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TODAY INTERNATIONAL

THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY

AUGUST 1988 £1.40

QUARTER WAVE LOADING LOUDSPEAKERS

Novel design to build

BEGINNERS

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RANDOM NUMBER DISPLAY

Large LEDs for fêtes and club games

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News, reviews and circuit ideas

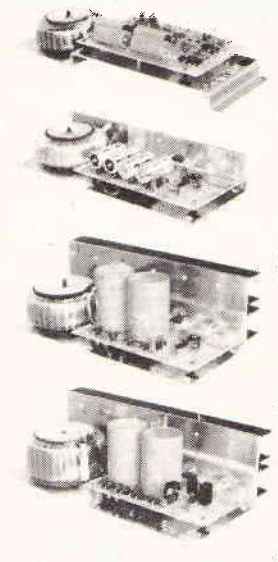
AUDIO • COMPUTING • MUSIC • DOMESTIC

OMP POWER AMPLIFIER MODULES

★ PRICES INCLUDE V.A.T. ★ PROMPT DELIVERIES ★ FRIENDLY SERVICE ★ LARGE S.A.E. 28p STAMP FOR CURRENT LIST

OMP POWER AMPLIFIER MODULES

Now enjoy a world-wide reputation for quality reliability and performance at a realistic price. Four models available to suit the needs of the professional and hobby market i.e., Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices. NOTE all models include Toroidal power supply. Integral heat sink. Glass fibre P.C.B. and Drive circuits to power compatible Vu meter. Open and short circuit proof. **Supplied ready built and tested.**



OMP100 Mk II Bi-Polar Output power 110 watts R.M.S. into 4 ohms, Frequency Response 15Hz - 30KHz —3dB, T.H.D. 0.01%, S.N.R. —118dB, Sens. for Max. output 500mV at 10K, Size 355 × 115 × 65mm.
PRICE £33.99 + £3.00 P&P.

OMP/MF100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 80, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. —125dB. Size 300 × 123 × 60mm. PRICE
PRICE £39.99 + £3.00 P&P.

OMP/MF200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 250, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. —130dB, Size 300 × 150 × 100mm. PRICE
PRICE £62.99 + £3.50 P&P.

OMP/MF300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 350, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. —130dB, Size 330 × 147 × 102mm. PRICE
PRICE £79.99 + £4.50 P&P.

NOTE Mos Fets are supplied as standard (100KHz bandwidth & Input Sensitivity 500mV). If required P.A. version (50KHz bandwidth & Input Sensitivity 775mV). Order — Standard or P.A.

Vu METER Compatible with our four amplifiers detailed above. A very accurate visual display employing 11 L.E.D. diodes (7 green, 4 red) plus an additional on/off indicator. Sophisticated logic control circuits for very fast rise and decay times. Tough moulded plastic case, with tinted acrylic front. Size 84 × 27 × 45mm.
PRICE £8.50 + 50p P&P.

BURGLAR ALARM

Better to be **'Alarmed'** then terrified.
Thandar's famous 'Minder' Burglar Alarm System. Superior microwave principle. Supplied as three units complete with interconnection cable. **FULLY GUARANTEED.**
Control Unit — Houses microwave radar unit, range up to 15 metres adjustable by sensitivity control. Three position, key operated facia switch — off — test — armed. 30 second exit and entry delay.
Indoor alarm — Electronic swept freq. siren. 104dB output.
Outdoor Alarm — Electronic swept freq. siren. 98dB output. Housed in a tamper-proof heavy duty metal case.
Both the control unit and outdoor alarm contain rechargeable batteries which provide full protection during mains failure. Power requirement 200/260 Volt AC 50/60Hz. Expandable with door sensors, panic buttons etc. Complete with instructions.

IDEAL for Workshops, Factories, Offices, Home, etc. Supplied ready built.

SAVE £138.00 Usual Price £228.85
BKE's PRICE £89.99 + £4.00 P&P
? Why buy a collection of self assembly boards!

OMP LINNET LOUDSPEAKERS

The very best in quality and value. Made specially to suit todays need for compactness with high sound output levels. Finished in hard wearing black vynide with protective corners, grille and carry handle. All models 8 ohms. Full range 45Hz - 20KHz. Size 20" × 15" × 12". Watts R.M.S. per cabinet. Sensitivity 1W. 1mtr. dB.
OMP 12-100 Watts 100dB. Price £149.99 per pair.
OMP 12-200 Watts 102dB. Price £199.99 per pair.
Delivery Securicor £8.00 per pair

OMP 19" STEREO RACK AMPS

Professional 19" cased **Mos-Fet** stereo amps. Used the **World** over in clubs, pubs, discos etc. With twin Vu meters, twin toroidal power supplies. XLR connections. MF600 Fan cooled. **Three models** (Ratings R.M.S. into 4 ohms). Input Sensitivity 775mV.

MF200 (100 + 100)W. £169.00 **Securicor**
MF400 (200 + 200)W. £228.85 **Delivery**
MF600 (300 + 300)W. £322.00 **£10.00**

1 K-WATT SLIDE DIMMER

- ★ Control loads up to 1Kw
- ★ Compact Size 4¾" × 1" × 2½"
- ★ Easy snap in fixing through panel cabinet cut out
- ★ Insulated plastic case
- ★ Full wave control using 8 amp triac
- ★ Conforms to BS800
- ★ Suitable for both resistance and inductive loads. Innumerable applications in industry, the home, and disco's, theatres etc.

PRICE £13.99 + 75p P&P

LOUDSPEAKERS 5" to 15" up to 400 WATTS R.M.S.

Cabinet Fixing in stock. Huge selection of **McKenzie Loudspeakers** available including Cabinet Plans. **Large** S.A.E. (28p) for free details.

POWER RANGE
8" 50 WATT R.M.S. Hi-Fi/Disco.
20 oz magnet 1½" ally voice coil. Ground ally fixing escutcheon. Res. Freq. 40Hz. Freq. Resp. to 6KHz. Sens. 92dB. PRICE £10.99 Available with black grille £11.99. P&P £1.50 ea.
12" 100 WATT R.M.S. Hi-Fi/Disco
50 oz magnet 2" ally voice coil. Ground ally fixing escutcheon. Die cast chassis. White cone. Res. Freq. 25Hz. Freq. Resp. to 4KHz. Sens. 95dB. PRICE £28.60 + £3.00 P&P ea.

McKENZIE
12" 85 WATT R.M.S. C1285GP Lead guitar/keyboard/Disco
2" ally voice coil Ally centre dome Res Freq 45Hz Freq. Resp. to 6.5KHz Sens. 98dB PRICE £29.99 + £3.00 P&P ea.
12" 85 WATT R.M.S. C1285TC P.A/Disco 2" ally voice coil. Twin cone.
Res. Freq. 45Hz Freq. Resp. to 14KHz PRICE £31.49 + £3.00 P&P ea
15" 150 WATT R.M.S. C15 Bass Guitar/Disco.
3" ally voice coil Die-cast chassis Res. Freq. 40Hz Freq. Resp. to 4KHz PRICE £57.87 + £4.00 P&P ea
10" 60 WATT R.M.S. 1060GP Gen. Purpose/Lead Guitar/Keyboard/Mid. P.A.
2" voice coil. Res. Freq. 75Hz Freq. Resp. to 7.5KHz Sens. 99dB. PRICE £19.99 + £2.00 P&P
10" 200 WATT R.M.S. C10200GP Guitar, Keyboard, Disco.
2" voice coil. Res. Freq. 45Hz. Freq. Resp. to 7KHz. Sens. 101dB PRICE £44.76 + £3.00 P&P
15" 200 WATT R.M.S. C15200 High Power Bass.
Res. Freq. 40Hz. Freq. Resp. to 5KHz. Sens. 101dB. PRICE £62.41 + £4.00 P&P
15" 400 WATT R.M.S. C15400 High Power Bass.
Res. Freq. 40Hz. Freq. Resp. to 4KHz. Sens. 102dB PRICE £89.52 + £4.00 P&P.

WEM
5" 70 WATT R.M.S. Multiple Array Disco etc.
1" voice coil Res. Freq. 52Hz Freq. 52Hz Freq. Resp. to 5KHz Sens. 89dB PRICE £22.00 + £1.50 P&P ea
8" 150 WATT R.M.S. Multiple Array Disco etc.
1" voice coil. Res. Freq. 48Hz Freq. Resp to 5KHz Sens. 92dB PRICE £32.00 + £1.50 P&P ea.
10" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
1" voice coil Res. Freq. 35Hz Freq. Resp. to 4KHz Sens. 92dB PRICE £36.00 + £2.00 P&P ea.
12" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
1½" voice coil Res. Freq. 35Hz Freq. Resp. to 4KHz Sens. 94dB PRICE £47.00 + £3.00 P&P ea

SOUNDLAB (Full Range Twin Cone)
5" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc
1" voice coil Res Freq 63Hz Freq Resp to 20KHz Sens 86dB PRICE £9.99 + £1.00 P&P ea
6½" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc
1" voice coil Res Freq 56Hz Freq Resp to 20KHz Sens 89dB PRICE £10.99 + £1.50 P&P ea
8" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc
1¼" voice coil Res Freq 38Hz Freq Resp to 20KHz Sens 89dB PRICE £12.99 + £1.50 P&P ea
10" 60 WATT R.M.S. Hi-Fi/Disco etc
1¼" voice coil Res Freq 35Hz Freq Resp to 15KHz Sens 89dB PRICE £16.49 + £2.00 P&P

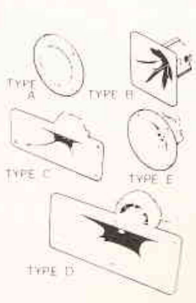
BSR P295 ELECTRONIC TURNTABLE

★ Electronic speed control 45 & 33⅓ r.p.m. ★ Plus Minus variable pitch control ★ Belt driven ★ Aluminium platter with strobed rim ★ Cue lever ★ Anti skate (bias device) ★ Adjustable counter balance ★ Manual arm ★ Standard ½" cartrige fixings ★ Supplied complete with cut out template ★ D.C. Operation 9-14v D.C. 65mA
Price £36.99 + £3.00 P&P

ADC Q4 mag. cartridge for above. Price £4.99 ea. P&P 50p

PIEZO ELECTRIC TWEETERS — MOTOROLA

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover **is not** required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER**



TYPE 'A' (KSN2036A) 3" round with protective wire mesh. Ideal for bookshelf and medium sized Hi-fi speakers. **Price £4.90 each** + 40p P&P
TYPE 'B' (KSN1005A) 3½" super horn. For general purpose speakers, disco and P.A. systems etc. Price **£5.99 each** + 40p P&P
TYPE 'C' (KSN6016A) 2" × 5" wide dispersion horn. For quality Hi-fi systems and quality discos etc. **Price £6.99 each** + 40p P&P
TYPE 'D' (KSN1025A) 2" × 6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. **Price £9.99 each** + 40p P&P
TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. **Price £5.99 each** + 40p P&P
LEVEL CONTROL Combines on a recessed mounting plate, level control and cabinet input jack socket 85 × 85 mm. **Price £3.99** + 40p P&P

PANTEC

HOBBY KITS. Proven designs including glass fibre printed circuit board and high quality components complete with instructions.

FM MICROTRANSMITTER (BUG) 90/105MHz with **very sensitive** microphone. Range 100/300 metres. 57 × 46 × 14mm (9 volt) **Price:** £8.62 + 75p P&P.
3 WATT FM TRANSMITTER 3 WATT 85/115MHz varicap controlled professional performance. Range up to 3 miles 35 × 84 × 12mm (12 volt) **Price:** £14.49 + 75p P&P.
SINGLE CHANNEL RADIO CONTROLLED TRANSMITTER/RECEIVER 27MHz. Range up to 500 metres. Double coded modulation. Receiver output operates relay with 2amp/240 volt contacts. Ideal for many applications. Receiver 90 × 70 × 22mm (9/12 volt). **Price:** £17.82 Transmitter 80 × 50 × 15mm (9/12 volt). **Price: £11.29** P&P + 75p each. S.A.E. for complete list.

3 watt FM Transmitter

STEREO DISCO MIXER

STEREO DISCO MIXER with 2 × 5 band L & R graphic equalisers and twin 10 segment L.E.D. Vu Meters. **Many** outstanding features. 5 Inputs with individual faders providing a useful combination of the following — 3 Turntables (Mag), 3 Mics, 4 Line plus Mic with talk over switch. Headphone Monitor. Pan Pot L & R. Master Output controls. Output 775mV. Size 360 × 280 × 90mm.
Price £134.99 — £3.00 P&P

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POSTAL CHARGES PER ORDER £1.00 minimum. OFFICIAL ORDERS WELCOME, SCHOOLS, COLLEGES, GOVERNMENT BODIES, ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER VISA/ACCESS/C.O.D. ACCEPTED

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POWER CONDITIONER

FEATURED IN ETI
JANUARY 1988

The ultimate mains purifier. Intended mainly for lowering the noise floor and improving the analytical qualities of top-flight audio equipment

The massive filter section contains thirteen capacitors and two current balanced inductors, together with a bank of six VDRs to remove every last trace of impulsive and RF interference. A ten LED logarithmic display gives a second by second indication of the amount of interference removed

Our approved parts set consists of case, PCB, all components (including high permeability toroidal cores, ICs transistors, class X and Y suppression capacitors, VDRs, etc.) and full instructions

PARTS SET **£28.50** + VAT

Some parts are available separately. Please send SAE for lists, or SAE + £1 for lists, circuit, construction details and further information (free with parts set)

KNIGHT RAIDER

FEATURED IN ETI JULY 1987

The ultimate in lighting effects for your Lamborghini, Maserati, BMW (or any other car, for that matter). Picture this: eight powerful lights in line along the front and eight along the rear. You flick a switch on the dashboard control box and a point of light moves lazily from left to right leaving a comet's tail behind it. Flip the switch again and the point of light becomes a bar, bouncing backwards and forwards along the row. Press again and try one of the other six patterns. An LED display on the control box let's you see what the main lights are doing

The Knight Raider can be fitted to any car (it makes an excellent fog light!) or with low powered bulbs it can turn any child's pedal car or bicycle into a spectacular TV-age toy!

The parts set consists of box, PCB and components for control, PCB and components for sequence board, and full instructions

Lamps not included

PARTS SET **£19.90** + VAT

CREDIT CARD CASINO

FEATURED IN ETI,
MARCH 1987

This wicked little pocket gambling machine measures only 3"x2"x½". It will play all kinds of casino games, including

- Roulette
- Craps
- Pontoon

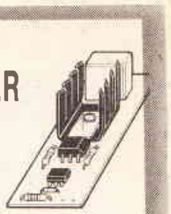
Our approved parts set comes complete with case; self-adhesive fascia; tinned and drilled printed circuit board; all components; hardware; full instructions and three different games to play!

PARTS SET ONLY **£5.90!** + VAT

Five extra games FREE with every order!

MAINS CONTROLLER

FEATURED IN ETI
JANUARY 1987



Have you ever wondered what people **do** with all those computer interfaces? 'Put your computer in control,' say the ads. 'The Spectrabeeb has eight TTL outputs.' What on earth can you control with a TTL output? A torch bulb?

The ETI Mains Controller is a logic to mains interface which allows you to control loads of up to 500W from your computer or logic circuits. An opto-coupler gives isolation of at least 2 500V, so the controller can be connected to experimental circuits, computers and control projects in complete safety. Follow your computer interface with a mains controller and you're **really** in business with automatic control!

The mains controller connects directly to most TTL families with external components, and can be driven by CMOS with the addition of a transistor and two resistors (supplied).

Your mains controller parts set contains: high quality roller tinned PCB; MOC3021 opto-coupler; power triac with heatsink, mounting hardware and heatsink compound, all components, including snubber components for switching inductive loads; transistor and resistors for CMOS interface; full instructions.

PARTS SET **£6.20** + VAT!

THE DREAM MACHINE

FEATURED IN ETI
DECEMBER 1987

Adjust the controls to suit your mood and let the gentle relaxing sound drift over you. At first you might hear soft rain, sea surf, or the wind through distant trees. Almost hypnotic, the sound draws you irresistably into a peaceful, refreshing sleep

For many, the thought of waking refreshed and alert from perhaps the first truly restful sleep in years is exciting enough in itself. For more adventurous souls there are strange and mysterious dream experiences waiting. Take lucid dreams, for instance. Imagine being in control of your dreams and able to change them at will to act out your wishes and fantasies. With the Dream Machine it's easy!

The approved parts set consists of PCB, all components, controls, loudspeaker, knobs, lamp, fuseholders, fuse, mains power supply, prestige case and full instructions

PARTS SET **£16.50** + VAT

AVAILABLE WITHOUT CASE FOR ONLY **£11.90** + VAT

The S101 professional respiration and heart-rate monitor is the ideal instrument to keep track of your progress in any kind of fitness or sports training. The average adult resting heart rate is around 80 beats per minute. For an athlete at the peak of physical fitness it can be 50 or less.

How fit are you? How quickly is your jogging or sports training strengthening your heart and respiration? How quickly do you recover from oxygen debt after exercise? For your own sake, you need to know.

The approved parts set consists of: case, 3 printed circuit boards, all components (including 17 ICs, quartz crystal, over 75 transistors, resistors, diodes and capacitors), liquid crystal display, switches, plugs, sockets, LEDs, leads, electrodes and sensors, and full instructions.

ARMSTRONG 75W AMPLIFIER

FEATURED IN PE
JULY 1988

A.J. Armstrong's exciting new audio amplifier module is here at last!

Delivering a cool 75W (conservatively rated – you'll get nearer 100W), this MOSFET design embodies the finest minimalist design techniques, resulting in a clean, uncluttered circuit in which every component makes a precisely defined contribution to the overall sound.

You can read all about it in the July issue of PE, but why bother with words when your ears will tell you so much more?

Parts set includes top grade PCB and all components.

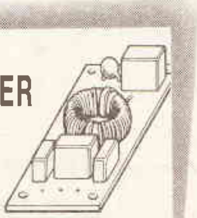
SPECIAL INTRODUCTORY PRICE FOR FULLY UPGRADED MODULES.

SINGLE PARTS SET **£14.90** + VAT
STEREO PAIR **£25.90** + VAT

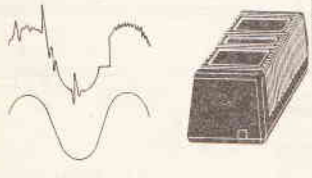
Please send SAE + £1 for data and circuits (free with parts set), including diagrams for matching pre-amp and power supply. This amplifier will **not** be available from your usual audio supplier – we produce the only designer approved parts set

MAINS CONDITIONER

FEATURED IN ETI
SEPTEMBER 1986



Cleans up mains pollution easily and effectively. You'll hardly believe the difference in your Hi-Fi, TV, Video, and all other sensitive equipment.

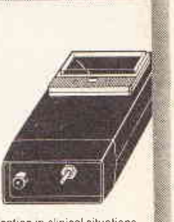


PARTS SET **£4.90** + VAT

RUGGED PLASTIC CASE **£1.65** + VAT

BIO-FEEDBACK

FEATURED IN ETI
DECEMBER 1986



Bio-feedback comes of age with this highly responsive, self-balancing skin response monitor! The powerful circuit has found application in clinical situations as well as on the bio-feedback scene. It will open your eyes to what GSR techniques are really all about.

The complete parts set includes case, PCB, all components, leads, electrodes, conductive gel, and full instructions.

PARTS SET **£13.95** + VAT

BIO-FEEDBACK BOOK **£3.95** (no VAT)

Please note: the book, by Stern and Ray, is an authorised guide to the potential of bio-feedback techniques. It is not a hobby book, and will only be of interest to intelligent adults.

POWERFUL AIR IONISER

FEATURED IN ETI
JULY 1986

Ions have been described as 'vitamins of the air' by the health magazines, and have been credited with everything from curing hay fever and asthma to improving concentration and putting an end to insomnia. Although some of the claims may be exaggerated, there is no doubt that ionised air is much cleaner and purer, and seems much more invigorating than 'dead' air.

The DIRECT ION ioniser caused a great deal of excitement when it appeared as a constructional project in ETI. At last, an ioniser that was comparable with (better than?) commercial products, was reliable, good to build and fun! Apart from the serious applications, some of the suggested experiments were outrageous!

We can supply a matched set of parts, fully approved by the designer, to build this unique project. The set includes a roller tinned printed circuit board, 66 components, case, mains lead and even the parts for the tester. According to one customer, the set costs about a third of the price of the individual components. What more can we say?

Instructions are included

PARTS SET WITH BLACK CASE **£11.50** + VAT

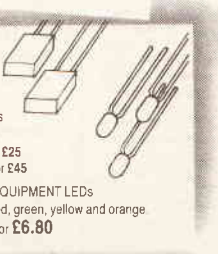
PARTS SET WITH WHITE CASE **£11.80** + VAT

LM2917 EXPERIMENTER SET

Consists of LM2917 IC, special printed circuit board and detailed instructions with data and circuits for eight different projects to build. Can be used to experiment with the circuits in the 'Next Great Little IC' feature (ETI, December 1986).

LM2917 EXPERIMENTER SET **£5.80** + VAT

LEDs



Green rectangular LEDs for bar-graph displays.

50 for **£3.50**	500 for **£25**
100 for **£6**	1000 for **£45**

DIGITAL AND AUDIO EQUIPMENT LEDs

Assorted 3mm LEDs: red, green, yellow and orange

25 of each (100 LEDs) for **£6.80**

BRAINWAVE MONITOR

FEATURED IN ETI
AUGUST 1987

The most astonishing project ever to have appeared in an electronics magazine. Similar in principle to a medical EEG machine, this project allows you to **hear** the characteristic rhythms of your own mind! The alpha, beta and theta forms can be selected for study and the three articles give masses of information on their interpretation and powers

In conjunction with Dr. Lewis's Alpha Plan, the monitor can be used to overcome shyness, to help you feel confident in stressful situations, and to train yourself to excel at things you're 'no good at'

Our approved parts set contains case, two PCBs, screening can for bio-amplifier, all components (including three PMI precision amplifiers), leads, brass electrodes and full instructions

PARTS SET **£36.90** + VAT

ALPHA PLAN BOOK **£2.50** + VAT

Parts set available separately. We also have a range of accessories, professional electrodes, books, etc. Please send SAE for lists, or SAE + £2 for lists, construction details and further information (free with parts set)

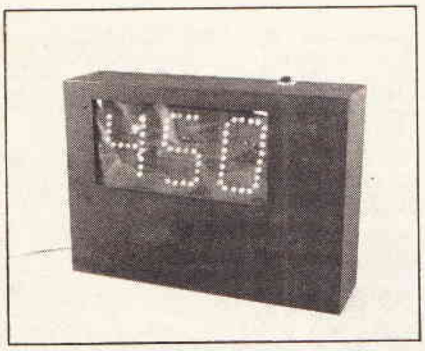
Prices shown are exclusive of VAT, so please add 15% to the order total. UK postage is 70p on any order. Carriage and insurance for overseas orders £4.50. Please allow up to 14 days for delivery.

Specialist SEMICONDUCTORS LIMITED

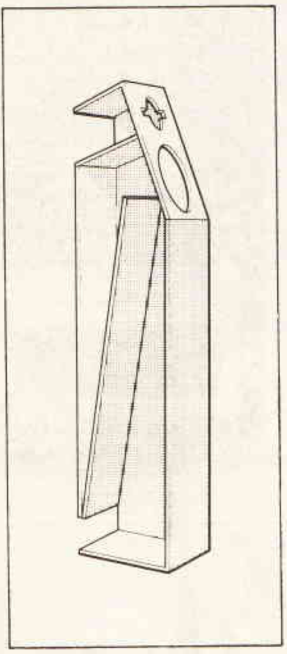
SALES DEPT., ROOM 107, FOUNDERS HOUSE, REDBROOK, MONMOUTH, GWENT.

August 1988

VOLUME 17 No 8



Page 36



Page 24

ISSN 0142-7229

ABC Member of the Audit Bureau of Circulation

● Subscription rates UK £16.80. Europe: £21.00. Middle East: £21.20. Far East: £22.80. Rest: £21.50 or US$32.00.

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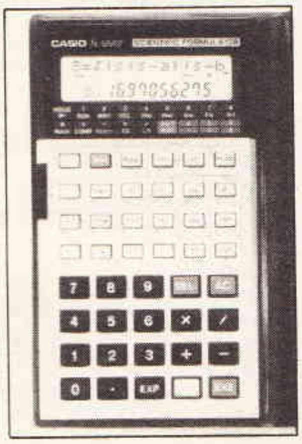
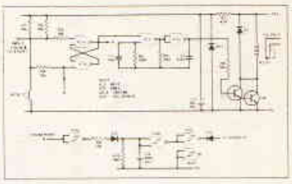
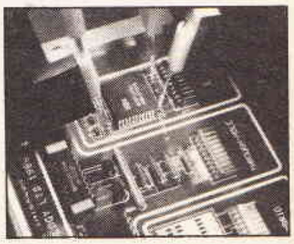
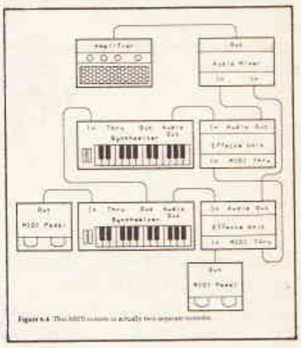








Published by Argus Specialist Publications Ltd., 1 Golden Square, London W1R 3AB. Tel: 01-437 0626. UK newstrade distribution by SM Distribution Ltd., 6 Leigham Court Road, London SW16 2PG. Tel: 01-677 8111. Overseas and non-newstrade sales by Magazine Sales Department, 1 Golden Square, London W1R 3AB. Tel: 01-437 0626. Subscriptions by Infonet Ltd., 5 River Park Estate, Berkhamsted HP4 1HL. Tel:(04427) 76661. US subscriptions by Wise Owl Publications, 4314 West 238th Street, Torrance, CA90505 USA. Typesetting and origination by Project 3 Filmsetters, Whitstable. Printed and bound by The Chesham Press, Chesham. Covers printed by Loxley Brothers Ltd., Sheffield.

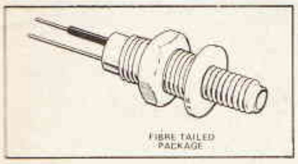
ETI
ELECTRONICS
TODAY INTERNATIONAL

FEATURES/PROJECTS

12

Just The Ticket

Brenden Foley takes to the tracks to give a behind-the-scenes look at the Londons Underground's new automatic ticket system



16

Brought To Light

Mike Barwise's *Chip In* continues to look at the world of opto-electronics. This month laser diodes and fibre optics come under scrutiny

19

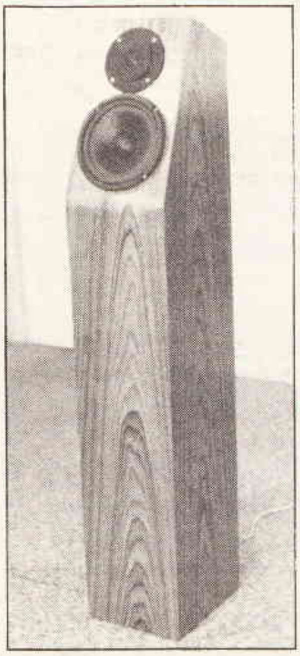
Op-amps

Paul Chappell is biased towards the *Circuit Theory* of Op-amps. The input stages of this building block are explained this month

22

Rad Alert

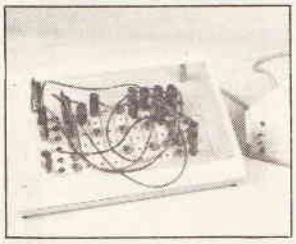
Ian Pitt goes Chernobyl-checking with three pocket-sized radiation monitors from Perspective Scientific



PROJECT 24

The QWL Loudspeaker

John Dix presents a novel loudspeaker enclosure design which takes up the space of a small speaker but gives the sound of the big boys



PROJECT 28

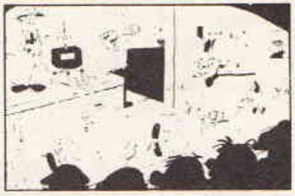
Analogue Computer

Paul Cuthbertson finishes off his analogue computer project with the details of building the main computer board

PROJECT 34

Phone Fun

Keith Brindley continues the *1st Class* for beginners with a telephone recording pickup project



PROJECT 36

Random Number Display

Eyes down for Geoff Phillips' three digit extra large sized random number display unit for clubs, pubs and anyone else wanting an element of chance

PROJECT 40

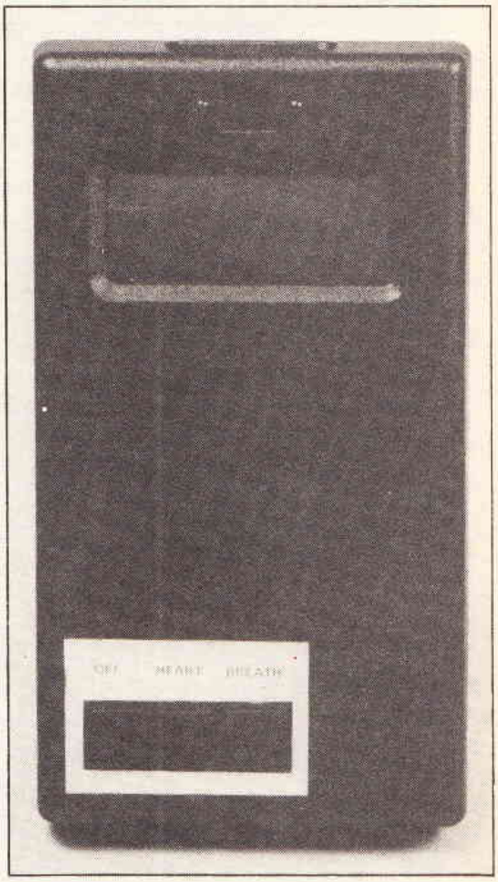
Every Breath You Take

Paul Chappell concludes his respiration and pulse rate meter with all the final constructional details and some information on how to keep fit and live longer

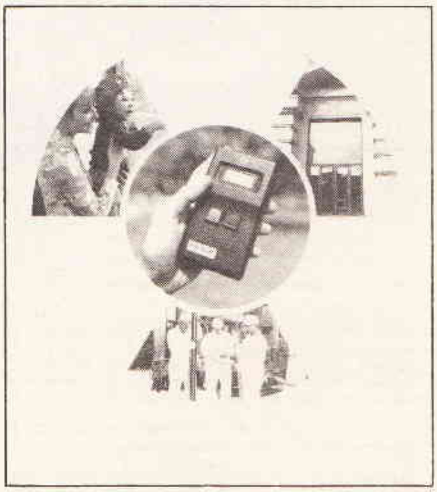
50

Tech Tips

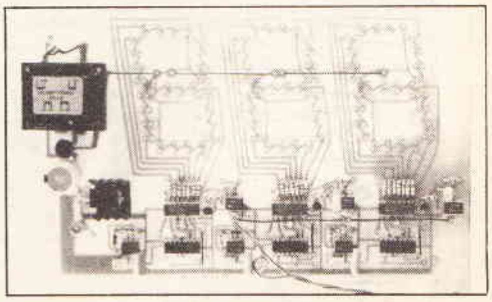
More circuit ideas from ETI's ever-inventive readers
Infra-Red Fault Finder
FM Bug
Anti-Thump Circuit



Page 40



Page 22



Page 36

NEWS

RESEARCH HEATS UP

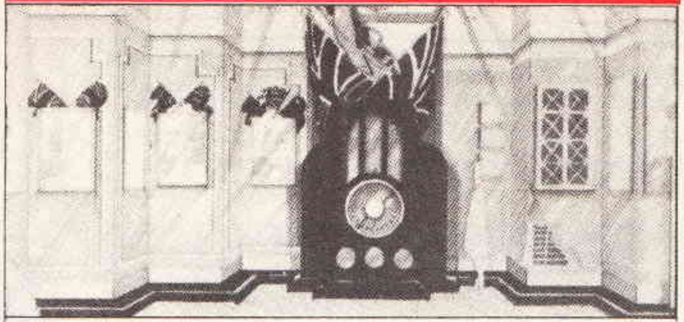
A third class of superconducting material has been identified by the Institute of Metallic Material Research in Tsukuba, Japan.

Unlike the structures pioneered by IBM Zurich and the University of Houston, the new material contains no rare-earth element and has a superconducting temperature 10K above Houston's confirmed results.

It consists of layers of copper and oxygen atoms held apart by strontium, calcium and bismuth oxide.

It seems likely that one of the new material's possible two states will superconduct above 100K (−173°C). Unfortunately this state is difficult to purify and so, as with the other superconductor classes, the commercial possibilities remain distant.

RADIO DAYS



Stand-by for a spectacular extravaganza of sound and light this autumn as the BBC takes over Earls Court to mount the BBC Radio Show.

The show has been organised to celebrate 21 years since the demise of the Home, Light and Third services and the introduction of Radios 1,2,3,4 with the network of Local Radio.

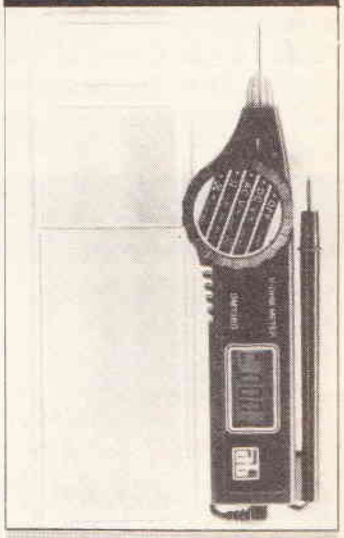
The show will also be used to showcase the increasing number of pies that BBC Enterprises now fingers, such as the Radio Data System (and hopefully the BBC Badged Radio).

The centrepiece of the show will be a theatrical display entitled *The Story of Radio* based around giant model radios in period settings from the 1920s to the 1960s.

There will be live broadcasts of local and national radio with both a music stage and a sound theatre for audience shows (mainly Radio 4). Most important of all, ETI will be there too!

The BBC Radio Show will run for nine days. Tickets (£5) will be sold either for the matinee (noon to 5pm) or for the evening (5pm to 10pm) and all shows will be on a first come first served basis. The show runs from October 1st-9th (starts 11am at weekends). For further details contact BBC Radio Show, PO Box 100, Chatham, Kent ME5 8LJ.

METER MADE IN WALES



The DM1360 is a neat little digital multimeter from AB of Cardiff.

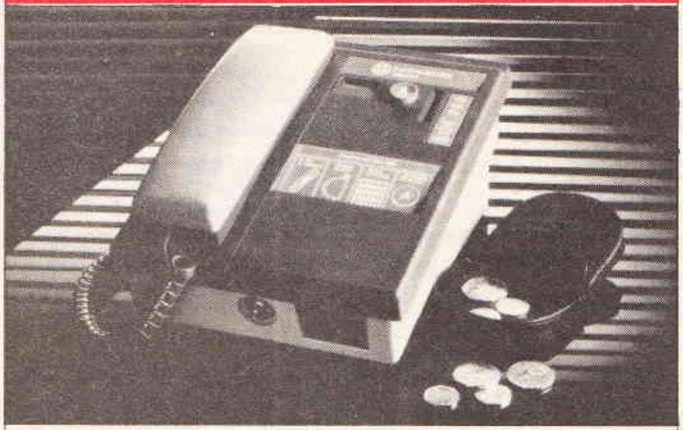
The meter is a pen styled instrument with a separate negative probe (shown here clipped to the meter for storage).

It measures AC/DC volts to 500V, resistance to 20M and is fully autoranging.

The 3½-digit display holds readings in case the meter is testing in awkward positions, and a continuity testing function bleeps to indicate a good path.

The DM1360 costs £36.95 from AB, Wharfdale Road, Pentwyn, Cardiff CF2 7HC. Tel: (0222) 733485.

WHAT PRICE PAYPHONES?



OFTEL, the UK telecommunications watchdog, has announced the deregulation of the private payphone market in the UK and the first private payphone is already on the market.

The Southwestern Bell Telecom PP1000 is a desktop payphone that simply plugs into a normal BT master socket for use in any supervised environment such as newsagents, pubs and so on. The owner empties the payphone and pays his bill in the usual way.

The phone is programmable (program functions and cash box are protected by sturdy locks). Southwestern Bell presets the phones to charge BT rates but owners can reprogram them to charge whatever they wish.

A special feature is included to charge weekend calls at weekday rates. Tariffs can be adjusted to charge anything up to 10p a second.

This sort of programmability should make the payphones very popular since purchasers can recoup the cost of the phone by overcharging the public, as well as by bringing in custom to the shop.

The prospect is rather more disturbing for the punters. The phone does not indicate how high tariffs have been set (this could easily have been included on the LCD display). Southwestern Bell indicate on purchase that a sign should be displayed stating call rates but with no proper regulation this is unlikely to occur and the only way of checking if you've been ripped off will be to carry a BT chargebook and a stopwatch.

This is certainly a well designed product, but it seems remarkable that it should have been allowed into the marketplace in its present form.

The PP1000 retails at £215+VAT from Southwestern Bell Telecom, Southall Lane, Heston, Middlesex UB2 5NH. Tel: 01-574 2222.

LOGIC TOOL

Thandar has a new logic analyser on the market just a little more complicated than our *1st Class* logic probe project last month.

The TA1000 can keep track of 32 channels at up to 25MHz, displaying information as either timing diagrams or data lists. Circuit loading is minimised by high impedance inputs.

It interfaces with RS232, Centronics and IEEE-488 standards and has battery backed CMOS RAM for storage.

The price is £1.799+VAT from Thandar, London Road, Huntingdon, Cambs PE17 4HJ. Tel: (0480) 64646.

WIRED

The second edition of Trevor Marks' *Handbook on the IEE Wiring Regulations* is now available from William Ernest Publishing.

The guide simplifies the regulations in more understandable language, shows how to use the various calculations and how to apply the results in practical wiring.

It costs £15.75 and may be obtained direct from the publishers if you cannot find it locally.

WEP, 32 Kimberley Road, Nuthall, Nottingham NG16 1DF.

FREEBIES

Opto-experimenters can obtain Lambda's 26-page colour brochure detailing its range of HeNe lasers and associated stuff absolutely free from Lambda House, Batford Mill, Harpenden AL5 5BZ. Tel: (05827) 64334.

The 1988 D&M Component Supply Service catalogue is now available from D&M, 2 Glentworth Avenue, Whitmore Park, Coventry CV6 2HW. Tel: (0203) 333195.

IMO's new catalogue is out listing all its display, switch and connection products. Free from IMO, 1000 North Circular Road, Staples Corner, London NW2 7JP. Tel: 01-452 6444.

And lastly in this month's list of jolly junk mail comes Greenweld which started its summer sale on July 1st. A 4-page list of bargains — half price or less — is available from Greenweld, 443 Millbrook Road, Southampton SO1 OHX.

GERMANY LIBERATED

West Germany is now set to follow Britain's lead by liberalising its telecommunications authorities.

The cabinet has now approved the splitting of the Bundespost — presently a combined telecom and postal authority similar to Britain's old Post Office — into three areas with limited competition allowed.

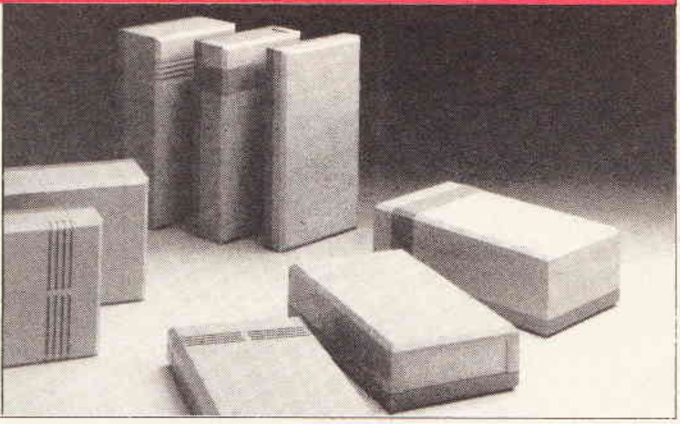
Provided that the reforms pass through the next two readings without incident, the split should take place next summer.

BOXING CLEVER AT WEST HYDE

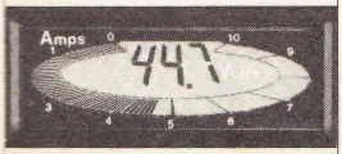
West Hyde Developments is celebrating "25 years enclosures experience" by creating a fresh range of boxes under the moniker *Elegant*.

The cases are styled to appear more modern than the standard Veroboxes used for most project building, with distinctive bevelled edges and a finely textured surface.

It's expected that the enclosures will become widely available shortly but for the moment it is easiest to deal direct with West Hyde, 9-10 Park Street Industrial Estate, Aylesbury, Bucks HP20 1ET. Tel: (0296) 20441.



DISPLAYS



Crompton is marketing an expensive but attractive set of elliptical bar graph displays for use in project instrument panels.

The graphs are 3½ins long with a 100-segment analogue elliptical bar graph (1% resolution) and a 3-digit digital readout (0.1% resolution). The inputs to the two displays are fully separated so that the units could display two different variables if required.

The one-off price is £45+VAT but significantly less for production quantities. Contact Crompton Modutec, Freebournes Road, Witham, Essex CM8 3AH. Tel: (0376) 512601.

AWARDS

This year's Lloyds Bowmaker Industrial Achievement Award is now open for entries from electronics firms which can show an innovative new idea successfully developed, coupled with the ability to exploit its profitability in the future.

Entrants must be British-owned companies with an annual turnover between £¼m and £15m, and must have been in business for two years.

The first prize is £1500 (in addition of course to the significant publicity) and there are four other prizes of £1000.

The closing entry date is August 31st.

For an entry form contact Lloyds Bowmaker, Christchurch Road, Bournemouth, Dorset BH1 3LG. Tel: (0202) 22077.

VHS 24-TRACK DATA

Racal Recorders in Southampton has produced a highly advanced instrumentation recorder that uses standard VHS video cassettes for data storage.

The V-Store recorder is designed to be compact and rugged to meet a variety of field applications from medical monitoring to high speed data logging.

Such a variety of use requires a great deal of flexibility and the V-Store can operate at over 20 different tape speeds — from 15/32in/s to 30in/s — with a corresponding increase in bandwidth (100kHz at top speed).

The V-Store can monitor up to 24 channels simultaneously (the number of channels supplied is optional) and the excellent display and sensible controls make the recorder easy, reliable and fun to play with.

But of course it's not in the pocket money price range. The price varies from £10,000 to £20,000 depending on the number of signal channels required.

Contact Racal Recorders, Hythe, Southampton SO4 6ZH. Tel: (0703) 843265.

IN A SPIN

Greenweld has released a very reasonably priced optical shaft encoder. The unit produces two phase shifted outputs (for position) and a sync pulse (for speed information) on each revolution.

The unit is supplied with comprehensive data and costs £8.50.

Contact Greenweld on (0703) 772501.

ON DRILL

A set of tools and attachments for any 43mm collar power drill is being offered by Electronic and Computer Workshop.

The package uses the power of a conventional drill and provides stands and extensions to form a precision vertical drilling machine, a grinding machine, an adjustable sanding table and a horizontal lathe to turn work up to 60cm long.

ECW is marketing the set at £125.48 inclusive of VAT and postage. For complete information contact ECW, Unit 1, Cromwell Centre, Witham, Essex CM8 3TH. Tel: (0376) 517413.

SPEAKERS' CORNER

The boom in semi-portable ghetto blasters with a '3D Super Woofer' has prompted Wilmslow Audio to offer a range of add-on sub-bass speaker kits.

The first two designs use a Volt dual voice coil sub-bass drive unit taking the bass of both stereo channels, integrating passively with existing mini speakers.

The other two designs use two Peerless units in push-pull configuration, for medium size main speakers.

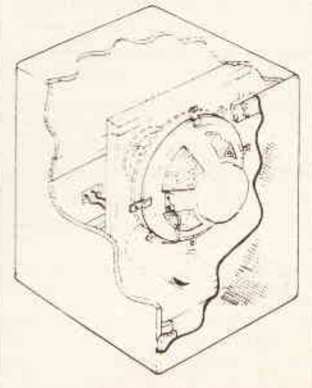
Wilmslow will also provide electronic crossover to run the bass units from a separate bass amplifier.

More loudspeaker news concerns Scanspeak of Denmark.

The D2008 tweeter has been superceded by the new D2010, now fitted with foam facia insert giving better dispersion characteristics.

Scanspeak's new 6½in and 8¼in bass units with hex wired voice coil and symmetric drive now have polypropylene cones, making them capable of handling higher power.

For details of the sub-bass units or the Scanspeak range contact Wilmslow Audio, 35/39 Church Street, Wilmslow, Cheshire SK9 1AS. Tel: (0625) 529599.



READ\WRITE

PATENTLY OBVIOUS

I recently designed a device that I intend to patent, so I wrote off for free information on the subject to the Patent Office and the British Technology Group. Having carefully read through all the booklets, I thought that I had a reasonable understanding until I read your comment in reply to a letter from Mr S Green in the April issue. You said: 'Only if they go into production (which they cannot without the permission of the author and ETI anyway) can a generalised approval etc . . .'

Now I cannot see you patenting all the projects in ETI because of the cost and I have never seen 'pat. app. for' against any project. Design protection applies to external appearance only and it has to be new — so that is out!

Therefore it can only be copyright. But just how tight is copyright? The hand-book from the Patent Office says that it applies to engineers' drawings and plans. If a manufacturer wanted to make an identical item, he would have to work from reproductions of the drawings and could therefore infringe the copyright. But what if he changes part of the design or circuit values — does this infringe copyright?

Take, as an example, the project *Clockwise* in the April issue. All the sections of the device have been done before and if a manufacturer chose to replace the timing part with a 555 then is the copyright infringed? Also, how about the enthusiastic constructor who builds a project for someone else. Is he allowed to take payment for his labour?

You said 'author and ETI . . .' but I am sure that I have seen in your magazine that all ideas and projects have to be assigned to ETI — so surely that leaves out the author?

Perhaps your legal eagles could write an article on the protection under which you publish so we will know exactly where we stand? Please note that I have left out moral considerations.

H Hodgson
Childer Thornton, Merseyside

It is indeed copyright which protects the projects (and features) in ETI. As you (and the Patent Office) say, the copyright on the plans (in this case the circuit diagram) prohibits a manufacturer from making an identical item. It could even be construed as prohibiting any reader from making the projects but the whole copyright issue is a fairly clouded one and it is generally taken as read that readers can make the projects in magazines!

This is well illustrated by the case of a well known car manufacturer which took a small company manufacturing pattern exhausts for one of its models to court for breach of copyright. There was no patent or design registration on the exhaust but by manufacturing an identical copy, the small company was deemed to have infringed the copyright on the original blueprint.

If you alter the design, things change. Then it is a different circuit diagram, with your copyright. That doesn't mean you can just alter a 100k resistor in a project to 98k and call it your design! This is where the 'reasonable man' much loved in English law comes in.

As a rule, Argus Specialist Publications has all rights to everything which appears in ETI. However, some projects are intended by the authors to be sold as kits and for these we grant the right to reproduce parts as required (especially the foil pattern) but only to the author.

A WARM WELCOME TO. . .

I have only just started reading ETI and was surprised to see so much packed into one magazine and how well presented it is.

I am especially interested in the *1st Class* series as I am only a beginner and just starting out in the world of electronics, I am now in the process of making the metal detector from the June issue.

I find your descriptions of how the magazine is made and the ink used interesting and amusing but couldn't you use the space for more readers' letters or news?

I would like to know what happened to June's Tech Tips — I was looking forward to making the test gear.

I am also waiting eagerly for your new Blueprint column as I am going to use that a lot — if it doesn't cost too much!

Kirk Chapman
Allesley Village, Coventry

We're glad you find ETI useful and entertaining. The 1st Class series is meant for newcomers to the subject such as yourself but don't be afraid to try your hand at the other projects too.

As to the recent Next Month pieces on ETI's origins: well we have to have some fun you know! As the saying goes — all work and no play makes Jack a really boring magazine. Sorry the Test Gear Tech Tips were held over from the June issue at the last minute. They did appear in July, however.

Blueprint starts this month — and it's free!

CHEAP AND CHEERFUL

I agree with Mr K Picton's comments regarding cutting costs of projects when stripboard can be used instead of the normal PCB (May ETI). I am told when a house is built (or for that matter any item) the labour costs are usually more expensive than the materials used in the construction. This theory does not appear to apply when building electronic projects.

I have only an hobbyist's interest in electronics, I have often wondered why bother to buy a magazine at £1.40, purchase all the parts of a project, have all the hassle of building it and the anxiety of will it work, (and if it does not, a heart attack). One can often buy off the shelf a ready built and guaranteed working model at less than the cost of the parts.

I appreciate one has the self satisfaction of having built the project. However, how much greater the encouragement would be for your readers, especially the young beginners if they could save half the cost of a similar commercially manufactured product.

You offer 'fame and fortune' to prospective contributers to ETI for submitting projects. I believe you should employ an expert in the field of electronics who has the ability to design without being involved in the commercial aspects of the business. Readers should be invited to write in with suggestions of projects they would most like to see published in ETI. You could select the ones most requested and your designer could then oblige.

I believe a proviso should precede every project suggesting if the reader intends to make and market any project it is the reader's own responsibility to take the necessary precautions of not infringing any patent or copyright.

The same applies if you brew your own beer, you can read how to make it but you cannot sell it, or even if you make a tape or video recording of a broadcast the same rule applies, it should only be for one's own use.

Some examples noted in various magazines: one advertiser offers a digital capacitance meter kit at around £40. In ETI a similar project is offered at a price of £25. How nice for your readers if your designer could publish a digital capacitor tester at around £12 or £14. In the March issue of another electronics mag, a semiconductor tester was offered as a project and then in kit form priced at £24. Tandy has offered a transister tester at £9.95 for the last four years.

So come on ETI, lets have some projects suggested by your readers with the emphasis on choice, not profit for the contributer. Remember experimenting for the beginner can be expensive.

Surely the whole essence of DIY in any field is cutting the cost of labour with the end result equal to any professional product. As one's own time costs nothing you can take all the time and care needed. The pleasure and self satisfaction of his successful effort is usually the only reward he desires.

C Burton
Bilston, West Midlands.

The cost of labour is only sometimes the major cost of manufacturing. In electronics in particular, many goods are manufactured in the Far East where labour cost is insignificant compared to European countries. Even assuming labour is the significant cost and assuming your own labours do indeed cost nothing (a debatable point), there are other reasons for building electronics projects than for the sake of saving a buck or two.

Many ETI projects shine not because of their cost but because they perform tasks either better than any other commercial unit or for which there is no commercial unit. The Respiration/pulse Rate Meter, the QWL speakers and analogue computer in this issue, for example, are items you cannot buy.

We do try to keep the cost of projects down but asking for a digital capacitance meter at half the price of the cheapest commercial unit is probably not on. If it can be done, we will try to do it, otherwise no amount of labour cost saving will help.

ETI does have a Projects Editor employed to produce novel, high quality and even cheap projects. He is always pleased to hear of readers' suggestions for projects. As to the rights proviso with every project: there is a copyright warning at the front of the mag. Inserting one before every project would be wasteful of space to say the least.

By the way, you cannot sell home brewed beer because of excise considerations, not patents and copyright, and you cannot legally copy a tape or video a TV programme regardless of who is going to use it.

THE WRONG COMPUTER

Thank you for publishing the excellent *The Forgotten Computer* article in the June issue. I look forward to the follow-up project.

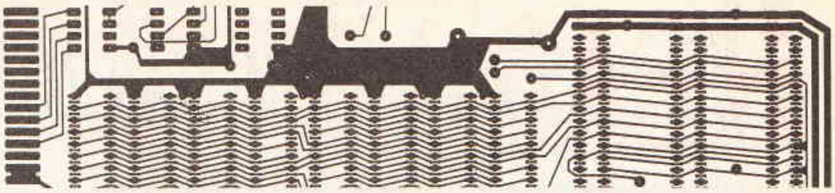
However, the front cover photo showed the Manchester Mark I — the first *digital* stored program computer. Oops!

M Robinson
Winsford, Cheshire

Curses, foiled again. It's true. We admit all. The picture of the Manchester Mark I was much prettier than any of actual analogue machines which we could find. We rather hoped no one would notice!

Glad you liked the article, though, and hope you have enjoyed the project too.

INSIGHT



The PCB marketplace is vastly over-supplied, with the lower end of the market becoming a cut-throat field of business, claims a new report from Key Note.

Although PCBs are an obvious key component in electronic equipment, PCB manufacturing generally takes a back seat in discussions of the industry. The new report rectifies this by examining the difficulties faced by companies trying to keep up with the advancing semiconductor component industry.

Excluding leading equipment manufacturers with in-house facilities, the majority of the UK PCB suppliers are small outfits.

Setting up a simple single/double sided board production line is reasonably easy and cheap, and as a result this end of the PCB market has become a cut-throat business.

Larger companies setting up production of multi-layer boards and flexible circuits find a more solid market but even here there is a great deal of spare capacity.

The biggest worry for UK makers of complex boards is the advance of the European board makers who often operate on a scale far above even our largest producers and are succeeding in cutting out territory in the UK.

PCB manufacturing is an ever advancing process. Improving chip integration and operating speeds require greater detail on PCBs. As component packing has advanced, it has become harder to correct faults after component placing, so higher quality and better pre-testing are also demanded by equipment manufacturers.

For the average UK PCB company, over three quarters of its costs come direct from production and there is little cash available for investment in new machinery to meet the demand for higher standards. With surface mount technology (SMT) in a major growth phase, many PCB companies may be forced into restrictive loans to keep ahead of the competition.

SMT is already employed on a large scale in Japan and the DTI is actively encouraging UK firms to adopt the techniques.

The National Economic Development Office's recent report on SMT estimates that some 16% of all components used worldwide in 1986 were surface mount, and expects that figure to more than double by 1992.

PCB makers that keep pace with SMT and that can advise users on its special problems will attract plenty of work but must face the prospect of manufacturing smaller boards with greater precision, and probably without improved prices.

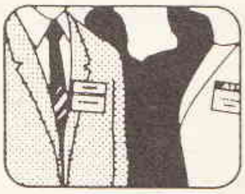
The next five years is likely to see far greater separation between high investment complex PCB manufacture and the more basic boards with the cut-throat market place.

UK companies should now decide which path they will choose to tread.

Key Note's *Printed Circuits* costs £105 from Key Note Publications, 28-42 Banner Street, London EC1Y 8QE. Tel: 01-253 3006.

The NEDO report *Introducing SMT — Electronic Components* is available from The National Economic Development Council, Millbank Tower, Millbank, London SW1P 4QX. Tel: 01-211 3060.

DIARY



IEE Vacation School On Local Telecommunications Network — July 10-15th
Aston University, Birmingham. Contact IEE on 01-240 1871.

RSGB National Radio Convention — July 15-17th
NEC Birmingham.

Image Processing And Its Applications — July 18-20th
University of Warwick. Organised by the IEE. Contact IEE on 01-240 1871.

Insight On-site — July 19th
Tudor Park Hotel, Maidstone. Seminar on electronic security systems. Contact Philips Scientific on (0223) 245191.

Insight On-Site — July 20th
Queen's Hotel, Farnborough. Seminar on electronic security systems. Contact Philips Scientific on (0223) 245191.

Insight On-site — July 21st
Crest Hotel, South Mimms. Seminar on electronic security systems. Contact Philips Scientific on (0223) 245191.

Alvey Vision Conference — August 31-2nd Sept
Manchester University. Conference on Alvey-funded work in computer vision and image recognition. Contact AVC88 on (0235) 445840.

Insight On-Site — September 6th
Excelsior Hotel, Birmingham. Seminar on electronic security systems. Contact Philips Scientific on (0223) 245191.

Insight On-site — September 7th
Novotel Manchester West, Manchester. Seminar on electronic security systems. Contact Philips Scientific on (0223) 245191.

Insight On-site — September 8th
Hilton National, Leeds. Seminar on electronic security systems. Contact Philips Scientific on (0223) 245191.

Conpar 88 — September 10-16th
Manchester. Contact British Computer Society on 01-637 0471.

Plasa Light And Sound Show — September 11-14th
Olympia, London. Contact the Professional Lighting And Sound Association on (0323) 646905.

European Conference On Optical Communication — September 11-15th
Brighton Centre, Brighton. Contact IEE on 01-240 1871.

Comex 88 — September 13-15th
Sanddown Park Exhibition Centre, Surrey. Contact Frametrack on 01-828 2905.

Personal Computer World Show — September 14-18th
Earls Court Exhibition Centre, London. Contact Montbuild Exhibitions on 01-486 1951.

Microjoining 88 — September 20-21st
The Welding Institute, Cambridge. Symposium on miniature electronic assembly. Contact The Welding Institute on (0223) 891162.

European Gallium Arsenide Conference — September 24-26th
Jersey, Channel Islands. Contact The Institute of Physics on 01-235 6111 for the venue.

Semiconductor International — September 27-29th
NEC, Birmingham. Contact Cahners Exhibitions on 01-891 5051.

Electronics In Engineering Design Show — September 27-30th
NEC, Birmingham. Contact Cahners Exhibitions on 01-891 5051.

BBC Radio Show — September 30th-9th October
Earls Court, London. 'Spectacular extravaganza' to celebrate 21 years of BBC Radio 1, 2, 3 and 4. Exhibition, live shows and megabucks ETI stand. Contact BBC Radio Show, PO Box 100, Chatham, Kent ME5 8LJ.

Electronic Displays 88 — October 4-6th
Wembley Conference & Exhibition Centre, London. Contact Blenheim Online on 01-868 4466.

Computer Graphics 88 — October 11-13th
Wembley Conference & Exhibition Centre, London. Contact Blenheim Online on 01-868 4466.

Digital Signal Processing Seminar — October 13th
Heathrow Penta Hotel, London. Contact ERA Technology on (0372) 374151.

Desktop Publishing Show — October 13-15th
Business Design Centre, London. Contact Database Exhibitions on 061-456 8383.

Satellite Systems For Mobile Communications And Navigation — October 17-19th
IEE, London. Conference organised by IEE. Contact IEE on 01-240 1871.

Internepcon — October 18-20th
Metropole Exhibition Centre, Brighton. Contact Cahners Exhibitions on 01-891 5051.

Testmex 1988 (Electronic Testing & Measurement) — October 18-20th
Business Design Centre, London. Contact Network Events on (0280) 815 226.

IC Outlook — October 19th
Centre Point Building, London. Market overview seminar. Contact Dataquest on 01-583 9171.

Commercial Awareness And Business Skills For Young Engineers — October 21-23rd
Strand Palace Hotel, London. Contact IEE on 01-240 1871.

INTRON (Irish Electronics Exhibition) — October 26-28th
RDS Main Hall. Contact SDL Exhibitions on Dublin 01-900 600.

Engineering Products And Technology — November (date to be finalised)
Exhibition and Conference Centre, Doncaster. Contact Trinity Exhibitions on (0895) 58431.

Electronic Information Delivery — November 8-9th
Tara Hotel, London. Contact Blenheim Online on 01-868 4466.

Cellular And Mobile Comms — November 10-11th
Tara Hotel, London. Contact Blenheim Online on 01-868 4466.

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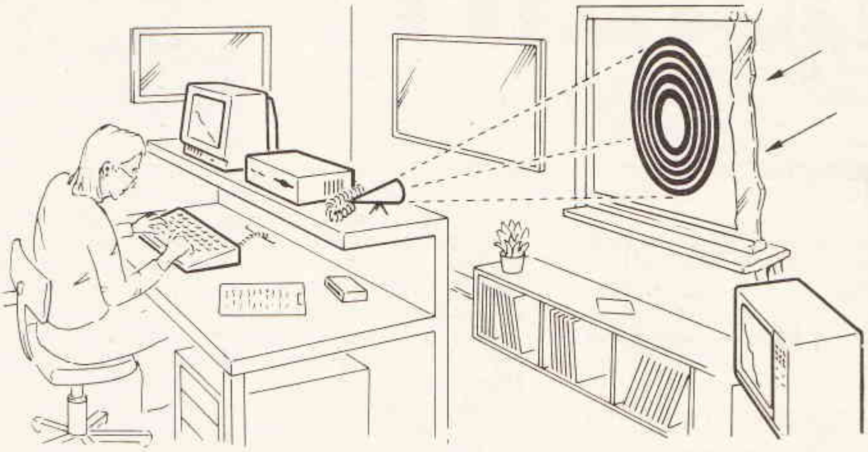

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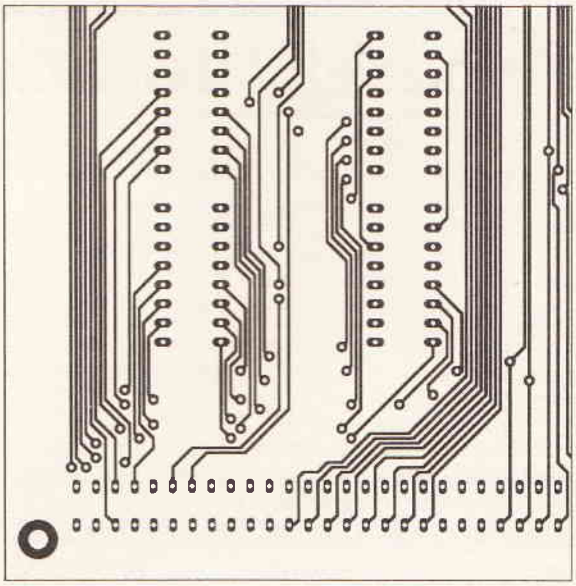

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Next Month in

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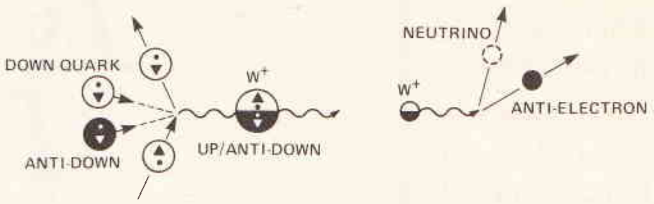

If you know what this diagram is all about, you won't need to buy next month's ETI (but do anyway). In the September issue we are going further into the theory than any electronics magazine has ever gone before — all the way to sub-atomic particles and stuff like that. Get next month's ETI for the first readable explanation of matter!

The Spectrum EPROM emulator promised for this month will be seeing the light of day next month instead. Brush the dust off your rubber keyboard and turn the moribund micro into a useful development tool.

For the square-eyed beginner we have a simple TV aerial amplifier to boost your reception in a caravan or camping site or even in your home.

For the workbench there's a very simple design of frequency meter which will keep your measurements up to scratch without that nasty pain in the wallet.

Plus, the September issue has a review of the latest loudspeaker kit from Maplin and all the regulars which go to make ETI the leading magazine for the electronics enthusiast.

The September ETI — out August 5th

The articles mentioned here are in preparation but circumstances may prevent publication

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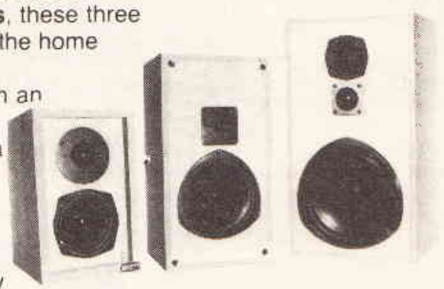

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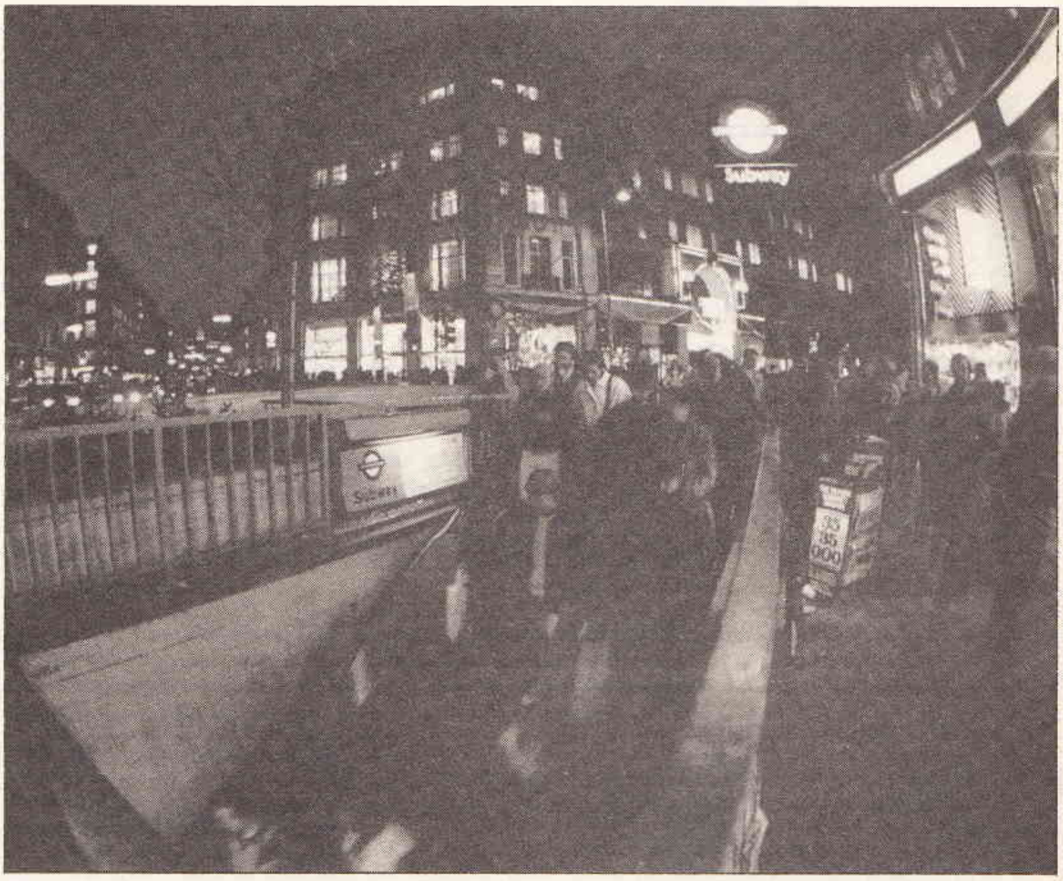
JUST THE TICKET

Brenden Foley has ticket, will travel to recount the design of the London Underground's new automated fare system

TUBE



760 million trips per year

An eager explorer, intent on locating Big Ben, little realises his journey is just one of 760 million such trips each year, made by commuters, shoppers and fellow visitors in a network which links no fewer than 248 stations in Greater London.

As the traveller emerges at the top of an escalator, he finds himself caught up in a huge herd of commuters shuffling forward sardine-style towards a bottle neck exit. A harassed ticket collector standing by the exit, tries to check three tickets at a time as they are waved in his general direction for a split second before their owners are swirled away towards the streets above.

The Problem

Many of the card tickets gathered by the collector are issued by machines designed in the late 1920s which, despite their appeal to fans of Flash Gordon, are finding it hard to cope with life in 1988.

If a tourist makes a valiant attempt to stop at the barrier to ask where to change for Westminster, the harassed ticket collector barely has time to point him towards the besieged information kiosk before the traveller is swept away on the endless stream of upwardly mobile humanity. Meanwhile, an artful fare dodger in a pinstripe suit takes advantage of the ticket collector's distraction to sneak through without paying. The pin-striped bandit goes on his way, unaware his crime-of-the-century was responsible for an annual fraud bill of £20 million.

Into this daily sea of trouble stepped Westinghouse Cubic, which London Underground charged with the task of creating a completely new ticketing system which would solve the problems of passenger flow and ease of access, while dealing a hefty blow to the fraud figures.

Westinghouse Cubic was formed in 1978 as a joint venture between Hawker Siddeley and the US-based Cubic Corporation, to pursue openings in the field of fare collection. The first main objective of the company was to win the London Underground contract. By securing the contract, they beat opposition from ICL/CGA (France), GEC (UK) and Plessey/Marubeni (Japan).

The Cubic Corporation has a world reputation for solving railway ticketing problems by applying solutions involving magnetic coding technology. They have worked on metro systems in Hong Kong, Singapore, San Francisco (Bay Area Rapid Transit) and the New York subway.

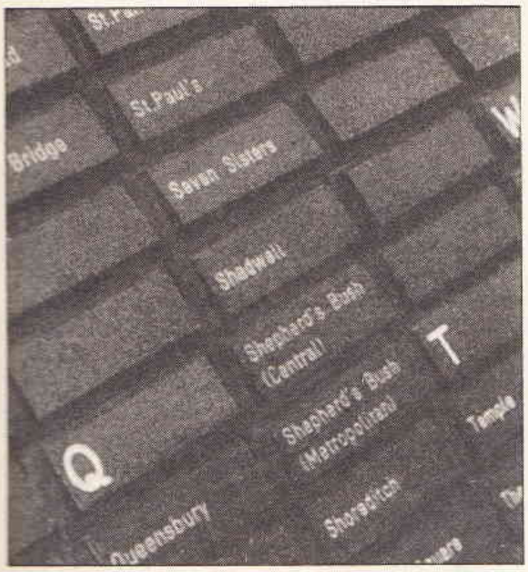
However, the ticketing system for London Underground posed all sorts of challenges to the development team. The problems included the sheer size of the underground system, the complexity of its fare structures and commercial rules, as well as the need for centralised management in the new system and tickets which had to be compatible with London buses and British Rail too.

The system also had to replace a manual ledger accounting system which had changed very little in the last half century.

Between 1985 and 1987 Westinghouse Cubic grew from five senior executives to an operation involving 186 people, working on the largest project ever undertaken in the specialised field of fare collection.

The Solution

From a passenger's eye view, the project has three main parts — the ticket dispensing machines, the ticket itself and the gates to get in and out. From the operator's point of view, a whole new range of equipment, to monitor and control the new system was needed.



The key to the design of the whole system is the ticket itself — an innocent-looking piece of card, about the size of a credit card, with a magnetic coding stripe on the back. The coding on the ticket is to a format agreed by a variety of major transport concerns including London Underground and the British Rail main line network.

The ticket contains 23 bytes of data — enough to detect any irregularities in ticket use through time, history, geography and price tests.

Although newspaper reports have suggested similar tickets on American underground system have been forged (one report claimed that a New York gang had built a thriving cottage industry out of manufacturing dummy tickets from cornflake packets and bits of cassette tape) Westinghouse claims the London tickets will be very difficult to forge. The paper is of a very specific type and thickness, the print type-face used is a very unusual one, and the magnetic tape itself is 'extremely complex'.

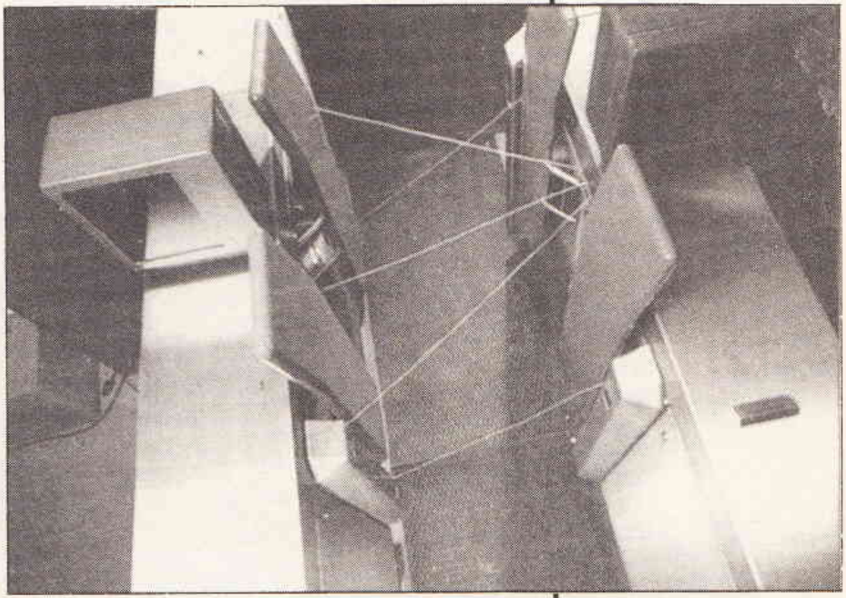
Safety

Safety aspects have always been high on the Westinghouse agenda and these have been highlighted by the calls for improved safety following the disastrous fire at Kings Cross underground ticket hall last year.

In an emergency, all the gates can be thrown open by a button which dumps the air pressure in their pneumatic power supply. This failsafe system bypasses the complex computer controls in the station equipment. A wider manually operated gate is available for people who would find the barriers difficult to use and the greater number of barrier exits means bottlenecks are less lightly to build up than in the old single exit system.

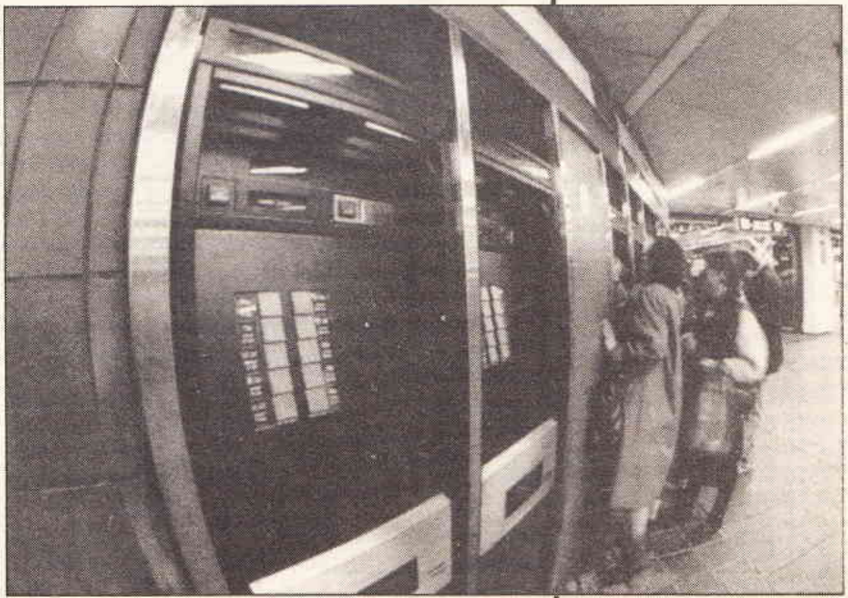
The machines used to dispense the tickets are of two main types. The bigger machines can provide tickets to any underground destination, as well as over 40 destinations controlled by British Rail and other operators. These machines accept not just coins but banknotes as well. The second type of machine can dispense any ticket for the 'top ten' destinations from that particular starting point.

The prime object of the new machines was customer acceptance and the prototype design was tested as early as 1979 at Vauxhall station. Passengers are guided through the system by a display and are given visual prompts if they go astray by using the keyboard incorrectly or not inserting the correct fare.

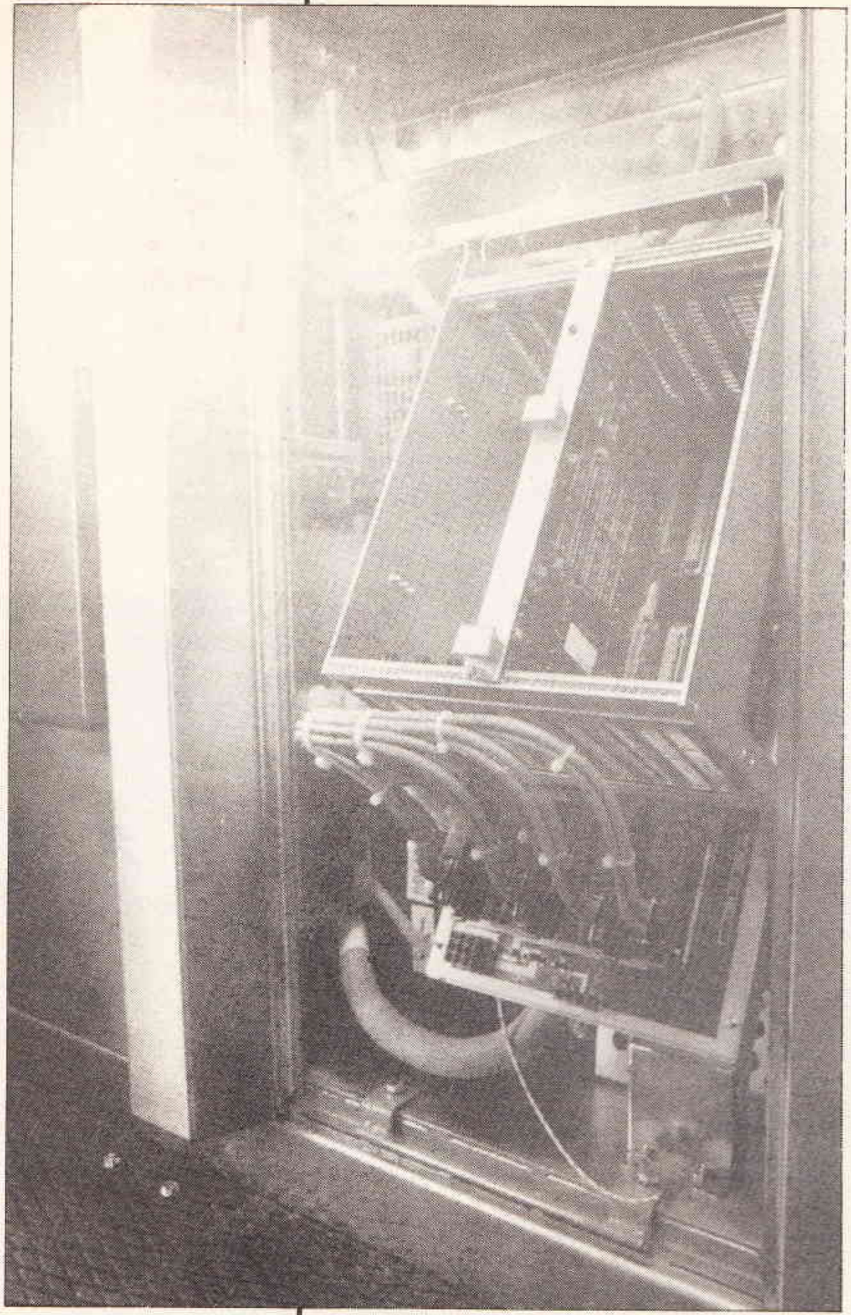


Network of light beams to let through just one at a time

Commuters on the London Underground are world famous for their limited sense of humour when faced with machine failure on the way to work at eight



2½ seconds per ticket



o'clock in the morning, so speed as well as accuracy is vital. The machines can dispense a ticket within 2½ seconds of the fare and destination being entered.

Production of both the ticket issuing machines and the automatic barriers is in full swing at the Westinghouse Signals factory in Chippenham where lines of ticket machines are undergoing rigorous tests. When the machine's ability to dispense change is being tested, the testsite rings with the sound of clattering coins like a busy night in Las Vegas.

The larger of the two machines contains four major modules for coin handling, banknote handling, ticket handling and a logic control processor, which controls the overall operation. The machine records details of all its transactions, which are passed on to the overall management centre. The new system can produce an exact audit for every machine and every operator each day. Data tables control all aspects of ticket printing and coding.

Money Money Money

The machine's ability to handle coins and banknotes took considerable development. It is a very difficult task, involving both electronics and mechanisms reliable enough to become accepted by the customer and sensitive enough to refuse invalid coins or notes. The problem was particularly acute with banknotes, which can remain in circulation even in a crumpled or worn state. The electronic sensors and note handling mechanism developed for the London underground had to strike a delicate balance between sophistication and reliability.

Money is carefully tracked through the machine, with detailed records ensuring the revenue cannot be removed at any stage without detection. All the cash ends up in coin and note vaults which are self locking and let the control centre know when they are nearly full. Each one has its own identification number. Staff access to use and maintain machines is by both identity cards and PIN codes, similar to those used by automatic cash dispensers at banks.

To enter or leave the underground system, the passenger will pass through one of a series of automatic gates which will read the ticket coding and then recode its value for future use. A valid ticket will open the pneumatically powered gate paddles. The gate paddles on the final version are taller than those on earlier prototypes to stop the more athletically minded miscreants from attempting to vault over them!

The motion of the paddles is controlled by a fiendishly clever array of light beams, designed to let a passenger burdened with luggage through while stopping two people trying to hustle through together in a vain attempt to convince the wily mechanism that they are either one fat person or a pantomime horse late for an engagement in the West End.

A casual observer could be forgiven for thinking that London is full of criminally deranged fraudsters determined to swindle the underground at all costs but the old system did little to discourage fare dodgers.

If old machines were out of order and passengers had to wait in long queues for a ticket, it was predictable that some people, particularly those in a hurry, would risk fare dodging. Add to this the difficulty of checking manual tickets on a crowded train and the chance of evading a busy ticket inspector at the other end and you can see why the old system needed to be changed. The new system is quicker and more reliable so not only is there less excuse for fare dodgers — they also stand a greater chance of being caught.

The new automated ticket checking methods will be augmented by increased numbers of mobile ticket inspectors armed with another Westinghouse device, a hand held ticket verifier, able to read and display the information held in the ticket's coded magnetic strip.

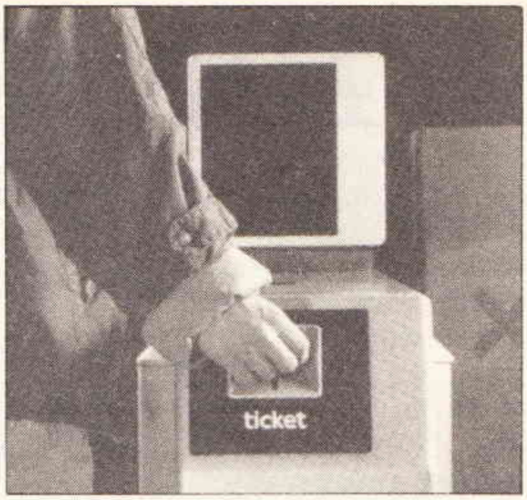
Computers

The network of ticket issuing and checking units comprises 2,200 computer-controlled machines and 300 general purpose computers which communicate with each other by means of London Underground's private cable system, running alongside the train tracks. Each station has its own computer, linked to the main computer at Baker Street. The workload of the computer centre is divided on either side of an isolation point which would enable an adequate management service to be maintained even in the event of major equipment failure, with no loss of data.

At individual station level, staff can monitor and control all equipment at their station. Machines can be brought into or out or use and the direction of passenger flow through a gate can be reversed. A VDU screen displays the status of all machines and gives warnings of any situation which might need action by a member of staff.

At the main computer centre faults can be pinpointed and diagnosed, new operating and pricing systems can be brought into operation throughout the system, records and accounts can be gathered and stored. The status of every machine at every station can be constantly monitored, and potential problems can often be avoided long before they would otherwise have been spotted.

Perhaps the most remarkable aspect of the entire project is that it's installation has had to be carried out while the underground system remains operational. It would be impossible to shut London down for even a day to allow the implementation of the new system so it has gone on station by station, with over 90 stations already up and running. Westinghouse is confident that all 248 stations will be in operation by the end of the year, with many of the stations being transferred from the old system to the new one in just 24 hours.

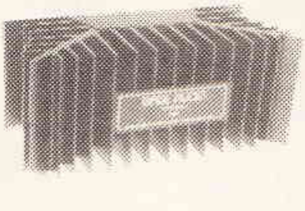


When fully operational the new system will have some 2,500 intelligent computer units communicating together in real time, controlling 900 self service ticket machines, 500 ticket office machines, 861 automatic passenger gates and the central computer at Baker Street, presiding over a rail empire that spans 254 miles of track.

The achievement is all the more remarkable when the age of the London Underground is considered — the first station was opened in 1861. By the year 1990 the Westinghouse Cubic system will be regulating 800 million journeys every year in the oldest, longest, busiest underground in the world.

ETI

Our thanks to Hawker Siddeley for the use of the photographs in this article.



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BROUGHT TO LIGHT

Mike Barwise positively shines as he fumbles with his fibres

To do anything very interesting with optical fibres, you need *coherent light*. This is the kind of light emitted by lasers, as opposed to that emitted from a domestic light bulb or a conventional LED. But what's so special about it, and about lasers?

Very basically, the laser can be considered as the optical equivalent of the tuned circuit. Just like the radio tuned circuit, it forms a resonant system which amplifies an on-frequency input by means of *constructive interference*. The main difference is the resonant frequency, which for the optical part of the electromagnetic spectrum is measured in tens to hundreds of gigahertz (thousands of megahertz).

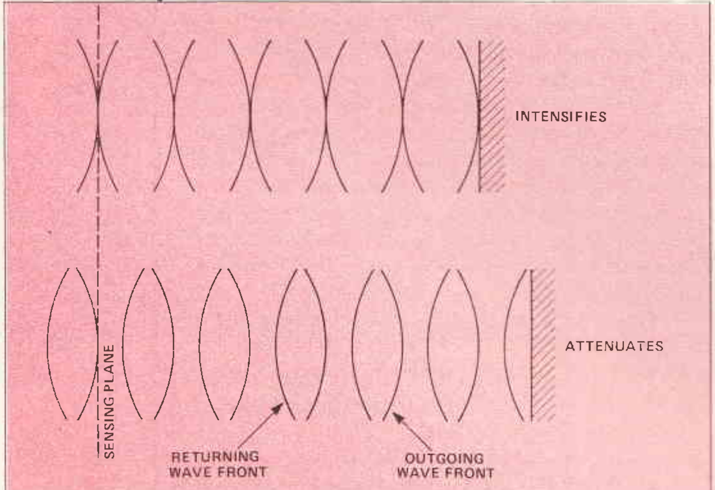

Fig. 1 (a) Outgoing wavefronts coincident with returning wavefronts. (b) Wavefronts not coincident

Constructive interference works like this. Assuming a *wave definition* of energy transmission (Fig. 1), energy reflected off an obstruction which returns *in phase* with outgoing energy is added to it (it interferes constructively). Energy waves which are superimposed out of phase interfere *destructively*, as the total energy is still the sum of all components. (This is actually a great over simplification, but it shows the principle).

The laser diode is in essence an LED constructed with a cavity along which the emitted light travels. The cavity is accurately sized to be an exact number of wavelengths of the wanted output frequency in length, so that it acts as an optical resonator.

This simplistic description tells us quite a lot about the nature of the light emerging from the device — the output from a resonant circuit is generally as close as possible to a single frequency component and is considerably amplified by virtue of the resonance maintaining constant phase (this is called *phase coherence*).

Thus *coherent light* is essentially *monochromatic* (consisting of only one wavelength), phase coherent and very intense. It also incidentally usually forms a nearly parallel beam.

Beware!

A warning — *If you are playing with lasers never look into the beam! Even the 0.3mW output from a laser diode can permanently damage your eyes!*

In practice, things are not as perfect as we would like (surprise surprise!). For any given laser there is a *coherence length*, the distance over which the output beam maintains its special property of phase coherence.

Beyond this distance minor phase discrepancies and hitherto insignificant secondary frequency components in the output combine to disrupt the effect.

This phase coherence is the most useful thing about laser light. For example, within its coherence length a laser can be used to measure distances to within a fraction of the wavelength of its emitted light. This is done by measuring the phase shift between the outgoing and returning light.

Non-coherent light could not be used for this, as it is a composite of many constantly drifting phase relationships.

Laser Diode Driving

Unlike the early bulkier and higher powered gas lasers, laser diodes need no high voltage supplies. They are driven much like LEDs by a controlled current, usually in the region of tens to hundreds of mA.

They are however extremely sensitive to overloading. The bandwidth of the diode (1 to 10GHz is typical) means that overloads as brief as a couple of *nanoseconds* can destroy the device. We are not just talking about static discharge — switch-on surges and transient noise in the supply are the most common modes of destruction.

There is, for any laser diode, a threshold current below which it acts like a super-bright LED but does not *lase* (produce coherent light). There is also an upper current limit beyond which the device self-destructs in the twinkling of an eye. The lower threshold is normally in the region of 40-50 mA, and the upper 90-100 mA.

Take Precautions

Given the working range of the average laser diode (about 40-50 mA current differential) this is not as disastrous a problem as it might sound if you take common sense precautions.

The most obvious precaution is to avoid running the laser diode at more than about 50% power. This will allow plenty of latitude for supply current drift or instability without exceeding the safe limit.

The very simplest driver would in this case be a *voltage regulator* and a series resistor similar to the LED current limiting resistor. This does have the limitation that switch-on surges might get through during the few microseconds the regulator takes to stabilise, so an adjustable regulator should be used, with its output voltage set as low as possible. Note that in event of regulator breakdown (short circuit mode) the laser diode would be destroyed.

Drive Safely

A much safer driver is shown in Fig. 2. This was designed in consultation with Richard Cripps at Oxford University, and is a 'belt and braces' design.

The first stage regulator (LM337) is used in voltage regulation mode and is protected by reverse current blocking diodes.

Also, C2 charges via R1 at switch-on causing the output voltage of the regulator to rise slowly. The C2/R1 time constant is *much* longer than the settling time of the regulator, so no significant voltage spike gets through.

The second regulator (LM317) is connected in *current regulation* mode (yes — it should be connected backwards!) to supply a controlled constant current to the laser diode.

The switch-on characteristic of the driver is shown above Fig. 2. Note the very small switch-on current surge which peaks nowhere near the danger threshold — even if the driver is delivering near maximum current.

Note the *negative* supply potential. This is solely because most laser diodes are packaged with their *anode* connected to the case or mounting frame, and this should be earthed.

Laser diodes come in various packages (Fig. 3) — the best for critical work are simply open junctions on ceramic carriers, but these are *very* tricky to handle. Easier are those mounted in small metal transistor cans or in SMA housings (as used for optical fibre connectors). Where the LD is to be used as an optical fibre light source, the fibre can be factory aligned and sealed into a metal can with the diode.

Used without addition stabilisation, the laser diode can be driven fairly easily, but there will be drift in the output wavelength and intensity due to temperature rise and other effects. In order to reduce this instability, a more complex driver is used with a *gain control* which is adjusted by feedback from a reference photodiode (intensity control).

A *Peltier element* is frequently used to stabilise LD temperature. The Peltier element is an electro-thermal device which acts as a heat pump. It develops a thermal gradient between its two opposite faces when a current is passed through it. Such control systems are beyond the scope of this humble article, but are widely documented in LD manufacturers' literature and elsewhere.

Some laser diode packages contain integral reference diodes and/or Peltier elements.

Use And Abuse

OK I hear you ask (and if not — why not?), we can afford a laser diode (around £150-£350 each), we can drive a laser diode in a basic safe fashion, but why do we want to bother?

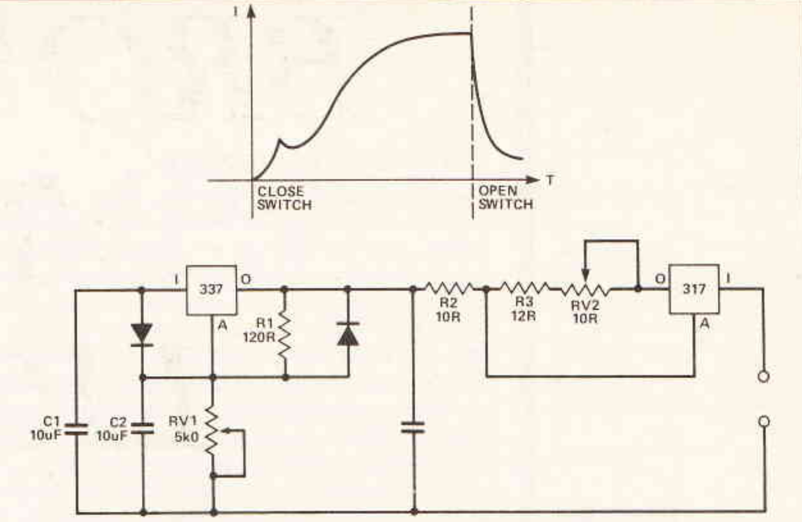

Fig. 2 Laser diode driver circuit with switch-on characteristic

This is where we return to optical fibres. You will of course remember that light propagates in a large diameter fibre along many different paths (there are many *modes of propagation*).

This assumption introduces one of the basic forms of *optical fibre intrinsic sensor.* Intrinsic here means that it is the fibre itself that contributes to the sensing task, rather than just being a means of getting the light to the right place for use in a sensing task.

The mechanism is called *fibre optic homodyne sensing* or *fibredyne* for short. The light propagating in the fibre along all these different paths varies in phase across the cross section of the fibre due to the differential path lengths taken by the different modes. This is the same effect as the *smearing* I mentioned last month in connection with comms links, except that with coherent light the phase relationships are relatively stable (all else being equal).

Thus a pattern of constructive and destructive interference is established at any cross section, and this pattern can be projected from a well finished end onto a screen or photo diode as a circular speckly image (Fig. 4).

Now comes the clever bit. If the fibre carrying the coherent light is stressed (pressure, sharp bending, vibration) the refractive index changes locally causing a shift in the speckle pattern which can be detected either visually or by photo electric means. This is in effect a kind of intrinsic interferometer.

A very sensitive *go/no go* detector is thus created, with one reservation — the whole length of the fibre is sensitive. Therefore this type of sensor is good for perimeter burglar alarms (this was demonstrated at University College London where I work), but not much good for point sensing as there will be masses of spurious signal every time the fibre between the laser diode and the 'sensor' wobbles in the wind.

One of the best experimental sensors is just a piece of fibre laid between two layers of coarse glasspaper. When you prod the resulting sandwich, the fibre is stressed at dozens of points along its length. The resulting multiple interferences can even reduce the light to be totally extinguished at the output!

Other sensing techniques are also possible, but most require much tighter control of the laser diode output wavelength (greater stability). A lot of work is going on at UCL in this field, but the required control (and its cost) are prohibitive for the amateur.

Have a go with fibredyne, but once again

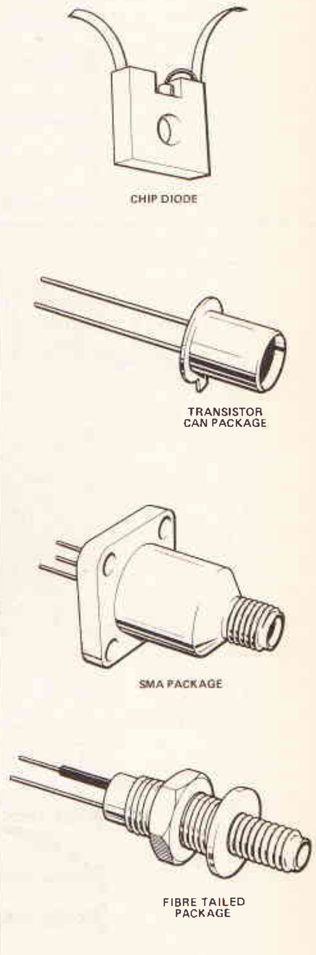

Fig. 3 Laser diode packages

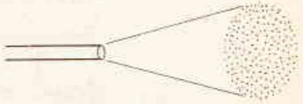

Fig. 4 Fibredyne speckle pattern

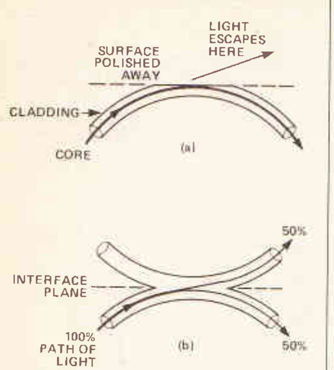

Fig. 5 (a) Half coupler. (b) Full coupler

remember *never look directly into the beam of your laser diode.* Finding out whether it's working by taking a look can permanently blind you!

Directional Couplers

Directional couplers are certainly beyond amateur experimentation (except for the most dedicated of millionaires), but they are of considerable interest.

Optical fibre conducts light along its axis by virtue of the differential refractive index of its concentric layers (step index fibre) or the gradual change in refractive index along a radius (graded index fibre). The structure is such that under normal circumstances very little escapes sideways. If, however, we cut away a portion of the side of a fibre (Fig. 5a) the refractive mechanism is disrupted, and light escapes.

Quite some time ago now, some clever person worked out that if you put two such cut away pieces of fibre in contact, light will couple from one fibre into the other. The result was the *polished fibre coupler* (Fig. 5b). These are very tricky to produce, but can be made by an expert with critically controlled *splitting ratios* (the percentage of the light which follows each path) and very low *excess loss* (the amount of light which is wasted and follows neither path).

There are also various ways of altering the coupling ratio 'on the fly', such as heating one half of the coupler causing a shift in refractive index.

This is just one of many ways of dynamic *optical switching*. There is also a cheaper and readily available form of coupler made by heating and twisting together two pieces of fibre. These are nothing like so good (they have high excess losses) but they are almost affordable.

On Reflection

A final interesting point is that, unlike electric current, light can travel in both directions at once along the same piece of fibre. It is therefore possible to pass coherent light along a fibre, through a directional coupler, off a mirror, back down the same fibre, and then split off the return signal at the coupler (Fig. 6).

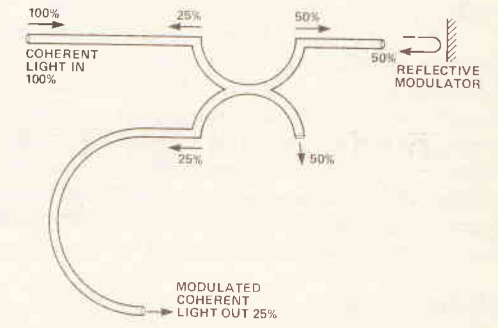

Fig. 6 Bi-directional optical sensing path

This forms the basis of a sensing system I have been working on recently. The method is somewhat lossy — you lose 50% on the outward split and another 50% (which now contains your sensor information) on the way back, plus any excess losses in the system. Fortunately laser diodes are very bright, so there is usually enough light to spare.

I hope this has been an enlightening (!) digression, and as we are now talking about sensors I shall stay on that topic next month and look at the various types of electronic sensors which abound.

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OP-AMPS

More from maestro Paul Chappell on the ubiquitous chip at the heart of many a circuit

If op-amps could be made just the way designers want them, without any of the constraints imposed by physics, one desirable feature would be that the input terminals should sense the voltages applied to them by magic. They should not take or add any current to the external components or interfere with the operation of the circuit in any way.

Real op-amps can be very good in this respect, with advanced devices requiring bias currents of the order of tens of femtoamps (1fA = 10^{-15}A, or 1/1000th of a pico-amp). On the other hand, more run of the mill ICs which might be affordable for home projects, are likely to need tens or even hundreds of nA. This can put a limit on the resistor values used in the circuit so it certainly can't be ignored.

Bias

Figure 1 shows schematic diagrams of the input stages of two popular types of op-amp. Figure 1a is the LM358/LM324 type and Fig. 1b the 741/MC1458 and so on. You can see that the reason for the bias current in both cases is the need to supply base current for the differential pair of transistors. You can also see that in some ICs the bias current will flow out of the terminals (Fig. 1a) and in some it will flow in (Fig. 1b). The data sheets don't always make it clear which so it's important to know — best check the internal circuit.

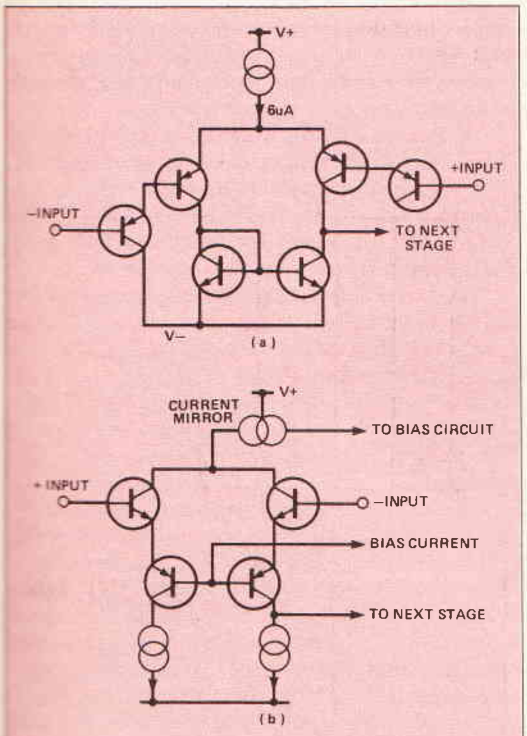

Fig. 1 Input stages of two popular op-amp types. (a) The LM358/324 type. (b) The 741/MC1458 type

The magnitude of the bias current can be up to 250nA for the LM358 and as high as 500nA for the 741. It's always advisable to take the maximum specified figures, by the way, since designing a circuit according to 'typical' figures is just asking for trouble — if your sample of the IC is a little on the wrong side of 'typical', the circuit won't work!

As often as not, there is no resistor specifically for bias purposes in an op-amp circuit. In Fig. 2, see if you can spot where each input terminal of each op-amp draws its bias current from. Where there is no input capacitor, you can assume that the circuit is driven from a perfect voltage source. You can also assume that the gain of each op-amp is high enough to make any voltage difference between the input terminals negligible. The question of where the bias current comes from is not always as simple as it seems, so if you reckon you know all this already, take one hundred lines if you don't get the answer spot on. OK?

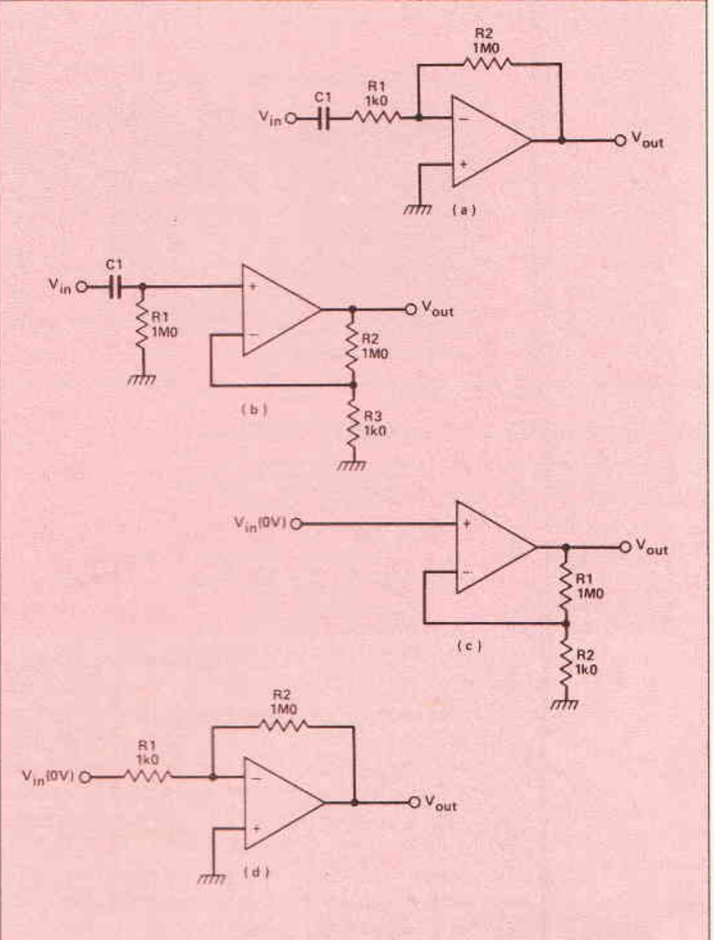

Fig. 2 Spot the source of the bias current

You might also like to work out the voltage at the output of each circuit, assuming that each input stage is of the 741 type and each input requires a bias current of 100nA. Ideally the output should be 0V in each case — what modifications would you make to each circuit to ensure that it actually is? One of the circuits is a complete dud as it stands — which one? Read on when you've got the answers (no cheating now).

Figure 2a is the standard shunt-feedback circuit with the addition of a capacitor for DC isolation. The bias current for the −terminal is drawn from the op-amp's output via R2 (1 point) and the +terminal bias from the 0V supply rail. The output will be at +100mV (2 points) and the easiest way to correct this is to connect the +terminal to ground via a 1MO resistor (1 point if you knew it already, or 10 points if you sussed it out for yourself!) This will put both input terminals at −100mV and leave the output at 0V.

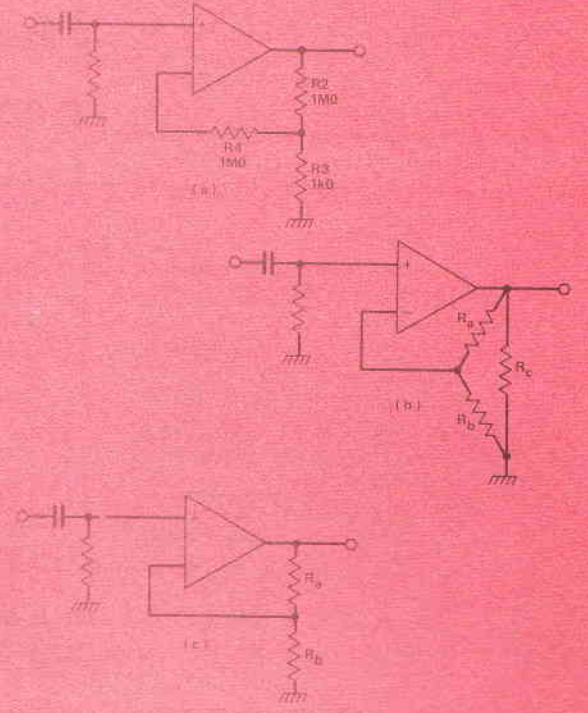

Fig. 3 Sorting out the 'dud' circuit. (a) Adding the 1M0 resistor. (b) After the Y-delta transformation. (c) Removing the now redundant R_c

Figure 2b is the series feedback circuit with a DC isolation cap. The +terminal bias comes from R1, provided for just that purpose (1 point) and the −terminal bias comes from R2 and *only* R2. (Five points if you got it right, no points if you thought it was both R2 and R3, −10 points if you thought you knew the answer and despite my warning didn't bother to look at it closely!)

The reason that the bias current comes only from R2 is this. The voltage across R3 is settled by the action of the circuit, which seeks to maintain the two input terminals at the same voltage. If the voltage across R3 is settled, so is the current through it. If you could somehow vary the bias current of the op-amp, the only voltage variation you would see would be across R2 as the current through it altered to supply the bias.

The voltage at the output can be calculated by considering each input separately then appealing to superposition. The voltage due to the −terminal bias current is +100mV (1 point). To this must be added the voltage due to the −100mV at the +terminal, which is amplified 1,000 times to give . . . . −100V? Oh dear! Yes, my friends, this deceptively OK-looking circuit is a complete dud. (Five points if you spotted it).

There are various ways of reforming the circuit so that it can lead a socially useful life. Most common is to wire a capacitor in series with R3 (often instead of C1). The value of R1 can be reduced but since this will reduce the input impedance it's not usually done. Another solution not often seen (Fig. 3a) is to insert a 1MO resistor (R4) between the R2/R3 junction and the −terminal of the op-amp. This works by placing both input terminals at −100mV, leaving the output at 0V. (Strictly speaking, the resistor would have to be a little less than 1MO to hit 0V spot on because it doesn't allow for the −terminal bias current which will still be drawn through R2. You won't find the necessary resistor value in the E12 series (or even in the E96 series for that matter) it's so close to 1MO and there are other effects which make the difference look foolishly small, so it's not worth bothering about).

Those of you familiar with a little basic circuit theory will recognise that if you perform a Y-delta transformation on R2, R3 and the new 1MO resistor, which we'll call R4, you'll end up with another potential divider between the op-amp output and ground together with a redundant resistor, which can be omitted, between the output and ground. In other words, the same effect can be achieved with only two resistors.

Without doing the calculations, can you see what values the resistors would have to be to make it work? This is an excellent test of your intuition — 10 points if you can get the values to within 1% (easier than it sounds) without getting out the calculator. Although a good test of intuition, sad to say the result is no good for practical purposes (but you don't know unless you try, do you?) so it's back to more practical matters.

Figure 2c is a repeat of the dud circuit, but this time it's DC coupled to the preceeding stage. The +terminal bias is drawn from the input, the −terminal bias from R1 (and *only* R1 — 1 point if you got it right after reading the last section, 5 points if you got it right beforehand). The output will be at +100mV and a quick cure would be to wire a 1kO (why 1kO?) resistor in series with the +terminal. (Ten points if you thought of this one, no points for wiring a capacitor in series with R2 — it may improve the circuit in other ways but it won't alter the output offset voltage caused by bias current.)

Figure 2d is the DC coupled version of Fig. 2a. Once again, the −terminal bias is drawn through R2 (and *only* R2. One point.) and the +terminal bias from the 0V rail. The output voltage will be +100mV and the cure is to wire a 1MO resistor in series with the +terminal (1 point).

Are there any general conclusions to be drawn? For the shunt feedback circuit, the usual rule of thumb is to wire a resistor equal to the feedback resistor between the +terminal and ground. The larger the value of feedback resistor, the more important it is to do this — just how large the feedback resistor has to be before it begins to cause problems depends on the application.

If you are amplifying a small signal, for example, and the output is AC coupled to the next stage, you may be able to get away with several volts of offset with still enough 'headroom' for the signal, so you may prefer to wire the +terminal directly to 0V. On the other hand, if you are DC coupling the output into, say, a voltage comparator or another amplifier, every bit of offset reduction may be critical and you'll want to balance up the inputs come what may. The only way to be sure is either to make a point of always wiring in the extra resistor or to do a quick calculation of bias current times feedback resistor and ask yourself: is this much voltage offset going to cause me any problems?

With the series feedback configuration, the rule is to make the +terminal bias resistor equal to the feedback resistor divided by circuit gain. For gains over 20 or so, there is an even easier rule: make it equal to the grounded resistor in the feedback potential divider (R3 in Fig. 2b. or R2 in Fig. 2c).

This is fine when the circuit is DC coupled as in Fig. 2c but the idea of making R1 in Fig. 2b 1kO doesn't have much appeal. One of the main advantages of the series feedback configuration is its high input impedence so adding a 1kO resistor to ground rather spoils the whole idea.

The situation is complicated by the fact the bias currents are never equal. In the data sheets you find the difference between them under the heading 'input offset current'. What you are doing by putting in the extra resistor is to exchange an output voltage offset caused by bias current of (bias current × feedback resistor) for one of (offset current × feedback resistor) which may be a factor of 10 lower. In other words, it helps but doesn't cure the problem entirely.

I should point out that the inclusion of R4 in Fig. 2b is not a practical solution to balancing up the circuit — it's OK as an answer to the question as I posed it but is knocked on the head by offset current. Can you see why? The only practical way to make this version of the circuit viable. at least where gains as high as 1000 are involved, is to introduce the capacitor in series with R3.

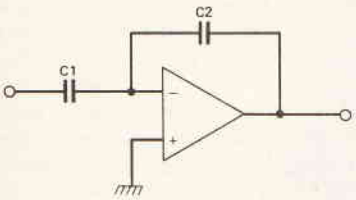

Fig. 4 Last month's puzzle

Before I forget. I'll give you the answer to the problem I posed last month, which was: what would the circuit of Fig. 4 do? It is, in fact, just another amplifier. The gain will be $-C1/C2$ (yes, that is the right way around) and the main disadvantage is that there is nothing to stabilise the DC levels in the circuit. If you imagine that the input and output are at 0V when the circuit is powered up, even if the input remains firmly at 0V for eternity, the output will drift because bias current must be supplied by C2. The rate of drift will be i_{bias} × C2 volts per second, so for a 1μO capacitor in the C2 position and a bias current of 100nA, the output will wander by 1V every 10 seconds.

If the drift didn't mess things up, the circuit would be quite useful as a level shifter: any voltage imposed on C2 would become the new 'ground' voltage about which the signal could vary. The circuit is in fact used occasionally but only with the addition of extra components to 're-set' it every now and again. Auto-zeroing circuits are based on this principle and the circuit has been used almost exactly as it stands in a commercial PID controller.

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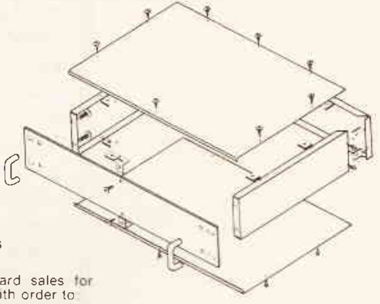

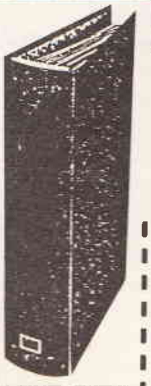

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RAD ALERT

Ian Pitt counts seiverts, Rads and Rems with handy radiation monitors from Perspective Scientific

REVIEW

The disaster at Chernobyl in April 1986 caused a great deal of public anxiety and confusion. The situation was made all the worse by people's inability to understand the complex radiation statistics issued through the news media.

Hundreds of people contacted ETI (and no doubt other technical magazines) with questions about the official measurements. Others decided to take their own measurements and asked us where they could buy a Geiger counter or how they could make one.

Needless to say we were only too glad to help, publishing a basic circuit almost immediately and a more sophisticated circuit some time later (ETI February 1987).

Others had also noticed this new-found interest in radiation measurement. Within little more than a year of the disaster a UK company was marketing a pocket radiation monitor aimed specifically at the anxious layman.

Of course there is a danger that this might look like an attempt to cash-in on public anxiety and perhaps because of this the company has gone to great lengths to present the monitor as an educational tool.

'Learn about radiation and alleviate anxiety,' the brochure promises. To this end the monitor comes complete with a beginner's guide to radiation and a wealth of other information on radiation measurements and health.

The Radalert 1310 is manufactured by Perspective Scientific. This is the basic model in a range of three instruments, all of which respond to gamma and X-radiation.

The Radalert 1310 is described as a 'high level' monitor and measures radiation dose rates from 15 micro-sieverts/hour up to 5 sieverts/hour (the sievert is the standard SI unit for dose equivalent in human beings — see the tinted box).

The next model up, the Radalert 1313, has a measurement range similar to that of the 1310 but is energy compensated over the range 50keV to 1.25MeV. Perspective says it is intended for armed forces, civil defence and local authority use.

The top-of-the-range Radalert 1201 is intended for use in scientific and medical applications and covers the range 0.5 micro-sieverts/hour to 10 milli-sieverts/hour. It is energy-compensated for the same range of radiation energy levels as the 1313.

All three models are fully auto-ranging and include a detector which provides visual and audible warning of Geiger tube saturation. An annual calibration service is also available.

The Radalert monitors have three operating modes. In 'Instant' mode they function as ratemeters, showing the dose rate (in sieverts) over successive six-second periods.

The 'integrated dose' model is similar but operates over 1, 2, 5, or 15 minute periods as selected by the user. At any time it is possible to view either the result of the previous integration or the progress of the current count.

The third mode is described as 'summing' and provides a normal Geiger-counter function. The display shows the elapsed time and an accumulating count of the number of radiation pulses detected.

An audible alarm system is available in the 'instant' and 'integrated dose' modes. The threshold can be preset between 1 and 9 micro-sieverts/hour (1 is the default value) and if the total count in any period exceeds this figure the alarm will sound.

The facility allows a Radalert to be used for unattended monitoring, operating continuously from the (optional) mains adaptor. Perspective claims a Radalert used in this way in North West England would have detected increased radiation levels from Chernobyl a day or so after the accident occurred.

I tested two models for the review, the top of the range 1201 and the 'layman's model', the 1310. There seemed little point in testing a 1313 since all its features are duplicated in the other two models.

The monitors are very light and comfortable to hold compared with most Geiger ratemeters I have encountered. They are also very simple to operate. At switch-on each of the functions is flashed up in turn on the display and the user simply presses a green button to select the function or a red button to reject it.

For practical tests I took the Radalerts to the R&D department of Philip Harris Ltd, a company whose activities include supplying radioactive sources and detectors for educational use.

With the help of some of the staff there I spent a few hours putting the Radalerts through their paces. Both models performed perfectly, operating correctly in all modes and producing results which agreed well with those obtained from several reference instruments. I then tried the two instruments out at home, at work, and in a variety of other places.

In all these environments the 1301 generally indicated little more than its normal background count level, giving higher indications only when placed near some obviously radioactive source such as a gas mantle. Only on long count periods could significant differences be detected and even then the results were often inconsistent and difficult to interpret.

By comparison, the 1201 found small but noticeable differences from one place to another even over relatively short count periods and gave believably consistent results on successive counts.

These differences do not indicate any shortcomings, they merely confirm that the 1310 is exactly what the manufacturer says it is — a high-level radiation monitor. Unlike the more expensive 1201 it is not really suitable for making measurements at normal background levels.

For this reason I don't think the 1310 will be of any real value to the person who simply wants to learn about radiation. You don't need a radiation monitor just to learn the basics and if you're tackling the subject at a more serious level you will probably find the 1310 far too limiting.

I suspect the people who will find it most useful will be amateur geologists, cavers or anyone else with a direct interest in measuring radiation above background levels.

Similarly, the energy-compensated Radalert 1313 should be of use in a wide range of professional and semi-professional applications where reasonably high levels need measuring.

The 1201 is a useful instrument by any standards. It's by no means the last word in portable radiation monitors but it offers a professional level of performance in a remarkably compact package and is very reasonably priced. It deserves to do well.

Finally, since the Radalert monitors are being marketed largely on the strength of their supposed educational value, it's worth looking briefly at the literature supplied with them. There are three main items. The first is a slim booklet which contains the 'beginners' guide' to radiation written especially for Perspective by a university lecturer in radiation biology. It's a little uneven in its coverage but very readable and suitably no-nonsense in its approach.

Radalert 1310: £86. Radalert 1313: £129. Radalert 1201: £169. Mains adaptor/charger: £7. All prices exclude VAT. Available by mail (add £3 plus VAT for postage and packing) from Perspective Scientific, 100 Baker Street, London W1M 1LA. Tel: 01-486 6837.

*The leaflet **Radiation and You** is available from the UKAEA, 11 Charles Street, London SW1Y 4QP. The booklet **Living with Radiation** costs £1.90 and is available from the NRPB, Chilton, Didcot, Oxfordshire OX11 0RQ or from any branch of Her Majesty's Stationery Office.*

The booklet also includes operating instructions and a very useful guide to using the Radalert for the first time.

The other items supplied are a copy of 'Radiation and You,' published by the United Kingdom Atomic Energy Authority, and a booklet from the National Radiological Protection Board called 'Living with Radiation.' These items are both generally available (in other words, you don't have to buy a Radalert to get them!) and can be obtained from the addresses given above.

The UKAEA leaflet is brief, graphic and highly-coloured in more ways than one! It does provide an easily-digestible introduction to radiation and its health effects but you don't need to be too much of a sceptic to find some of its assurances a little too glib.

The NRPB booklet is better, perhaps simply because it is longer (over fifty pages) and therefore has space to examine the issues in greater depth. Anyone who studies it from cover to cover should emerge with a basic but thorough understanding of radiation and radiation protection. However, it also gives a generally reassuring impression, along the lines of 'there are problems but don't worry, we're dealing with them.'

You may agree with this point of view (and there are plenty of experts who would too) but there are also others, just as expert, who would disagree strongly.

It would have been nice to have seen — either in this booklet or elsewhere in the Radalert documentation — some mention of these disagreements, some indication that there are still fundamental issues to be resolved. If Joe Public is to be educated about the dangers of radiation he at least deserves to be told the full story.

RADIATION UNITS

Radiation can be measured as nuclear activity, absorbed dose or dose equivalent. As nuclear activity:

1 Bq (Becquerel) = 1 nuclear disintegration per second.
1 Ci (Curie) = 3.7×10^{10} Bq.

The units of radiation as an absorbed dose are:

1 Rad = 0.01 joules absorbed per kg of absorbing material
1 Gy (Gray) = 100 Rad.
In both cases the absorbing material must be specified.

The units of dose equivalent take the type of radiation into account so that:

dose equivalent in Rem = absorbed dose in Rad × Q.
dose equivalent in Sv (Sievert) = 100 × dose in Rad × Q.
Q is the relative biological effectiveness, set (at present) as 1 for X-rays, Beta and Gamma and 20 (formerly 10) for Alpha.

The current maximum recommended dose for the public is 5mSv and for radiation workers is 50mSv (although the National Radiological Protection Board is somewhat controversially recommending a reduction to 15mSv).

THE QWL LOUDSPEAKER

John Dix presents an innovative loudspeaker design that enhances the low frequency response of small units

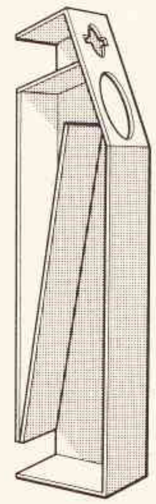


Fig. 1 Partly assembled enclosure

In these enlightened days of CD, DAT and all that is silent at the source, there is proportionately less in the music budget to be spent on the loudspeakers. The loudspeaker systems manufacturers have concentrated on smaller enclosure designs to achieve a cost reduction with the minimum possible sacrifice in performance.

Although it is more difficult to maintain the low frequency response with a small enclosure, reducing the dimensions has a number of advantages. A significant increase in structural stiffness reduces unwanted radiation from the cabinet walls. The narrow frontal area also improves the sound distribution.

Larger loudspeaker systems have to be complex because a mid-range unit is needed, with careful integration of responses to cover the whole frequency range. In a smaller unit, a single bass/mid-range unit provides seamless coverage beyond the critical mid-frequency range, easing crossover design and producing a radiation pattern conducive to a natural spread of sound and a usefully wide stereo sound stage.

However if a small enclosure results in an abrupt roll off of bass level below 100Hz, the bass lightness becomes readily apparent and there is therefore a limit to the economy feasible if a unit is to provide the reasonably long throw cone excursions necessary for adequately low frequency radiation.

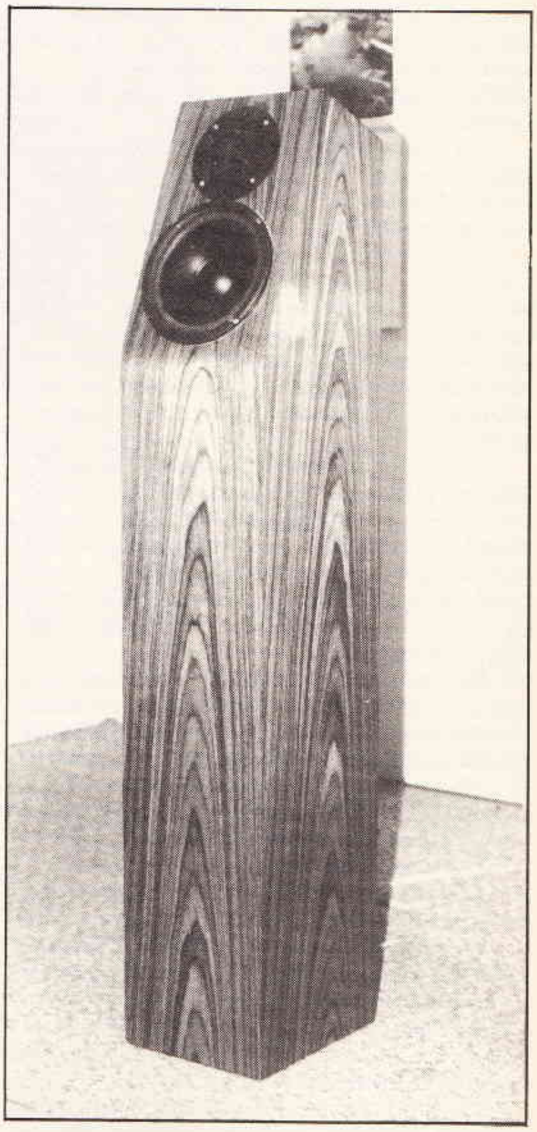
An obvious advantage of small speakers is their convenience — often they are placed on shelves in wall units and so on. However, close proximity to a wall can give rise to interfering standing wave patterns which deteriorate the stereo image. Having the speakers away from the wall, stably in space at a height such that the high frequencies are not absorbed by the sofa, gives an obvious improvement in depth and image precision.

Bearing all these points in mind it seems logical to consider whether the space within and under the speaker stands could not be used to enhance the low frequency response while maintaining a low cost, freestanding configuration.

Enclosure Design

A freestanding loudspeaker enclosure with similar dimensions to that of a small speaker on a stand, if of conventional design and construction, presents a difficult acoustic problem to the designer because of the long narrow parallel walls. These will tend to vibrate and resonate giving a resonant pipe-like colouration to the low frequency sound which is difficult to control and eliminate.

An alternative approach (satisfying from an acoustic engineering point of view) is to deliberately exploit the characteristics of a resonant pipe in such a way that the loudspeaker unit is correctly loaded and terminated at the low frequencies, whilst adequately suppressing unwanted pipe resonant modes.



The low frequency efficiency of such an arrangement is somewhere between that of a horn and a bass reflex enclosure and therefore reduces the demands made on the low frequency excursions of the small diaphragm bass speaker unit.

The principle involved utilises the properties of a closed at one end quarter wavelength pipe as originally proposed by Voigt in his patent No 447749 and subsequently adapted and described by R West and R Baldock in their designs. The design produced by R West was intended for a corner position with the speaker unit firing into the corner to spread the high frequency sound by reflection from the walls, and R Baldock's designs were intended for either a semi-omnidirectional sound distribution or a wall reflected distribution.

Present day practice favours loudspeaker operation away from corners and walls, firing directly at the listeners.

The Quarter Wave Loading Enclosure

The construction of the design is depicted in Fig 1. The bass enclosure consists of a quarter wavelength rectangular section pipe with a linear taper, resonant at about 50Hz.

The bass loudspeaker unit is situated at approximately halfway along the acoustic axis in the best position to suppress higher order resonant modes. At resonance the acoustic pressure is high at the tapered end and still reasonably high at the loudspeaker unit. This ensures that effective acoustic loading is presented to the loudspeaker cone and small excursions of the cone at high pressure are manifested as much larger low pressure movements of air out of the port at the bottom of the enclosure.

Such a process, similar to horn loading, contributes to efficient bass frequency operation with low distortion up to a frequency of 200Hz, where direct radiation from the cone takes over. The enhanced bass response produced by this method of loading compared with that from the same unit in a 10 litre sealed enclosure is shown in Fig. 2, where the curves were obtained under identical measurement conditions.

This enclosure not only satisfies the requirements of being free-standing with the drive units at a convenient height but also provides an enhanced bass response, using the space that would otherwise have been taken up by a stand. Furthermore, only small cone excursions are required in the bass loaded region and this places the minimum of demands on linearity of the cone suspension and the magnetic field in the voice coil gap, allowing reasonably low priced drive units to be employed.

Continuing the quest for a low price design, it is tempting to consider a wide range twin cone unit for use in this enclosure. Fig. 3 shows the high frequency response of a 165mm diameter paper cone bass unit used in this position with considerable ripple in the response due to cone "break-up" modes. Unfortunately, when a small tweeter cone is added to the main cone to widen the frequency range, any improvement in frequency response is accompanied by main cone "break-up" ripple as shown in Fig. 4.

A much smoother performer is the 165mm polypropylene cone bass unit with a frequency response as shown in Fig. 5 and this type is recommended for use in the quarter wave enclosure.

Because of the unsatisfactory response of twin cone units, space is provided in the top of the quarter wave enclosure, as shown in Fig. 1, to house a suitable tweeter.

Construction

The enclosure has been designed to make the construction as simple as possible and if the various pieces (see Fig. 6) are cut accurately square then there should be no difficulties in assembly.

Referring to Fig. 7 it can be seen that there are only two angle cuts to be made, those at the top of both the long front and back panels. All the rest are simple 90° butt joints and it is left to the individual constructor to decide whether to attempt the angle joints or simply butt the joints and fill the wedge shape gaps with whatever technique and material is convenient.

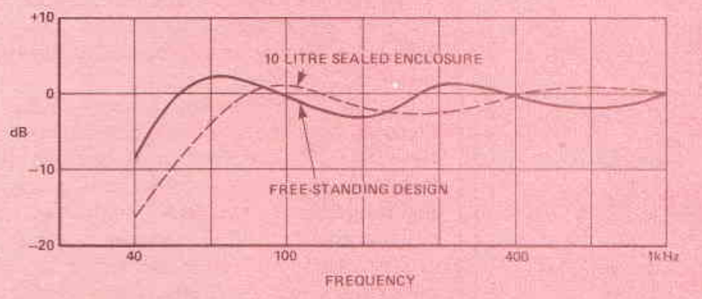


Fig. 2 Comparison of bass performance

The dimensions quoted are not critical provided everything is checked to fit as shown in the diagrams so that airtight joints are obtained, particularly in the high acoustic pressure areas in the tapered wedge and around the speaker unit.

The front, back, bottom, top and internal partition members are all made of nominally ½in thick chipboard and should all be matched to the same width of 7in. The two side panels are made of nominally ¼in thick plywood and it is recommended that one of the panels is marked out to indicate where the ½in thick panels are located. These can then be cut to size and checked for fit and the assembly pinned and glued together to form the structure drawn in Fig. 2.

As the assembly progresses check it for squareness and, if necessary, secure one or two cross pieces of plywood offcuts with pins driven a little way in to hold the assembly square while the glue sets.

Being reasonably liberal with the glue should ensure airtight joints but pay particular attention to the pointed end of the wedge section and if necessary run a fillet of glue along this particular joint.

Finally complete the assembly by glueing and pinning the second ¼ inch thick plywood panel into place. It will be noted that the enclosure is reasonably light and stiff and this minimises the energy

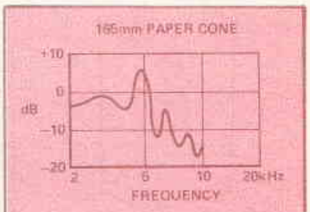


Fig. 3 Frequency response of paper cone unit

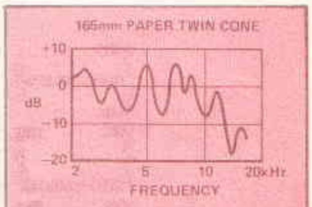


Fig. 4 Frequency response of twin cone unit

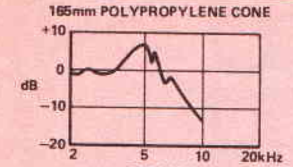


Fig. 5 Frequency response of polypropylene cone unit

storage in the enclosure walls. Tapping the sides of the enclosure produces different notes at different positions indicating that the internal bracing and asymmetry is working to minimise undesirable reflections and panel resonances.

Finishing tasks involve punching the pins home, filling and sanding prior to painting or covering with material or an iron-on veneer.

After several years experimenting with various drive units the best solution, both in terms of cost and performance, seems to be the simplest of crossover arrangements with a direct connection to the bass unit and a capacitor feed to the tweeter.

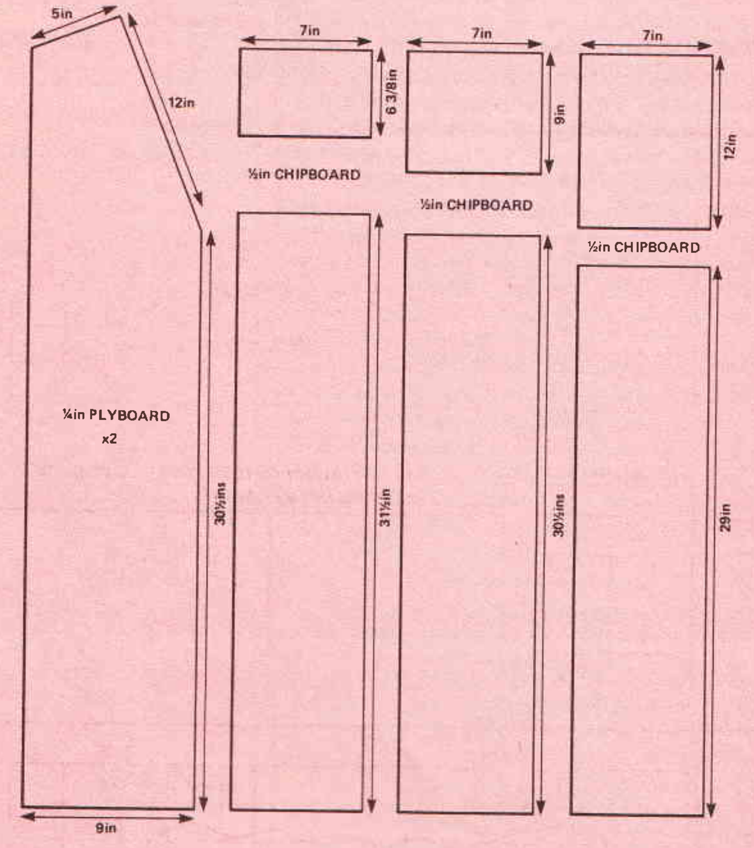


Fig. 6 The cutting diagram for a single QWL loudspeaker (the baffle plate is also needed and is shown in Fig. 7)

The need for attentuation is avoided by choosing a sensitivity for the high frequency unit just below that of the bass unit. The speaker baffle is as small as possible for rigidity and minimum frontal area. The sloping of the baffle time-aligns the outputs from the two units, improves the coupling of the bass unit to the air column in the enclosure. It also exploits an improved smoothness in frequency response of the bass/mid frequency unit observed at this angle off its central axis rather than complicating the crossover.

The Response

Figure 8 shows the combined anechoic response of the two units as derived from the manufacturer's quoted responses as a dotted line, with the in-room frequency response as a solid line (in-room measured using ⅓rd octave noise with a calibrated mic at 0.9m height). The responses show good integration and smoothness. A further bonus of the simple crossover and small sloping baffle is an excellent off-axis response as shown in Fig. 9.

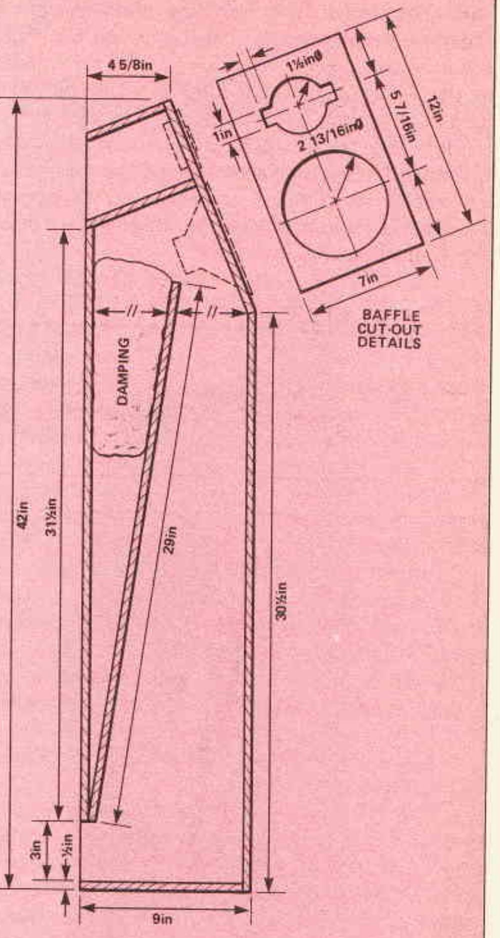


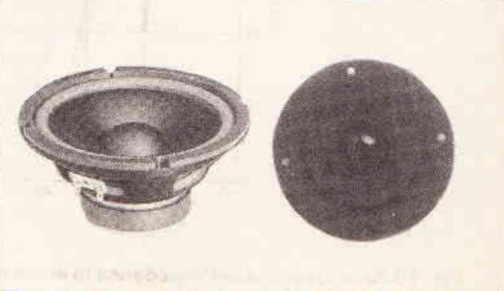
Fig. 7 Enclosure dimensions and construction

The modulus of the installed bass unit's impedance against frequency as shown in Fig. 10. A resonance was detected at about 250Hz but became inaudible with the insertion of damping material into the open end of the closed tapered section as indicated in Fig. 1. The effect of the damping is also shown in Fig. 10.

The damping material is a square metre of terylene wadding (from a dressmaker). It should weigh about 100 grams and is cut in two — a piece for each enclosure. Each piece is folded lengthwise in two and the resulting strip is folded again twice to form a 25cm square, ready for insertion.

The loudspeaker units are mounted from the outside of the enclosure and the bass unit needs a sealing gasket cut out of a thin sheet of plastic foam or paper depending on the surface finish of the baffle. Use chipboard screws and do not over tighten.

Electrical connections may be made to a



connector block fastened just above the port. The bass speaker lead is simply passed down through the bass enclosure and out through the port, whilst the tweeter lead is secured by clips down the back of the enclosure. The series capacitor supplied with the tweeter is a non-polarised electrolytic and readers may wish to upgrade the performance by replacing this component by a better quality version. Readers may also wish to experiment with the provision of steel or plastic spikes in the base of the enclosure.

Performance

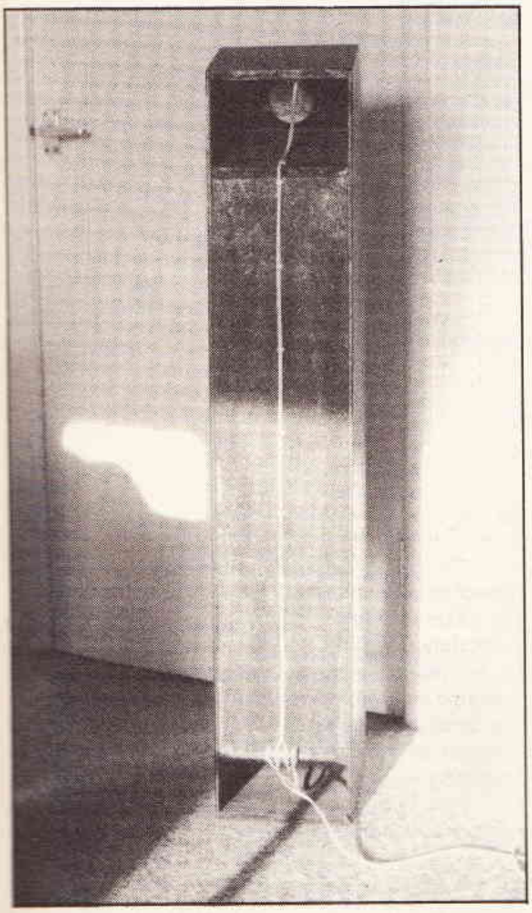
The choice of loudspeaker is often a very personal decision and the present design is the result of many hours of measurement and listening.

This QWL design is relatively cheap and easy to build but achieves a combination of good measured frequency response, stereo imaging, sound quality and efficiency. They occupy very little floor space, are easily moved and are the correct height to preclude the need for stands.

Happy listening. ETI

BUYLINES

The loudspeaker units recommended for this project are Tandy's 6½in woofer (cat no 40-1011) and dome tweeter (cat no 40-1276). Tandy's mail order address is Tandy Centre, Leamore Lane, Bloxwich, Walsall WS2 7PS. Tel: (0922) 710000.



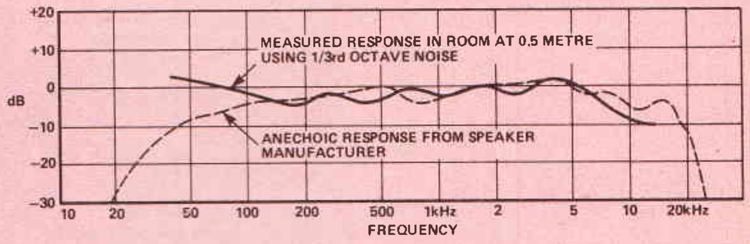
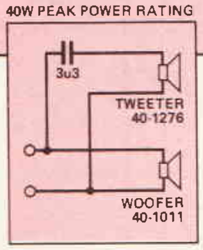


Fig. 8 Frequency response of complete loudspeaker systems



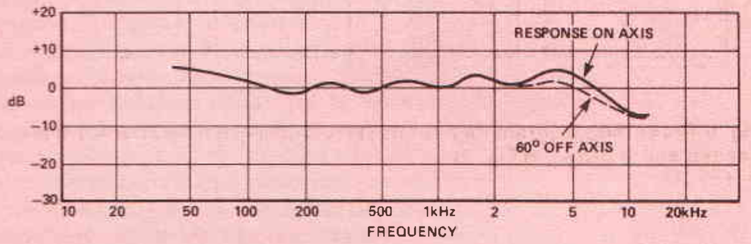


Fig. 9 Off-axis response

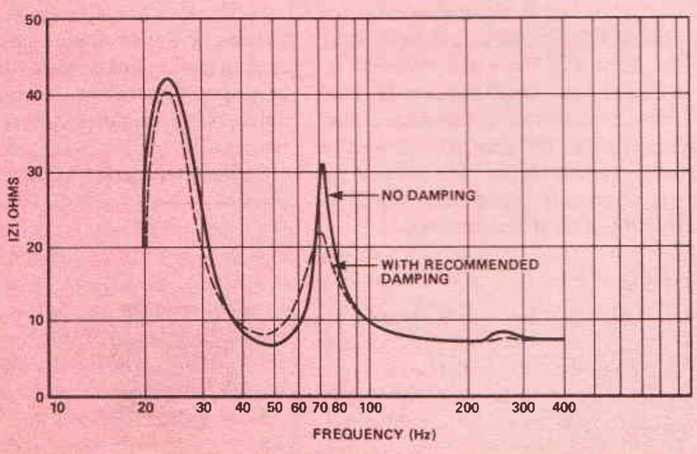
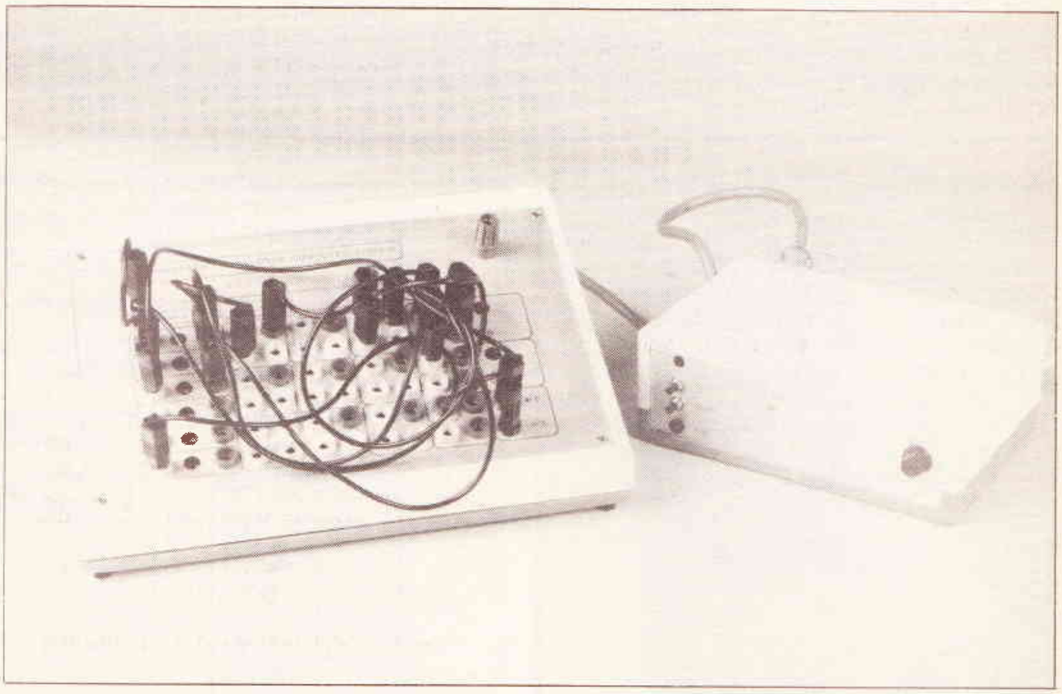


Fig. 10 Bass loudspeaker impedance in enclosure

ANALOGUE COMPUTER

Paul Cuthbertson continues to build his small analogue computer for use in the classroom or the laboratory



Last month I described the construction of the analogue computer's power supply. This month it is the turn of the main computer unit itself.

The suggested front panel layout is shown in Fig. 1. It can be quite tedious to mark out the front panel neatly yourself and so this panel is available as part of the kit from Grampian (see Buylines). However, you'll still have to drill your own holes!

Use a punch to mark the centre of each hole and a hand drill to drill a 2mm pilot hole at each position. Hold the panel firmly in a vice near the hole position (with a clean piece of rag in the vice to prevent marking the panel) to prevent it bending. With a little care good results can be had. Be particularly careful with the potentiometer holes as these have the edges showing.

Drill 6.5mm holes for the green terminal and the LEDs, 8mm for the 4mm sockets and large holes up to a limit of 8mm or 9mm for the pots. If in doubt drill a hole too small, try it out and then work up. Use an instrument file or similar to cut a small slot in the edge of the hole for the spigot on the terminals.

Fit and tighten all the panel components except for the yellow sockets at the top and bottom of the coefficient multiplier section. A ⅜in socket spanner held in the hand can be a good tool to use here. Don't overtighten them as the threads can strip.

Now solder the six potentiometers in place on the pot board (Fig. 2). To fix the pot board to the front panel, you'll need a couple of special brackets made from scrap aluminium — see Fig. 3. There's a left handed bracket and a right handed one.

No precise measurements are given because these will depend on your exact front panel layout. The last two yellow sockets tighten down on the fork, and the pot board then screws down to the small holes. Make sure the brackets do not connect to tracks on the pot board.

Solder a 15-way D-plug on the end of the 15-way cable trapping the braid in the cable clamp for earthing.

Drill a hole in the back right of the case, no further than 50mm from the end of the case for the 15-way cable. Use a grommet. Solder a length of earth wire to the braid and either trap the other end of this between the bracket and the pot board or use a solder tag onto the bolt which secures the pot board. Trim all but the −10V REF wire down to about 40mm length. Strip and crimp tags to the ends of the wires and push them into a 10-way cable shell in accordance with Table 1 (connections 63-72).

The +7V wire (position 63) needs a 8in piece of wire to reach the overvoltage indicator (LED2). The −7V wire (position 67) needs a slightly longer piece in with it. The 0V wire (position 72) needs a piece of wire about 250mm inserted with it. The −10V REF wire goes to the next cable shell at position 61 which is why it is longer than the rest. Cut the wings off this shell before using it.

Begin populating the main board by fitting all the connectors and all the IC sockets as shown in Fig. 4. Next fit all the links using insulated single strand wire.

Fit all the other components as shown in Fig. 4 making sure all the diodes and the translator are the right way round. Don't fit the ICs yet.

Several points on the board (labelled A-I) must be connected with insulated wire on the underside of the board. Some of these are corrected mistakes, some are there because there is no room elsewhere on a single sided board and others are an attempt to preserve the designers sanity!

Connect the pads with the same letters. There are two of most but five each of pads B and C and three each of D and E.

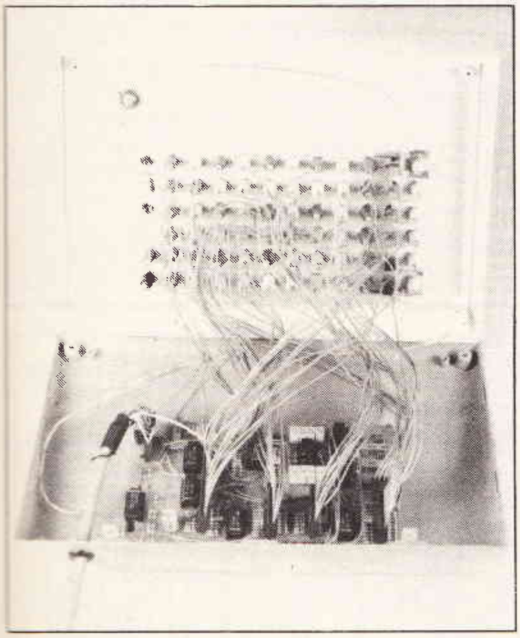
Testing

Most parts of the system can be tested at this stage before the front panel wiring goes in. Don't insert the ICs to their sockets yet but plug the leads from the power supply into the board.

Switch on the supply and quickly check that all supplies are present in the right places. If not, switch off immediately and investigate.

A rather strange property of all the ICs used in this project is that they are symmetrical. If the supplies are present but the wrong way round, you can plug the IC in upside down rather than rewiring!

Make yourself a couple of test links by crimping tags onto 200mm or so pieces of wire. Bare about 10mm at the other end. Now you can push each of these into a six way cable shell or other test position as appropriate, to apply signals to the various parts of the circuit. Refer to Fig. 3 and Table 1 to see whereabouts you are and to Table 2 to see which quarter of the op-amp is responsible for different functions.



Insert IC6/1300/1400. Power up and check you have about ±10V at each of the corner pins on the right of the IC. Then adjust the two pots at the bottom of the board to give precisely 10.00V. Do look at the 10V master reference too to see it has not changed. Power down each time before inserting the next IC.

Insert the top left IC (IC100/200/300/400) into its socket. Power up and check that all the outputs are at 0V by probing the corner pins of the IC. (In reality you may expect up to about 10mV either way — about 0.1% full scale). Now apply each of the ± references to each input in turn, monitoring at the output connector pin. +10V in should give −10V out, and vice versa. The outputs should be well within 1% of full scale, for ×1 inputs. Applying this input to a ×10 input will result in about 14V output or so but it does mean the input is connected properly. Strange results can be due to misconnection, solder bridges or a reversed diode.

1	Summing amplifier input 1,1	37	Integrator output 1
2	Summing amplifier input 1,2	38	Integrator output 4
3	Summing amplifier input 1,3	39	Integrator initial conditions 2
4	Summing amplifier input 1,4	40	Integrator initial conditions 1
5	Summing amplifier input 1,5	41	Integrator output 2
6	Summing amplifier input 1,6	42	Integrator output 3
7	Summing amplifier input 1,7		
8	Summing amplifier input 2,1	43	Summing amplifier input 7,1
9	Summing amplifier input 2,2	44	Summing amplifier input 7,2
10	Summing amplifier input 2,3	45	Summing amplifier input 7,3
		46	Summing amplifier input 8,1
11	Integrator input 4	47	Summing amplifier input 8,2
12	Integrator input 3	48	Summing amplifier input 8,3
13	Integrator input 2	49	Coefficient multiplier input 1
14	Integrator input 1	50	Coefficient multiplier output 1
15	Integrator initial conditions 4	51	Coefficient multiplier output 2
16	Integrator initial conditions 3	52	Coefficient multiplier input 2
17	Summing amplifier output 1	53	Coefficient multiplier input 3
18	Summing amplifier output 3	54	Coefficient multiplier output 3
19	Summing amplifier input 3,1	55	Coefficient multiplier output 4
20	Summing amplifier input 3,2	56	Coefficient multiplier input 4
21	Summing amplifier input 3,3	57	Coefficient multiplier input 5
22	Summing amplifier input 4,1	58	Coefficient multiplier output 5
23	Summing amplifier input 4,2	59	Coefficient multiplier input 6
24	Summing amplifier input 4,3	60	+10V Reference output
25	Summing amplifier output 4	61	−10V Reference input
26	Summing amplifier output 2	62	Coefficient multiplier output 6
27	Summing amplifier output 7	63	+7V Supply
28	Summing amplifier output 5	64	Overvoltage warning LED
29	Summing amplifier input 5,1	65	NC
30	Summing amplifier input 5,2	66	SET
31	Summing amplifier input 5,3	67	−7V Supply
32	Summing amplifier input 6,1	68	HOLD
33	Summing amplifier input 6,2	69	−15V Supply
34	Summing amplifier input 6,3	70	+15V Supply
35	Summing amplifier output 6	71	−10V Reference output
36	Summing amplifier output 8	72	0V

Table 1 Connections to the main computer board

Insert IC7 into its socket. This is the window comparator and latch. Remember this one is reversed relative to the rest (unless you've reversed any others yourself!). By applying ±10V to a ×10 input of a summing amp or the ±15V supply to a ×1 input, you should be able to see the leftmost corner pins of the IC dropping negative. They should be positive normally and respond momentarily to overrange outputs. It isn't necessary to test all the inputs this way incidentally, just one for each summing amp.

Next monitor pin eight of IC7. It should be positive if SET has not been pressed since the last overvolt condition. Press SET and check it goes negative.

Insert IC500/600/700/800 and use the same

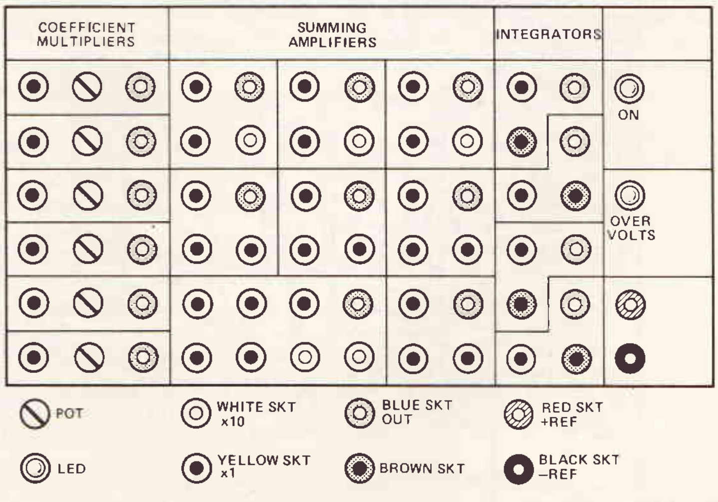


Fig. 1 The front panel layout

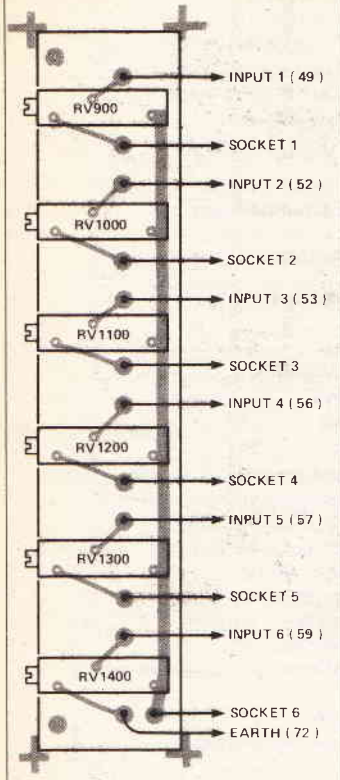


Fig. 2 The component overlay for the pot board

procedure for each summing amp — checking for zero, checking all inputs and finishing with an overvolt check on one input of each amp.

Now insert ICI500/1501/1600/1601, IC1700/1701/1800/1801 and IC1502/1602/1702/1802. These form the heart of the integrators. Power up, press SET and see that the four corner pins of the LM324 go close to 0V. You can expect a good 30mV here actually — about 0.3% full scale. Release SET. The op-amp outputs should drift very slowly. (In an ideal world this drift would be zero).

Apply +10V to the integrator input at the connector pin. The op-amp output should attain −5V in a second (approximately). Press SET a few times to verify the op-amp output returns to zero and ramps from there each time. It may be easier to monitor this on a scope or an analogue meter rather than a DVM. While this is in progress check the overvolt system responds to the op-amp output voltages.

Check HOLD by attempting to catch the op-amp

PARTS LIST

RESISTORS (all 1/4W 5% unless specified)	
R25-29, 31, 107-111, 114, 207, 208, 214, 307, 308, 314, 407, 408, 414, 507-509, 514, 607-609, 614, 707-709, 714, 807-809, 814, 1502, 1508, 1509, 1602, 1608, 1609, 1702, 1708, 1709, 1802, 1808, 1809	1M 1%
R30	470k 1%
R32-35, 39, 40, 41, 1503, 1505	100k
R36, 38	33k
R37	180k
R42, 1504, 1604, 1704, 1804	1M0
R43	22k
R44	680R
R100-106, 200-202, 300-302, 400-402, 500-502, 600-602, 700-702, 800, 802, 1507, 1607, 1707, 1807	10k
R112, 113, 209, 309, 409	100k 1%
R115	39k
R215, 315, 415	82k
R515, 615, 715, 815	330k
R1500, 1501, 1600, 1601, 1700, 1701, 1800, 1801	4k7 1%
R1506, 1606, 1706, 1806	470k
RV6, 7, 900, 1000, 1100, 1200, 1300, 1400	10k 20 turn pot
RV1500, 1600, 1700, 1800	1k0 20 turn pot
CAPACITORS	
C1500, 1501, 1600, 1601, 1700, 1701, 1800, 1801	470n
SEMICONDUCTORS	
IC (6/1300/1400), 7, (100/200/300/400), (500/600/700/800), (900/1000/1100/1200), (1502/1602/1702/1802), (1503/1603/1703/1803)	LM324
IC (1500/1501/1600/1601), (1700/1701/1800/1801)	4066
Q5	BC183L
D1-3, 100, 101, 200, 201, 300, 301, 400, 401, 500, 501, 600, 601, 700, 701, 800, 801, 1500-15004, 1600-1604, 1700-1704, 1800-1804	1N4148
LED1, 2	red LEDC
MISCELLANEOUS	
PL1	15-way D-type plug
PL2-22	stacking 4mm plug
SK1-4	green 4mm socket
SK5-9	white 4mm socket
SK10-27	blue 4mm socket
SK28-50	yellow 4mm socket
SK51	green 4mm socket

PCBs. Case. 6×10-way. 2×6-way PCB connectors. IC sockets. Connecting wire. Flexible wire. Nuts and bolts.

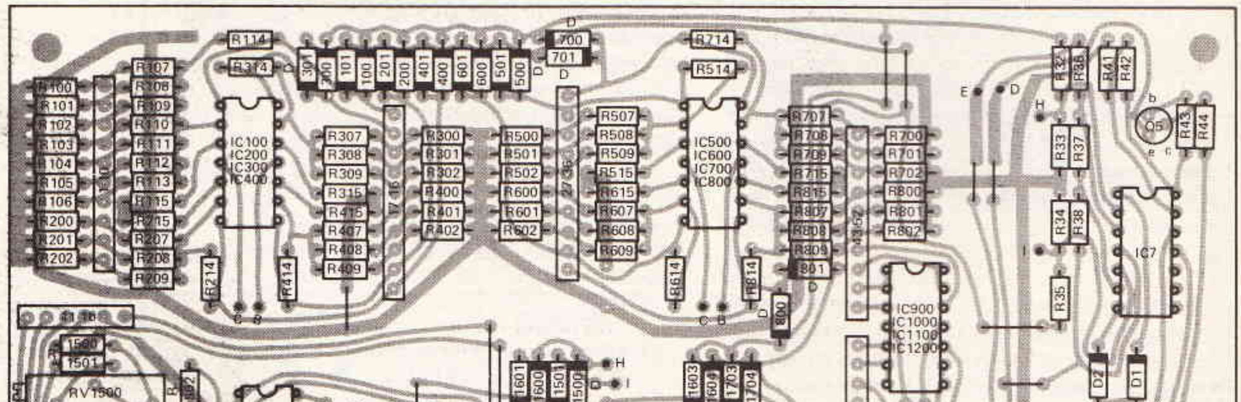


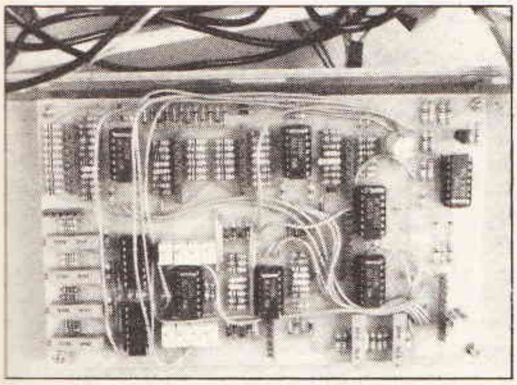
Fig. 4 The component overlay for the main board

halfway through its headlong rush. When in HOLD the integrators do drift — in an ideal world they would not — and this looks quite bad on a DVM (the drift rate can be about 50mV/s) but look at it with a scope and I would defy anyone to see it drifting from moment to moment.

On the plus side, the integrators behave very well if you apply 0V to the inputs — drifting about 1mV/s — so left to their own devices they will take about two hours to drift up to an overvolt condition! It is wise not to use HOLD for extended periods of time but see my comments on performance improvements below.

Insert the last IC (IC1503/1603/1703/1803) and check the outputs follow those of the previous stage (x2) and that when an input is applied to the IC (initial conditions) connector position this voltage appears inverted at the output. Keep SET asserted for this, using a shorting link if you like, as it is easier to see what's going on.

Also put ±15V in at the initial condition inputs (without SET asserted) to check the action of the overvolt connections. Calibration of the integrators must wait until the internal wiring is installed.



The prototype showing the internal overboard wiring

Wiring

Drill holes in the base of the case and bolt in the board, using spacers. The board should lie right at the back of the case where it just clears the 4mm sockets nicely.

Use small lengths of bare single strand wire to connect each of the yellow coefficient multiplier sockets to the clockwise end of each potentiometer on the pot board. Trim down the anode (long) leads of both LEDs and solder a 680R resistor between them. Lay the front panel face down with the back edge just leaning on the front of the case, so that it can 'hinge' back into position when the time comes.

Starting with those sockets and connections at the back, which would be awkward to reach with the rest of the wiring in place, cut and solder an appropriate length of wire to the socket. Refer to Fig. 3 and Table 1 continuously. I have chosen to number the inputs to the summing amps starting at the top left working right, then bottom left working right. The really essential thing is that groups of connections to one amp or integrator are kept together and a white (x10) socket always connects to an input with a 100k resistor.

The coefficient multipliers are numbered one to six from top to bottom. Connect a wire from each pot wiper pad to the input connector. The outputs go direct to the blue sockets. Connect a wire between the thick 0V track on the pot board and the green terminal. Connect the 0V wire from position 72 to the green terminal as well. Trim and connect the overvolt LED cathode to the appropriate connector position. Trim and connect the power LED cathode to the −7V position. Connect the +7V position to the overvolt LED anode along with the 680R resistor which is already in place.

Carefully lower the panel into position. Now is a good time to make up the patch leads. Two metres of extraflex wire will make ten leads of various lengths; I used six 0.25m lengths and four 0.125 ones. Connect 4mm plugs on both ends of each lead.

More Testing

All that remains is to check the summing amp and coefficient multiplier connections by applying inputs, checking outputs and by checking the integrator wiring and calibration of the integrators. Calibrate the integrators by applying a 0.50V signal derived from a voltage reference passed through a coefficient multiplier. Use your nice new patch leads to do this!

Using a stop watch, release SET, wait for 20 seconds and press HOLD. Make a quick mental note of the voltage attained before it wanders too far off. Adjust the integrator, using one of the four pots at the left edge of the board, using the 20s check each time an adjustment is made, until the integrator reaches ten volts plus the offset apparent when SET is asserted. That's the simplest method. If you've stuck with the wiring scheme outlined, you'll see that the pots are numbered one to four from back to front.

If you have a pulse generator which will give you a good pulse of known and stable amplitude and duration, you could use it to pulse the integrator and adjust the potentiometer to give a known final voltage. A +1V pulse for one second should result in −1V on the output. The important thing is that the integrators are the same. The only reason for having adjustment here, and not for any other circuit, is to remove the effects of the tolerance of the capacitors (5%) and to account for using two 470n rather than 1μO.

Improvements

The LM324 ICs used in the computer are the biggest

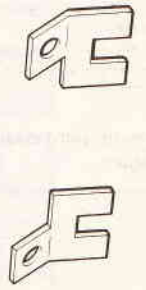


Fig. 3 Brackets to hold the pot board to the front panel

PIN	FUNCTION
	IC100/200/300/400
1	Summing amp output 1
2	Summing amp output 2
8	Summing amp output 4
14	Summing amp output 3
	IC500/600/700/800
1	Summing amp output 5
7	Summing amp output 6
8	Summing amp output 8
14	Summing amp output 7
	IC7
1	This output not used
7	Latch output (drive to overvolt LED)
8	Upper (+ve) comparator
14	Lower (−ve) comparator
	IC1502/1602/1702/1802
1	Integrator 2 first stage output
7	Integrator 4 first stage output
8	Integrator 3 first stage output
14	Integrator 1 first stage output
	IC1503/1603/1703/1803
1	Integrator 3 output
7	Integrator 4 output
8	Integrator 1 output
14	Integrator 2 output
	IC900/1000/1100/1200
1	Coefficient multiplier 2 output
7	Coefficient multiplier 3 output
8	Coefficient multiplier 4 output
14	Coefficient multiplier 1 output
	IC6/1300/1400
1	Coefficient multiplier 5 output
7	Coefficient multiplier 6 output
8	+10V reference output
14	−10V reference output

Table 2 Useful test point locations

BUYLINES

Most of the components for this project are easily available from usual suppliers. All the components are available individually or in a complete kit from Grampian Electronic Components, 266 Clifton Road, Aberdeen AB2 2HY (Tel: (0224) 495549).

The PCB is available from the ETI PCB Service as detailed at the back of this issue.

source of error, particularly in the integrators where their bias currents cause drift in the HOLD mode and very slight asymmetric operation and drift when running.

If any improvement is considered necessary, the biggest single step would be to replace those op-amps in the critical positions of summing amplifier and integrator. Some possibilities might be the LF347 which offers vastly improved bias currents or the OP400 with its very low offset voltage of 150μV maximum. If selecting an improved op-amp do not be concerned with bandwidth or slew rate for this application.

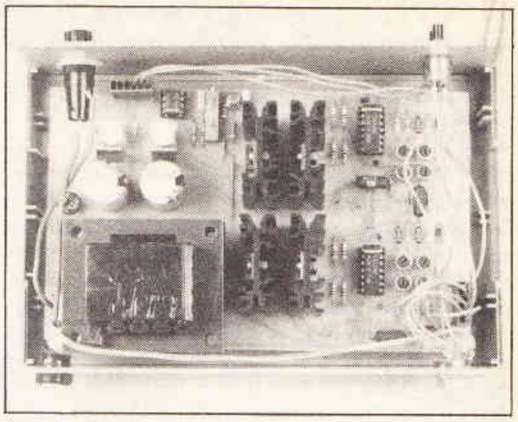
There are no other easy or relatively cheap roads to improvement. The next item on the list is perhaps the capacitors but closer tolerance types at 1μ are likely to be bulky and expensive. Using 100n instead of the 1μ in the prototype will speed up the computer by a factor of ten but will also express drift rates ten times faster. The important resistors could be replaced by 0.1% types but these are likely to be expensive too.

Having said all this, the computer is still more than adequate for control experiments and, dare I say it, a lot better than certain offerings I have come across recently.

Further Uses

The individual building blocks of the computer can be used for many other purposes. Variable and fixed gain amplifiers are easily implemented. There are sufficient integrators to build two rather fine, high Q state variable filters, although the range of operating frequencies may be restricted.

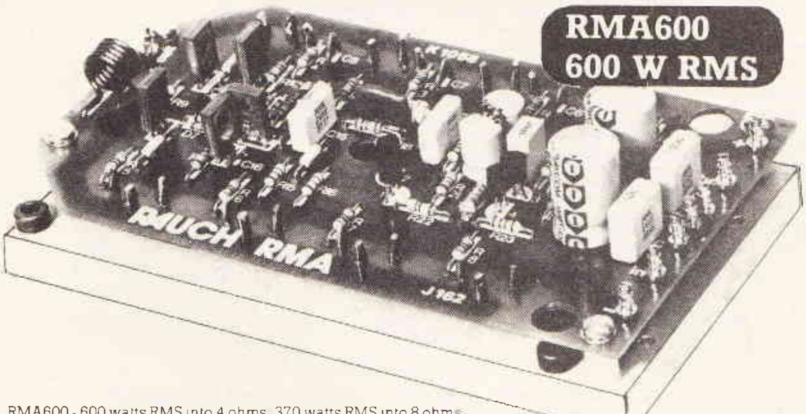
Don't be afraid to use external components in the patching. For example, a 10k resistor in series with any input will attenuate the signal by a factor of two, 90k by a factor of ten. This can be used to slow down integrators.



A very low frequency sine wave generator is another possibility, with the added advantage of quadrature outputs and high spectral purity (since it is a 'proper' sine wave and not something cobbled up from a triangle wave) but the amplitude will change slowly. Set up a state variable filter with a damping of zero for this. (By the way, ten out of ten if you recognised the computation in the article in the June issue as just that — a state variable filter!)

The whole computer can be easily expanded adding further main boards operating off the same power supply unit. Wiring up further D-connectors in the power supply is the way to do this.

Other functional blocks could also be added either to this main board or to an additional one. The possibilities are almost boundless. One thing is certain. Once the analogue computer is built, you will never again look at a digital computer with quite the same admiration. ETI



BACK NUMBERS

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Every now and again, it happens. You wish you had taken notes of that telephone conversation. Whoever you were talking to had said something of vital importance but you can't remember it, now. Or he made a commitment to you which you know he'll never keep — and being only a verbal commitment, how can you hold him to it?

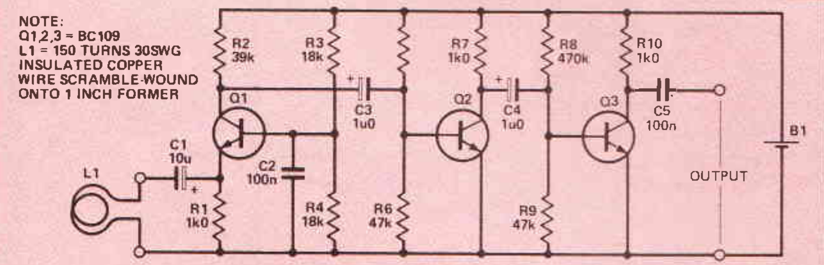


Fig. 1 The circuit diagram of the telephone recorder

The answer, of course, is to *record* the telephone conversation. Then you've got a firm record of the whole affair. However, short of dismantling your instrument (excuse the expression) and diving into the telephone's circuit, how do you do it?

A simple coil of wire is used in the ETI telephone recorder to pick up minute electromagnetic disturbances corresponding to the audio tones passing to and fro along the telephone line. The interface circuit merely amplifies these audio tone disturbances to a level sufficient to be recorded by any typical cassette recorder.

Telephone pickup coils are, of course, available from many electronics outlets and any one of these can be used as a pickup for the ETI unit, but we give details here to make your own, out of common-or-garden insulated copper wire. Our home-made version gives every bit as good results, too, as the more expensive purpose-made options.

Construction

Two methods of construction are offered: PCB or stripboard. Neither is difficult but the usual procedures and precautions should be taken, depending on your chosen method.

The PCB component overlay is shown in Fig. 2. On PCB, the only precaution is to leave the transistors until last. This way, there is less likelihood of heat damage from a slap-happy soldering iron. Watch for electrolytic capacitor polarisation — make sure you get them the right way round.

The stripboard overlay is shown in Fig. 3. Make all track breaks and solder the wire link first, before any components are positioned. Then, like the PCB, solder all components in leaving the transistors until last.

The pickup coil is made by winding 150 turns of 30swg insulated copper wire onto a 1in former. Leave about three inches of wire at each end of the coil free. Neither the number of turns or the former size is critical, so don't worry if you lose count or can't find a former which is exactly the right size. We used a bottle of Tipp-Ex typing correction fluid as our former (slightly over the inch in size) and that proved adequate.

Similarly, the wire gauge isn't critical either — anything from about 25 to 35swg wire will do. Once wound, slide the coil off its former and tie it with string, lacing cord, wire or tape.

The ends of the coil now need to be connected to the circuit board and screened cable should be used for this. If you have used enamel-covered copper wire for the coil, you'll need to scratch off the last few millimetres of enamel from the ends of the coil, baring the copper, before they will accept solder. If you've used polyurethane coated copper wire, this is self-fluxing and can be soldered direct. Whichever, solder earth and signal leads of the screened cable separately to the ends of the coil. It's best to insulate the connection, too, to prevent shorting. Heat-shrink sleeving is ideal for this but insulating tape provides a suitable alternative.

HOW IT WORKS

Fig. 1 shows the circuit diagram for the telephone recorder. The pickup coil transforms any local electromagnetic radiations into signal voltages. It has a very low impedance and any amplifying circuit connected to it must consequently have a similar low impedance.

Positioned somewhere near the earpiece of the telephone instrument, the coil will pick up anything which would normally be heard by the user. Readers unfamiliar with telephone equipment may be forgiven for thinking that the sound heard in the earpiece consists of only the incoming part of the conversation — the voice of the person at the other end. However, all telephone instruments inject a certain amount of *sidetone* into the earpiece circuit, which means a certain amount of the outgoing conversation is mixed with the incoming one. The result is that the user can always hear his or her own voice as well as that of the other participant.

First stage amplification is provided by transistor Q1, connected in a common base amplifying mode. This presents the necessary low impedance to the pickup coil, acting merely as an impedance matcher (that is, a buffer) rather than a signal amplifier. Its output impedance is much higher than its input impedance, so any following stage of amplification can have a more usual higher input impedance.

Second and third stage amplification is provided by identical amplifiers based around transistors Q2 and Q3. These are connected in common emitter mode, together providing around 1000 times voltage amplification.

PARTS LIST

RESISTORS (all ¼W 5%)

R1, 7, 10	1k0
R2	39k
R3, 4	18k
R5, 8	470k
R6, 9	47k

CAPACITORS

C1	10µ 16V axial electrolytic
C2, 5	100n polyester
C3, 4	1µ0 16V axial electrolytic

SEMICONDUCTORS

Q1, 2, 3	BC109

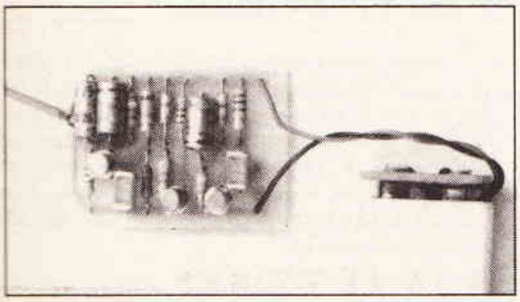
MISCELLANEOUS

B1	PP3 or similar 9V battery

PCB or Stripboard. Screened lead. 30swg insulated copper wire. Case to suit.

The length of screened cable between the coil and circuit board depends on your requirements but bear in mind that the longer this is, the more susceptible the project will be to interference. The circuit is basically a high gain amplifier, and any small levels of interference will be amplified greatly, along with the signal. Our prototype has about 1.5m of cable for this purpose and this seems to work without much interference at all.

The output lead (the lead from circuit board to cassette recorder) on the other hand, can be much longer. The signal here has already been amplified and so is much less affected by interference.



We leave the housing up to you. As the project is a high gain amplifier, a metal box earthed to the 0V battery line would be the best choice but is by no means essential. It all depends on where the circuit board is to be sited. If it's anywhere near a source of electromagnetic interference such as a mains power supply in a TV, computer or even your cassette recorder, the circuit may pick-up the interference in the form of hum. If it's nowhere near such a source, you may get away with a plastic box.

Even though we give all this advice about reducing interference, it's worth noting that the pickup coil itself will pick up more interference than the screened cable and the circuit board, because that's what its purpose is! In this respect, the position of the phone is probably more important than cable and housing. If the phone is close to an interference source, the pickup is going to pick up interference, too.

BUYLINES

Every component is easy to obtain. The PCB is available from the ETI PCB Service as detailed in the back of this issue.

Setting Up

The circuit itself requires no setting up but the coil may require some experimentation in positioning. Generally, the coil should be positioned somewhere near the earpiece of the phone — taped either to the back, or better still to the front, between earpiece and ear. Taped to the back the user won't feel the coil, but even between earpiece and ear the phone is still comfortable to use. Try different positions until you get the optimum.

If you really feel handy, you could mount the coil inside the handset of the phone, and fit a sub-miniature jack socket too, so that the phone is normally free of dangling wires. When you want to record a conversation, you only then need to plug in the screened lead to the circuit board and you're away. However, bear in mind that your telephone provider (BT, Mercury, Hull etc) might not like you tampering with equipment connected to the network in this way — particularly if you only rent the telephone!

It's worth mentioning here that some phones (older British Telecom version and some others like Slimphone) have an enclosed metal earpiece and the coil can't really pickup sufficient signal through the housing for the project to operate satisfactorily. However, all other modern phones we've tried have a plastic earpice which gives superb results. If yours is a phone with such a metal earpiece, it's worth trying to experiment with the coil elsewhere, say around a line-matching transformer inside the main unit. You can but try.

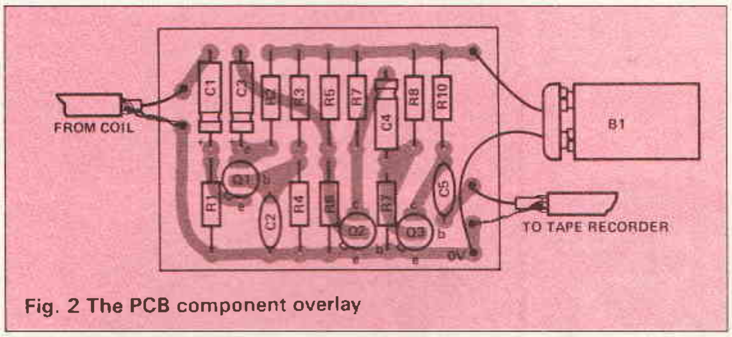


Fig. 2 The PCB component overlay

Setting up your cassette recorder is totally up to you. Remember that the signals you are trying to record are audio, in particular, voice signals — well renowned for rapidly changing in amplitude. So, if your recorder is set too high, some parts of the conversation will be over-recorded and distorted. On the other hand, if the recorder is too low, some parts may not be recorded at all. Try playing around with the recorder setting, perhaps first dialling the speaking clock service to give you a rough guideline about incoming voice signals.

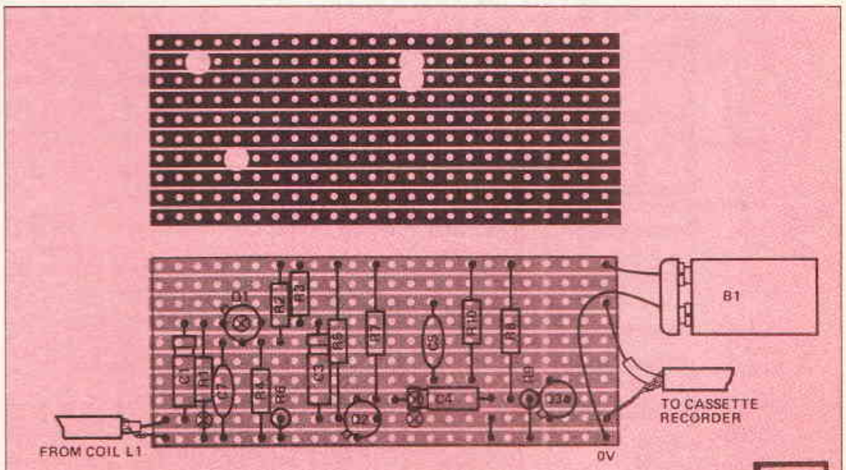


Fig. 3 The stripboard track cuts and component overlay

RANDOM NUMBER DISPLAY

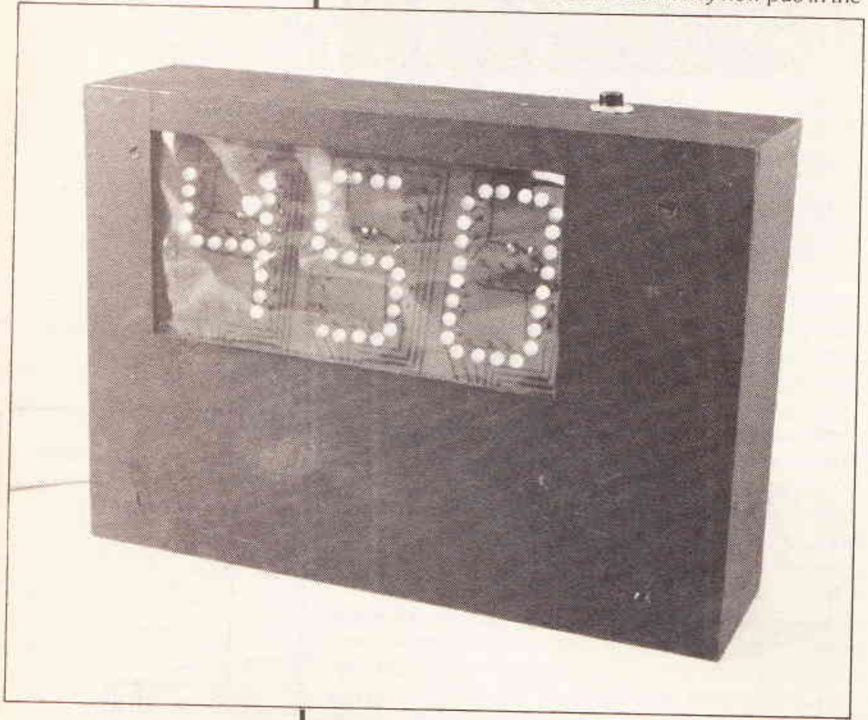
Geoff Phillips presents a tale from the country and a project to boot

Every week the Nether Wallop Grand Order of Tripe Trimmers and Offal Boilers held a prize draw. The committee were bored tripeless with laboriously tearing off all the ticket stubs every Saturday, folding up each one and placing them all in a hat.

They tried using a cage full of numbered balls, but some got lost during a ping-pong game and anyway the members were complaining that the draw wasn't fair.

"How can us members at the back of the hall be sure that the ball you've drawn has the number you say?" shouted one of the members. The integrity of the committee was in question and drastic measures were required. A special committee meeting was held.

"I think we should have one of them didgy-tell number machines like down that fancy new pub in the town," said the chairman of the committee. "But the club can't afford one of those things," the treasurer quickly added.



"The butcher's son Kevin fiddles with electronical things," said the steward. "Aye, and he goes to Polly-tick-nick too." chirped the chairman. So Kevin was asked to design and build an electronic random number generator.

What Kevin Did

There are never more than 1000 tickets sold at the draw so a 3-digit number generator would be adequate. It had to be simple to operate (for the committee) and the numbers had to be big enough to be seen from the back of the concert room. Kevin decided to use a matrix of conventional LEDs for the display as the seven segment displays available from his hobbyist supplies were too small.

The next problem was how to generate random numbers. Kevin had once visited the young people's Christmas disco party in the town. He wasn't too impressive at dancing, and the town girls seemed a little alarmed by the blood on his butcher's apron, but what did catch his attention was the one-armed bandit which stood in the lobby. He reasoned that each time the lever was pulled the time period before each drum stopped must vary slightly, otherwise a regular series of patterns would occur. The speed of the drums at each play probably varied too.

Kevin knew how to design an electronic counter which would cycle the digits 0 to 9 in a similar fashion to the wheels on the fruit machine, but the speed of cycling would be constant. He also knew how to generate a time delay electronically so as to simulate the time the drums spun, but again this would be constant each time it was triggered. He knew that if the members could spot a repetitive pattern of numbers generated by the machine he designed, there would be trouble (he might even be subjected to the Grand Order's ritual offal-dipping punishment).

If the numbers were cycling all the time however, and were stopped when a button was pressed, then the number should be random — the button pressing would not be linked to the electronic counter in any way.

But Kevin realised people would suspect foul play if the numbers were stopped by a committee

HOW IT WORKS

The circuit diagram is shown in Fig. 1. The timers IC1,2 and 3 are connected as free running astable multivibrators which generate three separate clock signals for the BCD counters IC5,7 and 9. These counters are running continuously and asynchronously irrespective of whether the start button has been pressed or not.

The outputs of the three counters are fed to three BCD to 7-segment decoders which drive the numerical display formed by the matrix of LEDs1 to 84. Four series-connected LEDs make up each segment of each digit. The BCD decoders have built in latches which can store the BCD code for any digit from 0 to 9.

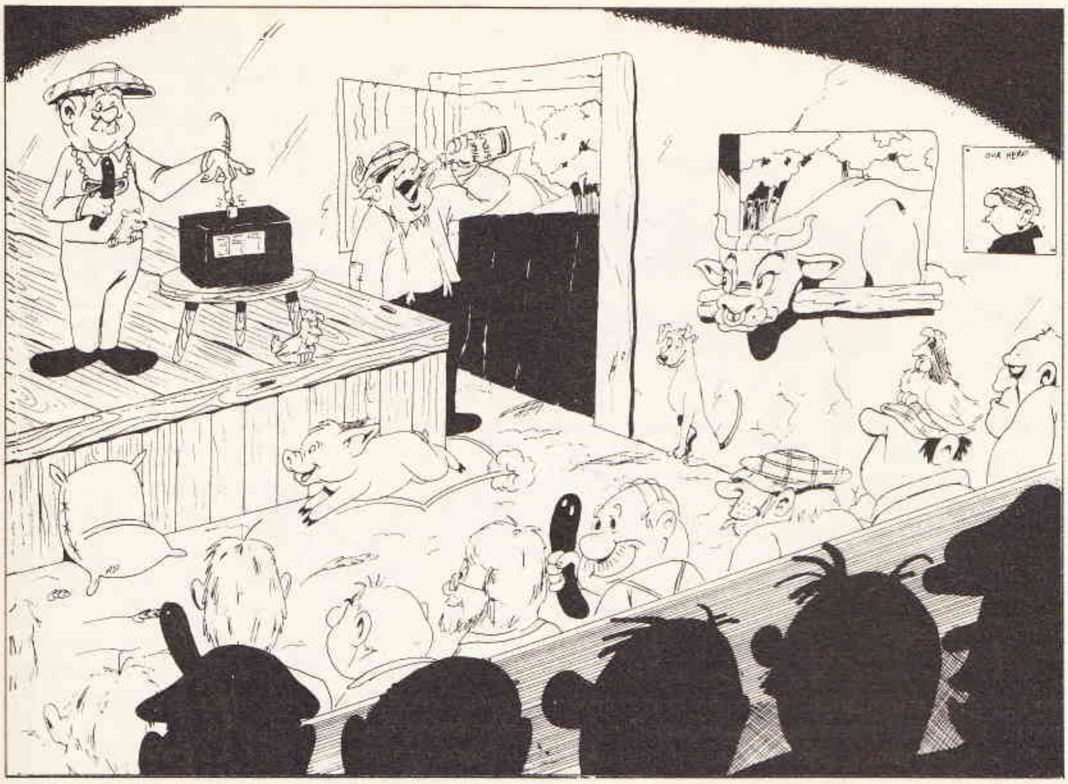
When the LE (latch enable) pin of the decoder is taken to logic 0, the latches are disabled,and the decoder gives the 7-segment drive voltages to the LEDs equivalent to the BCD codes at their inputs A,B,C,D. The LED displays are seen to cycle through the digits 0 to 9 as the counters cycle through the BCD codes.

When the LE pins of the decoders are taken to logic 1, the latches are enabled and store the code which was present on the inputs A,B,C,D at the time of the logic 1 application.

The outputs of the decoders then cause the LEDs to continuously display the number stored. The LE pins of the decoders are controlled by IC4,6, and 8 which are connected as monostables. When the start button is pressed, all three monostables are triggered and their outputs (pin 3) go to a logic 1 which (when inverted by Q1, 2 and 3) cause the LE inputs of the decoders to be taken to logic 0. The LED displays are then seen to cycle through the numbers.

The time of the monostable associated with the most significant digit of the display is arranged to be the shortest, so this digit freezes first, then the second digit and finally the least significant digit.

The counters cycle all the time and the randomness of the number frozen is due to the completely arbitrary time when a person presses the start button. It is similar to a blindfolded person being asked to stop a wheel of fortune which is spinning very fast (but this method is much less likely to cause an accident).



man. The machine had to appear to operate like the one-armed bandit with the numbers apparently stopping of their own free will.

For a few days this had Kevin stumped. Then, while he was trimming a particularly inspiring piece of rump, he had a brainwave. He could make the counters cycle all the time but only connect them to the LED display when the button was pressed. Using three separate time delay circuits would make the three digits freeze one after the other just like the fruit machine. Although the cycling time and the freeze delays would be constant, the final number displayed would be completely random because the button would be pressed at random with respect to the constantly cycling counters.

He would need three separate square wave oscillators to clock the three counters. He used 555 timers for the oscillators and the monostable or time delay circuits, as he had dozens of them in his spares drawer. He used the CMOS 4510 BCD counters which were quite cheap. The CMOS BDC to 7-segment decoder was ideal for driving the LED display because it had built-in latches which could store the winning number.

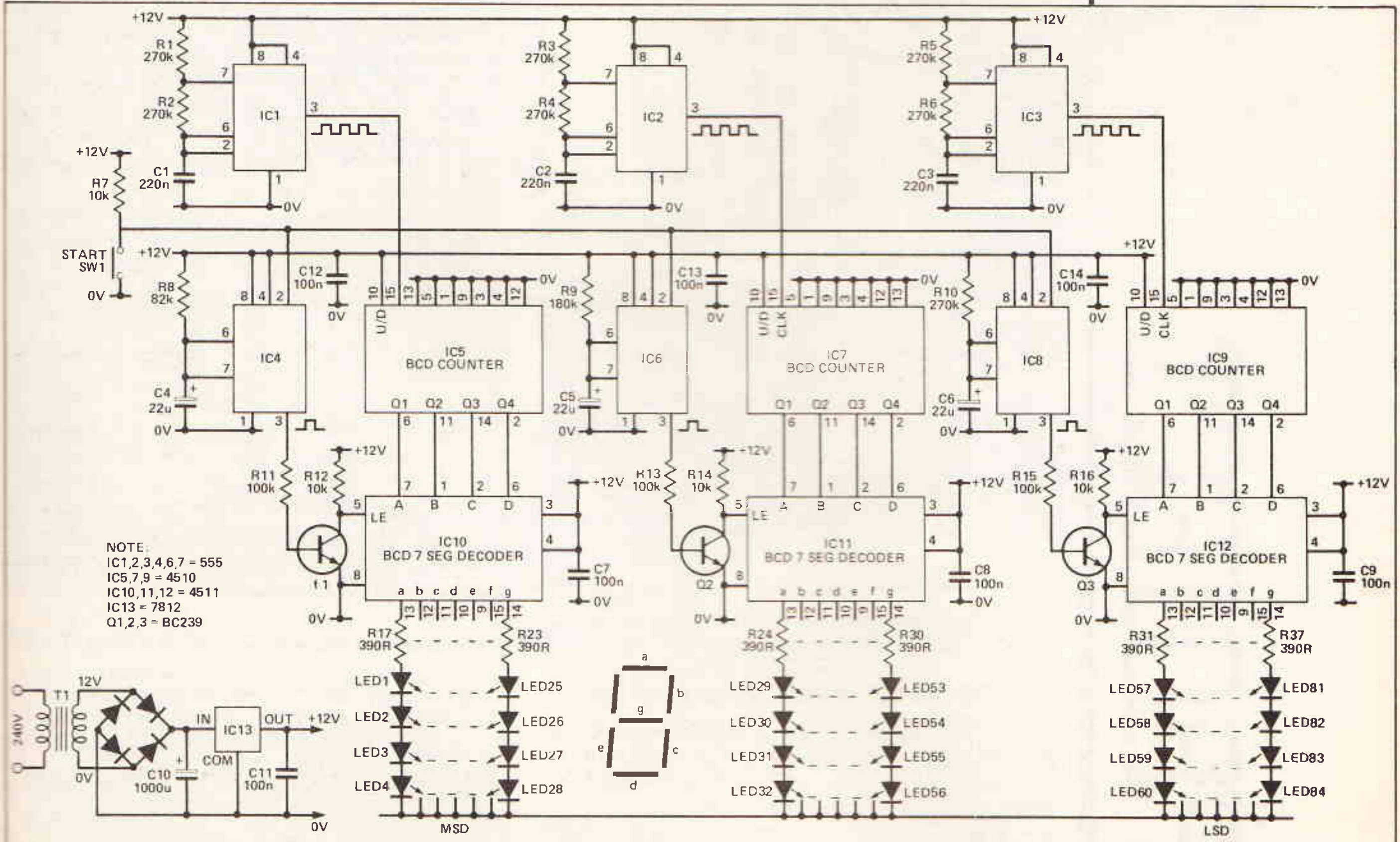


Fig. 1 Circuit diagram of the random number display

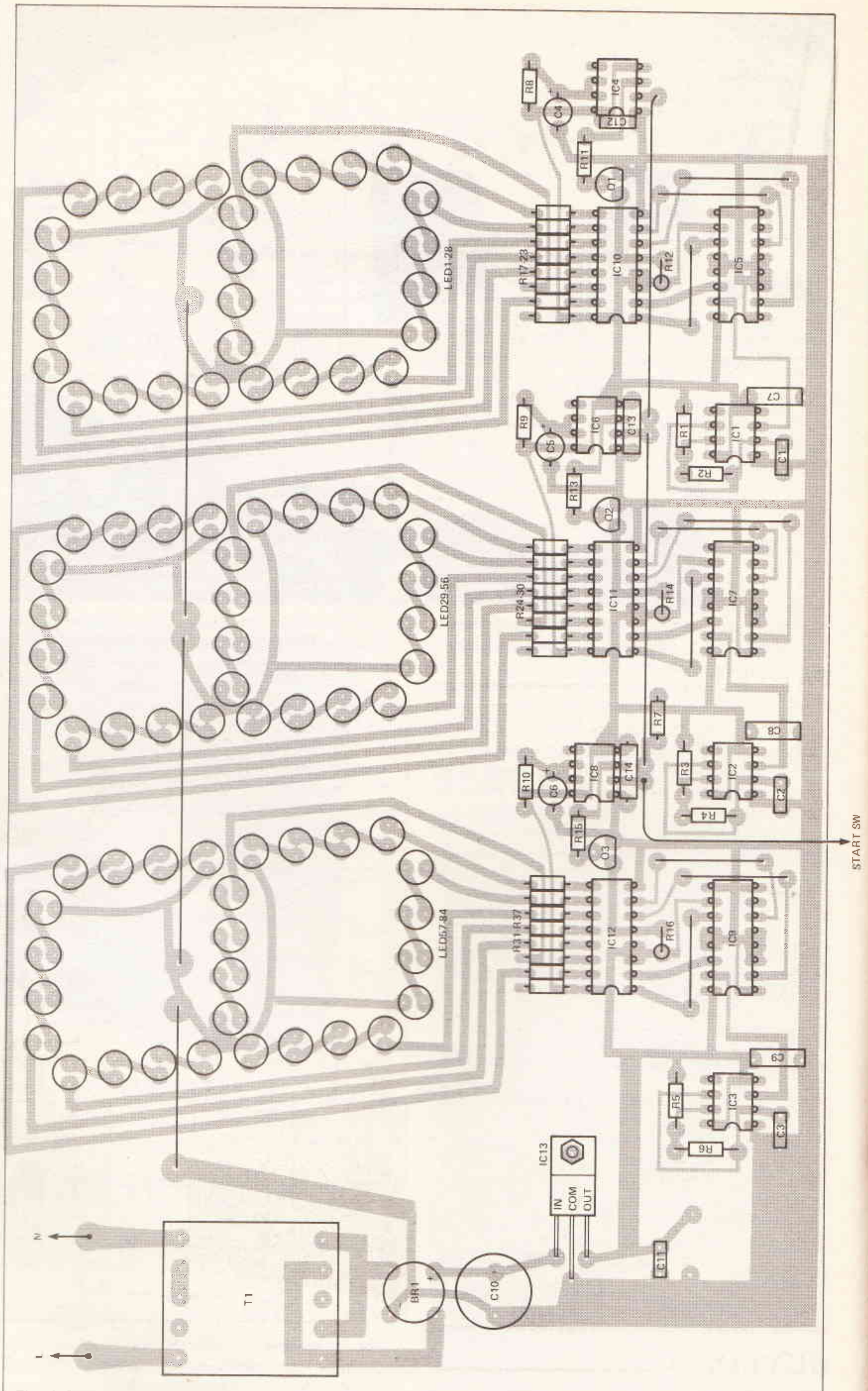
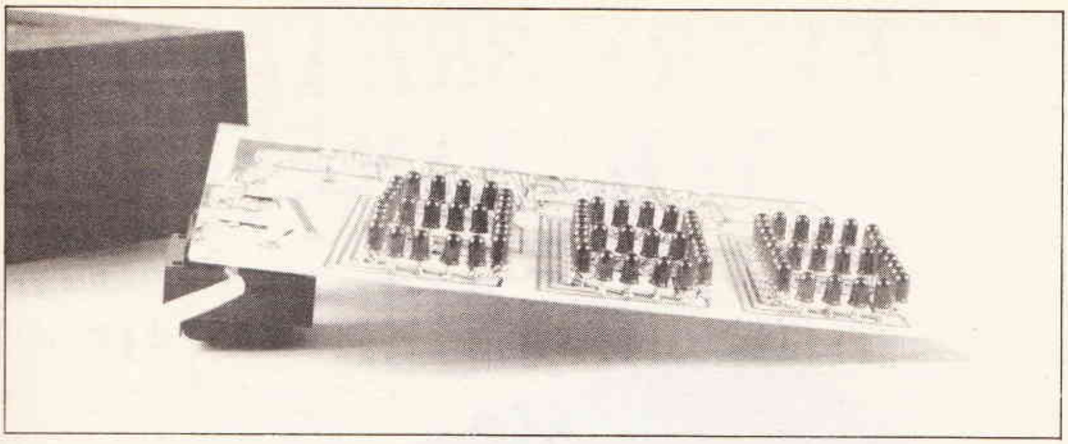


Fig. 2 Component overlay of the random number display

Kevin was quite good at laying out PCB artwork and with three identical channels, the amount of brain power required was reduced still further. Once the PCB was etched and drilled he set about construction.

The component overlay is shown in Fig. 2. Kevin writes: It is a good idea to build up the circuit a stage at a time and get it working before moving on to the next stage. Build the power supply first and once you are happy with the 12V rail at the output of IC13, insert ICs 1,2,3 and their associated components.

If you have access to an oscilloscope, confirm that the outputs of IC1,2 and 3 (pin 3) is giving a low



frequency square wave (it may be possible to observe the pulses with a good voltmeter).

Connect the counters IC5,7 and 9 and confirm operation by checking that pins 6,11,14 and 2 increment correctly.

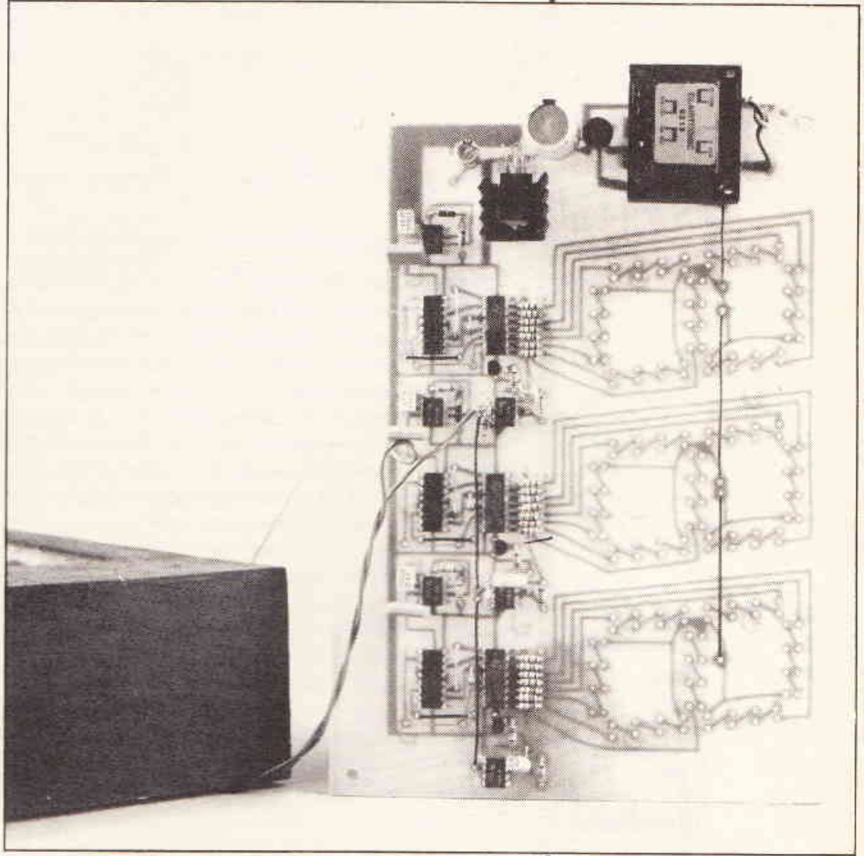
Connect up the decoders IC10,11 and 12 and all the LEDs. Note that the LEDs are connected on the reverse (copper) side of the PCB. Keep the coffee handy . . . fitting 84 LEDs the right way round needs a fair amount of concentration! Fit the associated components but omit Q1,2 and 3 and connect temporary short circuits across the collector and emitter pads of each transistor (effectively connecting LE of each decoder to OV). The LED displays should then be seen to cycle through the digits 0-9.

If one of the segments is not working, check to see that all the LEDs have been connected the right way around.

Finally connect Q1,2 and 3, the monostable ICs 4,6 and 8 and all associated components. The displays should then only cycle when the start button is pressed. The MSD should freeze after a time delay of approximately one second, followed by the second and third digits at similar intervals.

The finished PCB should be mounted vertically in a suitable case with a 80mm × 180mm cut out for the LED display as shown in the photos. The aperture should be fitted with a suitable semi-translucent filter material which allows light from the LEDs to pass through but hides the PCB copperwork and soldered joints. Professional red filter plastic is very expensive and it may be worthwhile experimenting with red cellophane or other red plastic material.

The ideal place for the start button is on the top of the box so that the operator can bring his hand smartly down on the button without fear of the box scooting across the table and into the audience (erroneous results and raucous laughter may result from such an occurrance).



PARTS LIST

RESISTORS (all ¼W 5%)	
R1-6,10	270k
R7,12,14,16	10k
R8	82k
R9	180k
R11,13,15	100k
R17-37	390R
CAPACITORS	
C1,2,3	220n polyester
C4,5,6	22µ 16V aluminium electrolytic
C7,8,9,11	100n polyester
C10	1000µ 25V aluminium electrolytic
C12,13,14	100n ceramic
SEMICONDUCTORS	
IC1,2,3,4,6,8	555
IC5,7,9	4510
IC10,11,12	4511
IC13	7812
BR1	1KAB10 or similar 1A diode bridge
Q1,2,3	BC239
LED1-84	red 5mm LED
MISCELLANEOUS	
SW1	push button
T1	6VA mains transformer, 240V:15V

PCB. Case. Filter material. Nuts and bolts.

BUYLINES

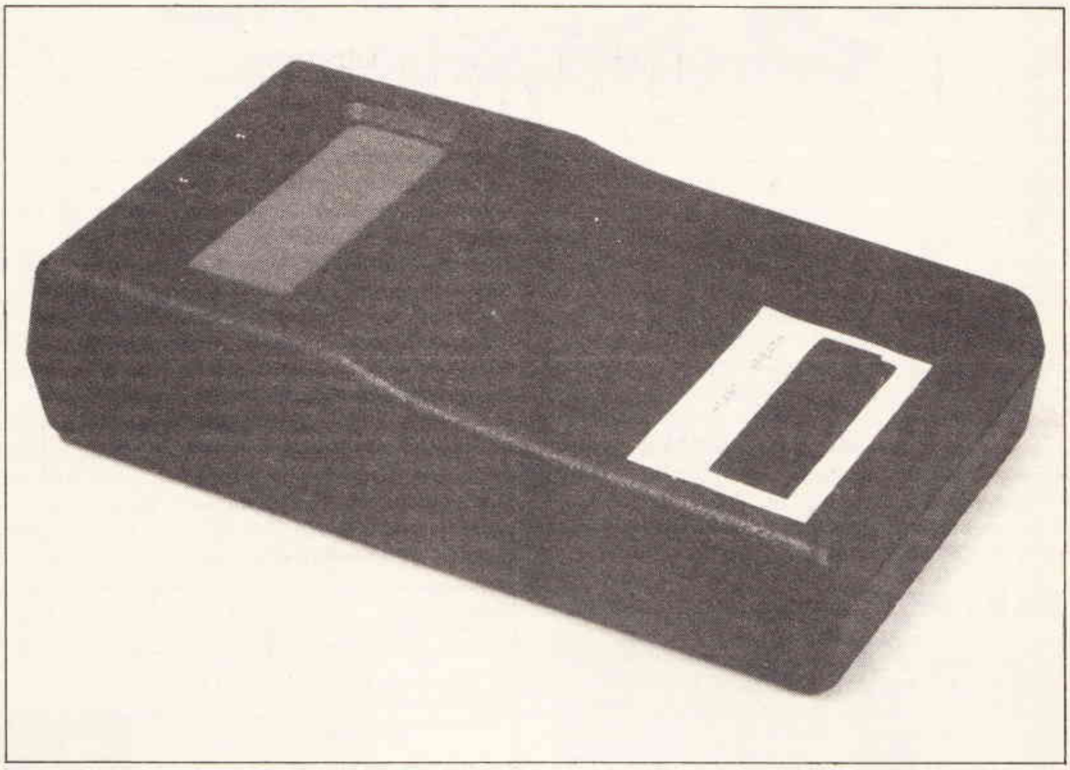
None of the components should prove difficult to obtain. The PCB mounted transformer is available from Farnell or from Trilogic on (0274) 684289.

The PCB is available from GP Electronic Services, 87 Willowtree Avenue, Durham DH1 1DZ.

ETI

EVERY BREATH YOU TAKE

Paul Chappell polishes off his respiration rate and pulse rate meter with the final constructional details and some hints on keeping fit



The main circuit item on the agenda for this month is the heart-rate input section. The circuit is shown in Fig. 1, and as you can see I've opted to pick up the electrical signals from the heart directly. The simpler method of detecting changes in blood flow with an infra-red source and sensor causes much less wear and tear on the designer but the ear or finger clip is inclined to fall off at the slightest provocation. OK for a fun circuit but not too good for serious use.

Before you start worrying about the need for expensive ECG electrodes, I should point out that I've already taken care of that problem for you. When designing the front end I was careful to make sure it would work effectively with a very poor signal. The electrodes used on the prototype cost exactly 2p — more to the point, they *were* 2p — a 1p coin soldered to each input lead! It's hard to find a less suitable electrode material yet the monitor behaved itself perfectly. I'll suggest a few more suitable alternatives later on.

The front end of the monitor compares the electrical signals from your hands or chest (depending on where you place the electrodes) and helps to extract the heart signal from the noise. A large proportion of the noise is 50Hz picked up by your body from the mains. (It's the hum you hear when you touch the input terminal to an amplifier. The heart signals are there too — can you hear them? I bet you can't! They are well and truly buried.)

Although the mains signal is very strong, it has a large common mode component and a much smaller differential mode component, so IC1b and 1c are very effective in increasing the ratio of heart signal to mains noise. Attach your amplifier input to the output of IC1c and you'd still hear a lot of hum but the heart sound would also be distinguishable.

The problem now is to remove the rest of the mains noise, along with all the thermal noise, amplifier input noise, radio signals and so on, which will all begin to make themselves felt once the 50Hz noise is no longer screening them.

Since the bulk of the noise is mains hum, I did consider following the input amplifier with a 50Hz notch filter. The trouble is that any single op-amp notch filter tends to be very sensitive to component variations. Most configurations require two adjustments — one to make sure that it's centred spot on 50Hz and the other to ensure that the signal is attenuated as much as possible when you get there. In the simpler versions the adjustments interact, which is no help at all.

Turning to a low pass filter instead, it's fairly obvious that the standard Butterworth or Chebyshev profiles just aren't going to give enough separation, bearing in mind that I am limiting myself to a single second-order section. The filter in Fig. 1 is a mad professor's Chebyshev! The gain is pumped up enormously below the cut off point, then the balloon is punctured and the gain shrivels to nothing:

'Pump up ze gain. Give me more pumpings.'

'But professor, the passband is getting out of control!'

'I care nothings for ze passband. Let it explode.'

'But professor, if this lot goes up it will take half of London with it!'

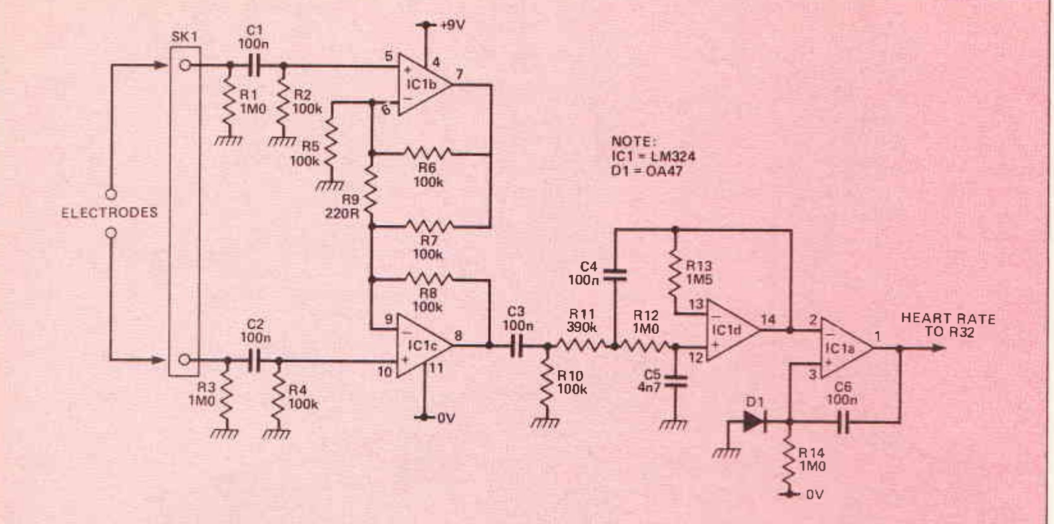


Fig. 1 The circuit of the heart rate detector

'Don't argue with me. More pumpings! More pumpings!'

The result is a filter which in this application performs far better than you could reasonably expect. It's not the kind of thing you'd choose for your hi-fi but since all we want to do is to detect the presence or absence of the heart signal, distortion is not a concern.

The limit to the professor's pumpings is that eventually the transient response of the filter will become too elastic — it will bounce all over the place. The values chosen get the balance just right and the filter behaves itself well.

The signal is now clean enough for a simple amplitude level detector to sense it. IC1a combines a level detector and monostable so that each heart beat results in a pulse of well defined length suitable for driving the logic circuit.

Circuit Changes

This project has been cooking for quite some time now, as you may have noticed! Over the past few months I've had plenty of opportunity to make improvements to the prototype and since I haven't yet described the construction there's still time to include them. To save you having to refer back to previous issues, the entire circuit is shown in Fig. 2.

Most of the changes have been made for aesthetic reasons. It didn't seem reasonable for the breathing rate circuit to have sole charge of the LEDs, so I've given the heart-rate section a crack at them too by driving them from the Schmitt which combines the two signals. The result is that when you select 'breathing rate' the LEDs light alternately as you breathe in and out, as before. When you select 'heart rate', the light flicks from one LED to the other and back on each heart beat.

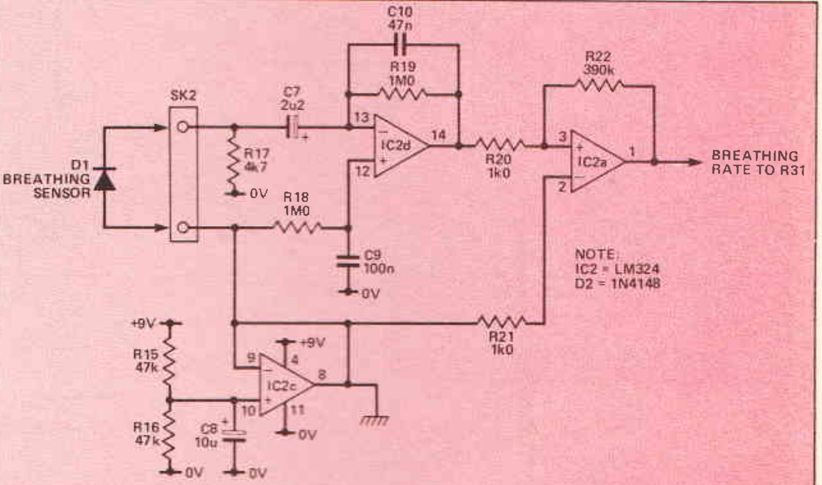
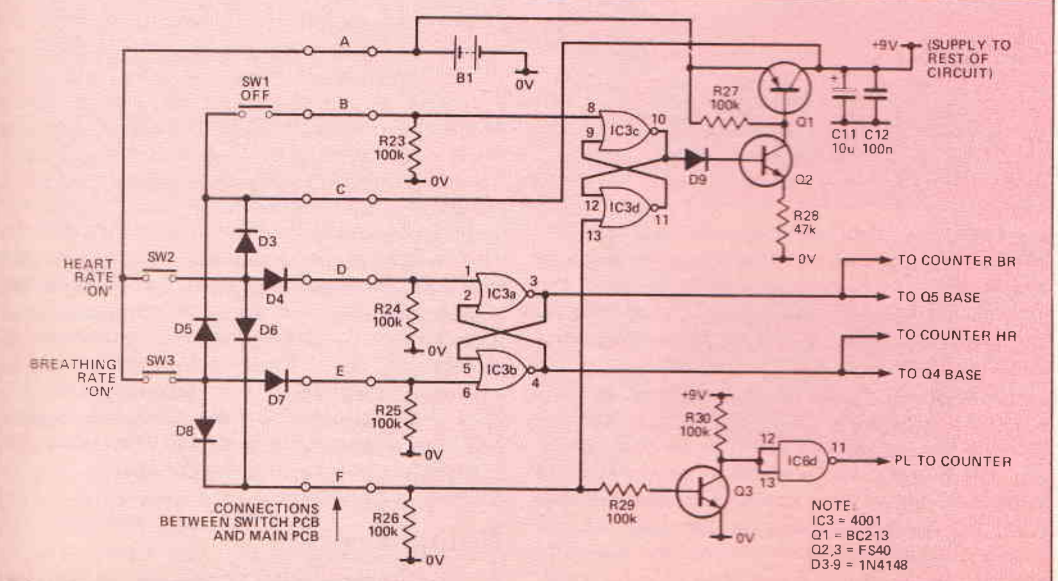


Fig. 2 The rest of the circuit, with additions and modifications. (a) Breathing rate detector.



(b) Switching circuit and power supply

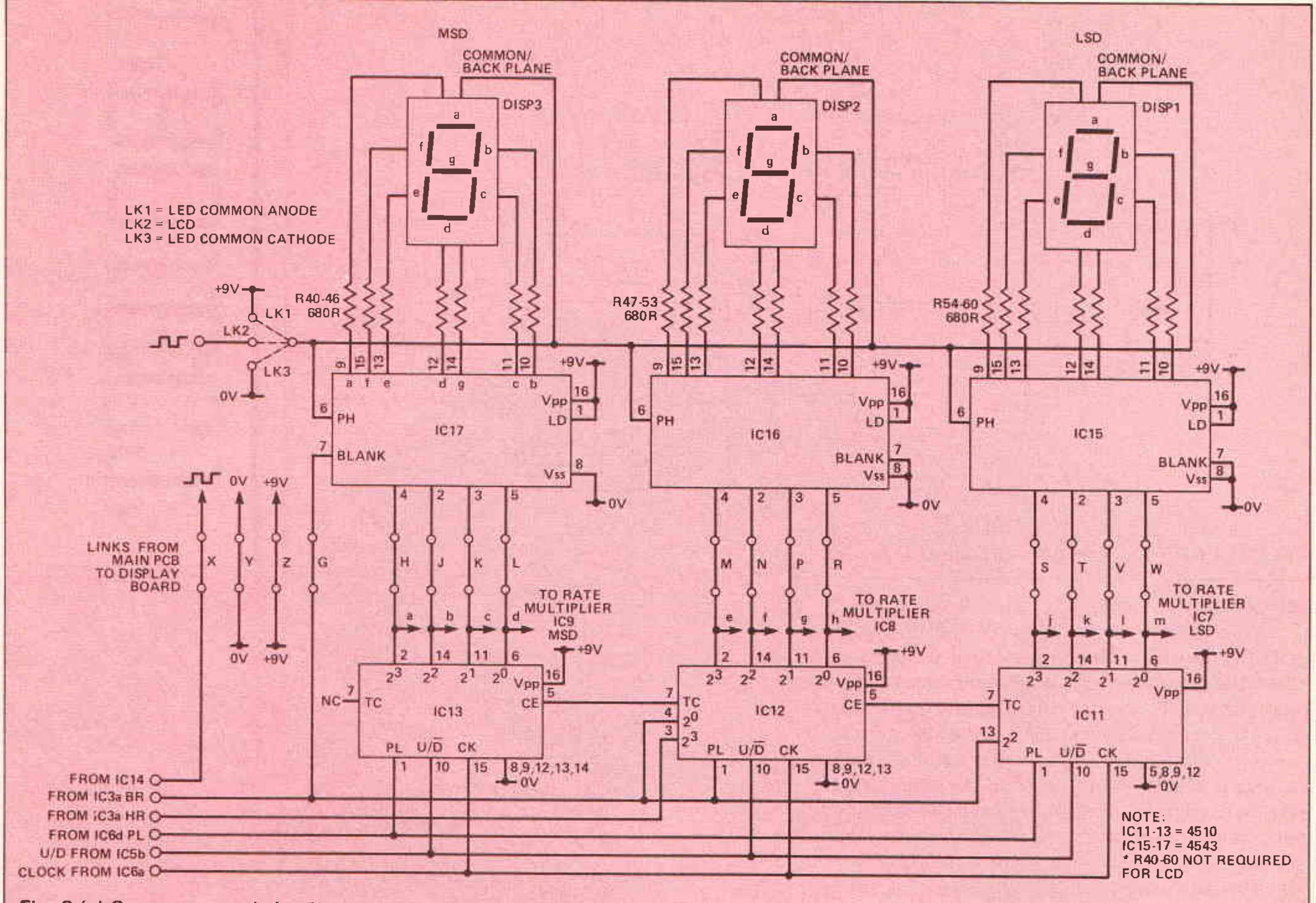


Fig. 2 (c) Counter control circuit

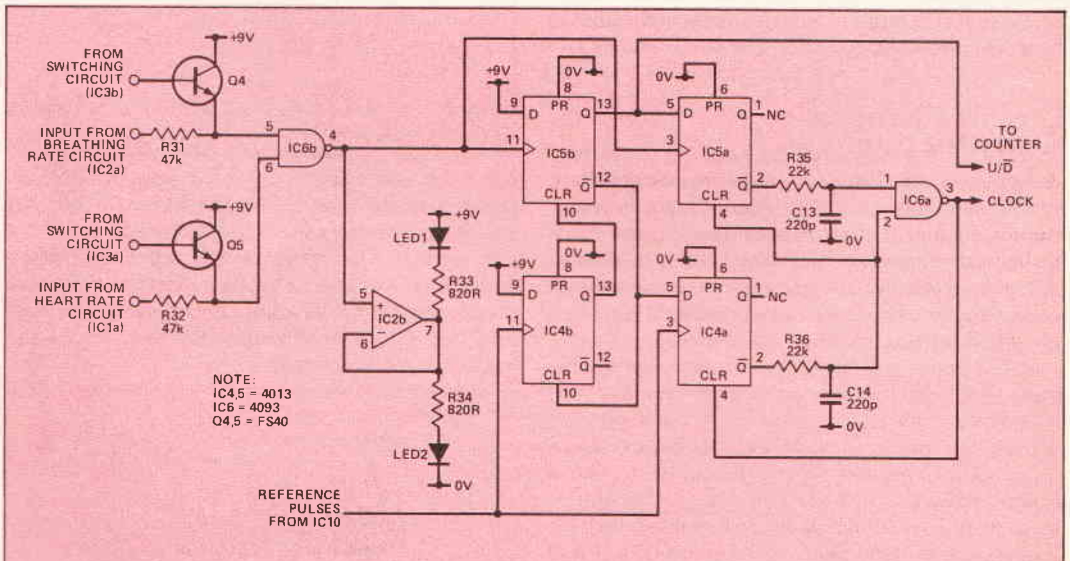


Fig. 2 (d) Counter and display

I have altered the circuit around the D-type flip-flops slightly to do away with the resistors, capacitors and diodes. The revised circuit makes use of the propogation delays of the ICs themselves to keep the timing right, so you have the satisfaction of knowing that it couldn't possibly go any faster.

The other circuit works perfectly well, so don't worry if you've already started building it. It's just that I find this one more elegant, and I do like neat circuits!

The addition to the divider chain is IC14 to provide the square wave for the LCD display. It may seem like overkill to use an entire 4040 for this purpose, but the IC costs no more than a separte oscillator. Not many LCDs have their AC drive crystal controlled!

The final addition to the circuit is the switching. This could have been done more easily with a rotary switch but I chose push buttons for the sake of appearance. Pressing the 'heart rate' or 'breathing rate' button turns the circuit on, supplying power to the board via Q1 and Q2. It also loads up the counter with an estimated heart rate (80) or breathing rate (14). IC3a/b decides which input circuit should be engaged and IC3c/d reminds the monitor if it's on or not, just in case it's in any doubt about the matter.

Components

Because the main PCB is densely packed with components, the main requirement is to choose ones that

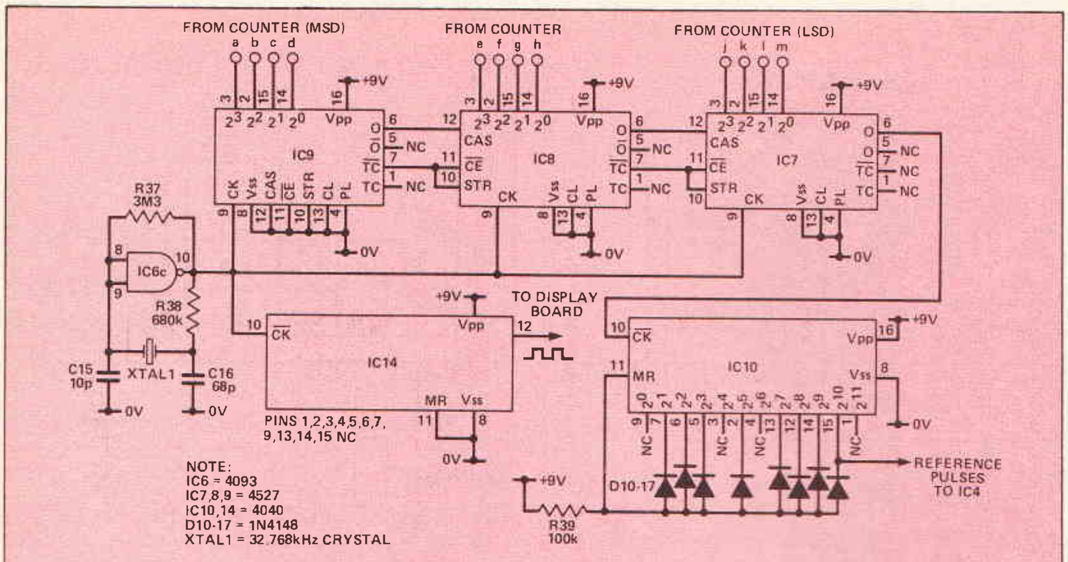


Fig. 2 (e) Rate multipliers, divider and LCD drive

are small enough to fit in the space allowed for them. The resistors should all be ¼W types — which is nothing unusual. The non-electrolytic capacitors should be monolithic ceramics for any values over 1n0 — other types almost certainly will not fit on the PCB.

For the electrolytics I have specified the minimum voltage in each case. Often there is nothing much to choose in size between a 16V tantalum and a 6.3V one, so don't be too concerned about seeking out the very smallest voltage. Standard electrolytics can be substituted for any of the tantalums as long as the case size is small enough.

The crystal used is in a tall, thin cylindrical case, roughly 8x3mm diameter. It seems usual for crystals of the specified frequency to be supplied like this but best check beforehand. The more common HC6/U or 13/U packages would be far too large.

Construction

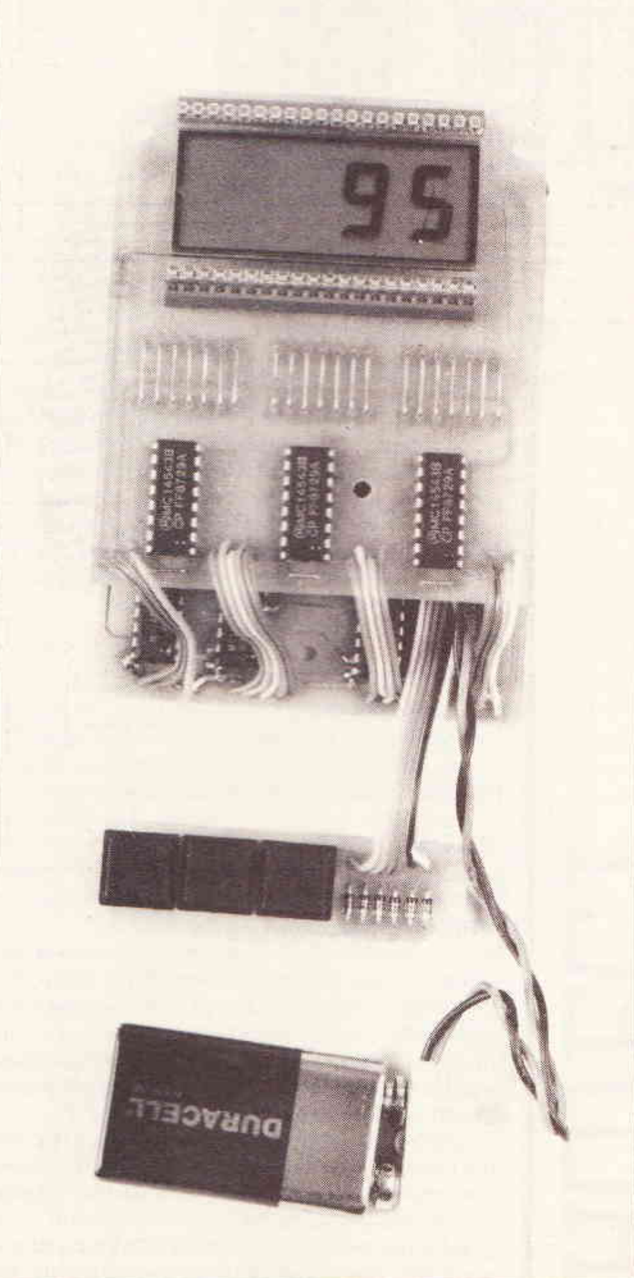
Assembly of the display board was described last month but since the components have been renumbered, and to help you see how the connections go between the various PCBs, the overlay is repeated in Fig. 3c. Note that the project as a whole uses an LCD, so resistors R40-60 are not required. Wire links are wired across their board positions.

The major task this month is to assembly the main PCB (Fig. 3a). The only thing that makes this board more difficult than usual is the close packing of the components, particularly at the input end of the board. You may have built other projects with a brazing torch and kitchen knife but for this one — forget it! A 15W soldering iron with a fine pencil bit, a good pair of radio pliers and a sharp pair of side cutters is the basic requirement.

Some through connections are made on component leads and some with wire links. It's a good idea to begin with the wire connections, since it's much more difficult to trim the wires when the board is full of components. If you find more than 24 connections, either my counting has failed me or you've bunged up a component hole. If you find less, keep looking!

The next step is to solder in all the ICs. Make the bottom connections first, then go right around the board one IC at a time and make all the top connections to each. Check as you go that you haven't left any solder spikes or blobs, particularly where tracks run between IC pins.

Finally, put in the transistors, diodes and passive components. Begin with the ones physically closest to the ICs and make the top foil connections as you



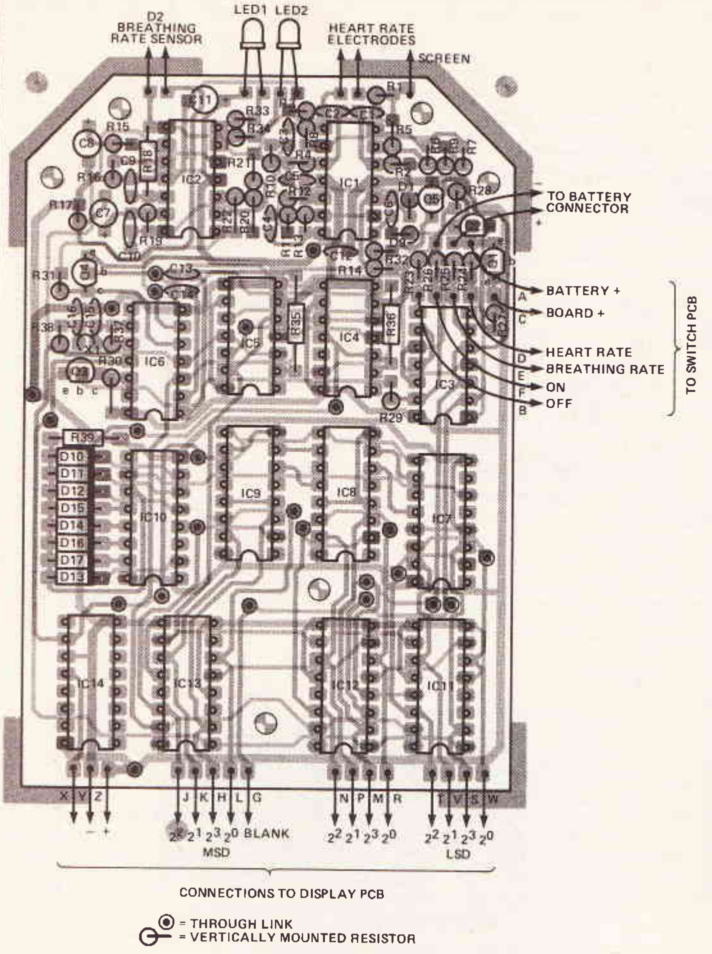


Fig. 3 (a) Component overlay for the main board

go. Most of the resistors mount vertically and if you put the body on the side shown in the component overlay you will find that all top connections are made on the free lead. The most awkward component to fit is D9, which needs to be soldered to the top foil at both ends. Let it stand about 2mm clear of the PCB at the body end, and be careful not to damage it by soldering close to the body for too long.

Joining the boards

Connections between the display board and the main board are made by short lengths of ribbon cable. The connections come in the same order at the edges of the two boards so it should be easier to wire them correctly than to make a mistake! The boards are mounted ½in apart and there is very little room in the case for hanks of spare wire, so resist the temptation to use any more than 1½in lengths. The connections are shown in Fig. 4.

Connections to the switch PCB are made via a 5in (at most) length of 6-way ribbon cable. The connection points on the main board are just above IC3. Once again, the wires connect in the same order on both boards, with the exception of the right hand wire (battery +) which has a slightly longer journey to connect next to the battery input.

The battery leads connect just above R23-R26 with the negative connection to the left. If the connector has long wire tails, trim them to a length that will allow a little slack inside the battery compartment.

When connecting up the wires, it helps if you twist the strands together and tin them very lightly first. This makes them easier to push through the holes and prevents any stray whiskers from missing the hole and shorting against component leads.

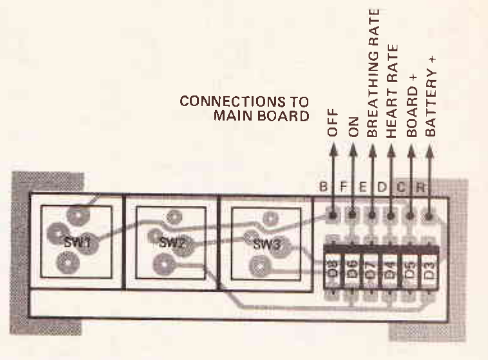


Fig. 3 (b) Component overlay for the switch board

Testing

The display PCB is supported on ½in plastic pillers attached to the main board. It's useful to have the pillars in place during testing to rest the display board on when you want to check the readings, so attach them to the main PCB before you start. Attach a few feet of wire temporarily to the sensor and electrode inputs. Solder a diode to the sensor input and two coins to the electrode leads.

The most expensive single component in the project is the LCD display, so the first thing to check is that no harm can come to it. Connect up the battery, press either the 'breathing rate' or the 'heart rate' button and you should see a number displayed on the LCD.

Check that a 64Hz square wave drive is present at the backplane and all segments of the display. You can pick up the backplane drive on the link that runs horizontally from the left of the display board to a point just under the left hand side of the LCD. The segment drives can be seen at the links in the R40-60 positions. If the 64Hz square wave is present on all these you can relax. All is well.

For the moment, short the two heart rate electrodes together — a paper clip will hold the coins in contact with each other. Press the 'heart rate' button and a reading of 80 should appear on the display. Left to its own devices, the monitor should begin to count down from this reading at a rate of a little over one count per second as soon as you release the switch. The count rate will get lower as the displayed number decreases. Let it run and check that the count goes all the way down to zero.

Press the 'breathing rate' button and the display should show a reading of 14. This too should count down when you remove your finger from the button.

If the monitor does not behave as I have described, it could be that it's just picking up noise at the inputs. Check that the LEDs are not flashing. Otherwise, the problem will be that you've missed a through link (you did make the link underneath IC5, didn't you?) or that you have missed a through connection on a component lead, shorted out a track with a solder spike or possibly that one or more of the connections between the PCBs is broken.

Hold the breath sensor diode an inch or so beneath your nose or in front of your mouth and breathe on it. Breathing in should cause one LED to light and breathing out should light the other. Let the display run down to zero, then check that each breath causes the count to advance by one. If it counts by more than one, and the LEDs seem to flicker a little as you change from breathing out to in or in to out, the problem is mains hum pickup on the input leads. The circuit should be fairly immune to this but if it does cause problems the solution is to reduce the value of R22 or to use screened cable for the input leads (which is a good idea for the final version in any case).

PARTS LIST

RESISTORS (¼W 5% carbon firm, except where stated)

R1,3,12,14,18,19	1M0
R2,4,10,23-27, 29,30,39	100k
R5-8	100k 1% metal film
R9	220
R11,22	390k
R13	1M5
R15,16,28,31,32	47k
R17	4k7
R20,21	1k0
R33,34	820
R35,36	22k
R37	3M3
R38	680k
R40-60	not required for LCD.

CAPACITORS (See text for capacitor types)

C1-4,6,9,12	100n monolithic ceramic
C5	4n7 monolithic ceramic
C7	2µ2 3V tantalum or miniature electrolytic
C8	10µ 6V3 tantalum or miniature electrolytic
C10	47n plate or monolithic ceramic or metalised film
C11	10µ 10V tantalum or miniature electrolytic
C13,14	220p plate ceramic
C15	10p plate ceramic
C16	68p plate ceramic

SEMICONDUCTORS

IC1,2	LM324
IC3	4001
IC4,5	4013
IC6	4093
IC7,8,9	4527
IC10,14	4040
IC11,12,13	4510
IC15-17	4543
Q1	BC213 or equivalent
Q2-5	FS40,BC317,MPS3646, etc.
D1	OA47
D2-17	1N4148
LED1,2	LEDs any size, shape or colour
DISP1-3	LED or LCD 7-segment display (3 digits)

MISCELLANEOUS

B1	PP3 battery and clips
SW1-3	Push button SPST switch
SK1,2	3·5m stereo jack socket
X1	32.768kHz crystal

PCB's, 20-way SIL socket strips for LCD. Ribbon cable for connection between boards. Stereo screened wire for electrode/transducer board connections and leads. ½in plastic pillars and suitable screws. Hand-held instrument case with battery compartment and display cut-out. Plastic film. Nuts and bolts.

BUYLINES

The switches used are Preh 75120-008 low profile keyboard switches, available form Eardley Electronics, 182-4 Camden Hill Road, London W8.

A complete parts set for the project (including case and switches) is available Specialist Semiconductors Ltd, Founders House, Redbrook, Monmouth, Gwent for £39.57 incl. VAT. Individual components can be obtained from the same source — send SAE for lists.

The PCB is available from the PCB Service — see the back of this issue for details.

If the diode seems sometimes to miss out a breath (as shown by the LEDs, not by the display count) the solution is to increase the value of C7. The real test as to whether this is necessary is if there is a significant delay between your breath changing direction and the LEDs changing. If there isn't, it could just be that you were holding the diode in the wrong place when the breath was missed! Changes to R22 and C7 shouldn't be necessary at all — I'm just trying to anticipate every problem that might conceivably turn up.

If you have enough patience to hold the diode beneath your nose for a while, press the 'breathing rate' button again and check that the monitor tracks up and down as you breathe faster or slower. If all the tests have worked so far then it certainly will but having gone to the trouble of building it you might as well play with it for a few minutes!

Now for the heart-rate section. Hold one of the coins against the palm of each hand, press the 'heart rate' button and watch the LEDs. The light should flick from one LED to the other and back a little more than once a second. If you are very fit, the rate could be less than once a second but in any case the pulse should be regular.

If you loosen your grip on one electrode or the other, the LEDs will flicker wildly since the input stage relies on having both electrodes connected for its noise immunity. Gripping both electrodes gently but firmly against the palm should restore the regular beat.

If there is no response when you have both electrodes in your hands, it could just be that your palms are unusually dry. If your hands are clean, licking them should overcome the problem. If they are not clean, licking them will still overcome the problem but I'd hate to think what you'll get in your mouth.

If dampening your plams doesn't produce any worthwhile results, it's time for a serious investigation of the problem. First of all, check that touching just one electrode will give rapid flashing of the LEDs. If not, the answer lies somewhere in your soldering, so check the PCB carefully.

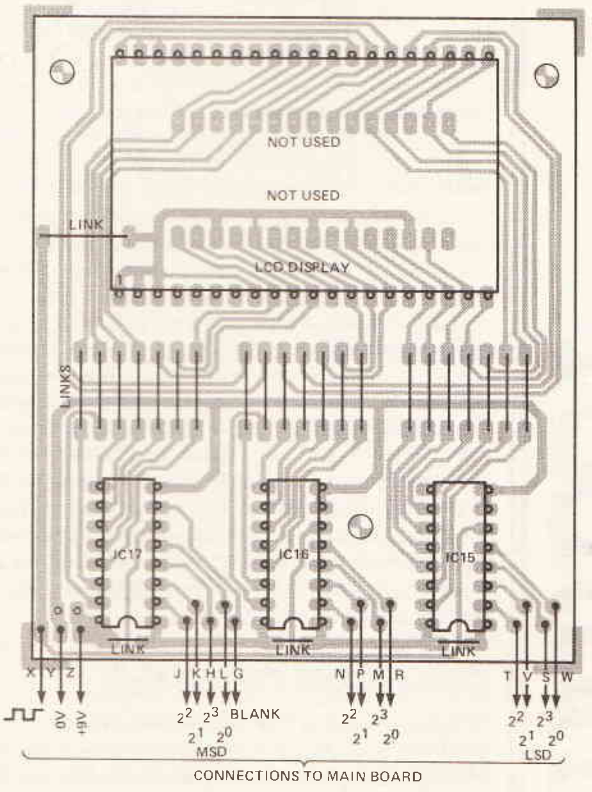


Fig. 3 (c) Component overlay for the display board

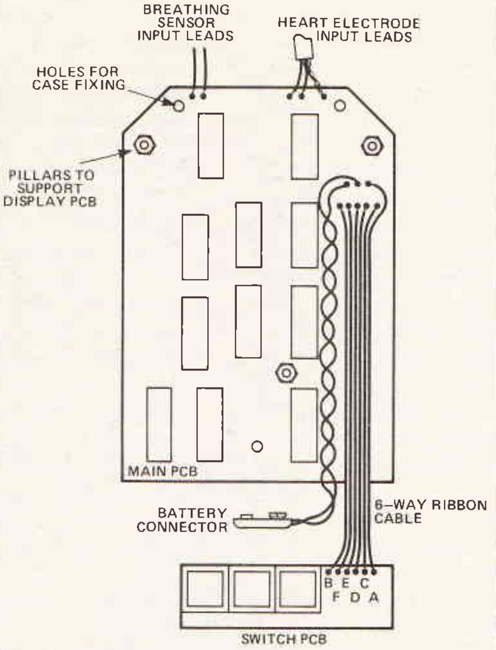
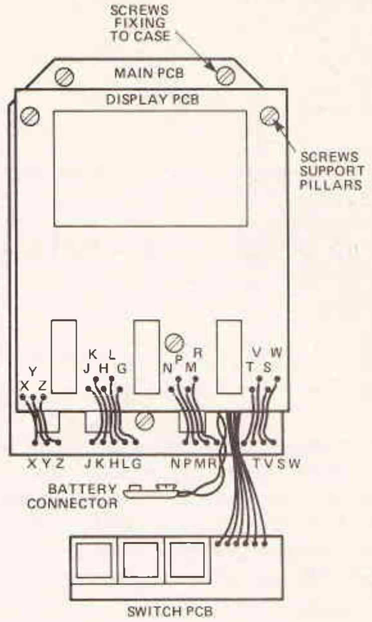
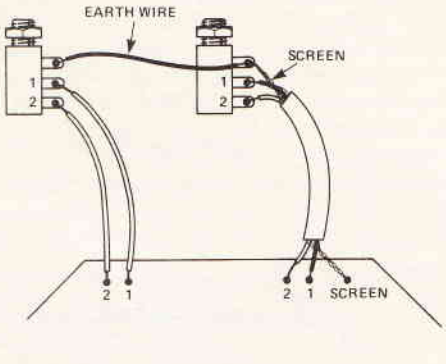


Fig. 4 (a) Connections between the main PCB and switch PCB.



(b) Connections between main PCB and display PCB.



(c) Wiring the input sockets

Make a voltage check at ICI pin 8. If this lies somewhere between about 2½V and 6V this is acceptable (assuming you're using a fresh battery). If not, it could be that you've soldered IC1 too hot and too long. Check that you haven't made any mistakes in assembling the PCB — if not, replace IC1.

If the voltage at IC1 pin 8 is within limits, reducing the value of R9 (try 180R first and 150R as a last resort) will set everything going. If you have the opposite problem — however you hold the electrodes the LEDs flash widly — increasing R9 slightly should overcome it. The change shouldn't be necessary but once again I'm trying to anticipate every eventuality.

Having assured yourself the circuit is working, press the 'heart rate' button again and check out your heart rate. If it's below the estimated 80, you'll survive for a while yet. If much above, turn to the section on training before it's too late!

Sensors And Electrodes

Although dangling a diode beneath your nose and clutching coins in your sweaty hands will produce usable signals, neither are very practical ways to derive the inputs. For the breathing sensor, the best solution I have found is to thread the diode through two diametrically opposite holes in a piece of plastic tubing. The type sold for wine and beer making will be OK for taking readings of your resting breath rate but a wider bore will make breathing much easier if you intend to measure during training. A piece of garden hose or tube for a washing machine may be more sensible. You can either breathe through the tube with one end in your mouth or fashion a cover for your nose and hold it in place with an elastic band. There's no reason not to connect two diodes in series to sense breathing from both mouth and nose.

The simpler way is just to hold the sensor in place just below your nose with an elastic band. Let's face it, whatever you do is going to look pretty damn silly but then so do the masks used with professional breathing analysis machines!

For the heart rate electrodes, it once again depends on how you intend to use the monitor. If you just want to check your resting heart rate every now and then to see if your jogging is really making you fitter, two lengths of copper tubing will fit comfortably in the hands. Offcuts of central heating tubing can be had for little or nothing.

If you want to use the monitor during training, the need to keep a steady pressure on the electrodes will be a nuisance, so something more professional is called for. For short sessions, the adhesive type of electrode (Fig. 5) with a low cost gel will be fine — a box of 100 can be had for less than £15 (15p each) so they are not at all expensive.

For long term use — for marathon runners and the like — the silver/silver chloride porous type can be worn for long periods without discomfort. They are more expensive at around £1.50 a pair, but unless you intend to run a marathon every day you won't use that many of them! The most economical way to use the monitor is to make do with the copper tubes for day to day checks on your heart rate and to bring out the ECG electrodes only for special training sessions.

The adhesive electrodes can be attached to the palms of your hands or to your chest — there is not much to choose between the signal available so the choice is simply one of comfort or of where they are less likely to be disturbed.

Final assembly

The case for this project already has a cut-out for the display, so the holes still to be made are a rectangular one ½in x 1½in above the battery compartment for the switches, two 3mm holes (assuming you choose 3mm LEDs) above the display and two holes in the back of the top case section to suit the jack sockets.

Your main concern with the circular holes is to drill them so that the sockets and LEDs can be mounted without fouling any components on the PCBs. A hole on either side of the square indentation above the display slot is OK for the LEDs. For the sockets, choose a position fairly high in the rear of the case, above the level of the components on the main PCB.

Rectangular holes always sound more of a problem than they really are. As long as you have the very basic manual skills needed to scribe a rectangle on the case top and then to cut or file away the surplus plastic, it's not at all difficult. In this case it's even easier than usual because you have an indentation in the case to help with the marking out. It's not quite long enough for the three switches but at least it settles the position of three out of four edges of the hole.

After scribing the rectangle, remove the bulk of the surplus plastic by drilling several holes around the inside edge of the mark. Then trim away the rest with a sharp knife or a file. If you use a file you'll find it cuts very quickly through the plastic, so don't go at it too enthusiastically or you'll find yourself with a hole larger than you intended. Easy does it!

The final cutting job is to file a flat groove in the dividing wall between the battery compartment and the rest of the case to allow the switch PCB and battery connector leads to pass.

Trim the LED leads down to about ¼in (if you leave the +lead slightly longer than the −lead on each, it will help identification later) and push the LEDs into their holes. Hold them in place with a dob of glue to fix them to the underside of the lid.

Push the switches through their hole, put a PP3 in the battery compartment and bring the two halves of the case together to check how far the switches have to protrude to allow enough clearance for the battery. A piece of thin foam plastic glued to the copper side of the switch PCB will serve to prevent the battery from rattling about and avoid shorts between the metal of the battery case and the PCB.

With the switch PCB roughly in the right position, glue around the switch bodies (underneath the lid!) with quick setting Araldite. Before the resin has cured, put the two halves of the case together again and make any final adjustments to the position of the switches. Keep an eye on the switches, or hold them if necessary, for the minute or so it takes the resin to go firm.

Connect up the input jacks to the PCB as shown in Fig. 4c. Connect two lengths of 2-way ribbon cable to the LED connections on the PCB. The LED wires should be long enough to allow sufficient separation of the case halves for you to solder the LEDs without melting the case! This is the one occasion when you can use longer wire than is required for the distance.

Glue a piece of transparent film over the display hole on the underside of the case. It's best to leave this until the last moment to avoid it becoming scratched during other acivities. Screw the main PCB to the case, solder the LED wires to the LEDs, bolt the two input sockets into their holes, screw together the two case halves and you're through! Reward yourself with a cup of tea, a can of lager or a shot of Glenlivet, depending on your tastes.

Health, Fitness, Exercise and Training

If you've built the project or even bothered to read the article so far, you must have at least a basic concern about health and fitness or be involved in a strenuous sport of some kind. In either case you'll find the monitor a great morale booster — there's nothing quite so encouraging as having a quantifiable result to show for your training efforts! Even on the crude basis of 'the lower the better' the monitor will allow you to check your progress day by day.

The differences you will see are not just a matter of a few percentage points. The resting heart rate of a sedentary office worker (or Projects Editor!) may be well over 80 beats per minute, whereas that of a regular jogger may be closer to 60 and for a keen athlete can sink towards 40. The differences are enormous.

The reason for the diminishing heart rate as you become fitter is that your heart will develop a larger stroke volume. In crude terms it shifts more blood on each beat so it doesn't need to pump as fast. Just like any other muscle, your heart becomes stronger when called upon to work hard from time to time. The strengthening takes place much more quickly if you can keep an eye on just what your heart is doing.

Whenever you exert yourself physically, your heart rate increases to transfer oxygen to your muscles at a higher rate. Up to about 120 beats per minute it can cope quite comfortably. At around 140 it is beginning to work hard enough to encourage strengthening. Above 160 beats per minute it is really exerting itself and the law of diminishing returns begins to take effect. Quite literally in this case, since it is the venous return (the rate at which blood arrives back at your heart) which diminishes. The blood volume is no longer sufficient to fill the chambers properly. Higher pulse rates do pump more blood but the rate of increase falls off as the pulse heads upwards.

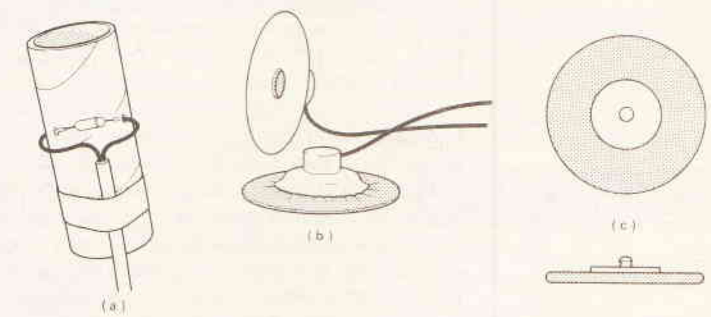
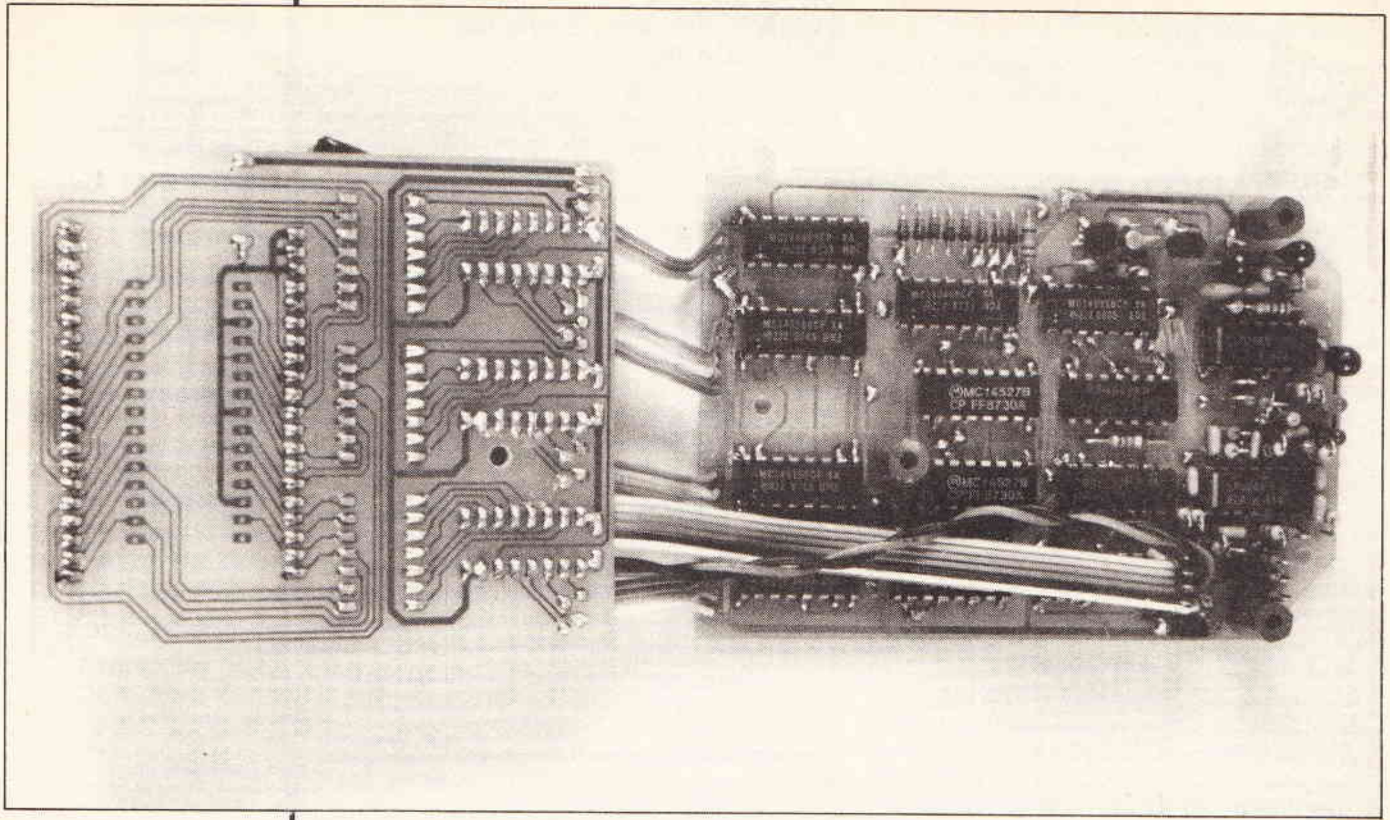


Fig. 5 (a) Breathing rate sensor. (b) Plastic self-adhesive ECG electrodes for short term monitoring. (c) Porous Ag/AgCl self-adhesive ECG electrodes for long term monitoring

A good training scheme for beginners is to jog, cycle or exercise in some way just enough to maintain a pulse rate of 100 per minute. Three times during each training session a burst of extra exertion brings the pulse rate to 140, after which it is allowed to fall back to 100 again. At first (if you're as unfit as I am) you'll find it takes very little exertion to raise your pulse rate to 100 and not a lot more to bring it to 140. As time goes on and your fitness improves, it will take more and more effort to give the same effect.

The sessions needn't last long. About ten or fifteen minutes a day will work wonders until you begin to toughen up. The trick is to do it every day without fail. Later on you can begin to extend the length of the sessions and work your heart harder, perhaps maintaining 120 beats per minute with peaks of 145 to 150. Competitive athletes will require



something much more arduous, sustaining rates of 140 to rise above 160 for brief periods, with rest breaks immediately afterwards. If you're training at this kind of level, you won't be needing ETI's advice!

The importance of a strong heart, aside from considerations of avoiding illness, is that it moves the blood around efficiently and so supplies the muscles with all the oxygen they need. At the top level, this might help you run a marathon. On a much lower level, you might feel better if you don't become breathless from climbing a flight of stairs.

The normal state of affairs is that the heart beats just fast enough to supply the oxygen being used up at the time. Your body is in 'oxygen balance'. At a certain level of exertion your hear and lungs will be supplying all the oxygen they possibly can but this doesn't immediately limit the amount of energy you can expend. Your muscles can operate *anaerobically* for a short time, allowing them to burn fuel much faster than the oxygen arriving from the blood steam would normally allow.

A by-product of the anaerobic process is that lactic acid is built up in the muscles, causing them to feel tired and eventually to stop working altogether. The oxygen balance is only restored when the lactic acid has been burned off, which is why sprinters will be short of breath and have a pounding heart for some time after the race is over.

The training for long distance runners and for sprinters represent two extremes of a wide spectrum. The distance runner is concerned to strengthen his heart and lungs in order to raise the level at which the oxygen balance can be maintained. This is also the concern of anyone interested in general fitness. The sprinter, on the other hand, will be primarily concerned to increase his body's ability to cope with extreme short term demands and to recover quickly afterwards.

For many sports, both are equally important. Tennis or squash players will need to sustain a fairly high level of exertion for extended periods, with still enough in reserve to make a full power sprint for the ball when called for. The lactic acid from the sprint will have to be burned off while the body is still in a state of high oxygen demand.

Improvements in your aerobic capabilities are indicated on the monitor by a reduction of your resting breathing rate. The best time to make measurements is while you are still in bed in the morning — during the day other factors can influence your breathing rate and confuse the measurements.

Your anaerobic capacity is indicated by the rate at which you recover from strenuous exercise. Measure your normal breathing rate, add three to the number you get and call this your low point. Double the low point and call this number your high point. After strenuous exercise (a sprint around the garden will work as well as anything) start timing when your breathing rate falls to your high point and stop as soon as it hits your low point. Keep a record of these times day by day to indicate improvements in your anaerobic capabilities.

Health Warning

As with all bio-electronic projects, the monitor must be run *only* from a battery and never from the mains. Don't use mains powered test equipment (oscilloscopes and the like) while the heart rate electrodes are in place. It's not just the chance of things going wrong, it's a matter of earth leakage currents which occur when equipment is, for most purposes, working correctly. Make sure you're still around to read the next issue of ETI, OK!

There have been cases, enough to cause concern, of people harming themselves or even killing themselves by suddenly taking exercise after years of sedentary life. Either they try to do too much too soon or their heart is not in top condition and just gives out under the strain of even mild exercise. To be entirely safe, have a general check up first. In any case, take it easy.

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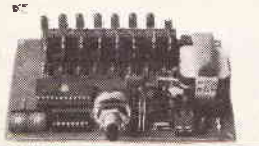

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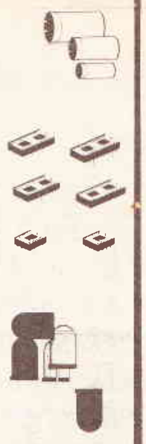

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Infra-red Fault Finder

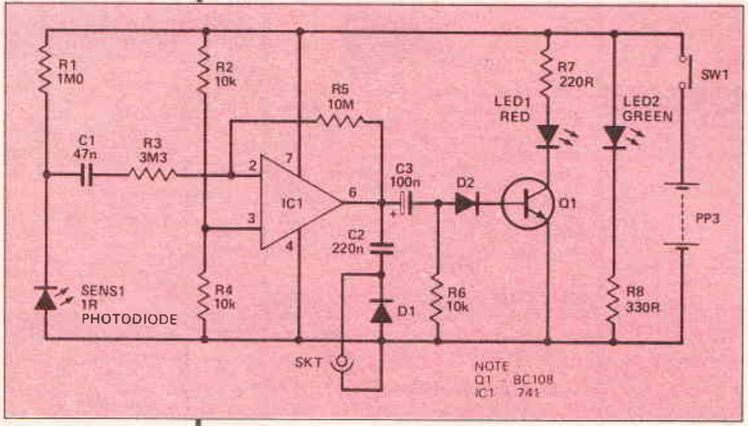
I. Spittlehouse,
Portsmouth, Hants.

Every TV service engineer knows the difficulty in deciding whether a faulty infra-red link is malfunctioning in the receiver or the transmitter. A scope is the normal solution, but this cheap and simple circuit is far more convenient.

The infra-red receiving diode D3 is reversed biased as normal and the pulses are passed to IC1 with the sensitivity reduced by the 3M3 resistor — this prevents the diode reacting to ambient light. IC1 feeds Q1 to indicate a received signal on LED1, and also passes the signal to a DC clamped socket for an oscilloscope (should further investigation be required). LED2 indicates power on and will dim when the battery is waning.

The unit will receive up to about 18ins from a reasonable transmitter.

SENS1 can be any infra-red photodiode, such as Maplin's YH71N.

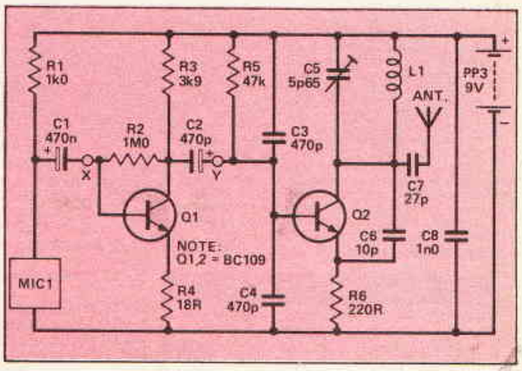


FM Bug

A. Atkins,
London E11.

This circuit operates as a small FM 'bug' transmitting on FM somewhere between 88 and 108MHz. This is of course completely illegal.

Just how small the bug is will be limited only by your design skills, although the PP3 battery prevents concealment in a telephone or secret flower vase.



The microphone signals are amplified by Q1 (if a less sensitive unit is required you could miss out R2,3,4,C2 and Q1).

Q2 operates as a ground-based oscillator, frequency determined by C5 and L1 and feedback derived from C6 (a fairly critical component — 10p should secure oscillation). As the audio signals arrive at Q2, the centre frequency of oscillation is shifted slightly producing the desired FM.

The mic is a small electret with integral amplifier. L1 is five turns of 20swg wire of 1/2in diameter. Five inches of insulated wire will serve as an antenna. C5 is variable to tune the transmitted frequency.

Anti-Thump Circuit

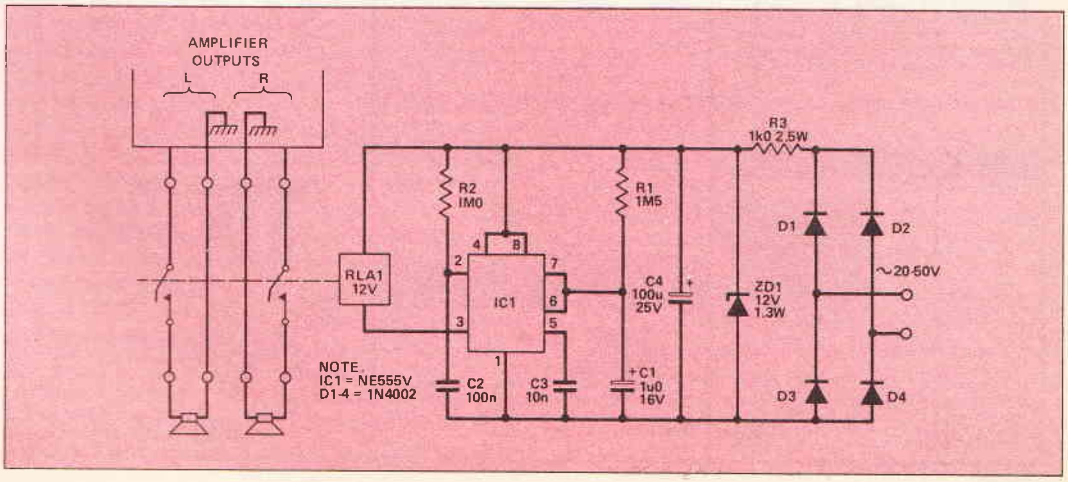
I. Lake,
Chilworth, Surrey.

When a power amplifier turns on there is usually a fairly large DC offset on the output until the DC blocking capacitors charge up.

The resulting 'thump' on the loadspeakers is potentially damaging, particularly if the speakers are under-rated. This circuit initiates a delay between switch on and speaker connection. There is no delay at switch off.

IC1 is a 555 in monostable mode, triggered by a negative going edge provided by R2 and C2. The output goes to the negative rail during the output pulse, so the relay is connected between the output and positive.

The time delay is approximately 1.1xC1xR1 — about 4 seconds with the components shown.



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DECCA 80 RGB - TTL + SYNC input for BBC type interface etc.
DECCA 80 COMP 75 Ω composite video input with integral audio amp & speaker ideal for use with video recorder or TELEBOX ST or any other audio visual use. **Only £99.00 (E)**

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MOTOROLA M1000-100 5" CRT black & white compact chassis monitor measuring only cm 11.6h ,12w, 22d, ideal for CCTV or computer applications. Accepts standard Composite video or individual H & V syncs. Operates from 12v DC at apprx 0.8a Some units may have minor screen marks, but still in very usable condition. Fully tested with 30 day guarantee & full data **Only £29.00 (C)**
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When ordering please specify RS232 or CENTRONICS interface.

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MASTER SYSTEMS type 2/12 microprocessor controlled **V22 full duplex 1200 baud.** This fully BT approved modem employs all the latest features for error free data comms at the staggering speed of 120 characters per second, **saving you 75% of your BT phone bills and data connect time** !! Add these facts to our give away price and you have a superb buy !! Ultra slim unit measures only 45 mm high with many integral features such as Auto answer, Full LED status indication, RS232 interface, Remote error diagnostics, SYNC or ASYNC use, SPEECH or DATA switching, integral mains PSU, 2 wire connection to BT line etc. Supplied fully tested. EXCELLENT slightly used condition with data and full 120 day guarantee.

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DATEL 2412 2780/3780 4 wire modem unit EX BT fully tested	£199.00 (E)
MODEM 20-1 75-1200 BAUD for use with PRESTEL etc EX BT fully tested	£49.00 (E)
TRANSDATA 307A 300 baud acoustic coupler with RS232 I/O Brand New	£49.00 (E)
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Quality 12 v 4 Ah cell pack. Originally made for the **TECHNICOLOUR** video company, this unit contains 10 high quality **GE nicad, D** type cells, configured in a smart robust moulded case with DC output connector. Dim cm 19.5 x 4.5 x 12.5. Ideal portable equipment etc **BRAND NEW £24.95 (B)**
12v 17 Ah Ultra rugged, all weather, virtually indestructable **refillable NICAD** stack by **ALCAD.** Unit features 10 x individual type **XL1.5** cells in wooden crate. Supplied to the **MOD** and made to deliver exceptionally high output currents & withstand long periods of storage in discharged state. Dim cm 61 x 14 x 22 **Cost over £250** Supplied unused & tested complete with instructions **£95.00 (E)**
EX EQUIPMENT NICAD cells by **GE** Removed from equipment and believed in good, but used condition. **'F' size** 7Ah **6 for £8** (B) Also **'D' size** 4Ah **4 for £5 (B)**

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End of line purchase enables this brand new unit to be offered at an all time super low price. The **NEC D2246 8" 80 Mb** disk drive features full CPU control and industry standard **SMD interface,** Ultra high speed data transfer and access times leave the good old ST506 interface standing. Supplied **BRAND NEW** with full manual. **Only £399.00 (E)**
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BOSHERT 13088 switch mode supply ideal disk drives or complete system. +5v 6a, +12 2.5a,-12 0 .5a,-5v 0.5a. Dim cm 5.6 x 21 x 10.8 **New £29.95 (B)**
BOSHERT 13090 same as above spec but outputs of +5v 6a, +24v 1.5a, +12v 0.5a,-12v 0.5a **New £39.95 (B)**
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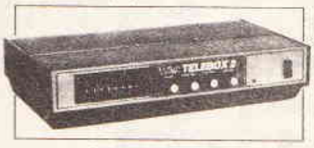
Brand new high quality, fully cased, 7 channel UHF PAL TV tuner system. Unit simply connects to your TV aerial socket and video monitor turning same into a fabulous colour TV. Dont worry if your monitor doesn't have sound, the **TELEBOX** even has an integral audio amp for driving a speaker plus an auxillary output for Headphones or Hi Fi system etc. Many other features: LED Status indicator, Smart moulded case, Mains powered, Built to BS safety specs. Many other uses for TV sound or video etc. Supplied BRAND NEW with full 1 year guarantee.
Carriage code (B)



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Colour when used with colour CRT. RGB version NOT suitable for IBM-CLONE type colour monitors. DATA sheet on request. PAL overseas versions CALL.

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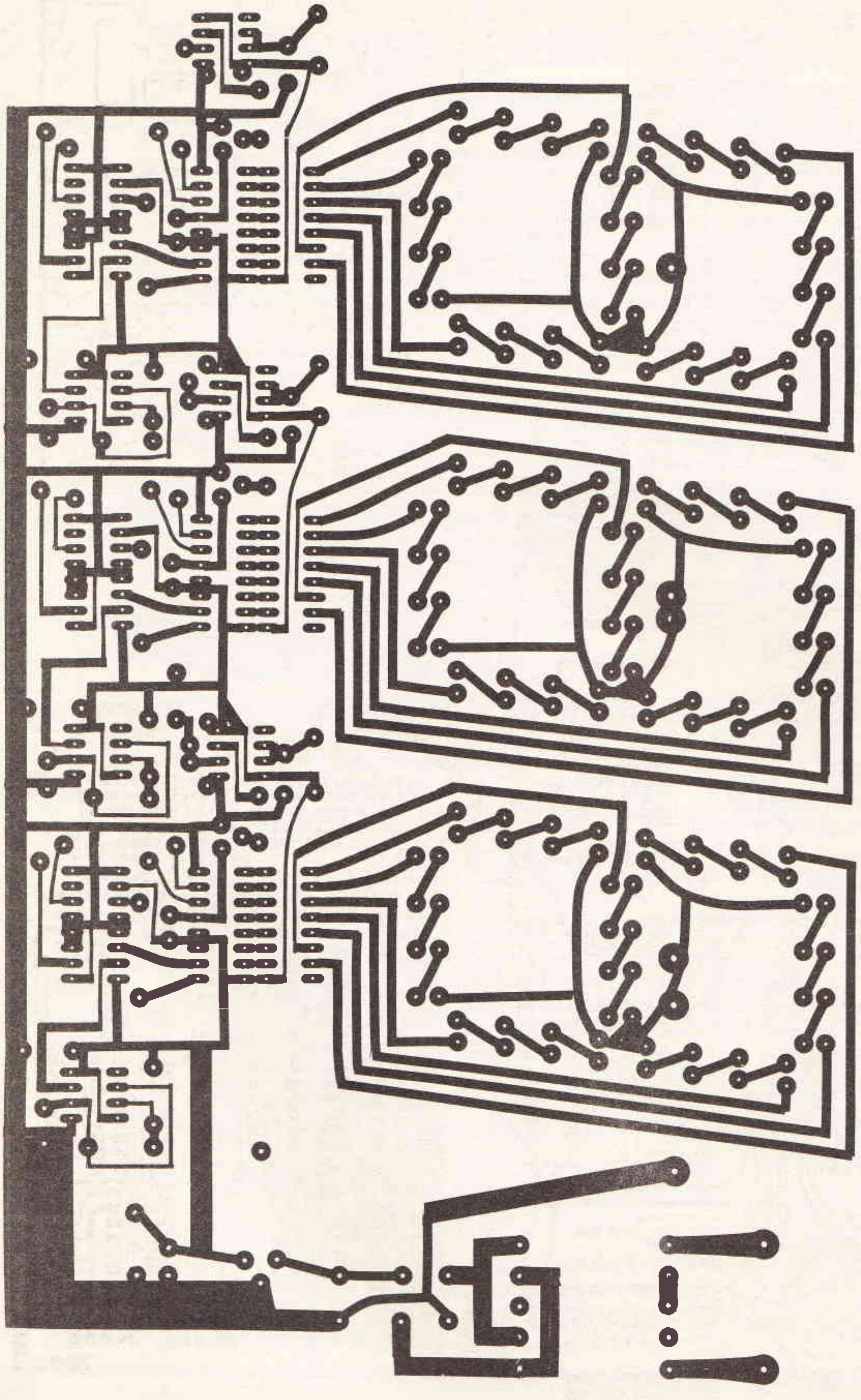
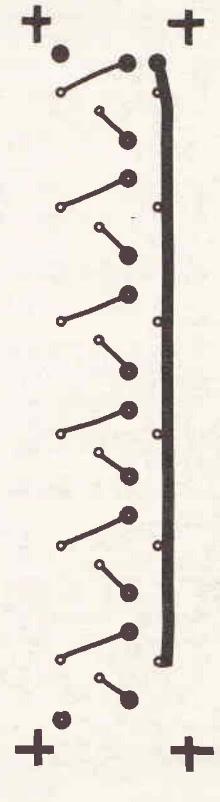
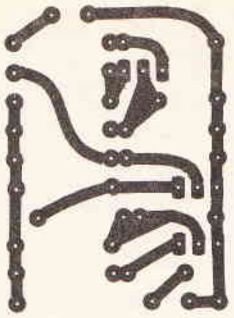
PCB FOIL PATTERNS



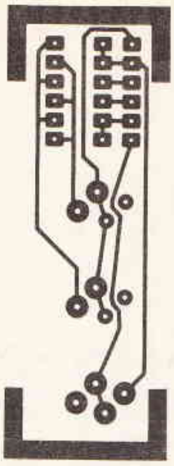
The Random Number Display foil



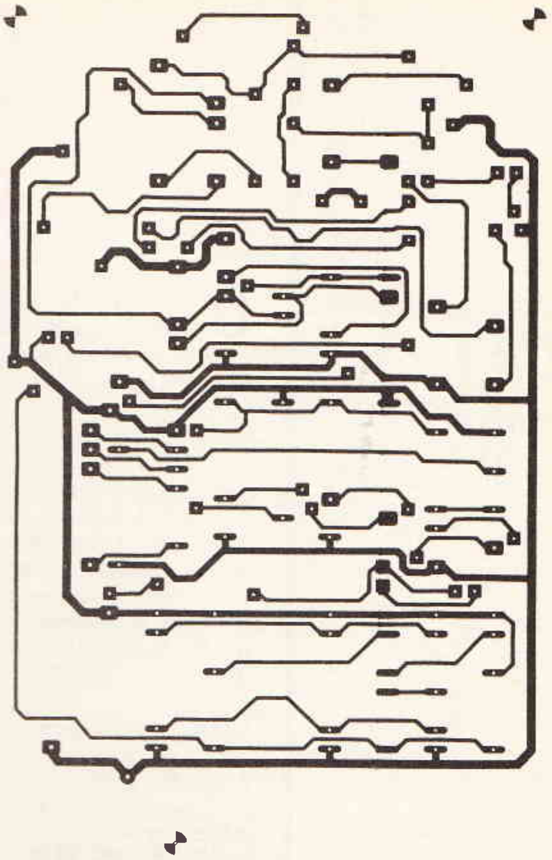
The analogue computer pot board



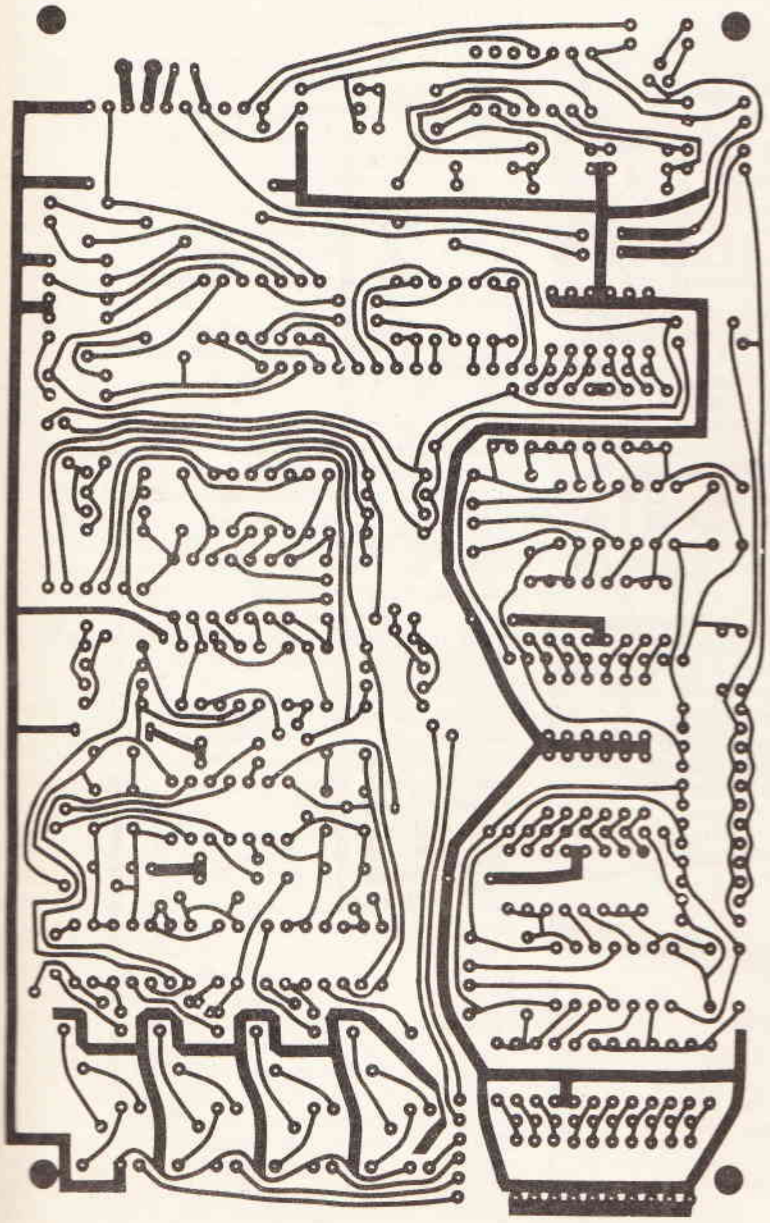
The 1st Class telephone recorder PCB



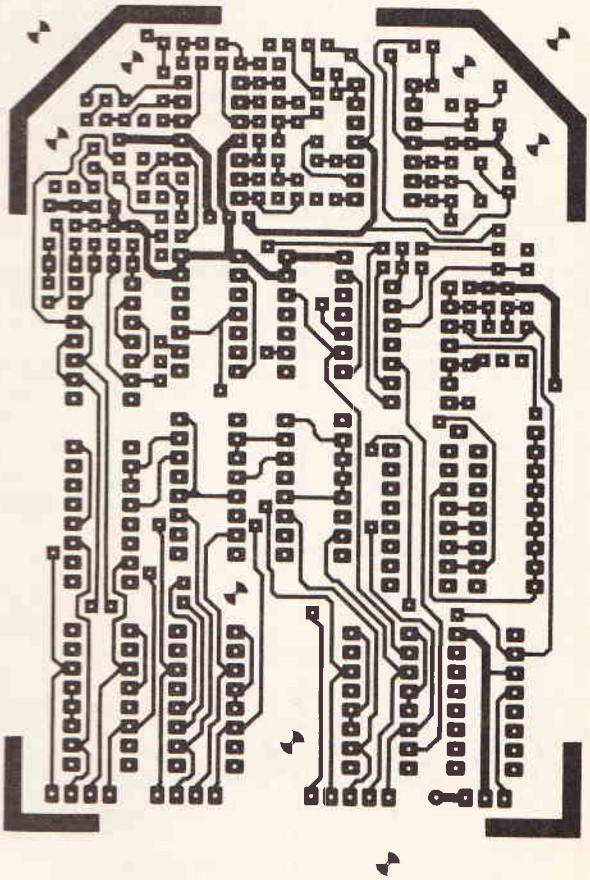
The respiration/pulse rate meter switch board



The respiration/pulse rate meter main board topside foil



The analogue computer main board



The respiration/pulse rate meter board solderside foil

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E8107-1	System A Disc Input board MC-MM	F
E8107-2	System A pre-amplifier Main	K
E8108-1	System A Power Amp	L
E8109-2	System A PSU	F
E8201-2	Infant Guard	C
E8202-5	MM Stage Disc Pre-amp (Tilsbrook)	G
E8206-5	Logic Lock	F
E8208-1	Playmate Practice Amp (3bds)	K
E8212-1	ELCB	F
E8301-2	Analogue to digital conv ZX81/Spectrum)	E
E8305-3	Dual Audio Power Supply, Linsley Hood	G
E8305-3	Balanced Input Preamplifier	F
E8307-2	Flash Trigger-sound or FR	F
E8308-1	Graphic Equaliser ⅓ Oct	M
E8308-2	Servo Fail-safe	C
E8309-1	NICAD Charger/Regenerator	F
E8310-3	Typewriter Interface — EX42	F
E8311-1	Mini Drum Synth	F
E8311-8	Moving Coil Pre-Pre-amp	F
E8312-3	Light Chaser EPROM Controlled (2 Bds)	K
E8402-1	Speech Board	M
E8402-2	Modular Pre-amp Disc Input Mono	F
E8402-3	Modular Pre-amp Stereo Output	F
E8402-4	Modular Pre-amp Relay, PSU	F
E8402-5	Modular Pre-amp Tone Main Mono	F
E8402-6	Modular Pre-amp Tone Filter, Stereo	F
E8402-7	Modular Pre-amp Balanced Output	F
E8402-8	Modular Pre-amp Headphone Amp	F
E8404-2	Mains Remote control Receiver	F
E8405-1	Auto Light Switch	F
E8405-2	ZX81 EPROM Programmer	N
E8405-3	Mains Remote Control Transmitter	H
E8405-4	Centronics Interface	F
E8405-6	Drum Synth	F
E8406-1	Oric EPROM Board	O
E8406-2	Spectrum Joystick	E
E8406-3	Audio Design RIAA Stage	G
E8406-4	AD Buffer/Filter/Tone	H
E8406-5	AD Headphone Amp	F
E8406-6	AD Preamp PSU	K
E8406-7	AD Power Amp	H
E8406-8	AD Power Amp PSU	J
E8406-9	AD Stereo Power Meter	F
E8406-10	AD Input Clamp	C
E8407-1	Warlock Alarm	M
E8408-2	EPROM Emulator	N
E8408-3	Infra-red Alarm Transmitter	E
E8408-4	Infra-red Alarm Receiver	F
E8409-1	EX42 Keyboard Interface	F
E8409-2	Banshee Siren Unit	F
E8410-1	Echo Unit	F
E8410-2	Digital Cassette Deck	N
E8410-3	Disco Party Strobe	H
E8411-5	Video Vandal (3 boards)	N
E8411-6	Temperature Controller	D
E8411-7	Mains Failure Alarm	D
E8411-8	Knite Light	D
E8411-9	Stage Lighting Interface	F
E8411-10	Perpetual Pendulum	E
E8412-1	Spectrum Centronics Interface	F
E8412-4	Active-8 Protection Unit	F
E8412-5	Active-8 Crossover	F
E8412-6	Active-8 LF EQ	F
E8412-7	Active-8 Equaliser	F
E8501-3	Digital Delay (2 bds)	T
E8502-1	Digital Delay Expander	N
E8502-2	Data Logger	J
E8503-1	Combo Preamplifier	F
E8503-2	THD Meter mV & oscillator boards (2 bds)	K
E8503-3	THD Meter Mains PSU	F
E8504-1	Framestore Memory	M

PCBs

E8504-3	Framestore Control	N
E8504-4	Buzby Meter	E
E8504-5	CCD Delay	F
E8505-5	Stereo Simulator	F
E8506-1	Audio Mixer Main	J
E8506-2	Audio Mixer PSU	F
E8506-3	Audio Mixer RIAA	D
E8506-4	Audio Mixer Tone Control	D
E8506-5	EPROM Prog MKII	O
E8508-1	RCL Bridge	N
E8508-2	EX42/BBC Interface	E
E8508-3	EPROM Emulator	L
E8509-1	Spectrum EPROM card	F
E8509-2	Direct Injection Box	E
E8510-9	Sunrise Light Brightener	K
E8511-1	MTE Waveform Generator	H
E8511-2	Millifaradometer	H
E8511-3	Cymbal Synth	J
E8511-5	Chorus Effect	H
E8511-7	Enlarger Exposure Meter	F
E8511-8	Switching Regulator	E
E8511-9	Second Line of Defence	M
E8512-1	Specdrum Connector	F
E8512-2	MTE Pulse Generator	H
E8512-3	Specdrum	L
E8601-2	Walkmate	L
E8601-3	MTE Counter-timer	M
E8602-1	Digibaro	O
E8603-2	Programmable Logic Evaluation Board	H
E8603-3	Sound Sampler Analogue Board	R
E8604-1	JLLH PA PSU	H
E8604-2	Matchbox Amplifier	C
E8604-3	Matchbox Amp Bridging Version	C
E8604-4	MTE Analogue/Digital Probe	M
E8605-1	Microlight Intercom	E
E8605-2	Baud Rate Converter	M
E8605-3	Baud Rate Converter PSU Board	C
E8605-4	Portable PA	H
E8606-1	MIDI-CV Converter Board	H
E8606-2	MIDI-CV Converter PSU	D
E8606-3	Troglograph	F
E8606-4	80m Receiver	H
E8606-5	Sound Sampler	R
E8607-1	Direction	E
E8607-2	Upgradeable Amp, MC stage (Stereo)	G
E8607-3	BBC Motor Controller	F
E8608-1	Digital Panel Meter	G
E8608-2	Upgradeable Amp, MM stage (mono)	H
E8609-1	Mains Conditioner	E
E8609-2	Experimental pre-amp	F
E8609-3	Upgradeable amp, Tone board (mono)	H
E8609-4	Upgradeable amp, Output board (mono)	F
E8610-1	Audio Analyser Filter Board	L
E8610-2	Audio Analyser Display Driver	K
E8610-3	Audio Analyser Display	H
E8610-4	Audio Analyser Power Supply	F
E8611-1	Audio Switcher (2 bds)	H
E8611-2	PLL Frequency meter (4 bds)	Q
E8611-3	Upgradeable Amp PSU	J
E8611-4	Call meter, main board	O
E8611-5	Call meter, interface board	N
E8612-1	Bongo Box	J
E8612-2	Biofeedback monitor (Free PCB)	E
E8701-1	RGB Converter	F
E8701-2	Mains Controller	D
E8701-3	Flanger	H
E8701-4	Audio Selector main board	M
E8701-5	Audio Selector PSU	H
E8701-6	Tacho-Dwell	F
E8702-1	Ratemeter main board	K
E8702-2	Ratemeter ranging board	F
E8702-3	Photo Process Controller (3 bds)	O
E8702-4	LEDline display board (2 off)	K
E8702-5	LEDline PSU and controller (2 bds)	G
E8703-1	Capacitometer	F
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E8704-1	BBC micro MIDI interface	L
E8704-2	ETIFaker patch box	H
E8704-3	24Hr Sundial	E
E8705-3	MIDI Keyboard keyswitch boards (3 bds)	W
E8705-4	Batlite	C
E8705-5	Budget Power Meter	E
E8706-1	Hi-fi Power Meter	N
E8706-2	MIDI Keyboard CPU	U
E8706-3	MIDI Keyboard Front Panel	O
E8706-4	Flame Simulator	G
E8707-1	MIDI Keyboard PSU	H
E8707-2	Telephone Alarm	J
E8707-3	Nuclear Strategy Simulator	J
E8708-1	Remindalite	F
E8708-2	Rear Wiper Alarm	G
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E8709-2	Amstrad Sampler (2 bds)	P
E8709-3	Portable PA	G
E8709-4	EEG Monitor (2 bds)	L
E8710-1	Concept CPU board	N
E8710-2	Concept Power board	K
E8710-3	Concept display board	G
E8710-4	Hyper-Fuzz	F
E8710-5	Big Digits digit board	N
E8710-6	Big Digits minute board	F
E8710-7	Big Digits battery board	G
E8711-1	Quiz Controller	E
E8711-2	256K Printer Buffer	N
E8712-1	Heating Management System	O
E8712-2	SWR Meter	H
E8712-3	Dream Machine (free PCB)	D
E8801-2	Passive IR Alarm	H
E8801-3	Deluxe Mains Conditioner	G
E8801-4	RGB Dissolve	L
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E8805-1	Virtuoso 2U PSU	M
E8805-2	Virtuoso 3U PSU	N
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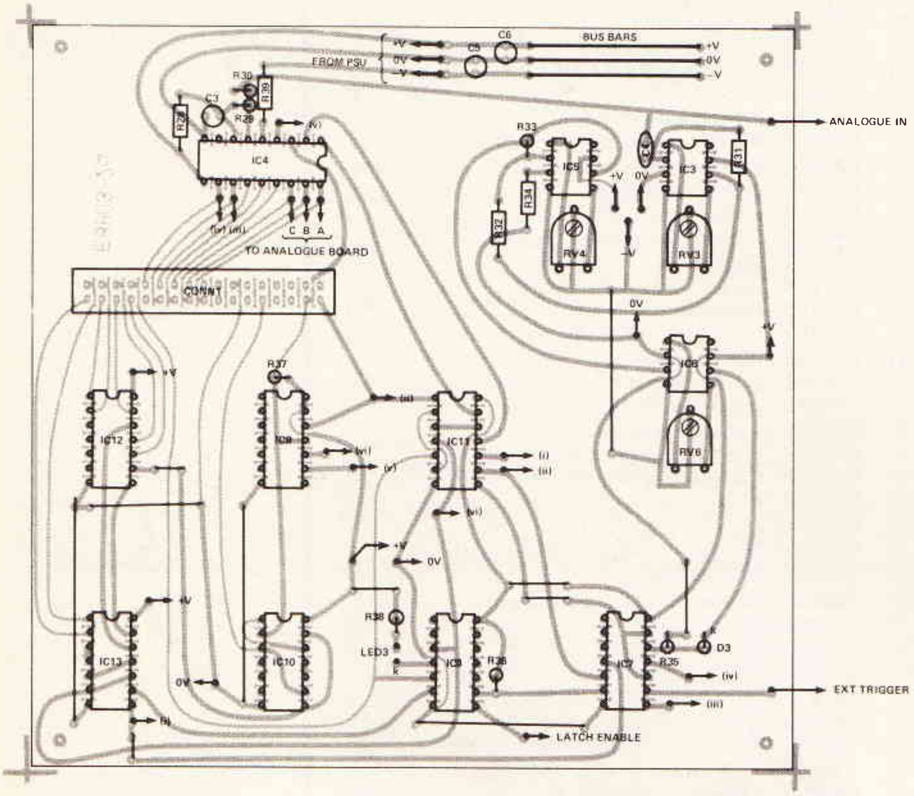
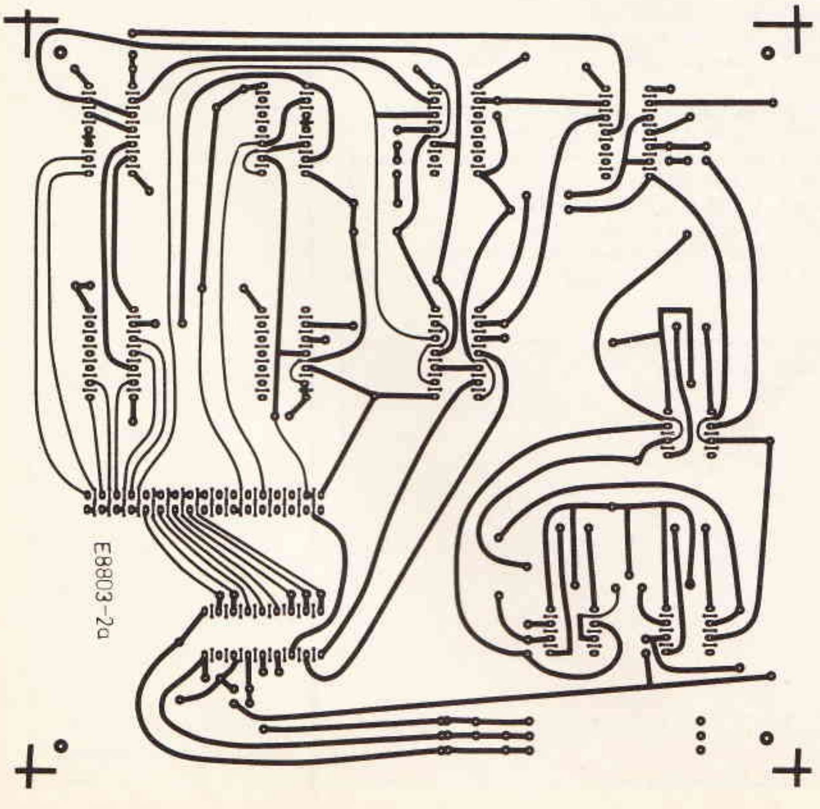
E8808-1	Breath rate main board	H
E8808-2	Breath rate switch board	C
E8808-3	Telephone recorder	D
E8808-4	Analogue computer main board (2 bds)	M
E8808-5	Random number display	O

We had some problems with the Beeb Scope digital board from the March 1988 issue. Some of the tracking from the PCB fell off at various stages of the publication process and the component overlay for this board was incorrectly labelled.
Both the corrected PCB foil and the re-labelled overlay diagram are given here (approx 70% full size).





OOPS!

Printer Buffer (November 1987)
The listed software for the EPROM has three errors. The byte at 039A should be 20, at 039B 14 and at 0492 30 (all hex). Connections to 21c and 22c in the circuit diagram disagree with Table 1. The table is correct. C3-28 are 100n as listed in the parts list and not 10n as in Fig. 2. C1 is orientated with the positive terminal to the right.

Dream Machine (December 1987)
The transistors used in this project are ST1702. BC108s can be substituted.

Heating Management System
(December 1987)
A 4116 is not a suitable alternative to the 6116 specified. A 4016 RAM chip will suffice. In Fig. 1 the junction of R1/D5 should connect to D1-4/C1 and not cross. The zener diodes above the temperature sensor ICs (IC16-19) should be deleted. C4 should be 220n and not 220μ. C7-10 should be 10μ. Q2-7 should be 2N3904 and not BC3904.

RGB Auto-Dissolve (January 1988)
In Fig. 5 there are marked two D6's. The right hand one should be D5 (they are both 1N148's anyway). In the text the reference to zener diode D5 should read ZD1.

Power Conditioner (January 1988)
There is confusion between the values of R7 and R8 in the Parts List and Fig. 1. These should be: R7-27k, R8-10k and not as given in the Parts List. In addition, ZD1 is incorrectly orientated in Fig. 3. The positive terminal should be at the southern end.

Passive Infra-Red Alarm
(January 1988)
Fig. 2(a) shows the base of Q1 connected to ground and to R14. It should be connected only to R14.

Transistor Tester (February 1988)
The foil pattern for the main board was printed reversed left-right on the foil pages.

Spectrum Co-processor (March 1988)
Mogul Electronics, given in the Buylines as suppliers of the RAM chips, have moved to: Unit 11, Vestry Estate, Sevenoaks TN14 5EU. Tel: (0732) 741841.

Dynamic Noise Reduction (May 1988)
The LM1894 is no longer available from the sources listed but it can be obtained from the author. Please address orders to Manu Mehra, 88 Gleneagle Road, Streatham, London SW16 6AF.

QL Outport Port (Tech Tips May 1988)
Several problems with the diagram for this one. A5 should read AS — that is, address strobe. Pine 22 and 24 should be connected to +5V and the junction of the (only) resistor and diode connected to VPA on the QL.

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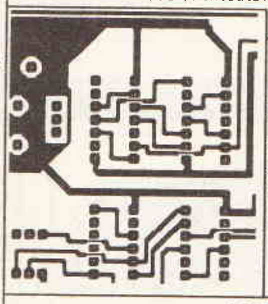

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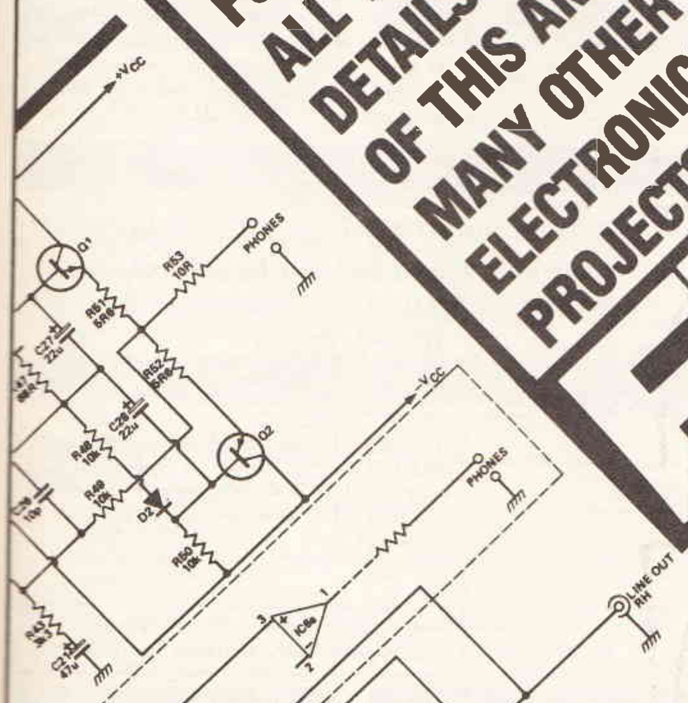

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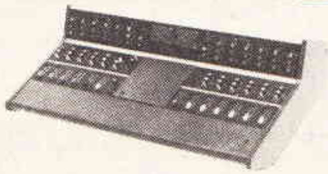

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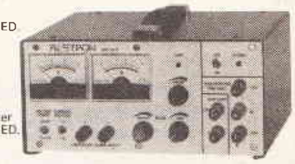

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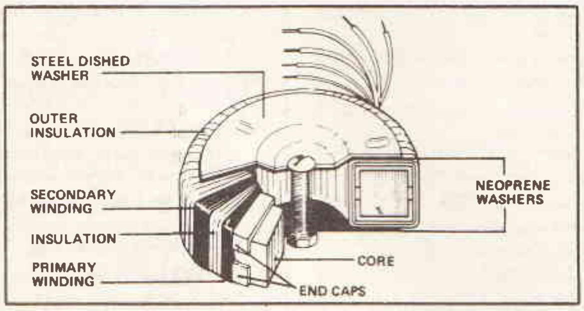

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OPEN CHANNEL

I'm a bit of an introvert, really. A reclusive and a hermit, too. I don't like going out the front door. I suppose it's all part of the job — freelance journalism, that is. If anyone happens to be gregarious, the freelance life is not for him (or her). Hours, days, weeks alone researching, writing, editing and telephoning interspersed with only occasional forays into the real world to pick other people's brains, visit the odd firm or travel to relevant exhibitors.

Perhaps the only time I get to see the wild side of life is when I go to the bank and building societies, to move money around from current to investment accounts and pay bills.

Until now this has been one of the banes of my life. At best a nuisance, wasting my time and making me meet people I didn't really want to bump into, forcing me to be sociable. At worst an affliction I can well do without. Its not easy being a dolphin!

The National Angle

Now, that's all changed. Thanks to one enterpreneurial building society, I don't need to meet the world on its financial terms anymore. I can organise my finances from home with the press of a few buttons. The building society, namely *Nationwide Anglia*, recently started a cheque book account called *Flexaccount* which gives users all the benefits of a traditional building society investment account (interest on invested monies) with all the advantages of a traditional bank account (cheque book and cheque card). Oh yes, and you get a plastic card enabling you to withdraw/deposit money into high street holes-in-the-wall, too.

Nothing new in this, you may say. A growing number of building societies are doing this, following recent changes in the laws governing societies' operations. Where Flexaccount is different is that users can, if they wish, take advantage of what Nationwide Anglia calls *Home Banking*.

Account Deposit

Home Banking is a banking facility that Nationwide Anglia has so far not been pushing very hard in its substantial Flexaccount advertising.

A refundable deposit of £10 provides you with a small hand-held, battery-powered unit which, coupled with your telephone, allows you to access a number of financial services through your Flexaccount. This *Home Banking unit* is merely a numerical keypad (0 to 9, ✳ and R) which emits standard multi-frequency tones via a small loudspeaker.

Use is simple enough. You dial the society's home banking telephone number: an electronically produced voice tells you you are connected. After this, the voice steps you through the procedures.

First, you key in your customer number (different to your account number) through your MF adaptor, followed by a PIN number (not the same PIN number as your hole-in-the-wall card). Then you key in codes pertaining to the service you want.

Other codes allow you to tell the voice to repeat the last message, cancel the message or end the call. On selecting the appropriate code, the services are stepped through in a similar manner.

Straightforward

It may sound pretty complicated from this description but in truth it's all straightforward enough because the voice guides you through each step of the way.

I suppose there's nothing particularly new about the type of service this offers. The *Royal Bank of Scotland* combined with the *Nottingham Building Society* a while ago to produce their own *Homelink* service, using British Telecom's Prestel, which allows similar facilites.

What *is* new with Flexaccount home banking, is that only one account is needed. In comparison, overall, Homelink is pretty expensive to run. Service charges for the account, and service charges for Prestel, mount up to a significant total. It is also considerably more complicated to use, requiring a Prestel terminal (dedicated or a personal computer). The low-tech approach which Flexaccount uses makes the system cheap and cheerful — more likely to catch on, I feel.

Multi-Frequency

The MF home banking unit is interesting. If you have an MF telephone, or one which can be changed from pulse to MF during a call, then the unit is unnecessary. All codes can be keyed in direct through your phone's keypad.

My Mercury phone, for example, allows me to do this — I set up the call, in the normal way, using the standard Mercury button (after which the phone automatically dials 131 in pulse form) to connect to the Mercury network. All numbers pressed after this are transmitted as MF tones.

Of course, the advantage of Flexaccount home banking is not that it makes the user a recluse. It merely saves time. Mind you if you are, like me, a natural hermit then this extra time you have can be put to more important aspects of hermitting around!

Keith Brindley

PLAYBACK

Not satisfied with producing 'perfect sound forever', it appears many CD manufacturers are doing their level best to improve on this perfection!

In the beginning these same companies were struggling with 16-bit linear or 14-bit 4x conversion topologies, shortly followed by 16-bit 2x and 4x oversampling systems employing two DAC's to eliminate interchannel phase errors.

Some cynical individuals have suggested that by playing the numbers game most manufacturers can hope to maintain a constant level of media attention and so continue to fire the consumers' imagination.

Bits And Bobs

Whatever the real motivation, some of the latest 16-bit 4x players (Philips, Marantz and Sony) are certainly fine examples of the art and represent a significant sonic advance on the earliest machines.

If numerical one-upmanship really is important then Cambridge Audio are clearly outstripping the field with their latest 32-bit 16x oversampling CD-player! However, a couple of very interesting players have also recently emerged from Japan, courtesy of Technics.

Plastered all over the front of the SL-P990 and SL-P770 is the legend '4-DAC 18-bit High Resolution', a promise of greater things to come perhaps. Nevertheless, once fired-up these players certainly do *sound* different.

Hi-fi reviewers (including yours truly) have commented on the peculiar and even nondescript sound of these units, their superficial accuracy frustrating the usual methods of description. Both seem to offer exceptional detail resolution, a thoroughly neutral balance and realistic soundstaging but somewhere along the line the ability for the music to excite a strong *emotional* reaction is lost.

Of course, these are purely subjective observations but a cursory glance at the technology involved may help to shed some light on this phenomenon.

Justifications

Some justification for the 18-bit logo may be wrought from Technics' new 4x oversampling (176.4kHz) digital filter. This is purported to offer 18-bit linearity, thereby improving the accuracy of both the filter coefficients and subsequent rounded solutions that comprise the three additional data points — a feature particularly important at low signal levels.

Quantisation errors are pushed to higher frequencies, in-band ripple is reduced to ±0.0001dB while the rejection of stop-band noise is apparently as good as −100dB.

A total of four Burr Brown PCM56P DAC's are used, each pair configured in a push-pull arrangement effectively doubling the number of available quantisation levels (2^{17} rather than 2^{16}). However, this will only achieve a theoretical 17-bit resolution, not 18-bit. The positive and negative-going outputs from each pair are duly summed in a proprietary differential amplifier, the overall technique reducing what Technics term 'Zero Cross Distortion'.

Shifty Solution

The final trick is to shift the data stream up by two bits when the effective audio level falls below −12dB. This elevates the low-level signal resolution by two bits to that theoretically enjoyed by a full 18-bit convertor, even though the working range of the system is still contained over 16-bits.

Naturally, subsequent to D/A conversion the level of the resultant audio signals must be normalised and this is achieved via a 6dB attenuator functioning in the *analogue* domain (the other 6dB or one bit is accommodated by the complementary 17-bit operation of the paired DACs).

LSI

Data shifting and control of the complementary DACs is accomplished through proprietary LSI (Large Scale Integration situated after the oversampling filter but prior to the convertors. So it is this LSI which flags the analogue level shifter, itself situated after the sample/hold circuits and differential amplifier.

The process of switching in and out an attenuator in accordance with the instantaneous signal level is rather more difficult to execute (synchronise) here than in the digital domain. The potential degradation caused by amplitude modulation, dynamic (TID) and thermal distortions, inadequate settling time and overshoot must surely throw a spanner in Technics' overall scheme of things.

Whether the constraints imposed by precise analogue switching and attenuation of musical transients have any correlation with the unusual sound quality of these players is only conjecture. Nevertheless, these are the only units currently employing such techniques, indicating that perhaps Technics have indeed been thwarted by their own eagerness to advance the state-of-the-art.

Paul Miller

ONCE OVER

How time flies. It doesn't seem so long ago that I was sitting in third form maths turning the handle of my two foot wide calculator, moving the plastic bit to multiply by ten and watching the numbers whizzing by. Now I can sit on the tube and get through twenty iterations of a fourth order equation before we reach Tooting Broadway. How time flies.

The fx-5000f is the latest scientific calculator to emerge from the Casio designers. It features a two row 28-digit display (16 dot matrix, 10-digit mantissa, 2 digit exponent) which is as happy displaying Greek letters as it is numbers. The problems of multiplexing a display this size is addressed by having a contrast control so the limited angle of view can be tailored to the table you're working at . . . it's also useful for working in the garden on steamy July afternoons (in my steamy July swimsuit).

The first thing notable with the fx5000 is the input routine. This is quite different from most calculators and has much more in common with computer syntax — to calculate the sine of 30° you would usually press '30','SIN', whereas here you type 'SIN','30','='. This seems trivial I know but it takes some getting used to and certainly means this isn't a calculator to lend to your mate the day he goes off to do his maths paper. Actually it makes more sense this way, as it enables long lines of calculations to be written on the top row of display (which scrolls) before any actual calculating is performed.

This top line of display can be edited very easily and (very useful) can be recalled and altered when the answer is patently obviously wrong.

A quick note on the number of functions on the keypad — it has everything I can think of and several others: standard deviation, binary, octal and hex, Boolean logic and all the rest. In fact there are so many functions that despite Casio's sensible five colour labelling, it can take some time to track down the more unusual keys.

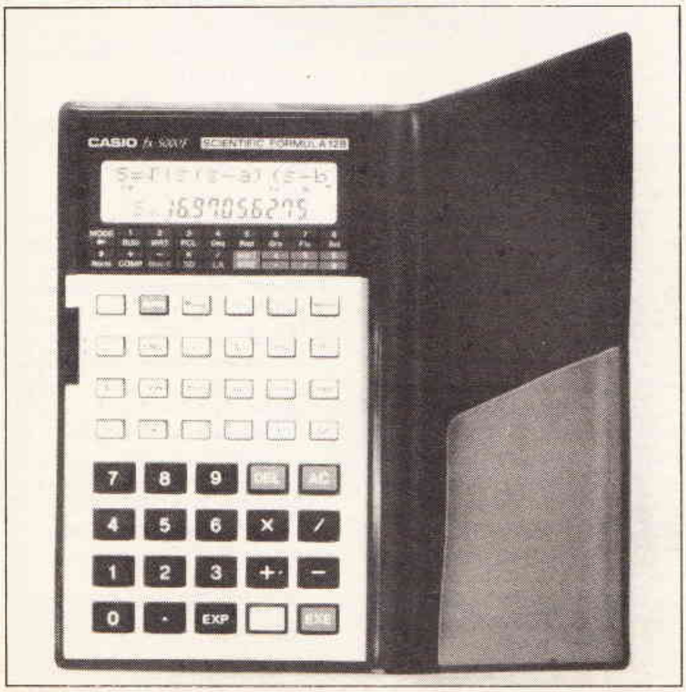
Okay, on to the bit I've been dying to tell you about — the programming capabilities. Because your program is written on the top line of the display as you go, it is so much more easy than the normal system of just hoping you pressed everything in the right order. Editing is simplicity itself — I didn't even need the manual to sort out what was going on. Your own programs can be up to 675 steps, divisable into 12 separate programs.

On top of this, Casio has preprogrammed some 128 formulas ranging from triangle areas through Doppler effects to minimum loss matching. The display prompts you (in Greek if need be) for the variables' values and calculates the result.

The only problem is remembering the number of the equation you want to use but Casio provides a little list to sit in the jacket next to the calculator.

The fx-5000f is a lovely piece of work — its only drawback being that because it is so fiendishly clever you might have problems getting it into the examination hall. It costs £39.95 and I want one!

Colin Cat



BLUEPRINT

This column is a new service to readers to provide electronic designs to order. Many a project never gets further than the drawing board because of difficulties with one small part. If you are stuck for a circuit or a technique, let the ETI expert help you out. Send your requirements, with as much detail as possible, to ETI Blueprint, 1 Golden Square, London W1R 3AB.

I need a simple circuit to provide one second duration pulses at two second intervals. The time periods need not be exact. The output of the circuit must switch 12 to 15V at up to 6A.

The circuit is for an alarm and should latch on, with a simple reset button. I am not familiar with the use of SCRs but have several to hand.

A.E. Carpenter.

The Solution

From the stated requirement I guess the circuit is intended as a car alarm, to sound the horn in one second bursts if anyone attempts to break in. If this is the case, then SCRs are not suitable to switch the load because once they are triggered they remain on while the load current is flowing, even if the trigger current is switched off.

It is possible that the horn current is sufficiently discontinuous to permit an SCR to switch off but without more information it would be unwise to make this assumption. Equally, one might use a GTO (gate turn off) thyristor but these are not so widely available as ordinary SCRs. Also, they require a negative gate voltage to switch them off, which it is inconvenient to generate.

The humble relay is a cheap and effective way to switch DC loads of a few amps, so this is the method chosen. The circuit shown consists of a latch, using half a CMOS nand gate package, a standard design of gated oscillator using the other half, and a pair of transistors driving a relay.

The latch is set by application of logic 0 to the input pin. This point may be connected to the courtesy light circuit, which is switched on when the door switch grounds one side of the lamp. Alternatively a trembler switch or any other suitable means may be used to start the circuit.

Several aspects of the circuit are designed with a car in mind. The resistors R3 and R4, in series with the latch inputs, are there to prevent spikes capacitively coupled into the wiring from destroying the CMOS chip. These resistors should be mounted close to the IC.

The addition of R7, C3, and D1 to the power supply circuit is also to protect the chip from destruction by electrical spikes, which can be very severe on car electrical systems.

C1 is included in the oscillator circuit to permit it to work smoothly even in the presence of radiated interference.

The circuit, as shown, will continue to sound the alarm until someone switches it off. This fact could cause problems if the alarm were triggered in the absence of the person who could stop it. It may even be against the law to leave an alarm sounding for hour after hour, so I have shown an optional timer circuit which can be added to the unit to switch it off after a few minutes. The reset switch can still switch it off immediately, of course.

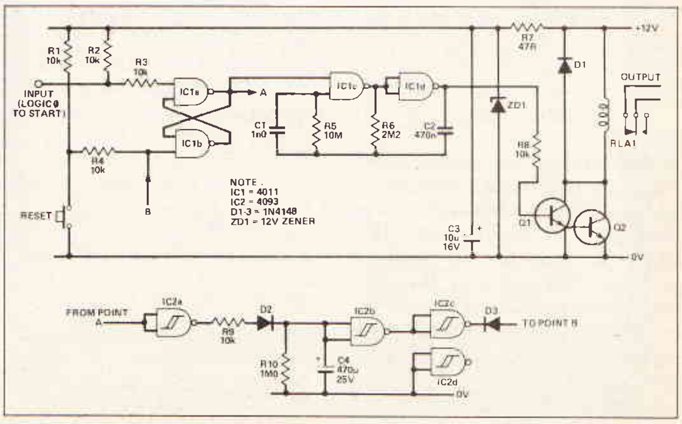
The timer works by allowing a capacitor to start to discharge when the alarm is triggered. When the capacitor voltage has declined to the Schmidt trigger level of IC2, the IC switches and pulls the reset pin of the latch to logic 0, thus resetting the alarm. The time period may be altered by changing the value of R10.

The timer could have been based on the *charging* of a capacitor but this method has two advantages. First, the capacitor is normally kept charged so that its leakage current will tend to be very low and will not significantly affect the time constant. Also, if the capacitor should become leaky in this circuit, it will just switch off sooner than intended. If the timing depended on the charging of a leaky capacitor it might never switch over.

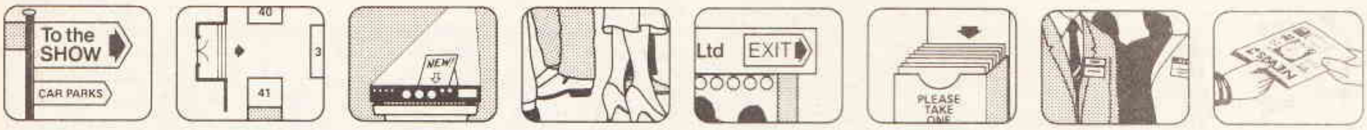
It is to minimise leakage current that a 25V capacitor is specified but most 16V ones will work well.

The power supply for IC2 is drawn from the same point as for ICI. Note that the unused inputs are grounded to prevent damage.

Andrew Armstrong



BRITISH ELECTRONICS WEEK



The British Electronics Week is that monster-sized show held annually at Olympia. It had its roots in the All Electronics Show started in the mid 1970s and was held for some years at the Grosvenor Hotel in Park Lane.

At the Grosvenor, the show occupied two or three rooms and it was possible to look at everything in an afternoon. The hyper-lobic omnicognate show at Olympia would require the full three days for which it is open to look at everything. However, this is not necessary because a very disparate range of exhibitors have been gathered together under one roof, and each visitor is likely to be interested in much less than half of what is on offer.

Caveat

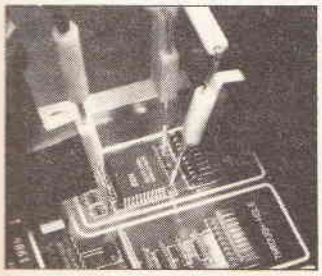
At this point a word of warning for those who may visit the show in future years. There are maps at regular intervals with 'you are here' markers. You need these, not only to determine where you should go next but to check along the way that you are still going there and not somewhere else entirely. Electronic route guidance would certainly help!

When you have walked several miles, you may feel the need of refreshment. Choose your snack with care. Most of the catering makes motorway food look cordon bleu by comparison but edible food is available at the show if you search.

I concentrated on the components and test equipment sections of the exhibition, the most useful to design engineers and likely to be the most interesting to ETI readers. There is little new in basic components, of course. Resistors and capacitors remain resistors and capacitors, with the main developments being in reliability, operating temperature range and approval by various standards authorities. This last is important if equipment is to be exported and must meet overseas standards.

It is becoming clear that some areas of electronics are now 'mature technology' where the rate of change has slowed and application is almost routine. This is illustrated by the increasing quantity of computer aided engineering software to apply design rules to analogue and digital circuitry.

For example, the BC108 was not new when I was at college. It has largely been replaced by its lineal descendants such at the BC182 but these are almost the same thing in TO92 instead of TO18. There are few startling developments in plain transistors but improved power MOSFETS and microwave devices are announced regularly.



There were more surface mount components on view this year. The range available is increasing and such things as 1% resistors are now a standard product, though 5% types are still much more common.

Judging by the relative quantities on show, I doubt that standard components will become obsolete quickly. Perhaps in ten years the home constructor will need to solder surface mount components, but not yet.

Another aspect of general note is that personal computers, often portables, were being used widely to illustrate or just draw attention to products even when these had little to do with computing.

There was also more emphasis on custom made components. Molex, for example, was running an American-sounding video explaining how, with the aid of computer aided manufacturing, customised high quality connector products could be produced economically in much smaller batch quantities. This probably means that in a few years, when you come to repair your hi-fi system, a connector or internal lead will only be replacable by the special part from the manufacturer (if he is willing to supply it).

The same trend means cheaper and higher quality consumer, industrial, and military products will be available in reasonable quantities, so that your hi-fi system should be less in need of repair.

Miscellany

Scattered around the show, in no obvious logical order, were several stands showing off computer aided design for PCBs. They offered different levels of facility roughly according to price. A software package costing around £3500, to run on an IBM AT or clone, would auto-route PCB tracks given a netlist generated from a circuit diagram.

Another package, available from Engineering Solutions for around £800, will allow manual routing with the facility to move components around on a layout dragging the connections with them. It also provided the ability to print any layer or layers quickly onto a matrix printer for ease of checking. They sell an autorouter add on package for £500 for later upgrading.

On an AT clone this software redrew a layout in about the time taken for one sip of coffee. They say it would run on an XT or even a PC if you had the patience to wait for it. If I had an AT and a bit of spare cash I would be tempted.

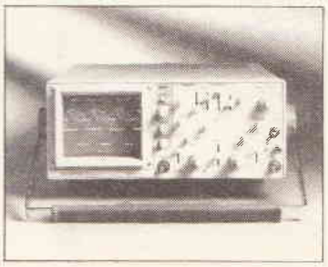
I was surprised to see what claimed to be the first moulded-on mains plug with solid pins, rather than the folded hollow type. At first sight a pedestrian improvement but I have at least one moulded plug which does not make proper contact in all sockets because the pin dimensions are not accurate. Another advantage of the new plug is that the solid pins can be sleeved at the top to protect the ham-handed from shocks.

Solapak and Chronar were exhibiting workmanlike arrays of solar cells. Chronar claims to be the largest manufacturer of amorphous silicon cells, which are much cheaper than crystalline ones but still rather less efficient. This year 8% efficiency is available but next year Chronar reckons 10% of the incident light will be convertable to electricity.

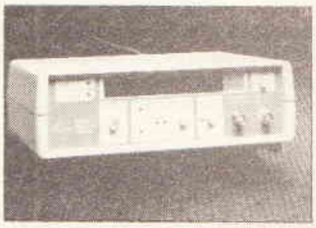
Solapak, on the other hand, offers crystalline cells which can produce useful power at light levels where amorphous cells produce little. Amorphous cells are also produced under the name 'thin film silicon'. Solapak also makes thermoelectric generating equipment, mostly burning propane to provide the heat. No doubt any of these power supply options is more reliable than a diesel generator to provide modest amounts of power for remote unattended locations.

Fakir

There was much test equipment on show but in general a scope is a scope is a scope. Not so the Thandar model with the LCD screen. It has al bandwidth of only 200kHz but would be useful for field servicing as well as being convenient size for constructors with limited workspace.



Thurlby are marketing a Kenwood realtime/sampling oscilloscope. Its bandwidth is 40MHz but it uses sampling techniques to achieve 100MHz on repetitive waveforms. For each cycle of the input waveform, the instrument samples one point and displays this. So, if there are ten samples per cycle, the scan rate on the screen is one tenth of the input frequency. Of course, with this technique trigger jitter causes worse waveform blur than a realtime display but the technique allows the manufacturer to offer a 100MHz oscilloscope with cursor measurement of voltage, time and frequency for £795.



Still on the test front, Global Specialities' press release claims its ergonomically designed frequency counter has a range of 5Hz to 1.3Hz. Close inspection of the photograph shows it means 1.3GHz. It is good for measuring low frequencies as well because it uses a phase locked loop to resolve to 0.01Hz in one second. Without the PLL this would take 100 seconds.

Some readers will have encountered or read about 'bed of nails' board testing. This is a good method for probing conventional PCBs of fairly high density, so long as some attention is given at the layout stage to make sure that all the points needing to be probed are accessible. However, a special bed of nails has to be made for each type of board to be tested, and the technique is not well suited to surface mount boards.

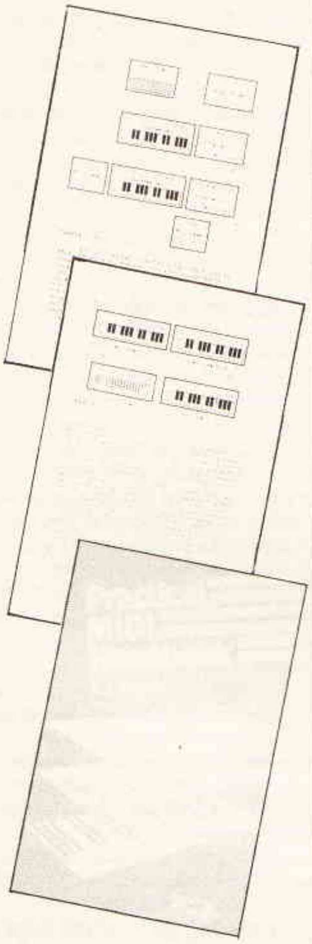
A company called Contax has introduced a system with three moving probes, which can be programmed to move to specific points and apply or measure signals. Test programs can be stored and retrieved easily so the same equipment can be changed to test different boards quickly and easily.

This is another technology which will allow smaller scale manufacturing to standards previously only available in mass production. One of the many themes to emerge from this overwhelming show is that design, manufacture and test equipment made adaptable by the use of microprocessors can bring some economies of scale to short run manufacturing. Let us hope so, because that will give us more choice and scope for innovation.

BOOK LOOK

The latest volume from the prolific processor of Mr Penfold is a catch-all study of the MIDI standard and its applications. Most musicians would agree that the manuals supplied with MIDI equipment often leave much to be explained and discovered by experimentation. Fun as discovery may be, a book to provide a knowledge base on which to build the instrument specifics would be a valuable tool. This is what the Practical MIDI Handbook purports to provide.

Practical MIDI Handbook by R A Penfold, PC Publishing. £5.95.



The book is aimed fairly low so that musicians with little computer experience can follow what's going on. This means the inclusion of basic explanations of binary numbers, ADSR envelopes, serial interfacing and so on.

Much of this is common knowledge to ETI readers of course and there really isn't much to learn in the first thirty pages.

However, the book is well written and it isn't too much of a wade to get through the bits you think you understand (avoid skipping if you can, since Penfold sometimes drops an illuminating remark in the middle of a humdrum passage).

The first section examines the situation before MIDI came along. It describes in some detail the gate/CV methods of controlling remote keyboards, concentrating on the problems (this is a MIDI book after all), the lack of sophistication and the masses of wires required (ah, but didn't it look great!)

The serial interfacing is then explained, the similarities to RS232C systems are pointed out and then the different methods of interconnecting MIDI sockets are clarified.

The next two chapters are without doubt the meat of the book. The MIDI modes and channels are described fairly briefly at first so that the reader can see the differences between modes before getting involved with the possibilities each offers.

This is the time for MIDI equipment owners to scurry off and get their manuals to find out if their synth is actually as wonderful and versatile as the man in the shop said it was.

It is almost an impossible task to describe the actual control of MIDI signals since almost every manufacturer and model does it differently. What Penfold has done is describe each message type showing what it means and how it is made up.

Just about everyone can learn from this section and prospective MIDI software programmers can sink their teeth into the listings of control numbers and coding values that follow. A few examples might have been useful here to show how the information all fits together to form a complete message.

After this section, the book unfortunately descends into a *very* simple explanation of microprocessors which again is of little use to anyone who has ever touched on computing.

A trip to your local keyboard store for a demo will furnish you with just as full a picture of available MIDI music packages, although to be fair Mr Penfold does thankfully steer you away from the floundering MSX packages towards Commodore and Atari STs.

The section on non keyboard/computer MIDI is surprisingly brief (a half page on guitars, a half page on drums, for example) and the closing chapter really just summarises the rest of the book — though here at least the kid gloves are removed and the pace picks up.

Unfortunately the book then stops.

I'm not really criticising. The book achieves its aim in providing a good basic knowledge of MIDI. It's certainly a better investment for the novice than reading 20 different 'What is MIDI?' magazine articles. The expert can learn a fair bit as well but may prefer to await a more technical and specific guide.

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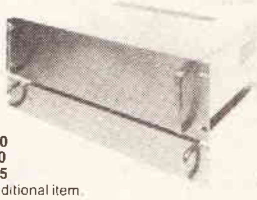

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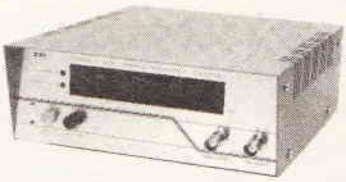

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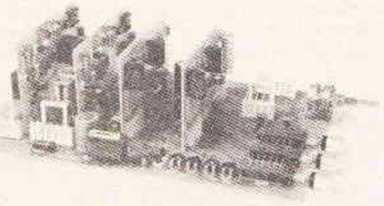

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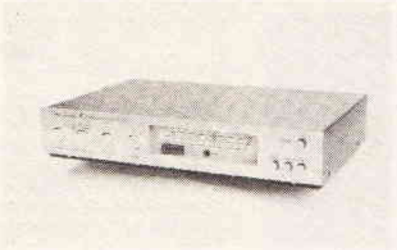

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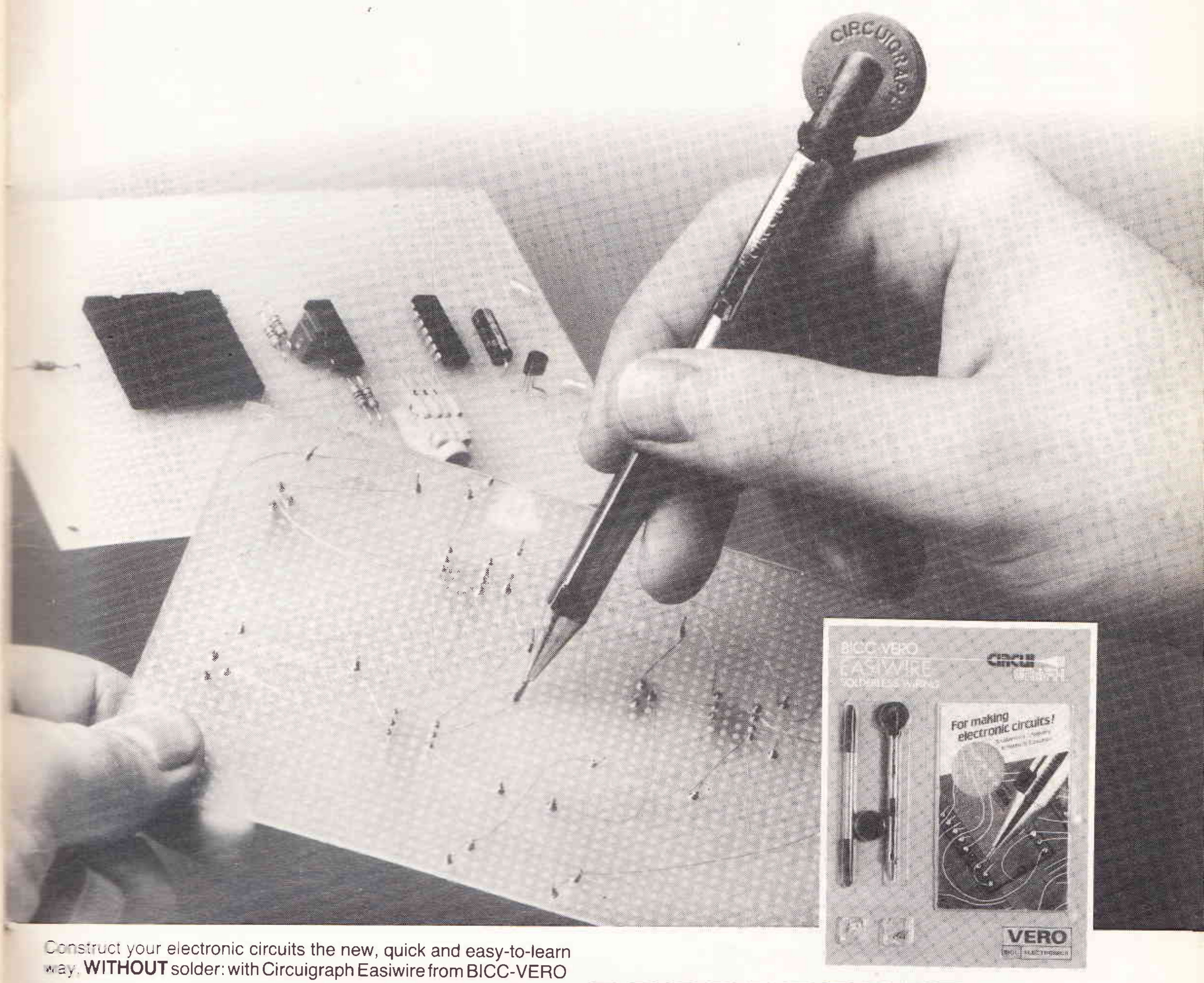
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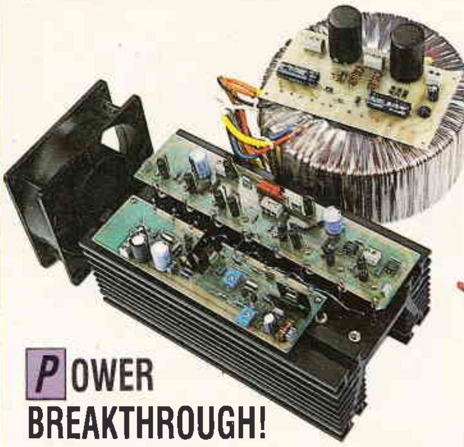

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