atmospheric pressure) and the disc then used in a modified hard disc Winchester drive.

The head skims only just above the surface. It's so close that it is as near as makes no difference touching. There is no crash problem because the surface is flexible.

Recording density is high because there is close contact. For the same reason the disc can be used in the future for vertical recording. Cost is low, around half Winchester price but the warp factor is reduced by a factor of at least 12.

Because the disc is so dimensionally stable it can be spun at the Winchester speed of 3600 rpm, instead of the floppy speed of between 300 and 600 rpm. Magnetic coercivity is high, around 575 oersted instead of the normal 300 for floppies and Winchesters. 3M find that it is only necessary to change a couple of resistors in the head drive circuit and use a head made from manganese-zinc instead of nickel-zinc to avoid saturation of the head material.

STRETCHED SURFACE RECORDING

When I visited St. Paul the laboratory had been running a converted Winchester drive for seven months without problems. They had achieved a recording density of 11000 flux changes per inch, compared to 9700 flux changes per inch for a Winchester.

The new technology is called SSR, stretched surface recording. Error rate is the same as for a Winchester (100 times better than a floppy) and track density is over 500 an inch. This puts storage capacity for a $5\frac{1}{4}$in. SSR disc at around 10 or 12 megabytes, the same as for a Winchester. With vertical recording the density could rise as far as 100 megabytes. 3M are currently talking to the Japanese.

The main advantage of the new technology is that it builds on equipment already available for old technology. There is no need for a completely new type of disc drive, just a standard Winchester with slightly modified heads and drive circuits.

Copies of British Patents can be obtained from: The Patent Office, Sales, St. Mary Cray, Orpington, Kent (£1.75); copies of Foreign Patents can be obtained from the Science Reference Library, 25 Southampton Buildings, London WC2A 1AJ. (Prices on application)

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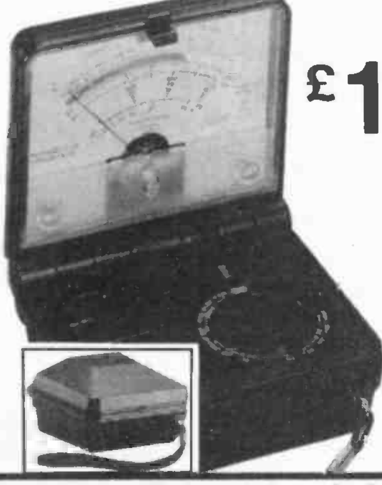

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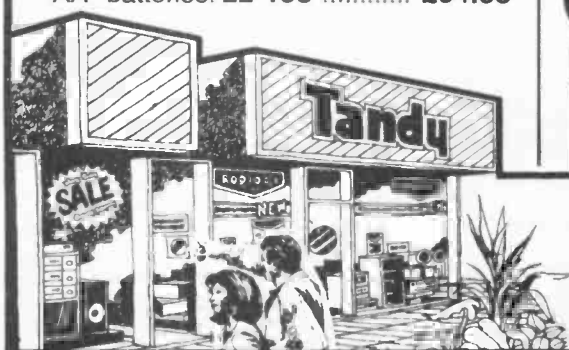

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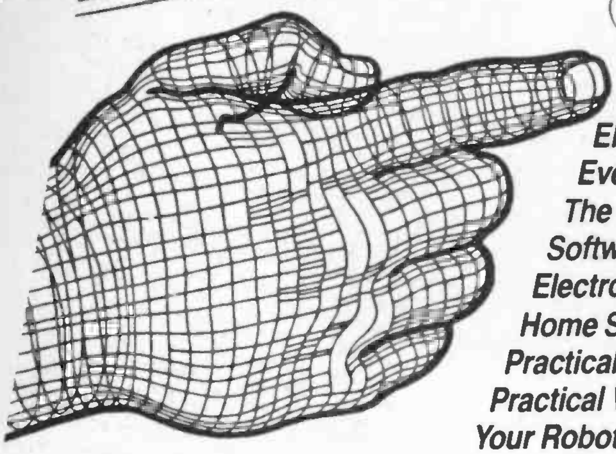

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THE TEARS OF ST. LAWRENCE

August is the best month of the year for observing meteors, or shooting-stars. The Perseid shower—otherwise known as the Tears of St. Lawrence—reaches its peak on 12 August, and there should be many meteors seen between 27 July and 17 August. It is true that this year there will be interference from moonlight (the Moon is full on 11 August); all the same, the Perseids will be worth studying.

A meteor is a very junior member of the Solar System. Most meteors are smaller than pins' heads, and so long as they stay clear of our atmosphere we cannot see them. If, however, a meteor dashes into the upper air, and comes down below a height of about 120 miles, it has to force its way through the atmosphere. This sets up friction, and the particle becomes so hot that it burns away in the streak of luminosity which we call a shooting-star. In general, meteors burn out above heights of 40 miles, and finish their journeys in the form of very fine 'dust'. What we see, of course, is not the tiny particle itself, but the effects upon the atmosphere. Some meteors may be brilliant, leaving trains which persist for some seconds or even, occasionally, minutes. A meteor of this sort is termed a fireball.

Let me stress one point. There is no connection between a meteor, which produces a shooting-star, and a meteorite, which is much larger and which may land intact (or at least, partly so). Meteorites are believed to come from the belt of minor planets or asteroids, between the orbits of Mars and Jupiter; there may be no distinction between a large meteorite and a small asteroid. Meteorite craters are known, the most famous example being the mile-wide crater in Arizona. Meteors, on the other hand, are cometary débris.

PERSEIDS

Now let us look back at the history of the Perseids. The first record of them goes back to the year AD 36, when a shower of shooting-stars was noted by the Chinese. The Perseids were first recorded from Europe in 811, and ever since then there have been regular observations of them. The association with St. Lawrence goes back to the Spanish martyr who was put to death on 10 August 258—almost at the maximum of the Perseid shower.

In 1835 the Belgian astronomer A. Quételet made an important discovery. The August meteors seem to come from one particular point or "radiant", lying in the constellation of Perseus (now rising in the north-east, and quite easy to identify, though it contains no really bright star). In fact, the Earth is ploughing through a swarm of meteors and "scooping up" numbers of them.

To show why the Perseids appear to come from one special radiant, consider the view of a motorway obtained from a bridge overlooking it. The motorway lanes are parallel, but as seen from the bridge they appear to converge at a distant point, which may be termed the "radiant" of the lanes. It is the same with meteors. Those in any particular shower are moving through space in parallel paths, which is why they seem to come from a definite radiant. Actually, there are many annual showers, each with its own radiant, but the Perseids are the most reliable. (There are also meteors which do not belong to showers, and may appear from any direction at any moment. These are known as sporadic meteors.)

COMETS

Another important discovery was made in the 1860s, this time by the Italian astronomer G. V. Schiaparelli. He realised that meteors are associated with comets. A comet is made up of ice, tenuous gas and "dust"; as it moves, it leaves a dusty trail behind it—and it is this dust which produces meteors. Halley's Comet, now in view after over seventy years even though it is still too faint to be seen with telescopes of the size used by amateurs, is associated with two meteor showers. The Perseid parent comet was discovered in 1862 by two observers, L. Swift and H. P. Tuttle, and is therefore known as Comet Swift-Tuttle. It was found to have a revolution period of about 120 years, and was expected back in the early 1980s. Unfortunately, it has not shown up. Either the computed period was wrong, or we have missed discovering it, or something disastrous has happened to it—which is not inconceivable; there are several examples of periodical comets which have disintegrated, and it is certainly true that comets are comparatively short-lived members of the Sun's family, because they lose a certain amount of their material by evaporation every time they make their closest approach to the Sun itself.

Many Perseids are seen each August, but the shower in 1980 was exceptionally rich. It was less brilliant in 1981, 1982 and 1983, which is one reason why I suspect that Comet Swift-Tuttle has come and gone unseen. But I may be wrong; the comet may yet put in an appearance (in 1862 it was visible with the naked eye), and it is also possible that we will have a really good Perseid shower this month.

Incidentally, the regular appearance of the Perseids shows that the meteors are scattered all along the very elliptical path of its parent comet. In other showers the meteors are bunched up, so that we see a good display only when we pass through the main shoal. Thus the Leonids (radiant in Leo, the Lion) tend to be spectacular every 33 years, as last

THE SKY THIS MONTH

This month is not a particularly favourable time for those who are interested mainly in the planets. Venus has begun to move outward from the Sun, and is visible very briefly above the western horizon after sunset, but no telescopes will show anything definite upon its cloud-covered surface. Mars and Saturn are both in the south-west during evenings; Mars, which has been in the constellation of Libra since the beginning of the year, now moves rapidly eastward into the northern part of Scorpio, and it is interesting to compare its colour with that of Scorpio's leading star, Antares. Antares is a red supergiant; its name means 'the rival of Ares'—Ares being the Greek equivalent of the war-god Mars. At present the planet is a magnitude the brighter of the two, but the colours are much the same, and it requires an effort of imagination to realise that Antares is a vast sun, many times more powerful than ours, while Mars is a planet smaller than the Earth.

Saturn, higher up than Mars, is still a magnificent sight through a telescope, because the rings are excellently displayed. Jupiter, in Sagittarius (the Archer) is brilliant, and may be seen low in the south during evenings, but by the end of the month it sets before midnight.

The lovely blue star Vega is almost overhead after sunset; this, as I mentioned last month, is one of the two stars found by IRAS (the Infra-Red Astronomical Satellite) to be associated with material which may be a planetary system, or at least a planetary system in the process of formation. (The other star is Fomalhaut, in the Southern Fish, about which I will have more to say next month.) Also very high are Altair in Aquila (the Eagle) and Deneb in Cygnus (the Swan). Cygnus is often nicknamed the Northern Cross, for obvious reasons; the pattern is that of a somewhat distorted X—unlike that of Crux Australis, the famous Southern Cross, which is too far south to rise over Britain, but is more like a kite than a cross.

The Plough or Great Bear is rather low in the north-west, but as seen from Britain it never sets, so that it may be seen whenever the sky is sufficiently dark and clear. The brilliant orange Arcturus, in Boötes (the Herdsman) is dropping in the north-west, while the Square of Pegasus is rising in the east. Note also the W of Cassiopeia, high in the north-east; this is another very distinctive constellation which never sets over the British Isles.

happened in 1966, and are very feeble at other times.

Typically, a Perseid meteor enters the atmosphere at a speed of about 135,000 m.p.h., and may become as bright as Venus, even though it weighs no more than about one gramme. Its moment of glory is brief, and it has no chance of penetrating through to the ground without being destroyed.

AMATEUR CONTRIBUTION

Until comparatively modern times, most of our knowledge about meteors was drawn from the work of amateur observers—and it is true that amateurs can still make a useful contribution. If a meteor is observed from two points on the Earth's surface, some distance apart, its height can be found—a principle first adopted just before 1800 by two German students, Brandes and Benzenberg.

The observer needs to determine the track of the meteor against the starry background. This is best done by holding up some sort of marker (a ruler will do quite well) and lining it up along the track of the meteor which has been observed; the path can then be plotted on a star-chart. Obviously, a good knowledge of the constellations is needed, but it is surprisingly easy to learn one's way around the sky; a few nights' practice will work wonders—and it is also true that the stars become much more interesting when you know which is which.

It is also useful to count the numbers of meteors seen over definite periods. This is a measure of the Z.H.R., or Zenithal Hourly Rate—the number of meteors which would be seen with the naked eye under ideal conditions, with the radiant at the zenith or overhead point (conditions which, of course, are almost never realised). The Perseids have a Z.H.R. of about 70, but it must be remembered that not all meteors observed during early August will be Perseids, as there are several minor showers in progress quite apart from the unpredictable sporadic meteors.

Finally, why not try photography? Point your camera somewhere near the radiant and leave the shutter open for, say, ten to twenty minutes. The stars will leave trails as they move across the sky, and if a bright meteor happens to cross the camera field you have a good chance of recording it.

It is a pity that this year the Moon is full at an inconvenient moment, but at least it will not seriously interfere with the early part of the shower. So let us hope for clear skies, so you can view "the Tears of St. Lawrence".

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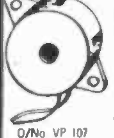

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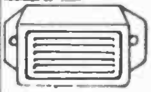

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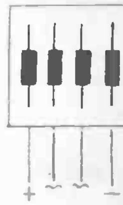

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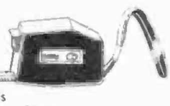

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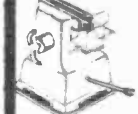

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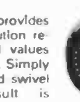

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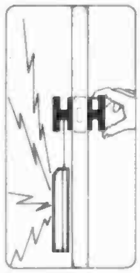

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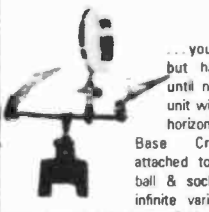

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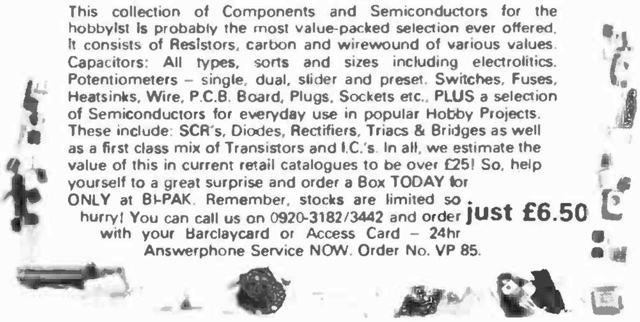

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SEMICONDUCTOR CIRCUITS

TOM GASKELL BA(Hons) CEng MIEE

VOLTAGE AND CURRENT REGULATOR (L200C)

THE design of simple regulated power supplies is a straightforward process these days. The majority of circuits use some form of i.c. regulator; usually the 78 or 79 series (7805, 7915, etc) or the LM340 series. When a continuously variable regulated voltage is required the LM317 series of regulator is often used, and is an excellent basis for simple variable voltage bench power supplies. These i.c.s all have built in current limiting for protection purposes, but this limiting is fixed at usually quite a high level, and there is no direct provision for varying the maximum output current over a wide range. This month we look at a regulator i.c. which allows for both voltage and current regulation; the L200C from SGS.

BLOCK OPERATION

The block diagram of the L200C is shown in Fig. 2. A current source and reference voltage generator combine to produce an accurate voltage, V_{ref}, of approximately 2·77V. This is compared with the voltage from pin 4 in an error amplifier, the output of which controls the pass element (effectively a series transistor) which in turn provides the regulated output to pin 5. (Assume for the moment that R_{sc} is a short circuit.) Pin 4 thus provides negative feedback to the i.c., and hence the external feedback resistors R_f and R_g determine the gain of the error amplifying circuitry, by the familiar equation:

$$A_v = \frac{R_f + R_g}{R_g}, \text{ i.e. } A_v = \left(1 + \frac{R_f}{R_g}\right)$$

V_{ref} is therefore multiplied by this factor, and the output voltage is given by:

$$V_o = 2\cdot77\ 1 + \left(\frac{R_f}{R_g}\right)$$

If R_f is made a variable resistor then we have an excellent way of adjusting the output voltage over a wide range. Because of the possible variation of V_{ref} from 2·64V to 2·86V, as shown in Fig. 1, it should be assumed that the minimum output voltage available from the i.c. is 2·86V. In normal operation, due to the action of the negative feedback, the voltage at pin 4 should remain at exactly V_{ref}.

When R_{sc} is not a short circuit the operation of the i.c. becomes a little more complex.

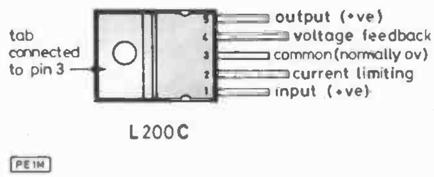


Fig. 1. Pinout and specification

Characteristic	Notes	Min Value	Typically	Max Value	Units
Input Voltage	Continuous			40	V
Input Voltage	Peak—*less than 10ms*			60	V
Quiescent Current	Pin 3 (for I/P=20V)		4·2	9·2	mA
Temperature Range	At *junction*, not case	−25		150	°C
Max Dropout Voltage	*i.e.* Maximum permissible voltage between pins 1 & 5			32	V
Min Dropout Voltage	Between pins 1 & 5; O/P current=1·5A		2	2·5	V
O/P Noise Voltage	$V_o=V_{ref}$, O/P current=10mA		80		μV
O/P Voltage Range	O/P current=10mA	2·85		36	V
Voltage Load Regulation	O/P current changes from 0 to 2A		0·15	1	%
	O/P current changes from 0 to 1·5A		0·1	0·9	%
Voltage Line Regulation	O/P voltage=5V, I/P voltage changes from 8 to 18V	48	60		dB
Ripple Rejection	O/P=5V, O/P current=0·5A, I/P changes by 10V pk/pk at 100Hz	48	60		dB
Reference Voltage V_{ref}	I/P=20V, O/P current=10mA	2·64	2·77	2·86	V
Bias Current at pin 4			3	10	μA
Output Impedance	$V_o=V_{ref}$, I/P=10V, O/P current=0·5A frequency=100Hz		1·5		mΩ
Voltage Between pins 2 & 5	$V_o=V_{ref}$, I/P=10V, O/P current=0·1A	0·38	0·45	0·52	V
Peak Short Circuit Current	Pins 2 & 5 shorted, dropout voltage=14V			3·6	A
Current Load Regulation	I/P=10V, O/P voltage changes by 3V				
	O/P current=0·5A		1·4		%
	O/P current=1·0A		1·0		%
	O/P current=1·5A		0·9		%

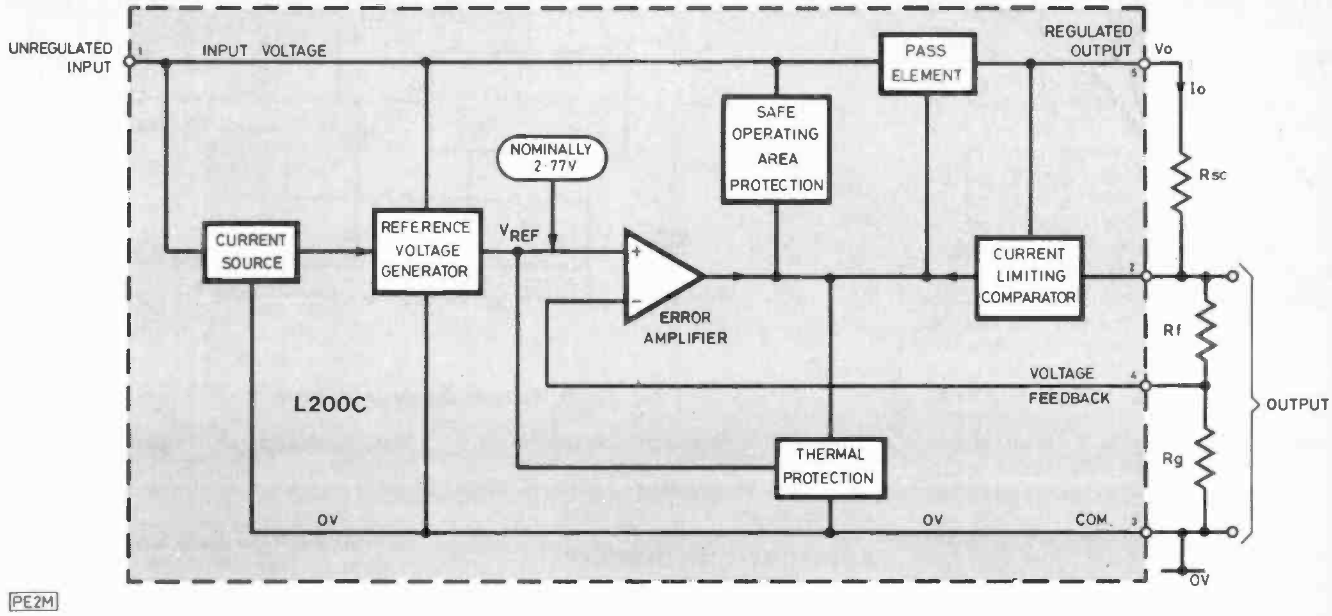


Fig. 2. Block diagram

Current limiting circuitry internal to the i.c. compares the output voltage at pin 5 with the voltage at pin 2. When the voltage drop between pins 5 and 2 exceeds a threshold of typically 0·45V the comparator output reduces the drive to the pass element, which results in the lowering of the regulated output voltage. This, again, is a negative feedback loop (with a 0·45V offset) so it causes the output to stabilise at a point where there is 0·45V (or less) between pins 5 and 2. The maximum output current is then given by:

$$I_o = \frac{0{\cdot}45 \text{ (typically — see Fig. 1)}}{R_{sc}}$$

Hence, varying the value of R_{sc} will vary the output current available to the external load.

PROTECTION

The L200C has excellent internal protection, making it much better than normal at withstanding misuse! Thermal protection shuts down the i.c. at high junction temperatures to prevent permanent damage. Internal current limiting keeps the maximum output current down to below 3·6A peak (for a typical 14V drop across the regulator), even if no external current limiting is provided. Finally, safe operating area (S.O.A.) protection is fitted internally, as shown in Fig. 3. The term 'safe operating area' refers to the area enclosed by the two continuous (non-dotted) lines on the diagram; it caters for the fact that the i.c. can pass more current if its own dissipation is reduced, i.e. there is little voltage drop across it, but only low currents if the voltage across it is very high (corresponding to a very low output voltage for a very high input voltage). S.O.A. protection will not be needed as long as the i.c. is operated within this area of the current vs. voltage graph. When the i.c. is taken outside the safe operating area the protection acts on the pass element to bring the conditions back into the safe area. Note that Fig. 3 is not a steady state diagram; it assumes certain specific conditions of duty cycle and time period. However, it is a good pointer towards the type of performance which can be expected. Under normal circumstances the i.c. should be externally limited to provide a maximum of 2 amps. When used at any current over a few hundred milliamps, or when dropping a large voltage across it, the i.c. should be mounted on a substantial heatsink.

USING THE I.C.

A simple variable voltage regulator is shown in Fig. 4. C1 and C2 help to ensure stability of the i.c. R_f varies the output voltage as already described, and R_{sc} determines the

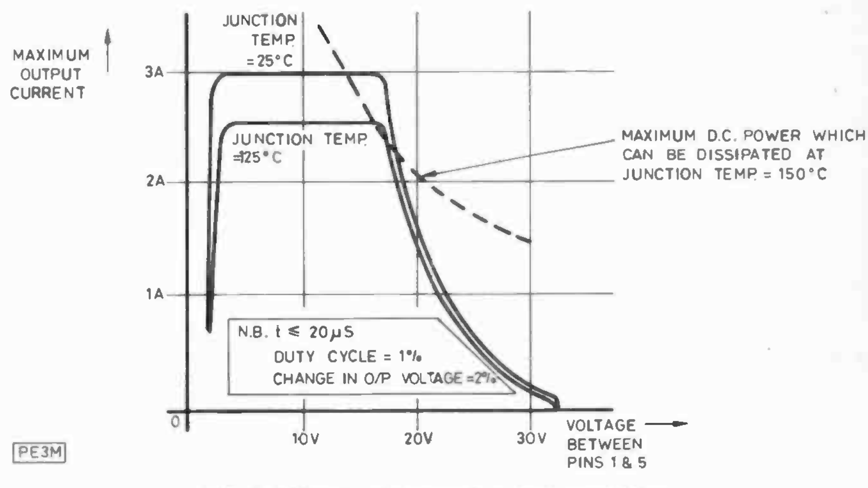


Fig. 3. Typical safe operating area protection

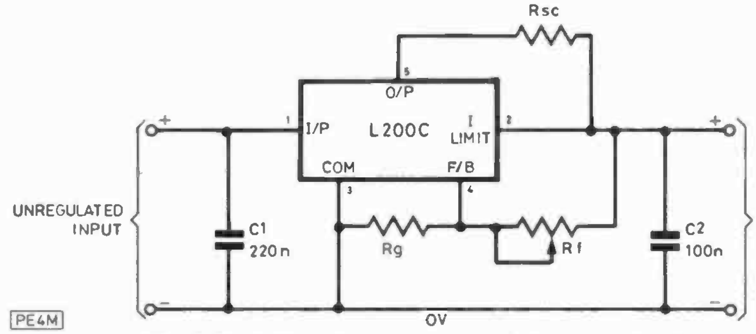


Fig. 4. Variable voltage regulator with current limiting

maximum output current. In most practical circuits R_{sc} is made very small in value; typically 0·5 ohms to limit at just under 1A, or 0·22 ohms to limit at 2A. If R_g = 820 ohms, and R_f = 10k, then the output voltage range provided will be 2·9V to 36V. If a current source alone is wanted, rather than a variable voltage source, then omit R_g and R_f, and connect pin 4 to 0V. This forces the unloaded output to as high a voltage as possible, providing a current source with an output current dependent on the value of R_{sc}.

A circuit where the current limiting facility is not used is shown in Fig. 5, allowing for maximum current to be fed out from the L200C if required. The interesting part of this circuit is the sensing arrangement, which should be used whenever the load is a considerable distance (typically more than a metre) from the i.c. and high currents are involved. Since there will be finite voltage drops in the connecting wires, the feedback and common points are taken off the 'load end' of the wires; this will cause the feedback to increase the i.c. output voltage to compensate for any losses.

For most purposes R_{sc} should be a very low value; typically less than 1 ohm. This makes continuous variation of output current by a variable resistor, for example, somewhat impractical. This problem is overcome in the applications circuit shown in Fig. 6.

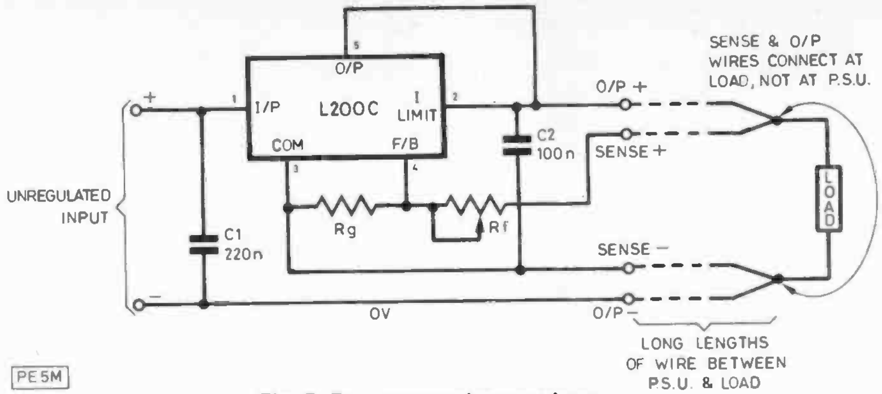


Fig. 5. Remote sensing regulator

APPLICATIONS CIRCUIT

An adjustable voltage and current supply is shown in Fig. 6. Transformer T1 feeds 20V r.m.s. to the bridge rectifier, the d.c. output of which is smoothed by C8, which should be as large as possible and have a ripple current rating of several amps. IC1 regulates this supply as already described. Since current limiting is controlled by measuring the voltage drop between pins 5 and 2, and adjusting the output current until this is 0·45 volts, then providing amplification of the voltage drop across the series resistor R4 will cause the output current to drop by the equivalent amount. IC2 provides this amplification, with VR1 deter-

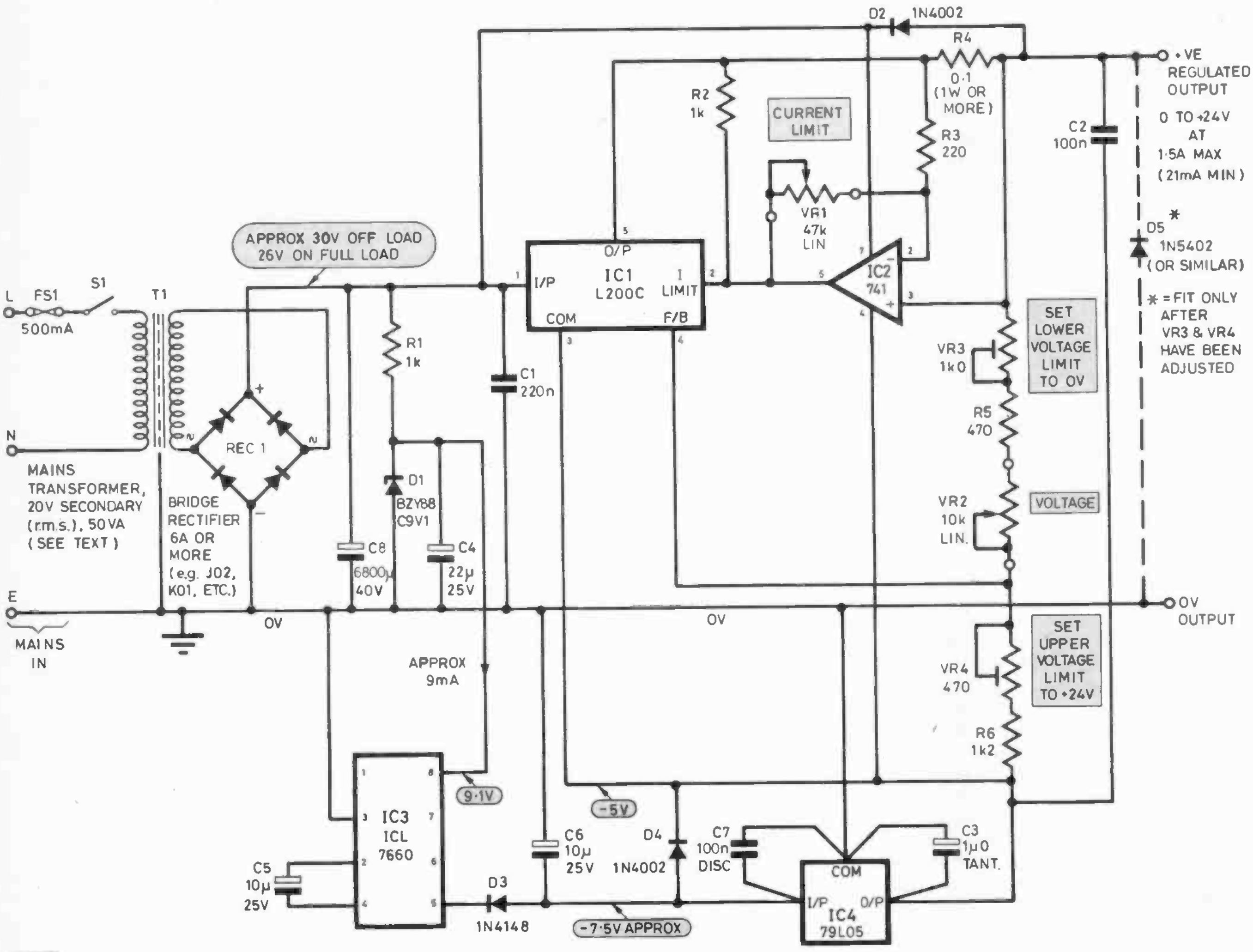


Fig. 6. Adjustable voltage and current supply

mining the gain, which can vary from ×1 to ×214. Hence the current through R4 can be limited from 21mA

$$\left(\text{i.e.} \frac{0{\cdot}45\text{V}}{0{\cdot}1 \text{ ohms}} \times \frac{1}{214}\right)$$

through to a theoretical 4·5A

$$\left(\text{i.e.} \frac{0{\cdot}45\text{V}}{0{\cdot}1 \text{ ohms}} \times \frac{1}{1}\right)$$

In practice, the i.c. can only supply 2A. If required, a small resistor in series with VR1 will limit this maximum current, but this is not normally of any consequence since it only affects the last few degrees of travel of VR1.

One potential shortcoming of the circuits shown in Fig. 4 and Fig. 5 is that current limiting and output voltage variation are only operational down to V_{ref}, an output voltage of 2·77V or thereabouts. Hence, the output voltage cannot be turned completely down to zero, and short circuits to 0V will be limited by the 'worst case' internal limiting of the L200C, not by the external limiting facility. To overcome this a negative supply has been provided to feed IC1, IC2, and the voltage feedback potential divider. Zener diode D1, with R1 and C4, produces a stabilised 9·1 volt supply from the unregulated input to IC1. This is used to feed IC3, a voltage converter which produces a negative output voltage of similar magnitude to its positive supply. This i.c. was covered in *Semiconductor Circuits* in the August '83 issue of PE. The output of IC3, following D3 and when suitably loaded by IC4 and the other circuitry, is approximately −7·5V. This is regulated by a −5V regulator, IC4, to reduce the otherwise significant amount of ripple and regulate the supply.

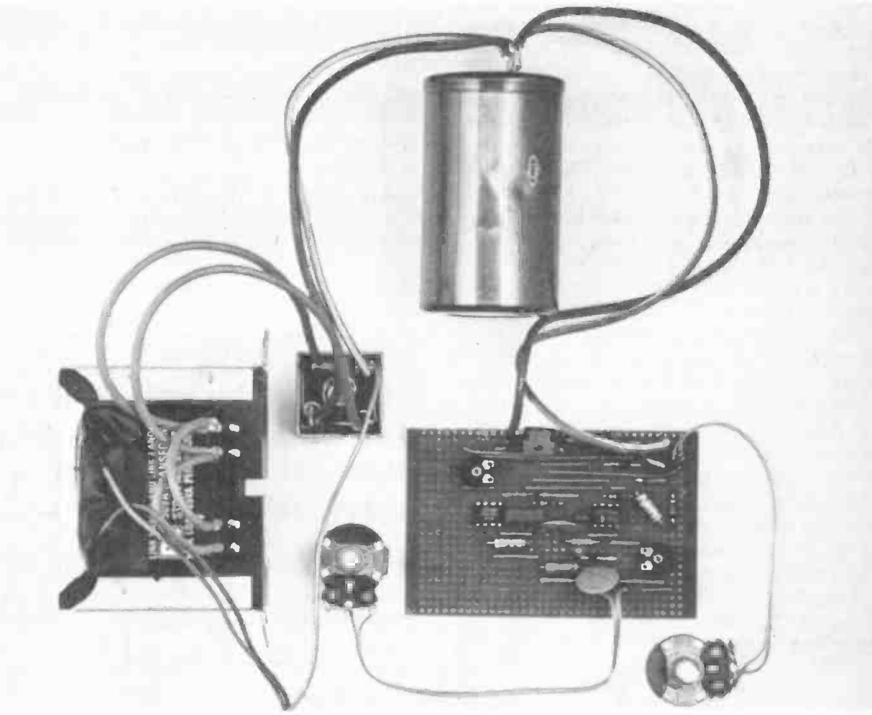
Because of the −5V supply to IC1, IC2, etc., the regulated output of IC1 could now swing slightly negative. This could cause problems when used as a general purpose 'bench supply', so VR3 is provided to set the lower voltage limit to exactly 0V. VR4 in turn sets the upper limit to +24V, so that the range of VR2 is exactly defined. VR3 and VR4 do interact somewhat, so need adjusting several times each to achieve an accurate final result. D2 and D4 protect their respective regulators from damage if the unregulated supply is shorted out.

BUILDING THE CIRCUIT

A Veroboard layout of the circuit is shown in Fig. 7. IC1 is positioned at the edge of the board to allow it to bolt directly to a LARGE heatsink after smearing with heatsink compound, or similar. A suitable insulating kit should also be used. C8 is not board mounted due to its large size, and REC1 is also left off the board due to large size and the potential requirement to mount it on the heatsink for safety. Use a bridge with a higher current carrying capability than nominally required (at least 6A), ensure that the forward voltage drop is 1·1V or less at 2A or below, and beware that some bridge rectifiers will not adequately handle 6800µ capacitors; if in doubt use a J02 or K01 or some similar large rectifier. The mains transformer should be a 50VA 20V type; if less voltage or current is provided, then the maximum outputs of the circuit will reduce correspondingly. As specified, the circuit can provide a maximum voltage of +24V, and a current of 1·5A, within the limitations of the safe operating area.

Take great care with the mains wiring; ensure that all the wires are completely sheathed and the connections covered over for safety. Use a low value fuse as shown, and connect 0V, all metalwork, the heatsink, and the transformer case to mains earth. (Note that the L200C tab is connected to pin 3 internally, so it is necessary to insulate the tab from the heatsink before the heatsink is earthed.) All wiring from the secondary of the mains transformer to the bridge rectifier, C8, and the Veroboard should be in very heavy duty wire and should be kept as short as possible. To protect against fault conditions dragging the output negative, D5 should be added to the circuit, but only after VR3 and VR4 have been adjusted correctly. If required, meters can be added to continuously monitor output current and voltage, in the usual way.

The L200C is a versatile and easy to use i.c. which can provide the basis for many projects which need variable voltage supplies, variable current sources, or both. It can be obtained from **Cricklewood Electronics Ltd.**, 40 Cricklewood Broadway, London NW2 3ET. (01-452 0161).



Photograph showing the complete circuit

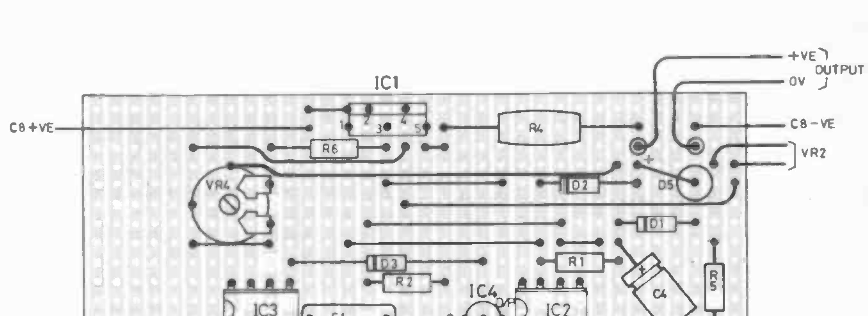


Fig. 7. Veroboard layout

VERNON TRENT *at Large!*

V.T.'s views and opinions are entirely his own and not necessarily those of PE

WE British are great ones for "days", "weeks" and "years". One of the best-known and most widely-observed is "Mothers' Day", for which the lads in the flower industry annually drop to their knees in grateful thanks. A close runner is "Fathers' Day" when lucky old dads collect enough after-shave to last them throughout this life and well into the next.

Someone tried to foist a "Grandmothers' Day" on us once. It never really caught on. Perhaps the grandads got a bit huffy at being left out.

At Oxford they have "May Week" (which is held in June) when maidens and men spend all day messing about in boats and half the night dancing. In the industrial north everyone looks forward to "Wakes Week"—which provides a first-class excuse for getting stoned at Blackpool.

Some time back we celebrated "The Year of the Child". It was totally out of place, of course. As every parent knows, and the bank statement proves it, *every* year is the year of the child—yea, even unto the late teens. We hand an "Information Technology Year" too. Sorry, I thought you might have noticed it.

Thankfully, the day-week-year movement has been kept under reasonable control and so far we have been spared such excesses as "Be Friendly to a Ferret Fortnight", "Talk to a Tree Week" or, most horrendous of all, a "Scargill Sunday", when nobody lifts so much as a finger.

★ ★ ★ ★

Now, switching to another track—and you'll see why shortly—let's look at the position of women in society. Once the downtrodden slaves of the male, they have barely looked back since the days of Emmeline Pankhurst and her doughty daughters, Christabel and Sylvia.

Getting the vote was an opening of the floodgates of emancipation in every other direction and now no door seems to be closed to them. Short of becoming somebody's father or being elected Pope, there is little a woman cannot achieve in competition with men. And a good thing too.

If ever I'm trapped by fire on the fifth floor, I hope I'll have the luck to be rescued by a curvy firewoman who'll soothe my panic with gentle pats. So much better, I've always thought, than being slung over the shoulder of some fireman smelling of dried smoke and the memories of that Madras curry he had to abandon when the bells went down.

However, there is still one profession upon which women have made no more than a dent. That's engineering. Julia Watson, education and training officer of the Engineering Council, tells me that as recently as 1980 women formed only 21·5 per cent of the total engineering workforce and that 94 per cent of all women in engineering were employed in unskilled jobs. Only one per cent of all the Chartered Engineers registered are women.

Why is this so? The Engineering Council believes that this marked under-representation of women in engineering and science-related professions stems to some degree from the old-fashioned idea that it's a job for men only. Engineering is, erroneously, still thought of as a "heavy" profession—evoking pictures of dungarees, protective footwear and frequent swabbing of the hands with cotton waste.

This image has to some extent been perpetuated by general social attitudes. Look at any picture illustrating engineering as a calling. Ten to one it will feature a man or a boy. And, twenty to one, he'll be wearing a hard hat.

"Getting the vote was an opening of the floodgates of emancipation in every other direction..."

"In school," said Julia, "science is still looked upon as a boys' subject and this often leads to girls making narrow-option choices without taking into account the actual job opportunities available to them later on. In 1981 only 25·5 per cent of those taking 'O' level physics were girls. In the 'A' level sector this dipped to 19·5 per cent.

"By turning down what science and technology offers as a rewarding career, girls are to all intents and purposes closing the door on a whole range of job-openings. This has a special significance at the present time when advancing technology is continually increasing the demand for a highly-qualified workforce—with a high degree of its attendant career fulfilment."

Rated against the 1980 figures, the Engineering Council forecasts an expansion of 14·3 per cent in jobs for engineers and scientists and 12·5 per cent in those for technicians and draughtsmen by 1990.

"OK," said Julia. "Of course manufacturing industry is slimming down and adopting fresh techniques and new technology. But this clearly points to a change in the traditional picture of engineering as seen by young persons and, more important, their advisers. The very introduction of modern techniques only increases the need for youngsters who are versatile and of the right calibre."

It is clear that unless positive steps are taken by all concerned, the irrational situation where girls and women are deterred by sex from entering the engineering profession will result in employers becoming short of the talents they are going to need in the future—particularly in the field of advanced electronics.

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So what is the Engineering Council doing about it?—and here we return to the earlier theme. At the beginning of 1984 they launched WISE (Women in Science and Engineering). And what more laudable year can you have than that?

The aim of WISE, between January and December, is to invite every interested party to discuss the issues involved and to come up with practical proposals. WISE hopes thereby to stimulate projects in all sectors of education.

WISE has been launched in co-operation with the Equal Opportunities Commission (by a happy coincidence Baroness Platt is chairman of the former and a member of the Engineering Council). Activities include major advertising campaigns and the distribution of leaflets and information packs to primary and secondary schools.

In further and higher education there are residential courses for sixth form girls; courses for women in electronics and computing; and the chance for women who wish to retrain in science and technology.

They are also looking to industry to play a leading part as well. Engineering and science-based companies are being helped and encouraged to develop and strengthen their links with schools and colleges, with a positive accent on career-development for females. An important factor here, which has not been forgotten, is the preparation and design of recruitment material, making it more attractive to women and not, by male-bias or strict neutrality, sustaining the image that engineering's a man's world.

The Equal Opportunities Commission began to roll the ball earlier this year with a major advertising campaign on information technology. This involved the distribution of leaflets, posters and guidelines for teachers.

Next month (September) sees the opening of the second phase, devoted to engineering. Various companies and organisations will contribute to information packs for primary and secondary schools.

I got the impression from Julia that there's no real sex problem in science and engineering. There's little or no intolerance on the part of men and they're perfectly happy in the main to work alongside women, once they have shown to have the spark. Pay and status do not differ. And you can't get more civilised than that.

★ ★ ★ ★

"Don't think," said Julia, "that once *WISE '84* has drawn to a close, everyone's going to lean back and forget about the whole thing. The need for encouragement will still be there and it's essential that all the hard work put in by education and industry to change what is a totally unsatisfactory situation is continued and built upon."

Wherever the Pankhurst ladies are now, they must be smiling broadly.

MICRO-BUS

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WARM START FOR ZX81

Sir—One of the most frustrating features of the ZX81 is its lack of a hardware 'BREAK' key. This is particularly apparent when developing and trying out machine code programs. So long as the machine is in BASIC it is possible to exit from a program loop by means of the software-scanned BREAK key on the keyboard; but once the ZX81 ceases to scan the keyboard, as will occur during the execution of a machine code program which either intentionally or unintentionally gets stuck in a loop, one loses all control of the machine; it becomes completely inaccessible and unresponsive. All you can do is pull the plug on it, reconnect, re-load your programs, and start all over again.

I have tried many different approaches to try to implement a Warm Start, and finally came up with a successful method which is extremely simple.

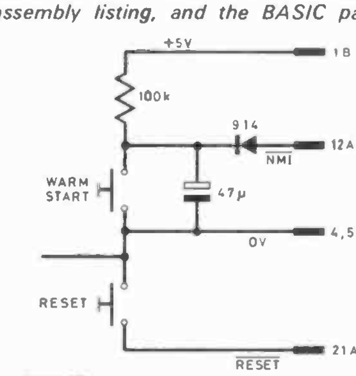
The obvious approach is to use the interrupt system, but I was initially discouraged from doing this because the ZX81's interrupt system is completely tied up with its display hardware and routines. Furthermore, the interrupt 'vectors' for the NMI and all INT modes except 2 (fully vectored interrupts) lie in the ROM, and so cannot be changed. On receipt of an NMI, control is transferred to the frame-configuring routine at 0066 hex; a mode 0 INT transfers control to the line-outputting routine at 0038 hex.

However, believe it or not, there is a way. Inspection of the NMI handler routine reveals that it is normally exited by either a RET or by a JP (IX), an indirect jump to the address pointed to by the IX register. Now, provided that the alternative accumulator contains zero, after the initial incrementing at the beginning of the NMI routine, exit from the routine will be via the JP (IX). Thus all that is necessary is to preface one's machine code program with a segment of "rescue code" which ensures that the alternative accumulator will be found to contain zero after its initial incrementing by the NMI routine, and that the IX register will contain an appropriate address for re-entry into the BASIC command-level keyboard scan/display loop. Now if an NMI pulse is generated (the $\overline{NMI}$ input of the Z80 is negative edge sensitive), control will be transferred to the NMI routine at 0066 hex in ROM, and an indirect jump will be forced back into BASIC.

There are two very important additional points: (1) This method is only possible in FAST mode, when the NMI routine is not in use for display purposes, and the SCL chip is not generating $\overline{NMI}$ pulses. This is no problem, because chances are one will want to execute the machine code program without interruption by the system display hardware (except of course for flicker-free graphics applications), and once back in BASIC one can switch between FAST and SLOW modes as desired, (2) The Warm Start push button must not be used while in BASIC, otherwise the system will hang up.

Clearly it is also necessary to avoid using the IX register and the alternative accumulator for any other purpose.

Thus it is necessary only to make sure that the system is in FAST mode before doing the USR call, and to make sure that the Warm Start button is used only to exit from a machine code program which has been prefaced by the rescue code. I have found that the easiest way—in conjunction with the ZXAS Assembler by Bug-Byte—is to LOAD "ZXAS", RUN, NEW, and then LOAD a "starter" program which incorporates an initial REM line with enough space for machine code, and the rescue code assembly listing, and the BASIC part of



ZXAS needed to actually use it (slightly modified–to ensure that FAST mode is retained throughout).

Once the rescue code has been assembled from decimal 16514 in the initial REM line, the source listing for the rescue code may, if desired, be deleted. Thereafter assembly should be from location dec. 16521, which is the next location after the rescue code. It will be found that it is possible to do a Warm Start out of the machine-code routine by a single press of the Warm Start button. The rescue code may of course be made into a separate subroutine, useful when working with more than one machine code program, or with a program with multiple entry points.

Note that a USR call from BASIC automatically disables maskable interrupts, so your machine code program will not be interrupted by the INT handler at 0038 hex (unless you should explicitly re-enable interrupts in the course of your code), and on encountering RET, or via the Warm Start via JP (IX) to address 0410 hex, maskable interrupts are re-enabled, so that the display system continues to work correctly.

The "Starter" Program for use with ZXAS. Certain lines are part of Bug-Byte's ZXAS Assembler, which should have been previously LOADed, followed by RUN, then NEW

10 REM 0000000000000000000 0000
i.e. enough space for machine code
20 REM (
30 REM EX AF.AF'
40 REM LD A.255
50 REM EX AF.AF'
60 REM LD IX.$0410
} Rescue code source listing.

Space for rest of assembly listing.

4000 REM)

Space for additional BASIC programs.

9000 FAST
9010 INPUT ZZZ
9020 POKE 32461, INT (ZZZ/256)
9030 POKE 32460, ZZZ-256*INT (ZZZ/256)
9040 RAND USR 28565
9050 PRINT AT 21,0;"ERROR"; PEEK 32651

For assembly use GOTO 9000. Assemble and execute from dec. 16514; if lines 30 through 60 deleted after assembling rescue code, then assemble program proper from dec. 16521, but still execute from dec. 16514. Rescue code in hex is 08 3EFF 08 DD211004.

So few components are required that they may easily be fitted to the ZX81 pcb. The push-to-make Warm Start switch may be fitted to the case or brought out to some convenient position. While carrying out this modification it is worth fitting a RESET switch at the same time; this achieves the same as the power-on reset, but without the need to disconnect or turn off the power supply.

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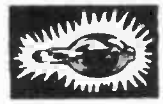

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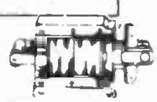

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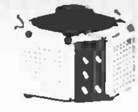

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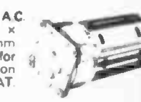

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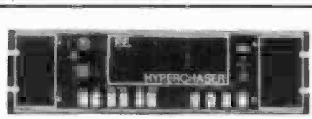

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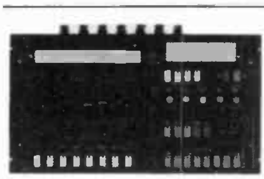

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