EVERYDAY ELECTRONICS

SEPTEMBER 1991

INCORPORATING ELECTRONICS MONTHLY

£1.50

BRAINWAVE

SIMPLE ENTRAINMENT PROJECT

DRY CELL RECHARGER

12V LAMP DIMMER

CAPACITANCE METER

09

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The No. 1 Magazine for Electronics & Computer Projects

UNIDEN SATELLITE RECEIVER Brand new units (model 8008) £60.00 ref 60P4 also some 7007s also £60.00 ref 60P5
SPECTRUM +2 COMPUTER Built in data recorder, 128K, psu and manuals £59.00 ref 59P4
SPECTRUM +3 COMPUTER Built in disc drive, 128K, psu and manuals £79.00 ref 79P4
AMSTRAD CPC464 COMPUTER No manuals but only £79.00 ref 79P5
AMSTRAD CPC6128 COMPUTER Again no manuals but only £149.00 ref 149P4
AMSTRAD GT65 Green screen monitor £49.00 ref 49P4
AMSTRAD PORTABLE PC'S FROM £149 (PPC1512SD). £179 (PPC1512DD). £179 (PPC1640SD). £209 (PPC1640DD). MODEMS £30 EXTRA.NO MANUALS OR PSU.

AMSTRAD PC BARGAIN!!!!!!
PC 1512DD COMPLETE WITH CGA COLOUR MONITOR, 2 DISC DRIVES, MANUALS ETC ONLY £249.00 REF 249P4

HIGH POWER CAR SPEAKERS. Stereo pair output 100w each. 4ohm impedance and consisting of 6 1/2" woofer 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30.00 Order ref 30P7
2KV 500 WATT TRANSFORMERS Suitable for high voltage experiments or as a spare for a microwave oven etc. 250v AC input. £10.00 ref 10P93
MICROWAVE CONTROL PANEL. Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable). Ideal for all sorts of precision timer applications etc. £6.00 ref 6P18
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PASSIVE INFRA-RED MOTION SENSOR. Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual overide facility. Complete with wall brackets, bulb holders etc. Brand new and guaranteed. £25.00 ref 25P24.

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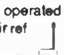
VIDEO SENDER UNIT Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel). 12v DC op. £15.00 ref 15P39 Suitable mains adaptor £5.00 ref 5P191
FM TRANSMITTER housed in a standard working 13A adapter (bug is mains driven). £26.00 ref 26P2
MINATURE RADIO TRANSCEIVERS A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases. £30.00 ref 30P12

FM CORDLESS MICROPHONE. Small hand held unit with a 500' range! 2 transmit power levels reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42A

10 BAND COMMUNICATIONS RECEIVER. 7 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead **NOW ONLY £19.00!! REF 19P14.**

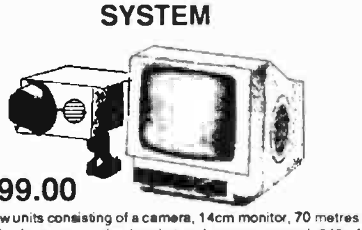
WHISPER 2000 LISTENING AID. Enables you to hear sounds that would otherwise be inaudible! Complete with headphones. Cased. £5.00 ref 5P179.
CAR STEREO AND FM RADIO Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. £25.00 ref 25P21.
LOW COST WALIKIE TALKIES. Pair of battery operated units with a range of about 150'. Our price £8.00 a pair ref 8P50



7 CHANNEL GRAPHIC EQUALIZER plus a 60 watt power ampl 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14.

NICAD BATTERIES. Brand new top quality. 4 x AA's £4.00 ref 4P44. 2 x C's £4.00 ref 4P73. 4 x D's £9.00 ref 9P12. 1 x PP3 £6.00 ref 6P35
TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE. The ultimate equivalents book. Latest edition £20.00 ref 20P32.
CABLE TIES. 142mm x 3.2mm white nylon pack of 100 £3.00 ref 3P104. Bumper pack of 1,000 ties £14.00

VIDEO AND AUDIO MONITORING SYSTEM



£99.00

Brand new units consisting of a camera, 14cm monitor, 70 metres of cable, AC adapter, mounting bracket and owners manual. 240v AC or 12v DC operation complete with built in 2 way Intercom. £99.00 ref 99P2

1991 CATALOGUE AVAILABLE NOW IF YOU DO NOT HAVE A COPY PLEASE REQUEST ONE WHEN ORDERING OR SEND US A 6"X9" SAE FOR A FREE COPY.
GEIGER COUNTER KIT. Complete with tube, PCB and all components to build a battery operated geiger counter. £39.00 ref 39P1
FM BUG KIT. New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158
FM BUG Built and tested superior 9v operation £14.00 ref 14P3
COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39.
SINCLAIR C5 MOTORS 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £20.00 ref 20P22.

As above but with fitted 4 to 1 inline reduction box (800rpm) and toothed nylon belt drive cog £40.00 ref 40P8.
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600 WATT HEATERS Ideal for air or liquid, will not corrode, lasts for years. coil type construction 3"x2" mounted on a 4" dia metal plate for easy fixing. £3.00 ea ref 3P78 or 4 for £10.00 ref 10P76.
TIME AND TEMPERATURE MODULE A clock, digital thermometer (Celcius and Farenheit (0-160 deg F) programmable too hot and too cold alarms. Runs for at least a year on one AA battery. £9.00 ref 9P5.
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ELECTRONIC TICKET MACHINES These units contain a magnetic card reader, two matrix printers, motors, sensors and loads of electronic components etc. (12"x12"x7") Good value at £12.00 ref 12P28.
JOYSTICKS. Brand new with 2 fire buttons and suction feet these units can be modified for most computers by changing the connector etc. Price is 2 for £5.00 ref 5P174.
GAS POWERED SOLDERING IRON AND BLOW TORCH Top quality tool with interchangeable heads and metal body. Fully adjustable, runs on lighter gas.£10.00 ref 10P130
SMOKE ALARMS Ionization type 5 year warranty complete with battery only £5.00 ref 5P206
ANSWER MACHINES BT approved remote message playback, intergral push button phone, power supply and tape. Exceptional value at £45.00 ref 45P2
CAR IONIZER KIT Improve the air in your car! clears smoke and helps to reduce fatigue. Case required. £12.00 ref 12P8.
6V 10AH LEAD ACID sealed battery by yuasha ex equipment but in excellent condition now only 2 for £10.00 ref 10P95.
12 TO 220V INVERTER KIT As supplied it will handle up to about 15 w at 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17. Larger transformer £12.00 ref 12P41
VERO EASI WIRE PROTOTYPING SYSTEM Ideal for designing projects on etc. Complete with tools, wire and reusable board. Our price £6.00 ref 6P33.
MICROWAVE TURNTABLE MOTORS. Ideal for window displays etc. £5.00 ref 5P165.
STC SWITCHED MODE POWER SUPPLY 220v or 110v input giving 5v at 2A, +24v at 0.25A, +12v at 0.15A and +90v at 0.4A £6.00 ref 6P59

HIGH RESOLUTION 12" AMBER MONITOR 12v 1.5A Hercules compatible (TTL input) new and cased £22.00 ref 22P2
VGA PAPER WHITE MONO monitors new and cased 240v AC. £59.00 ref 59P4
AMSTRAD DMP3000 PRINTER New 9 pin printer, centronics i/f £69.00 ref 69P4
AMSTRAD DMP 3160 PRINTER New 9 pin printer, centronics i/f £79.00 ref 79P4

25 WATT STEREO AMPLIFIER ic. STK043. With the addition of a handful of components you can build a 25 watt amplifier. £4.00 ref 4P69 (Circuit dia included).
LINEAR POWER SUPPLY Brand new 220v input +5 at 3A +12 at 1A, -12 at 1A. Short circuit protected. £12.00 ref 12P21.
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MINI RADIO MODULE Only 2" square with ferrite aerial and tuner. Superhet. Req's PP3 battery. £1.00 ref BD716.
HIGH RESOLUTION MONITOR. 9" black and white Phillips tube in chassis made for OPD computer but may be suitable for others. £20.00 ref 20P26.
BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92, PACK OF 100 £30.00 REF 30P16
CB CONVERTORS. Converts a car radio into an AM CB receiver. Cased with circuit diagram. £4.00 ref 4P48.
FLOPPY DISCS. Pack of 15 31/2" DSDD £10.00 ref 10P88. Pack of 10 51/4" DSDD £5.00 ref 5P168.
SONIC CONTROLLED MOTOR One click to start, two click to reverse direction, 3 click to stop! £3.00 each ref 3P137.
FRESNEL MAGNIFYING LENS 83 x 52mm £1.00 ref BD827.
LCD DISPLAY. 4 1/2 digits supplied with connection data £3.00 ref 3P77 or 5 for £10.00 ref 10P78.
ALARM TRANSMITTERS. No data avaliable but nicely made complex transmitters 9v operation. £4.00 each ref 4P81.
100M REEL OF WHITE BELL WIRE figure 8 pattern ideal for intercoms, door bells etc £3.00 a reel ref 3P107.
TRANSMITTER RECEIVER SYSTEM originally made for nurse call systems they consist of a pendant style transmitter and a receiver with telescopic aerial 12v. 80 different channels. £12.00 ref 12P26
CLAP LIGHT. This device turns on a lamp at a finger 'snap' etc. nicely cased with built in battery operated light. Ideal bedside light etc £4.00 each ref 4P82.
ELECTRONIC DIPSTICK KIT. Contains all you need to build an electronic device to give a 10 level liquid indicator. £5.00 (ex case) ref 5P194.
UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36.
ONE THOUSAND CABLE TIES! 75mm x 2.4mm white nylon cable ties only £5.00 ref 5P181.
PC MODEMS 1200/75 baud modems designed to plug into a PC complete with manual but no software £18.00 ref 18P12
ASTEC SWITCHED MODE POWER SUPPLY 80mm x 165mm (PCB size) gives +5 at 3.75A, +12 at 1.5A, -12 at 0.4A. Brand new £12.00 ref 12P39.
VENTILATED CASE FOR ABOVE PSU with IEC filtered socket and power switch. £5.00 ref 5P190.
IN CAR POWER SUPPLY. Plugs into cigar socket and gives 3,4,5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167.
CUSTOMER RETURNED switched mode power supplies. Mixed type, good for spares or repair. £2.00 each ref 2P292.
DRILL OPERATED PUMP. Fits any drill and is self priming. £3.00 ref 3P140.
PERSONAL ATTACK ALARM. Complete with built in torch and vanity mirror. Pocket sized, req's 3 AA batteries. £3.00 ref 3P135
POWERFUL SOLAR CELL 1AMP .45 VOLT only £5.00 ref 5P192 (other sizes avaliable in catalogue).
SOLAR PROJECT KIT. Consists of a solar cell, special DC motor, plastic fan and turntables etc plus a 20 page book on solar energy! Price is £8.00 ref 8P51.
RESISTOR PACK. 10 x 50 values (500 resistors) all 1/4 watt 2% metal film. £5.00 ref 5P170.
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CAPACITOR PACK 2. 40 assorted electrolytic capacitors £2.00 ref 2P287.
QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92.
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FERRARI TESTAROSSA. A true 2 channel radio controlled car with forward, reverse, 2 gears plus turbo. Working headlights. £22.00 ref 22P6.
ULTRASONIC WIRELESS ALARM SYSTEM Two units, one a sensor which plugs into a 13A socket in the area you wish to protect. The other, a central alarm unit plugs into any other socket elsewere in the building. When the sensor is triggered (by body movement etc) the alarm sounds. Adjustable sensitivity. Price per pair £20.00 ref 20P34. Additional sensors (max 5 per alarm unit) £11.00 ref 11P6.
WASHING MACHINE PUMP. Mains operated new pump. Not self priming £5.00 ref 5P18.
IBM PRINTER LEAD. (D25 to centronics plug) 2 metre parallel. £5.00 ref 5P186.
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STRIP BOARD CUTTING TOOL £2.00 ref 2P352.
3 1/2" disc drive. 720K capacity made by NEC £60.00 ref 60P2
TV LOUDSPEAKERS. 5 watt magnetically screened 4 ohm 55 x 125mm. £3.00 a pair ref 3P109.
SPEAKER GRILLS set of 3 matching grills of different diameters. 2 packs for £2.00 (6 grills) ref 2P364
50 METRES OF MAINS CABLE £3.00 2 core black precut in convenient 2 m lengths. Ideal for repairs and projects. ref 3P91
4 CORE SCREENED AUDIO CABLE 24 METRES £2.00 Precut into convenient 1.2 m lengths. Ref 2P365
TWEETERS 2 1/4" DIA 8 ohm mounted on a smart metal plate for easy fixing £2.00 ref 2P366
COMPUTER MICE Originally made for Future PC's but can be adapted for other machines. Swiss made £8.00 ref 8P57. Atari ST conversion kit £2.00 ref 2P362.
6 1/2" 20 WATT SPEAKER Built in tweeter 4 ohm £5.00 ref 5P205
5" X 3" 16 OHM SPEAKER 3 for £1.00!! ref CD213
ADJUSTABLE SPEAKER BRACKETS Ideal for mounting speakers on internal or external corners, uneven surfaces etc. 2 for £5.00 ref 5P207
PIR LIGHT SWITCH Replaces a standard light switch in seconds light operates when anybody comes within detection range (4m) and stays on for an adjustable time (15 secs to 15 mins). Complete with daylight sensor. Unit also functions as a dimmer switch! 200 watt max. Not suitable for flourescents. £14.00 ref 14P10
2 MEG DISC DRIVES 3 1/2" disc drives made by Sony housed in a 5 1/4" frame 1.2 meg formatted. £66.00 ref 66P1.
CUSTOMER RETURNED 2 channel full function radio controlled cars only £8.00 ref 8P200
WINDUP SOLAR POWERED RADIO! FM/AM radio takes NICAD batteries complete with hand charger and solar panel 14P200
240 WATT RMS AMP KIT Stereo 30-0-30 psu required £40.00 ref 40P200
300 WATT RMS MONO AMP KIT £55.00 Psu required ref 55P200
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ALARM PANELS 2 zone cased keypad entry, entry exit time delay etc. £18.00 ref 18P200
35MM CAMERAS Customer returned units with built in flash and 28mm lens 2 for £8.00 ref 8P200
STEAM ENGINE Standard Mamod 1332 engine complete with boiler piston etc £30 ref 30P200

TALKING CLOCK
What more can we say??£14.00 ref 14P200.

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SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

VOL. 20 No. 9 SEPTEMBER 1991

EVERYDAY ELECTRONICS

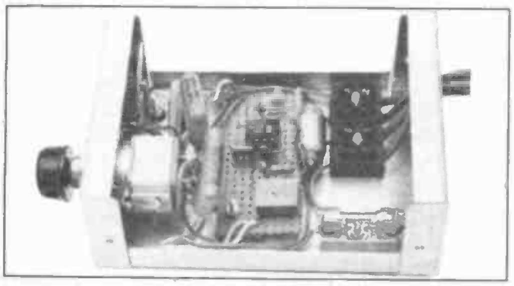
INCORPORATING ELECTRONICS MONTHLY

ABC

The No 1 Magazine for Electronic & Computer Projects

ISSN 0262 3617

PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .



Projects

Series

Features

Our October '91 Issue will be published on Friday, 6 September 1991. See page 539 for details.

JUST A SMALL SELECTION FROM OUR RANGE OF OVER 120 KITS

KIT No:	DESCRIPTION	PRICE £ (EA)
1001	0.2 WATT FM TRANSMITTER	4.25
1006	800 WATT MUSIC TO LIGHT	5.10
1009	1 WATT FM TRANSMITTER	5.53
1013	AM-FM-VHF RECEIVER	13.62
1014	3X700 WATT WIRELESS MUSIC-TO-LIGHT	11.06
1018	GUITAR TREMELO	7.24
1022	METAL DETECTOR	4.25
1026	RUNNING LIGHTS	8.51
1028	4 WATT FM TRANSMITTER	14.46
1034	CAR BATTERY CHECKER	2.98
1036	TRANSISTOR TESTER	3.83
1037	DISCO STROBO LIGHT	11.49
1038	AM-FM AERIAL AMPLIFIER	2.98
1049	ULTRASONIC RADAR	15.31
1055	FM RECEIVER USING TDA7000	12.76
1059	TELEPHONE AMPLIFIER	8.51
1065	INVERTOR 12V D.C. TO 12V A.C	21.27
1069	12V D.C. FLOURESCENT TUBE UNIT	5.53
1073	VOX	6.38
1075	ELECTRONIC DICE WITH L.E.D.'S	6.80
1111	LOGIC PROBE	3.83
1114	ELECTRONIC LOCK	7.66
1119	TELEPHONE LINE RECORDING	4.25
1125	TELEPHONE LOCK	6.80
1129	NEGATIVE ION GENERATOR	14.46
1130	TELEPHONE "BUG" DETECTOR	3.41
1203	MINI FM TRANSMITTER WITH MIC (SUPPLIED READY ASSEMBLED)	4.25

All kits contain a Silk Screened high quality P.C.B. components, solder, wire and FULL instruction sheet.

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60 MEG TAPE STREAMER
DC600 - 5.25" TRAY

SUITABLE FOR ALL IBM COMPATIBLES

PRICE: £150.00

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3.5"	1.44M	INTERNAL	£48.00
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5.25"	360K	EXTERNAL	£27.00

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5.25" ADAPTOR KIT FOR 3.5" F D D	£8.00
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IDC PIN TO EDGE CONNECTOR PCB	£4.50
SHORT F D D CONTROLLER CABLE 2'	£4.00
LONG F D D CONTROLLER CABLE 4'	£8.00
POWER SPLITTER	£4.50
HARD DRIVE CABLES	£6.00
MICRO 'T' SWITCH - RS232	£7.45

END OF LINES

3" - 180K EXTERNAL FLOPPY DISC DRIVE
REVERSIBLE - FDI BY AMSTRAD - BLACK
WITH POWER SUPPLY
SPECIAL OFFER PRICE £30.00

3.5" - 720K EXTERNAL FLOPPY DISC DRIVE
NEW - GREY CASE - BY WELL KNOWN MANUFACTURERS
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3.5" - 1.44M INTERNAL FLOPPY DISC DRIVE
BLACK ONLY - BY WELL KNOWN MANUFACTURERS
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5.25" - 360K INTERNAL FLOPPY DISC DRIVE
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SPECIAL OFFER PRICE £24.00

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12" VGA PAPER WHITE MONITOR £75.00

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3 STATION NETWORK SYSTEM
ALL PARTS FOR 3 STATIONS SUPPLIED INCLUDING DRIVER SOFTWARE AND DATA – USES TWISTED PAIR CABLE EXPANDABLE EASY INSTALLATION – APPROX 30 MINS. – BY WELL KNOWN NETWORKING MANUFACTURER – IMB TRANSFER RATE
SPECIAL OFFER PRICE £97.00

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LINK MASTER	£30.00
SUPER CALC 2 FOR CP/M PLUS	£25.00
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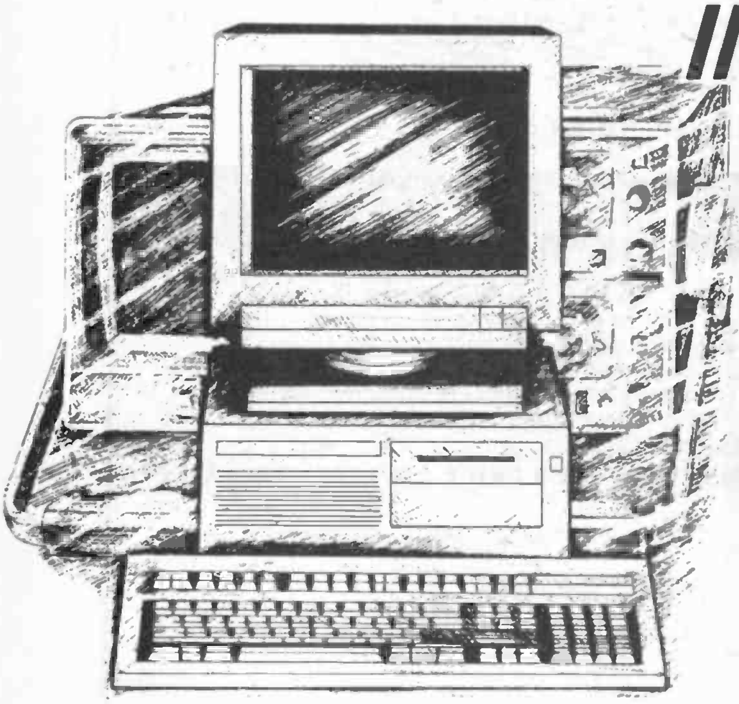
FREE WITH THE OCTOBER ISSUE OF EVERYDAY ELECTRONICS

MARCO TRADING 132 PAGE 1992 ELECTRONIC COMPONENTS AND EQUIPMENT CATALOGUE

PC-SCOPE INTERFACE



This interface enables any PC-compatible computer to be used as an oscilloscope. It samples and stores waveforms of any shape and speed up to around 1MHz. The computer reads the memory store and plots the waveform within a screen window. There is a choice of display modes, formatted wide or medium window, and high speed unformatted. The software is written in GW-Basic and may be used with colour or monochrome screens. Waveform frequency and amplitude are also calculated by the software and displayed on screen

UV EXPOSURE UNIT

Probably the main disincentive from making your own p.c.b.s must be the cost of the ultra-violet exposure unit required for fast and constant results. However, now that the first ever surface-mount projects are appearing, there surely can't be a better time to get started. This project therefore describes a safe and inexpensive UV Exposure Unit, suitable for the production of traditional or SMD printed circuit-boards up to 4 inches by 10 inches in size. It is easy to build, and runs off a 12V d.c. supply such as NiCad batteries, a lead/acid battery or a mains adaptor. The circuit can also be used to drive ordinary 8W flourescent tubes from a 12V supply.

EVERYDAY ELECTRONICS

OCTOBER ISSUE ON SALE FRIDAY SEPTEMBER 6, 1991

RTVC HAVE DONE IT AGAIN!

We have secured all stocks of nearly new factory refurbished units with manufacturer approval, at unrepeatable prices. We also offer a 6 month guarantee with all units (this only applies to products marked ★ on this page.)

Alba digital auto reverse push button AM/FM / LW car stereo with separate bass/treble control APPSS on tape. 25 watts per channel output, with line output for car components use.

★£79.40 + £2.30 pp

Sparkomatic Phoenix Digital auto reverse AM/FM/LW car stereo, with tape volume and balance control. 9 watts output per channel

★£52.40 + £2.80 pp

AM/FM CAR RADIO CASSETTE PLAYER

In-dash fitting controls for volume, tuning, fast forward and wave change. Output for two speakers. Total power output 10 watts. Size 178(W) x 124(D) x 43(H) mm

(Supplied with instructions and circuit diagram). **£16.90** + £2.60 pp

fILOFAX.

PERSONAL ORGANISER RADIO/CALCULATOR

Solar Powered Calculator

Eight Digit Display

Imperial, Metric Conversion Tables

Battery Powered AM Radio

High/Low Volume Control

Earphone provided

Punched with 6 holes to fit into all personal organisers

Listed price £19.95 OUR PRICE **£8.95** plus 75p p&p

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MULTIBAND RADIO

VHF 54-176MHz + AM CB BANDS 1-80

Listen to: AIR TRAFFIC CONTROL, AIRCRAFT, RADAR, PUBLIC UTILITIES, RADIO AMATEURS AND MANY MANY MORE SQUELCH CONTROL "RUBBER DUCK AERIAL"

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ROSS PUSH BUTTON RADIO

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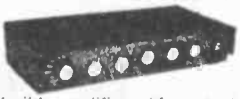

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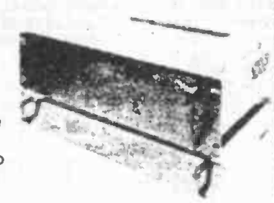

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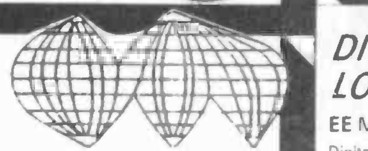

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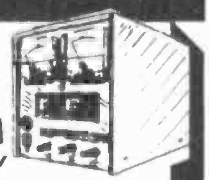

EE FEB 88

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EE NOV '87

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4 CHANNEL LIGHT CHASER

EE Jan '90

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KIT REF 833

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EE OCT '88

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LIGHT RIDERS

EE OCT '86

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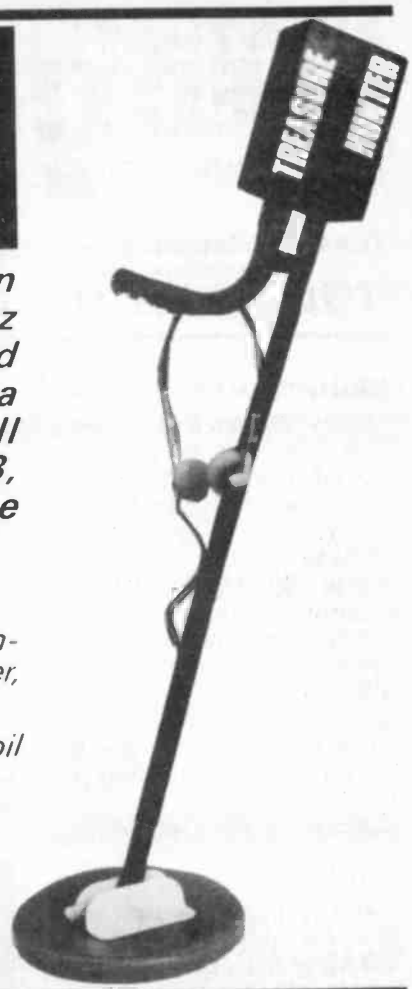

A highly developed and acclaimed Magenta design giving excellent performance and reliability. Quartz crystal controlled circuit with MOSFET coil drive and high slew-rate DC coupled amplification. Detects a 10p coin at 20 cm and larger objects much deeper. Full kit includes ALL components, drilled and tinned PCB, search head, handle, case and all plastic parts . Some simple drilling is required.

- *Efficient CMOS design with low battery drain.*
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BRAINWAVES

Every so often a new avenue of mind relaxation is explored in our pages. This subject by its very nature is interesting, to a certain extent experimental, and almost inevitably impossible to quantify in terms of usefulness – everyone will probably react in a different way and will also have their own views on any benefit gained.

The subject is a fascinating science in its own right and for many readers will be all the more interesting because they can build their own relatively inexpensive equipment to try out the phenomena. Our first "entrainment" article *Brainwave* gives an insight into what it is all about and the *Brainwave* project will allow you to see if the subject is of help to you. We will shortly follow up this design with a more complex unit from the same author. I am sure you will find the whole thing "mind bending"!

Just one word of warning, anything designed to "adjust" the normal workings of the mind must be treated with due respect. Make sure you read the article fully and understand the warnings given in it before you try out any entrainment equipment.

PRICE

You might think I need my brain tested, but regetfully, I must advise you of a cover price increase on EE – it is a year since our last rise. I hope you will agree that EE will still be good value at £1.60 – our cover price from next month. Most of the other magazines in this market have been charging more than us for some time. We will, of course, make sure that we continue to produce the best possible magazine and that we are as efficient and cost effective as possible. The new price represents an annual increase of just under seven per cent.

You could, of course, avoid paying more by taking out a subscription before the next issue (or even by extending your subscription by a year if you already have one!). The price of an annual subscription is presently £17 (about £1.42 per copy) and this will not be increased until 1st September, it will then go up to £18.50. Full information on subscription orders is given below.

Mike Kenward

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COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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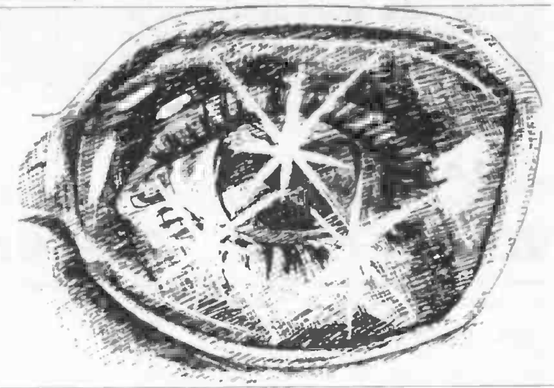
Constructional Project

BRAINWAVE



ANDY FLIND

Ancient Chinese did it! Buddhists do it! Hindus do it! Now you can do it in your own home by building this simple "entrainment machine".

FOLLOWING the publication of the *EEG Biofeedback* project (EE November, 1989), we received an intriguing letter, drawing attention to biofeedback developments elsewhere in the world, especially in the United States. More correspondence ensued, bringing fascinating information which led to much thought and experiment. In particular, an American book entitled *Megabrain*, by Michael Hutchison and copies of his newsletter *The Megabrain Report*, were most useful.

BIOFEEDBACK

For readers new to biofeedback, who may have missed the original EEG project, the aim with EEG biofeedback is to encourage the generation of specific electrical frequencies within the brain. Success is claimed to induce mental states including "alert relaxation" and intense visual imagery, similar to those said to be attained by mystics after years of meditation.

Conventional EEG ("*electro-encephalography*") biofeedback tries to achieve this by detecting the electrical activity of the brain with electrodes on the surface of the scalp. The tiny signals received are amplified and filtered, so that when a desired frequency appears the user will know. In theory, if you know you are producing the signal, you can learn to create and enhance it at will.

A variation on this theme is based on the fact that the brain has two sections, or "hemispheres". If the electrical activity in these two parts can be synchronised, a special state of awareness, perhaps the mystics' "nirvana", is thought to be a possible result.

WARNING NOTICE

Photic stimulation at Alpha frequencies can cause seizures in persons suffering from Epilepsy. For this reason such people MUST NOT try this project.

A user who is not a known epileptic, but when using the "Brainwave" begins to experience an odd smell, sound or other unexplained effect, should turn it off immediately and seek professional medical advice.

Because of the above possibility the **Brainwave** ***should not be used while on your own. YOU MUST TREAT THIS UNIT WITH DUE RESPECT.***

ENTRAINMENT

That's the theory. Producing these frequencies, even with the aid of a monitor, is usually quite difficult. It seems American experimenters gave up the effort a long time ago; instead they now try to artificially induce them!

This process is termed "entrainment", and various methods are employed. The earliest was the passing of a tiny current across the head at the desired frequency, a technique evolved from devices used for treatment of pain and drug or alcohol dependency.

It is thought to stimulate the production of chemicals known as "endorphins", a sort of natural morphine. Needless to say the passing of currents through the brain will *not* be encouraged in *Everyday Electronics*.

A safer method, widely used is "recreational" units, is to flash lights in the user's eyes. This is easy to design and relatively safe, the only danger being that it may precipitate fits in epileptic subjects. Suitable warnings are usually given with designs operating on this principle.

Sound is also sometimes used. One type, called "Hemi-sync" by the inventor and "Binaural beat" by others, consists of two audio tones differing in pitch by the desired brainwave frequency. If these two tones are played together, the difference is heard as the familiar "beat" note.

Playing the tones, one to each ear, through headphones is claimed to "tune" the brain to the difference frequency and synchronise the hemispheres. To the user, the effect is a pleasant bell-like tone, and when combined with, and synchronised to, flashing lights it does seem to enhance the "entrainment" effect.

RED or . . .

From the "Megabrain Report" it is obvious that much research and discussion continues around these methods, with their supporters still far from agreement as to which is the most effective. There is argument over frequencies, waveforms, and light duty-cycle. There is even serious debate as to whether the lights should be red or white!

"Red fans" claim that, viewed through closed eyelids, the light will be red anyway, and the low cost and fast response of l.e.d.s makes them the best choice. High intensity l.e.d.s produce plenty of light and their narrow beams are effectively diffused by the eyelids.

. . . WHITE

"White" buffs, meanwhile, claim the narrow beam is a problem and that some colours still penetrate the eyelid and are necessary for correct stimulation. One manufacturer uses tiny incandescent bulbs designed for the American military, which have a very high reliability and a claimed response time of just three milliseconds.

In the United States "entrainment" devices are readily obtainable, ranging from complex table-top machines to Walkman-type portables. Many use microprocessors to provide programmable effects. The "FDA", a US government department controlling the sale of medicines and the like, has been trying to ban them on the grounds that they are "medical" products.

MIND GYM

Advertisers in the US now avoid mention of stress relief or other therapeutical use! In both the USA and Japan, there are "Mind Gyms" where sessions of relaxation and mental regeneration may be enjoyed on these machines, as one would go for a sauna or workout in an exercise gym.

In Britain, these devices are just starting to appear. There have been some articles in the press and the occasional mention on television, notably a full hour on the BBC's *QED* some months ago, and the instruments themselves are beginning to arrive as imports. They are still rare and expensive, however.

EE readers, of course, may build their own entrainment units at a fraction of the cost and try the effects for themselves. More experienced constructors can experiment and modify, and may contribute significantly to future developments.

In our December issue we plan to start publishing full constructional details of an advanced instrument with lights, "binaural sound", and simple programming. To start with though, this simple lights-only project will enable readers to get a feel for themselves of what entrainment is like and whether it is for them.

BRAINWAVE

The Brainwave flashes l.e.d.s at approximately 2Hz to 20Hz. It uses a 25 per cent duty cycle, meaning that they're "on" for a quarter of the time. This allows them to be overdriven, providing adequate brilliance whilst reducing battery drain. The frequency range covers most of the brainwave frequencies of interest, from Delta, sleep, through Theta and Alpha up to Beta, the normal alert and wide-awake frequency.

Although simpler lamp-flashing circuits have appeared in American magazines, the Brainwave circuit offers superior performance. It consists of an oscillator, frequency divider, and two current sources for the l.e.d.s

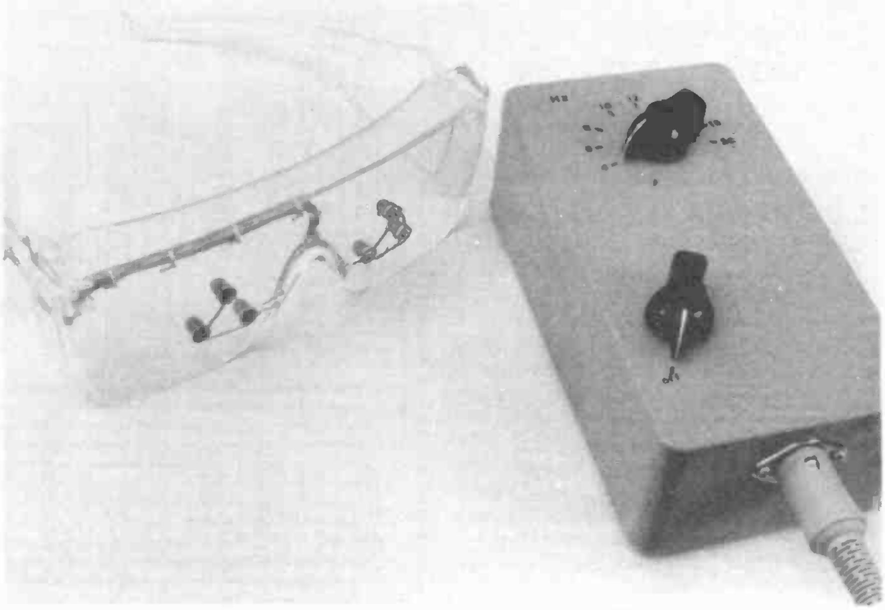
The oscillator action is best described with reference to the simplified diagram of Fig. 1. This shows an integrator formed around inverting amplifier A1 and a Schmitt amplifier A2.

If the output of A2 is low, the input to the integrator is low and A1's output will ramp upwards. When it is high enough A2's output will switch to the high state and the output of A1 will then ramp downwards. When it is low enough, the output of A2 will go low again, and so on.

The output frequency of A2 will depend on *R*, *C*, and the voltage fed back from the control *VR*. The merit of this circuit is that, provided the value of *R* is high compared to *VR*, the output frequency will be almost linearly related to the position of *VR*.

CIRCUIT DESCRIPTION

In the full circuit diagram of the Brainwave, Fig.2, IC1a replaces A1, and the Schmitt amplifier A2 is formed by internal gates in IC2, a CMOS 4060B. The Schmitt switching levels are set by resistors R5 and R6.



The completed Brainwave control unit together with suitable glasses.

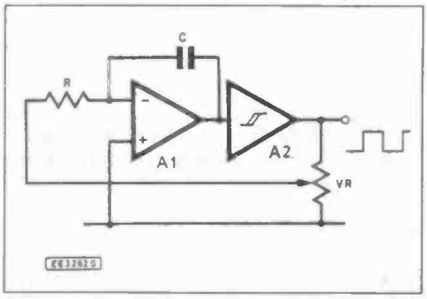


Fig. 1. Simplified schematic of the oscillator stages of the Brainwave circuit.

Although the circuit is theoretically independant of supply voltage, brief drops caused by l.e.d. currents can affect it, so the oscillator is supplied from a 5V regulator IC3. A 2.5V "ground" for VR1 is supplied by resistors R1, R2, and IC1b. Resistor R4 sets the minimum frequency.

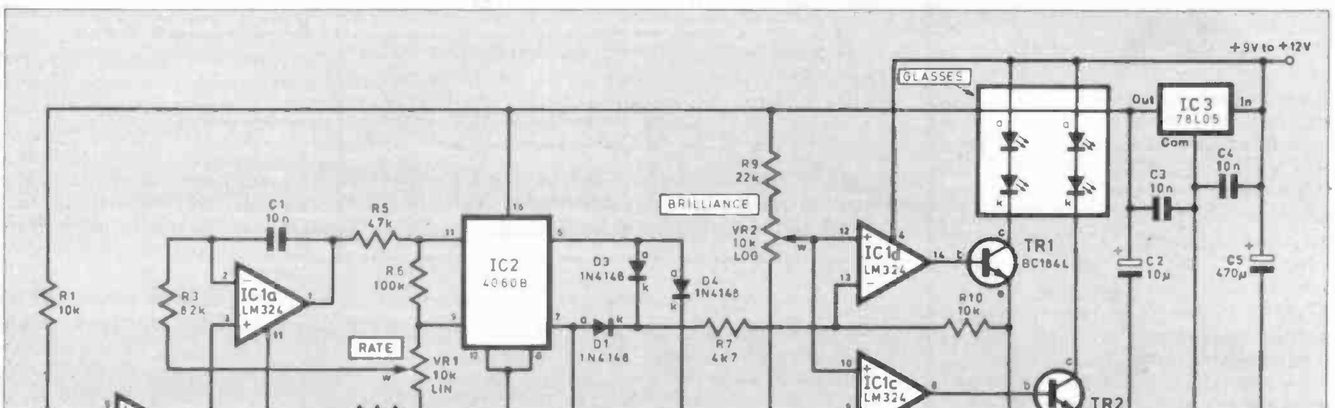
The oscillator runs at 32 times the desired frequency, which is taken from the appropriate divider stage. By "AND"ing this and the preceding stage with diodes D1 to D4, the circuit gives a 25 per cent duty cycle at all frequencies.

Most readers will know that the human ear responds logarithmically to sound intensity, since "log" pots are used to control amplifier volumes. The eye too is logarithmic, so the l.e.d. current source control must also follow a log law.

Due to supply voltage constraints the l.e.d.s are driven in two groups, and if the brilliance is to appear similar at low levels the control must be accurate. This is done by two op-amp current sinks (IC1c, IC1d), both following the voltage from the "log law" potentiometer VR2. The maximum current is limited by resistor R9.

The currents are, in fact, turned "off" by high outputs from IC2. When either pin 5 or pin 7 of IC2 is high, the associated diodes conduct, pulling the inverting inputs higher than the control voltage from VR2 and causing the op-amp outputs to fall to zero, turning off transistors TR1 and TR2. Since the IC2 outputs are both low for only

Fig. 2. Complete circuit diagram for the Brainwave unit. The glasses l.e.d.s are connected to the control box via a DIN plug and socket.



a quarter of each cycle, the required 25 per cent duty cycle is achieved.

CONSTRUCTION

The Brainwave unit is constructed on a piece of 0.1 in. matrix stripboard, with 13 strips of 34 holes. This was chosen in preference to a p.c.b. so that it could be made quickly from materials (hopefully) to hand, for a cheap and simple demonstration of it's effect.

The circuit board component layout and details of breaks required in the underside copper strips is shown in Fig. 3. Construction should begin with the track breaks, 36 in all. A common problem with stripboard is a minute strip of track remaining around the edge of a "break", so they should be checked with a magnifying glass.

Construction can proceed, in order of the components' physical height for ease. Links first, a total of 15, then diodes D1 to D4, the horizontally mounted resistors R1, R2, R3, R5, R7, R8, R9 and R13, then the sockets for IC1 and IC2.

The three 10n capacitors C1, C3 and C4 should follow, then the remaining resistors, the two transistors and IC3, and finally the electrolytic capacitors C2 and C5. The use of solderpins will make access to the external connections easier, especially during testing.

Although some idea of the final assembly and layout for this project can be seen from the photographs, precise details are not given as it is in no way critical and many readers will have their own ideas regarding housing. The external connections for controls, supply and outputs are shown in Fig. 4.

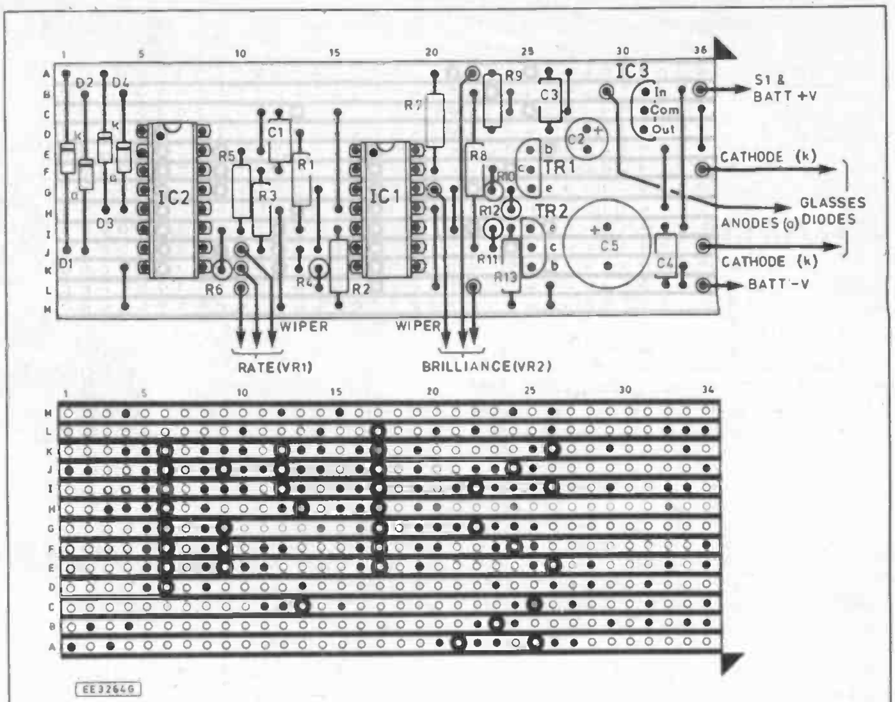


Fig. 3. Stripboard component layout and details of breaks in the underside copper strips.

TESTING

Testing can be carried out in easy stages. If the board is powered without IC1 and IC2, there should be a brief surge as the two electrolytics charge, then the current should settle to about 2.5mA. The 5V regulator (IC3) output can be checked, an easy place to find this is across pin 8, negative, and pin 16, positive, of IC2's socket.

If the above checks out, potentiometers VR1 and VR2 can be temporarily connected, a single l.e.d. placed across each output, IC1 and IC2 inserted and, with the two controls at about mid-position, the circuit powered. The l.e.d.s should flicker rapidly, whilst the current will be somewhere around five to 10mA.

Control VR1 should adjust the flicker from about 2Hz to 20Hz, whilst the log control VR2 should vary the brilliance from zero to very bright. Brightness "tracking" should be good almost to zero. The current will depend on brilliance, from a minimum of about 4mA to a maximum of about 40mA.

GLASSES

Construction of the l.e.d. glasses for this project is also largely up to constructors' preference. First experiments by the designer had l.e.d.s fixed with "Blu-tack" to plastic safety glasses obtained from a DIY store. Later versions used the same glasses with the lenses drilled for l.e.d. mounting, for a neater and more permanent job.

Great care has to be taken to ensure the l.e.d.s are positioned right over the eyeballs though, and they may not then suit different users. A better arrangement employs swimming goggles obtained from a sports shop.

These place the l.e.d.s more accurately, and allow individual adjustment. Two or three l.e.d.s may be used for each side, in

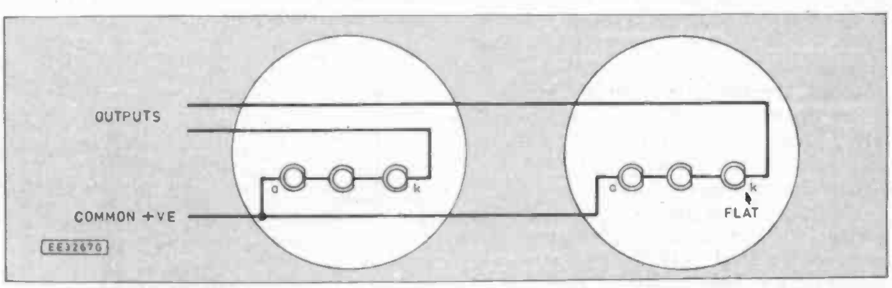
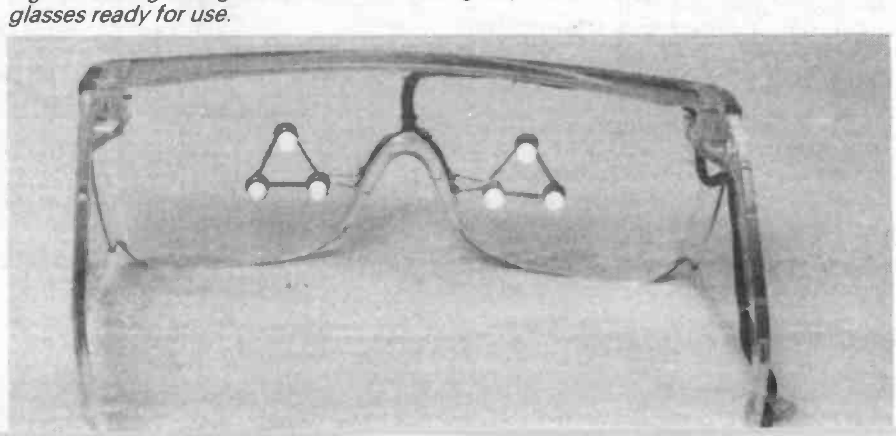


Fig. 5. Wiring the glasses l.e.d.s in two groups and below the modified safety glasses ready for use.



COMPONENTS

Resistors
R1, R2, R10, R11 — 10k (4 off)
R3 — 82k
R4 — 1k2
R5 — 47k
R6 — 100k
R7, R8 — 4k7 (2 off)
R9 — 22k
R12, R13 — 22 (2 off)
All 0.6W 1% metal film.

See SHOP TALK Page

Potentiometers
VR1 — 10k rotary carbon, lin
VR2 — 10k rotary carbon, "log", with switch

Capacitors
C1, C3, C4 — 10n polycarbonate (3 off)
C2 — 10µ radial elect., 50V
C5 — 470µ radial elect., 35V

Semiconductors
D1, D2, D3, D4 — IN4148 silicon diode (4 off)
TR1, TR2 — BC184 *npn* transistor (2 off)
IC1 — LM324 quad op-amp
IC2 — 4060B CMOS 14-stage counter, with internal oscillator
IC3 — 78L05 5V 100mA positive voltage regulator

Miscellaneous
Stripboard 0.1in. matrix, size 13 strips x 34 holes; 16-pin d.i.l. socket; 14-pin d.i.l. socket; l.e.d.s for glasses (6 off – see text); case; knobs; DIN plug/socket; eight AA batteries with holder; thin screened-twin lead for glasses; safety glasses or swimming goggles, see text.

Approx cost guidance only **£13** *excl. Bat. & Glass.*

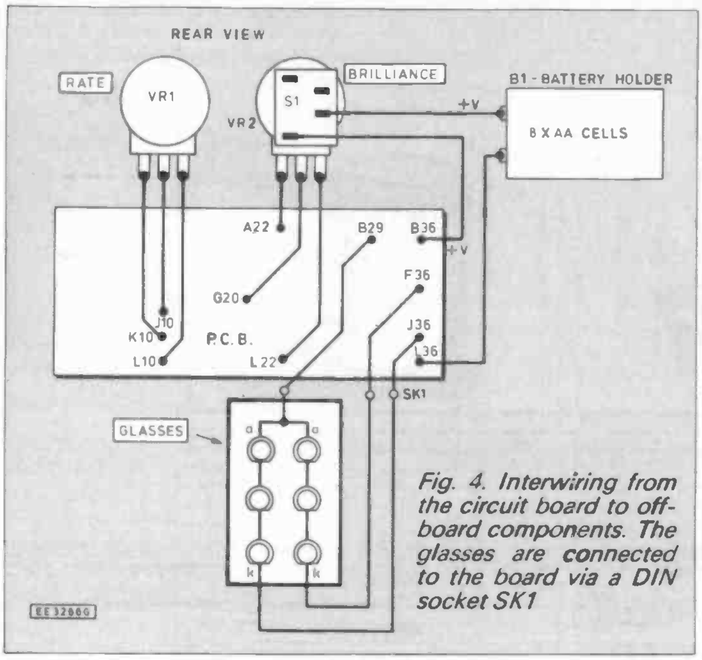
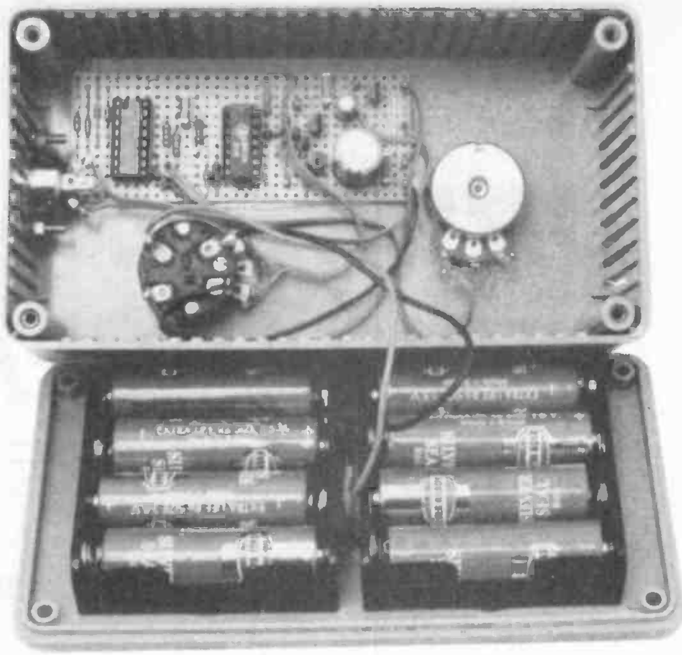


Fig. 4. Interwiring from the circuit board to off-board components. The glasses are connected to the board via a DIN socket SK1



Layout of components inside the control unit.

two series-connected groups, with a common anode connection as shown in Fig. 5.

The number of l.e.d.s that can be driven depends upon the supply voltage. Allowing for the battery voltage to fall by a third before replacement, a nine-volt battery can operate two l.e.d.s for each eye. The circuit could operate with a single alkaline PP3, though the current drain makes a pack of six AA cells a better choice.

A similar pack with eight AA cells, giving a nominal 12 volts, allows three l.e.d.s for each eye. Three cores are needed in the connecting lead. Very thin screened twin has proved ideal, with the screen used for the "common" anode connection to the positive supply.

Various types of l.e.d. have been tried. For adequate brilliance all were driven well in excess of their specification, but with the low duty cycle they seem to withstand this abuse quite happily. At least, none have failed so far!

Good results were obtained with "low current" types, but the best to date are 5mm "Hyperbright", with a claimed output of 1cd, or 1000mcd. These give an excellent light level and when diffused through closed eyelids their narrow beam angle is no problem.

The Brainwave should be used where the wearer can relax without fear of disturbance for the intended period, usually around half an hour. Background noise should be minimised to avoid distraction, although suitable sounds can be helpful.

Soft music, or pink noise are suitable. The author's *Seashell* project (EE November, 1988), which generates realistic surf sounds, has proved most effective.

The unit should be used with the ***eyes closed***. The light intensity should be set to a comfortable level, and the frequency adjusted until it feels "right". It can then be gradually lowered to produce (hopefully!) a sensation of deep relaxation.

Generally accepted bands of frequencies and their effects are as follows, from high to low:

Beta – 14Hz to 25Hz. This is the predominant brainwave frequency where the subject is wide awake and concentrating. You are (hopefully!) generating Beta signals as you read this article.

Alpha – 7Hz to 14Hz. Said to indicate a state of "relaxed awareness" this was the original frequency discovered at high levels during the meditation of Zen adepts, leading to the first biofeedback experiments. An early American EEG instrument was called the "Alphaphone".

Theta – 4Hz to 7Hz. Interest in Theta has increased recently. It is claimed to encourage vivid imagery, a kind of "waking dream" state, helpful in increasing personal creativity.

Delta – 2Hz to 4Hz. Found in sleep, and in young babies. The author can confirm that if the user is tired and sitting comfortably, a spell of 2Hz will induce sleep! A nappy hasn't proved necessary yet, though!

IN USE

Various people have tried versions of this project during development. Most found the lower frequencies deeply relaxing and were enthusiastic about it.

It can certainly reduce stress and, if used in the evening, the reduction is often apparent well into the following day. First-time users often report kaleidoscopic "patterns", but these seem to diminish with successive use.

Most forms of meditation are aimed, in the initial stages at least, at reducing the number of "thoughts" passing through the mind. With a little co-operation from the user, entrainment seems to achieve this far more efficiently than the "mantras" usually employed. Whether it has any use for reaching the deeper states sought by advanced meditators remains to be seen.

On the down side, it's not for everyone. Anyone subject to epilepsy should beware, see the appropriate warning elsewhere in this article. A couple of people simply didn't like it, one found it frightening. The author has at times experienced a sensation approaching vertigo, a sense of being "sucked in", hard to describe.

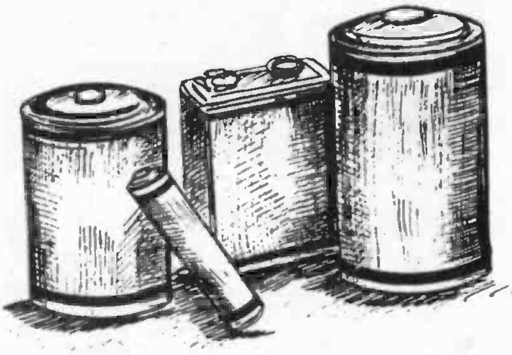
Any attempt to quieten the "conscious" mind tends to allow stored subconscious images to surface. This may cause a night or two of interesting and vivid dreams, but for most this is probably a healthy "balancing" process. Anyone who suspects they have some repressed painful experiences should perhaps be cautioned, though. Finally, a couple of users reported nausea!

Such negative effects were relatively infrequent, and should not discourage most potential users. This simple and inexpensive project is intended to allow readers to find out if this new technology suits them, personally.

Within the next few months, we will continue to explore this fascinating subject with a further design offering "binaural sound" in addition to the lights to enhance the effect. It will also be voltage-controlled for the future addition of programmed operation. □

Constructional Project

DRY CELL RECHARGER



ALAN TONG

Last month's feature article described "Better Use of Dry Cells", this month we show how to use your cells up to twenty times.

IN LAST months article it was established that zinc carbon and alkaline cells are far superior products to nickel cadmium rechargeable cells (NiCad's). It may then come as some surprise that ordinary "primary" zinc carbon and alkaline cells can be recharged.

Recharging Dry Cells

There are several advantages to recharging dry cells as opposed to NiCad's. Firstly the capacity of dry cells (especially alkaline) is much greater than that of NiCad's. This means that in a typical application a recharged dry cell will last five times as long as a NiCad.

NiCad's discharge themselves rapidly on standing, this makes them unsuitable for some applications such as clocks and emergency lighting, while recharged dry cells are suitable. The biggest argument for recharging dry cells however is cost. NiCad's cost several pounds while "used" dry cells are effectively free since they are usually thrown away.

Why then are 20 billion batteries thrown away every year? As already mentioned most people don't realise that they can be reused. Manufacturers will admit (reluctantly) that these cells can be recharged. If there was no possibility of cells being recharged there would be little point in telling you not to recharge them, since nobody would try.

Warnings printed on the cells range from the mild *Do not recharge* to the extreme *Danger of leakage or explosion*. Firstly cells cannot explode (unless thrown on a fire), all cells from reputable manufacturers have either a weak spot or wax plug built in to prevent any serious pressure build up. This can occur if a cell is inserted the wrong way around or if a discharged cell is inserted with fresh ones. The safety "vent" allows the gases to escape in a controlled way. An engineer working for a well known battery manufacturer told me that he had been recharging dry cells for several years.

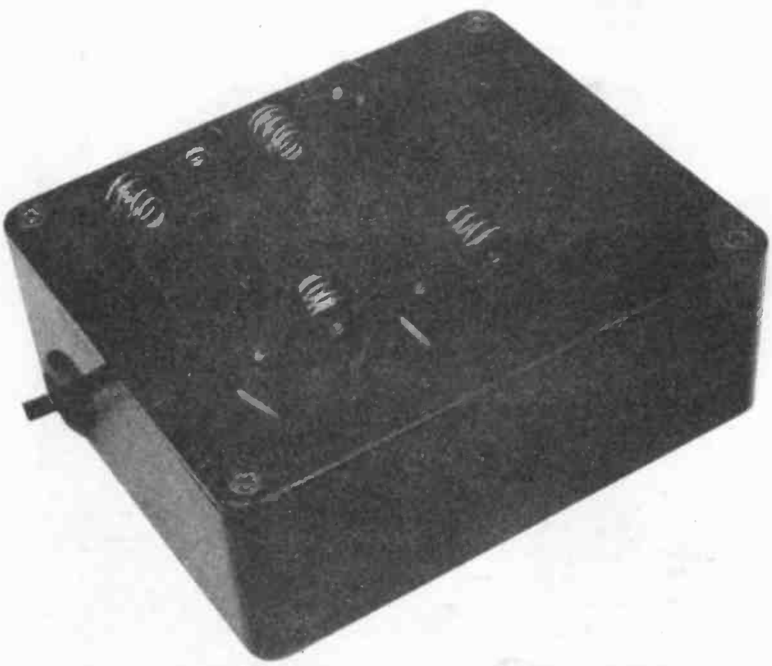
If a standard dry cell is plugged into a NiCad recharger it will be partially recharged, but there is an increased chance that it will leak. The amount of charge retained will also be a barely useful amount. *I do not recommend even trying this.*

Matter of Chemistry

The chemical process involved in discharging a typical cell is shown in Fig. 1. When in use the anode, often zinc, is oxidised forming zinc oxide. This oxygen has come from the cathode which has been reduced (different processes occur in different types of cell but these are best left to chemists).

To recharge this cell we have to get the zinc oxide back to zinc. This is a process similar to electroplating. If you can remember electroplating experiments from the dreaded chemistry lessons you will recall that it involves an electric current flowing through a solution; copper sulphate is commonly used to demonstrate this.

In this experiment copper is deposited on to one of the electrodes. The problem is that the electrode has not been plated with a coat of shiny copper, instead the copper is in spongy lumps. This is what happens when you recharge an ordinary cell in a NiCad recharger. NiCad rechargers simply



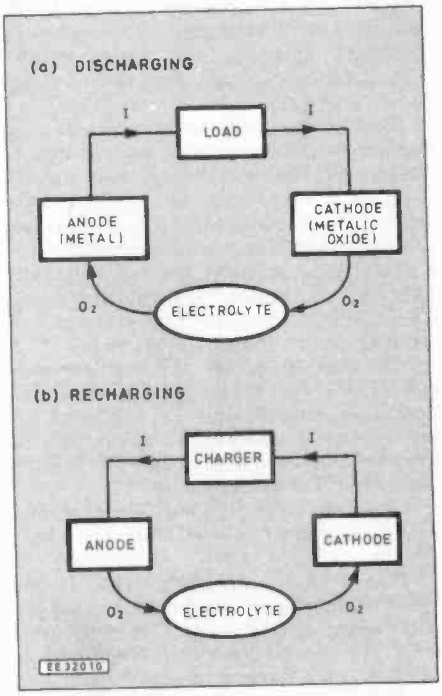


Fig. 1. Chemical process involved in discharge and charge.

force a d.c. current through the cell in the opposite direction to normal (Fig. 1b).

Inside the cell the zinc is plated out into a spongy mess instead of the original hard compact state. This re-plated zinc will take up more volume than it originally did, causing the internal components to distort. This distortion prevents an effective recharge and can lead to leakage.

Periodic Current Reversal

Not surprisingly the electroplating industry has found a way to produce successful results with these metals. The solution is known as periodic current reversal (PCR). PCR as it's name suggests consists of reversing the current flow at regular intervals, this prevents dendrite formation (see Part One) and gives a smooth finish.

When PCR is used to recharge dry cells the internal structure is not distorted and the cell can be successfully recharged without risk of leakage. It should be noted at this point that dry cells can only be recharged about 20 times before the capacity drops off, but when you consider that this is equivalent to recharging NiCad's 100 times and that the cell was "free" in the first place it is not a serious problem.

Safety

It is worth re-examining the question of safety at this point. Cells will not explode unless thrown on a fire, and with a bit of care they will not leak. Then why are warnings printed on cells? One reason may be that *a little bit of knowledge can be a dangerous thing*. If people know that cells can be recharged, but not how to recharge them, then mistakes could be made.

We cannot really expect the battery manufacturers to promote dry cell recharging. The dry cell market is a saturated one and any serious reduction in the number of cells sold might cause companies to fold.

The situation, however is different in other countries. In Japan recharging is officially encouraged and battery companies sell rechargers (mostly d.c.). In these countries there are no warnings on the cells, although export batteries still bear warnings! A well known manufacturer of alkaline cells in the UK prints on its cells for the home market "Do not recharge or dispose in fire, may explode or leak" curiously batteries for export simply state "Do not recharge".

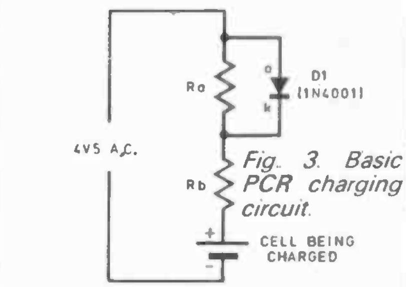


Fig. 3. Basic PCR charging circuit.

TABLE 1

CELL SIZE	AAA	AA	C	D
Ra	1k5(½)	560R(½)	220R(½)	68R(1)
Rb	120R(½)	47R(1)	18R(3)	6R8(5)
T1 RATING	1VA	1VA	2VA	5VA

FIGURES IN BRACKETS SHOW POWER RATINGS FOR RESISTORS.

N.B. FOR STANDARD (1200mAh) D SIZED NI-CAD'S USE VALUES AS FOR C SIZE. FOR 'INDUSTRIAL' (4000mAH) USE D SIZED VALUES.

EE32036

Table 1. Resistor selection for various batteries.

Important Guidelines

Some guidelines are necessary for safe and efficient recharging. It would be irresponsible to publish a recharging circuit without them *(a little bit of knowledge . . .)*.

1. Recharge using PCR, do not use d.c.
2. Limit the forward and reverse currents. (see Table 1)
3. Limit the recharge time, or in other words do not try to put more energy back into a cell than it originally contained.
4. Recharge soon after discharge as cells left in a discharged state for a long period of time (more than a few weeks) will not accept a recharge.
5. Do not fully discharge cells, some cells especially zinc chloride dry out as they discharge.

If a cell fully dries out the chemical reactions cannot be reversed so the cell cannot be recharged. In practice this means stopping using cells when the radio begins to distort or the torch bulb seriously dims.

6. Use cells from reputable manufacturers, these will be better quality so will last longer and are less prone to leakage.
7. Do not keep cells for long periods of time, cells get more prone to leakage as they get older. Discard cells after one or two years.
8. Only use the following PCR Recharger with zinc carbon, zinc chloride, alkaline and Ni-Cad cells (these are the most common anyway).

In five years of recharging I have never had a cell leak when using PCR, some old cells have leaked when I have used d.c. but since they have only leaked in the charger, not when in use, no damage was done.

Design

To recharge cells, a current of the correct magnitude that will be reversed at regular intervals is required. The frequency at which this reversal occurs is not critical so it makes sense to use mains frequency (50Hz). Obviously applying an ordinary alternating current (a.c.) to a battery will achieve nothing as on positive cycles it will charge the cell, on negative cycles it will discharge the cell (Fig. 2). What is required is a waveform where the forward charge current will be greater than the reverse current. This can be achieved by biassing the a.c. waveform to give it a non zero average.

A simple way of achieving this is to shunt a resistor with a diode; this leads to a very simple circuit shown in Fig. 3. When current is flowing in the forward charge direction it will flow through the diode bypassing R_a and then flow through R_b. This will give a current of $I=(4.5-0.7-1.5)/R_b$. The 1.5V being the voltage from the cell when it is recharged and the 0.7V being the voltage drop across the diode.

When the current flows in the opposite direction it passes through both R_a and R_b (the diode is reverse biassed so no current will flow through it). The reverse current is given by $I=(4.5+1.5)/(R_a+R_b)$. The most efficient ratio of forward to reverse currents is about 5 to 1. To make the charger compatible with NiCad's, standard NiCad charging currents have been used.

As a design example AA size batteries require a forward charge current of 50mA. Rearranging the equation for forward charge current we get $R_b=(4.5-1.5-0.7)/0.05$. This gives a value of 46 ohms, the nearest available resistor is 47 ohms. The reverse current (one fifth of the forward) should be 10mA. Rearranging the reverse current equation we get $R_a+R_b=(4.5+1.5)/0.01$. This gives a value of R_a of 553 ohms, the nearest available value is 560 ohms. The power

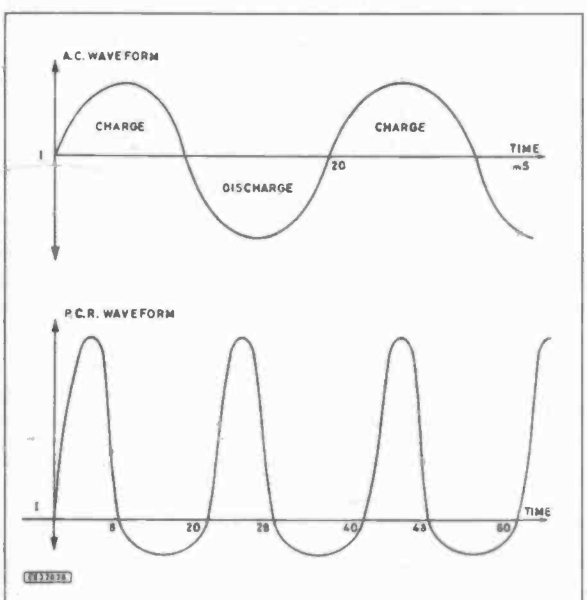


Fig. 2. Standard a.c. and PCR a.c. waveform.

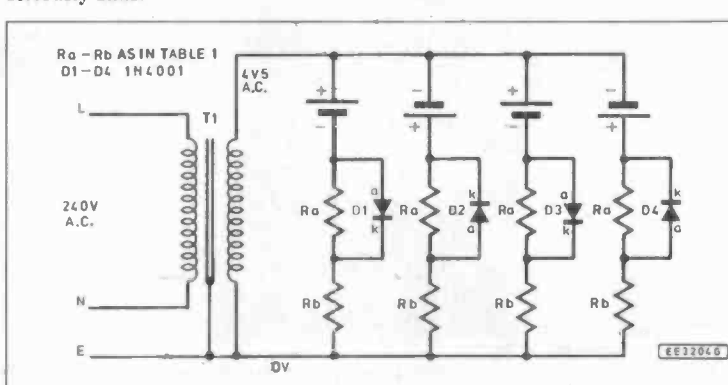


Fig. 4. Complete circuit of the Dry Cell Recharger.

COMPONENTS

Resistors
R_a and R_b see Table 1 (4 off each)

See SHOP TALK Page

Semiconductors
D1 to D4 1N4001 (4 off)

Miscellaneous
T1 Mains (240V) primary, 4.5V secondary at 1VA to 5VA – see Table 1

Mains lead and fused (1A) plug; stripboard – see text; MB3 plastic box – see text; battery holder for four cells (AAA to D size – see Table 1); earth tag and fixings for T1, battery holder and stripboard; connecting wire; mains lead grommet and cable clamp.

Approx cost guidance only **£8.50**

rating for the resistors and transformer must also be calculated. All the necessary values are in Table 1.

The full circuit diagram (Fig. 4) allows for four cells to be charged at once. A higher rated transformer will be required if you wish to recharge more than four cells at once. Note however that an even number of cells should be recharged at one time, this ensures that a balanced load is provided to the transformer. – Note that the diodes and cells are reversed in each section of the circuit.

The circuit as it stands is very simple. This is deliberate as in an article designed to save money it seems pointless to add the usual flashing l.e.d.'s and timing units found in most NiCad chargers.

Construction

Construction (Fig. 5) should cause no problems due to the simplicity of the project. The exact components used will depend on the size of batteries you wish to recharge. The circuit is built on a piece of stripboard. The size used can be chosen to fit in the box used. The minimum sensible size being 12 strips by 21 holes.

Connections to the transformer should be double checked and any terminals connected to the mains should be insulated. Where the mains cable enters the box a grommet and cable clamp should be used to prevent possible damage to the cable. The size of hole drilled for this will depend on the grommet used.

The mains plug used should have a one amp fuse rather than the usual thirteen amp. The transformer should be securely fixed within the box and its frame should be connected to the mains earth lead.

Five holes will need to be drilled in the top of the box to connect to the battery holders. Ensure enough wire is run to the battery holders to allow the lid to be removed. The holders can either be glued or screwed to the top of the box. One practical note about the battery holders; the metal terminals will have to be carefully soldered or the plastic surrounding them will melt.

The case used for this project was a MB3 plastic box measuring 115 × 95 × 43.5mm. If you choose to use a metal box **ensure that it is correctly earthed.**

Testing

An ammeter can be used to test the circuit. If the meter leads are connected to the terminals on one of the battery holders, and the recharger plugged into the mains, a current slightly less than the forward charging current should be measured.

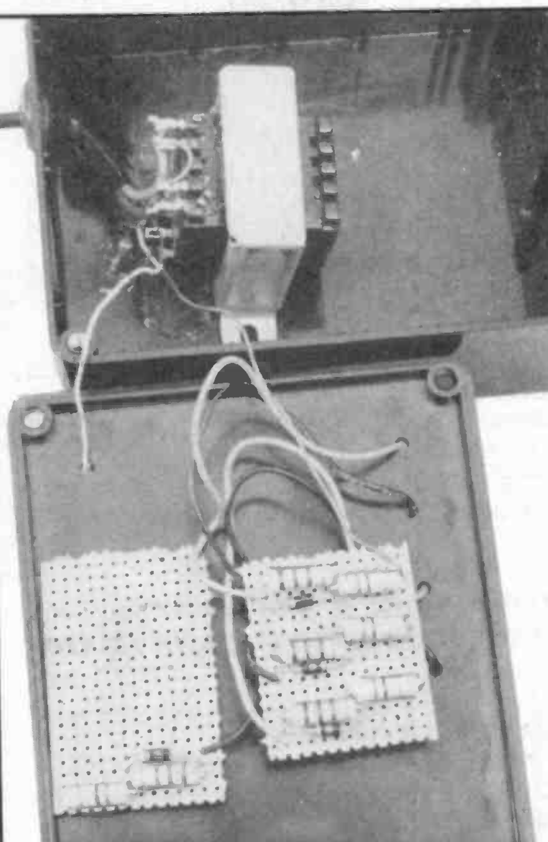
Disconnect the unit from the mains and insert some cells to be recharged. Measure the voltage across one of the cells, then plug the unit into the mains again, a slight rise in voltage should be observed. If this rise is observed then the cell is being recharged.

In Use

Operation is simple, discharged cells are simply inserted into the battery holders and the unit connected to the mains. The only question is how long to charge cells for? This depends on what type of cell is being recharged and how discharged the cell was in the first place.

Zinc carbon and zinc chloride cells usually require 12 to 18 hours to recharge. Alkaline cells, since they have much higher capacities, require 24 to 36 hours. By using a battery tester, the state of charge of a cell can be measured (see part one of this article). Recharging should be halted when a cell gives a slightly lower reading than a new cell. Do not try to put more into a cell than it originally contained as it could leak.

The recharger only has to be used a few times to pay for itself. □



Prototype charger was made using scraps of stripboard to hold the components. Mains connections to the transformer should be insulated before testing.

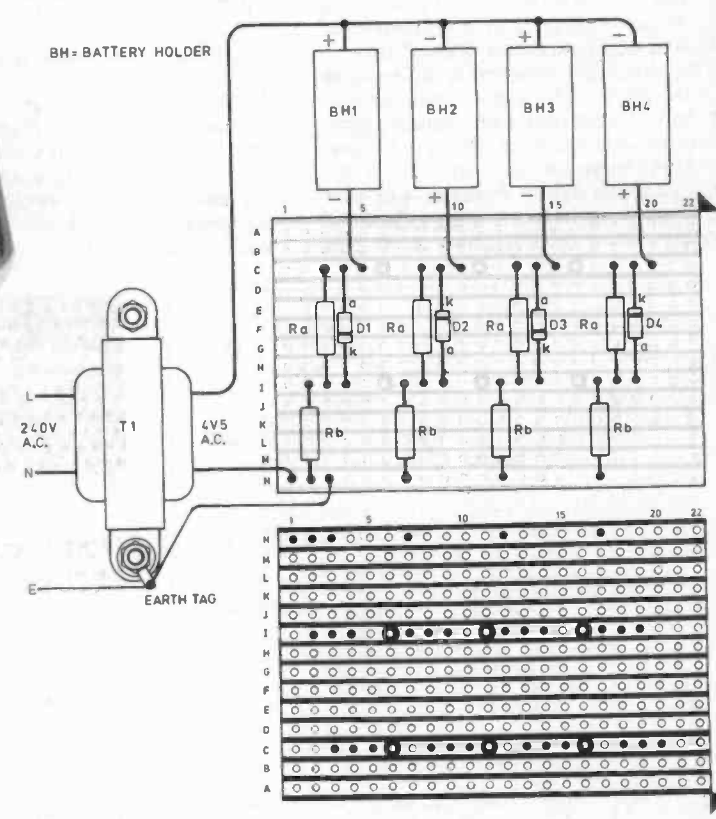
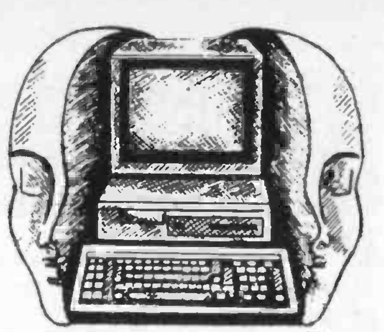


Fig. 5. Construction of the Dry Cell Recharger.

INTERFACE



Robert Penfold

AS EXPLAINED last month, a technical problem with my printed circuit design program prevented details of the p.c.b. for the improved PC prototype card from appearing in that issue. As promised, details of the board are included in this month's *Interface* article. Fig.1, Fig.2, and Fig.3 respectively show the top side, underside, and component overlay. This is basically just the original (passive) PC prototyping card with the four output address decoder (as described last month) added on to it.

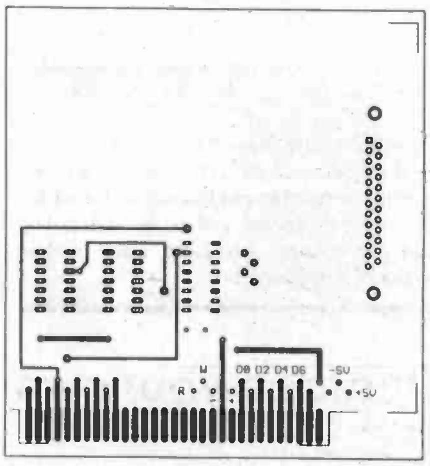


Fig. 1. The top (component) side of the PC prototyping card (½ scale). Only the component area of the board is shown.

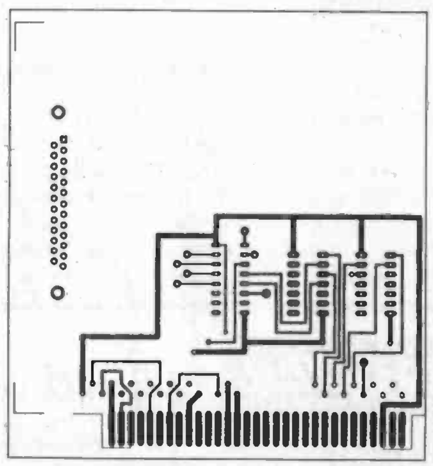


Fig. 2. The underside track pattern of the prototype board. Only one end of the board is shown.

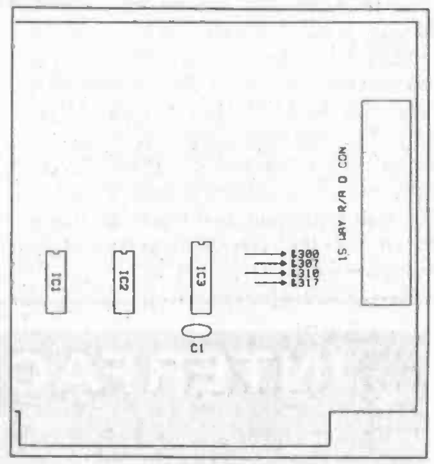


Fig. 3. Component layout of the "working area" of the PC prototyping card, the board measures 204mm x 100mm.

There is a slight change to the basic board in that an extra connection to the expansion bus has been provided. This is the "RESET" line. This will not be compatible with all add-on circuits, which may therefore need some processing of this line in order to provide a suitable signal. In some cases the add-on circuits will need to have their own independent reset circuit.

However, it is advisable to use this line to originate the reset signal whenever this is possible. This ensures that the add-on circuit will be reset if the computer should happen to be reset some time after switch-on and the initial reset cycle. The reset pin is the one between the 0V and −5V pins (i.e. the third from the right when the board is viewed from the component side). Apart from this addition, the connections to the expansion bus are as before.

Although you might think that there would be no output pulses from the four decoded outputs unless you access an I/O address in the appropriate range, this is not in fact the case. Remember that the address decoder does not process any of the read or write lines, and it therefore provides less than full decoding. Pulses from the decoded outputs is therefore only to be expected, and is not indicative of a fault.

As explained in a previous *Interface* article, a 2-input NOR gate is all that is needed in order to decode one of the address decoder's outputs with IOR or IOW. If the peripheral chip or chips used with the card have suitable "RD" and "WR" inputs, then these should be fed from IOR and IOW of the expansion bus, with no further decoding being necessary.

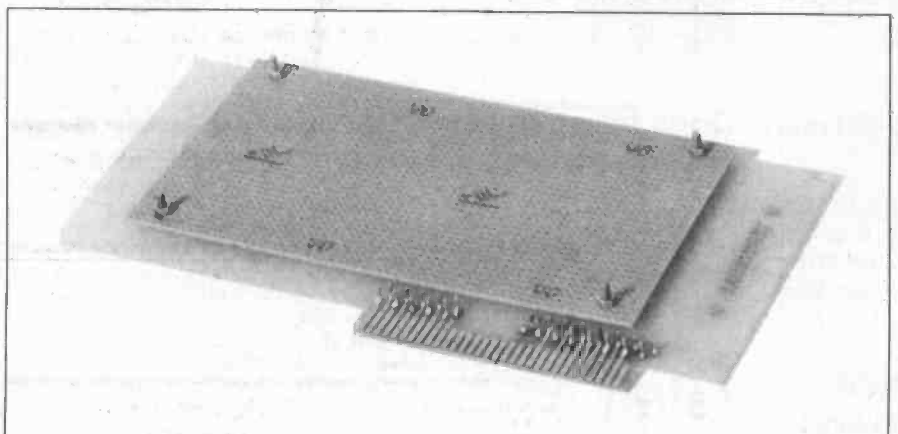
8522 PIA

Of the various types of PC prototyping system I have tried, I find that this card, fitted with a couple of "Veroblocs" or similar breadboards, is very easy to use. Once fitted with some single-strand insulated wires to provide connections between the data bus etc. and the breadboards, it is quick and easy to prototype various types of input/output port.

One way of improving the unit still further would be to have some input/output lines available on-board. In other words, to have something similar to the user port of computers such as the BBC micros included on the board. This would permit non-bus compatible devices such as some D/A converters to be easily interfaced to a PC. For bus compatible devices the version of the card which only carries the address decoder would probably still be the best option.

There are several parallel interface chips which can be used with the 8086 series of microprocessors, but the 8255 seems to be the most popular choice. This chip will be familiar to many readers, as it has been popular over the years as the basis of add-on parallel interfaces for Z80 based computers such as the Sinclair Spectrum.

This provides some twenty four input/output lines arranged as three



An early stripboard version of the DIY PC prototype card described in our July '91 issue.

eight-bit ports which are ports A to C. In fact port C can operate in a split mode where it effectively functions as two four-bit ports. This split operation is mainly used where port C will provide the handshake lines for ports A and B.

An important point to bear in mind when using the 8255 is that apart from this split mode of port C, the lines of each port must all be set as inputs, or all as outputs. It is not possible to control the function of each line individually.

This makes the twenty four lines of the 8255 in some ways less versatile than the twenty lines of devices such as the 6522 and 6821, which do offer this individual control. In fact I much prefer the 6821 and 6522, which offer some elegant methods of handling handshaking. Unfortunately, these devices do not interface easily to an 8086 series bus.

Right Connections

As an 8255 is bus compatible with the PCs, an 8255 plus last month's address decoder is all that you need in order to produce a PC PIA card, or a PIA equipped prototyping card. Fig.4 shows connection details for the 8255 when it is used in this way. The chip select input is a negative active type which can be driven directly from one of the address decoder's outputs. The read, write, and reset inputs are simply driven from the corresponding lines of the expansion bus.

The 8255 has four registers, and the required register is selected via A0 and A1. These would normally (as here) be fed from A0 and A1 of the computer's address bus, placing the chip at four consecutive addresses. For example, if the &H300 output of the address decoder is used, the 8255 will appear in the input/output map in the way shown below:

Address (Hex/Dec)	*Function*
&H300/768	Port A
&H301/769	Port B
&H302/770	Port C
&H303/771	Control Register

These registers will also appear at echoes from &H304 to &H307, rendering these addresses unavailable for use with other circuits. From GW BASIC you can write to the chip using the OUT instruction, and read it using the INP function. Most BASICs for the PC have these or equivalents, but not all BASICs provide for direct control of input/output devices. The 8086 series of microprocessors do not have memory mapped input/output, which means that PEEK and POKE cannot be used.

Although BASIC languages tend to be regarded as out of date by many people, they are actually well suited to the control of user add-ons. An interpreted BASIC such as GW BASIC is very well suited to initial testing of user add-ons, even if something faster such as assembler or a compiled BASIC is used for the final software. Since virtually all PCs are supplied complete with

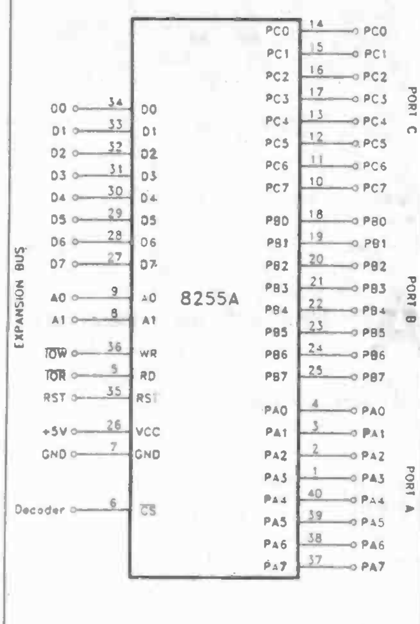
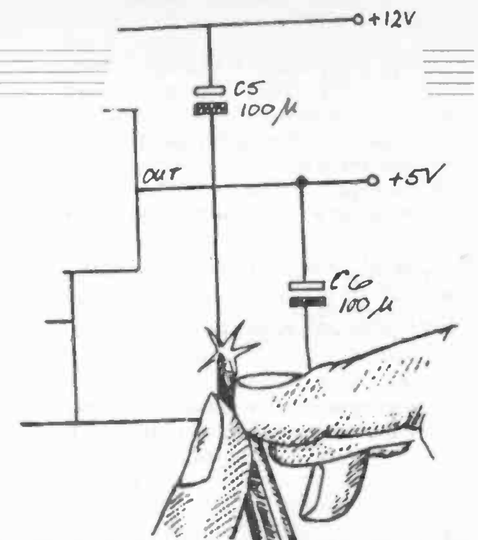


Fig. 4. Interfacing an 8255A PIA to the PC expansion bus.

a copy of GW BASIC, this is the language we will use for example software routines.

Next Month: Programming the 8255 will be discussed, and (p.c.b. design program permitting) a suitable printed circuit board for the 8255 Protocard will be provided. We will also consider interfacing other devices to the PC expansion bus.



DESIGN YOUR OWN CIRCUITS

What next?

MIKE TOOLEY BA

PART 10

This final part takes a look back through the preceding nine parts and provides a number of ideas for future projects. We also deal with some comments, queries and suggestions made by readers. We begin, however, with some timely advice on circuit layout and construction together with a number of hints and tips on stripboard and printed circuit board design.

When the time comes to assemble and test a circuit, there are a number of techniques which can be employed, including matrix boards, stripboards and printed circuits.

Constructional techniques

Matrix boards and stripboards are ideal for initial breadboarding and one-off prototype construction. Matrix boards are usually punched with a 0.1 inch matrix of holes (either 0.040 inch or 0.052 inch in diameter) which are designed to accept push-fit soldering pins. The pins are available as either single or double sided and, with the latter the user is able to mount components (such as transistors, diodes and resistors) on the upper side of the board whilst the wiring (using short lengths of tinned copper wire or insulated wire) is carried out on the lower side of the board. This method is, however, somewhat less suited to breadboarding integrated circuits since wire links must be soldered directly to the pins of the i.c. sockets and this is often a rather messy process!

Stripboards, on the other hand, provide the user with a matrix of holes linked together with copper strips. Here again, terminal pins may be fitted but there is no need for them (apart from off-board wiring) since component leads can be inserted through the holes and soldered directly to the tracks on the lower side of the board. Tracks may be broken using a small drill bit or "spot-face cutter". This method is ideally suited to integrated circuit breadboarding since it allows i.c. sockets to be soldered directly in place.

Provided care is exercised in component positioning, the stripboard technique offers the advantage that relatively few wire links are required and that components can be mounted and soldered directly to the copper strips without the need for pins.

Unfortunately, conventional (types of stripboard (those with parallel runs of strips throughout the entire board surface) are generally unsuitable for relatively complex circuitry of the type associated with microprocessor systems. For such circuits, special purpose stripboards are available with copper tracks arranged in groups which permit the mounting of d.i.l. integrated circuits (including the larger 28-pin and 40-pin types).

For those intending to use standard enclosures, card frames and "backplanes", stripboards are also available in a range of standard card sizes (single and double Eurocard being most common). These cards (which can be quite expensive!) are generally available with plated-through holes and are often provided with edge connectors (either direct or indirect types).

Stripboard layout

Before attempting to start wiring a stripboard circuit it is well worth spending a little time laying the circuit out on paper! This exercise is sometimes seen as a chore but can be instrumental in minimising the number of links and soldered joints required as well as making the most effective use of the available space on the boards. The following steps are recommended:

(a) Make a copy of the circuit diagram and mark all components (such as switches, connectors and variable resistors) which will require "off-board" mounting.

(b) Mark on the circuit diagram (using appropriate letters and/or numbers, e.g. SK1 pin-1, SK5 pin-3, etc) all points at which an "off-board" connection is to be made.

(c) Identify any multiple connections (e.g. data and/or address bus connections) required between integrated circuits or between integrated circuits and connectors.

(d) Estimate the total area of stripboard required to accommodate your circuit and select a board of appropriate size (in some cases the size will be dictated by the enclosure or the need to use a standard card size). A simple rule of thumb is to allow about two square inches of board for each 8, 14 or 16-pin dual-in-line integrated circuit used.

A similar area should be reserved for each transistor (and associated components) and an overhead of about 10 per cent allowed for connectors. Hence a board measuring five inches by four inches can be expected to accommodate up to nine 14-pin integrated circuits.

Note that, in most (but not all) cases the layout will be most efficient if the copper tracks are aligned with the major (longer) axis of the board. It is, of course, advisable to use standard sizes of stripboard wherever possible. Furthermore, where larger boards have to be cut down to a particular size, it is usually more efficient to align the strips along the major axis of the board.

(e) At this stage, it may also be worth considering the means of mounting the stripboard. If it is to be secured using nylon or plastic snap-fit pillars or bolts and threaded spacers, it will be necessary to allow adequate clearance around the mounting holes when positioning. Note also, that larger boards may require a number of mounting pillars placed at appropriate points (not just at the four corners).

(f) Having ascertained the board dimensions, it is worth producing a rough component layout for the stripboard, using paper ruled with squares; the corners of the squares representing the holes in the stripboard. I recommend carrying out this process "actual size" using 0.1 inch graph paper. For preference, it is wise to choose paper with a feint blue or green grid as this will subsequently disappear after photocopying leaving you with a "clean" layout!

(g) The next stage involves reserving some of the copper strips for distribution of the supply rails (including the provision of an effective ground/0V connection to all points on the board).

At this stage, it is particularly important to identify all conductors which will be handling high currents (i.e. those in excess of 1A) and use adjacent strips connected in parallel at various points along the length of the board. It is also worth reserving the strips (if not the same) which will be used to convey the supply rails; as far as possible these should be continuous from one end of the board to the other.

Note that it is often convenient to use adjacent strips for supply and 0V since decoupling capacitors can easily be distributed at strategic points. Ideally, such capacitors should be positioned in close proximity to the positive supply input pin to all integrated circuits which are likely to demand sudden transient currents (e.g. 555 timers, relay drivers, i.c. power amplifiers, etc).

Finally, in high frequency circuits it is important to link all unused strips to 0V at regular points. This promotes stability by reducing stray signal coupling and ensuring that the 0V rail is effective as a common rail.

(h) Next, consider the placement of the "off-board" connections identified in (b). It is often desirable to have these located at the edges of the board however in some cases there can be advantages in locating these points in more central positions.

If multi-pole connectors are to be used, it is nearly always worth deciding upon the optimum position for these first. Supply and other signal connections can usually be placed later. However, it is advisable to keep inputs and outputs at opposite ends of the board as this not only helps maintain a logical circuit layout (progressing from input to output) but, in high gain circuits, it can also be instrumental in preventing instability due to unwanted feedback.

(i) Next arrange the components in (c) in physical proximity and with an orientation which minimises the number of links required. These components should be placed on the layout diagram and aligned so that their connections follow the major track axis of the board.

(j) Now identify components which require special attention (such as those which require heatsinks or have special screening requirements). Ensure that these components are positioned sensibly bearing in mind their particular needs.

(k) The remaining integrated circuits, transistors, diodes and passive components can then be placed. Here again it is important to place each component in such a way as to minimise the length and number of links required. These should be made on the upper (component) side of the stripboard. Only in exceptional cases should links be made on the underside (foil side) of the board.

(l) It is often worth experimenting with the positioning of integrated circuits (it is good practice, though not essential, to align them all in the same direction). Furthermore, in order to minimise strip usage and the number of links required, logic gates may often be exchanged from package to package (or even within the same package). However, if you do have to resort to this dodge, don't forget to amend the circuit diagram!.

(m) Having completed the stripboard layout, it is important to carefully check it against the circuit diagram. Not only can this save considerable frustration at a later stage but it can be instrumental in preventing some costly mistakes. In particular, one should follow the positive supply and 0V strips and check that all chips and other devices actually receive their supplies!

The recommended technique for carrying out this task is simply that of tracing each connection in turn on the circuit diagram and also on the layout diagram. Coloured pencils should be used together with photocopies of the circuit and layout diagrams.

Stripboard assembly

Fortunately, the assembly of a stripboard prototype is usually quite straightforward. The first stage is to identify any mounting holes required (e.g. to accommodate pillars) and drill these whilst the board still offers a perfectly "flat" surface. Thereafter, the sequence used for stripboard assembly will normally involve mounting i.c. sockets first followed by transistors, diodes, resistors, capacitors and other passive components.

Finally, terminal pins and links should be fitted before making the track breaks. On completion, the board should be carefully checked, paying particular attention to all polarised components (e.g. diodes, transistors and electrolytic capacitors).

Printed circuit layout

Whilst stripboards provide a fast and efficient means of assembling prototype and "one-off" circuits, many readers will doubtless wish to produce their circuits using printed circuit boards. This technique is particularly appropriate where several boards are to be produced or when a breadboard circuit is to be turned into a final "production board".

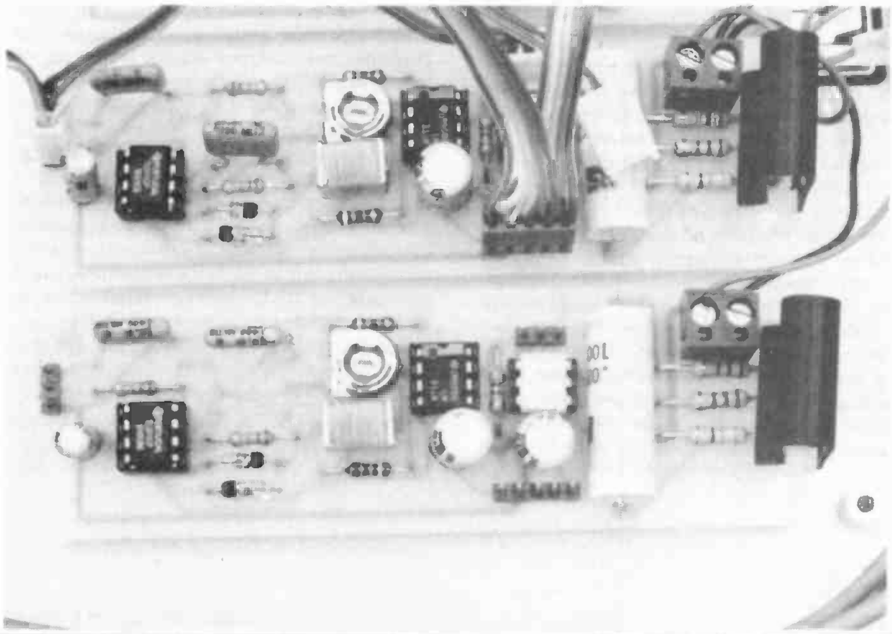
Printed circuit boards (p.c.b.s) comprise copper tracks bonded to an epoxy glass or synthetic resin bonded paper (SRBP) board. The result is a neat and professional looking circuit. Furthermore, printed circuits can easily be duplicated or modified from original master artwork and the production techniques are quite simple and should thus not deter the enthusiast working from home.

There are two methods which can be used for laying out a printed circuit board; manual and computer aided. The former technique runs along the same lines as that employed for layout of stripboards with the important exception that the constraints in having conductors which only align in one direction no longer applies.

Where a computer aided design package is available, this can considerably simplify the process of producing printed circuit board artwork. Some of the best CAD packages for printed circuit design provide the user with component libraries, rubber-banding of connections and automatic track routing together with a choice of track widths and pad shapes. Some of these packages (notably those designed for professional use) are expensive but some are now very reasonably priced.

Anyone who intends to regularly produce printed circuit boards is strongly advised to consider the packages that are available. Furthermore, it is not essential to have a plotter as acceptable results can be produced using an ordinary dot matrix

Example of p.c.b. layout, these boards are part of the Disco Lights Controller, the Teach-In project published in the July '91 issue.



printer to produce the master artwork from which transparencies for photo-etching are produced.

The following steps should be taken into consideration (along with those previously mentioned under "Stripboard layout"):

(a) When manually designing printed circuits and unless the design makes extensive use of p.c.b. edge connectors, it is worth ensuring that a common 0V foil is run all round the periphery of the board. This offers a number of advantages not the least of which is the fact that it will be then be relatively simple to find a route to the 0V rail from almost anywhere on the board!

(b) When mounting the p.c.b. (and particularly if it is to be secured using metal bolts and threaded spacers) you may also wish to ensure that the holes are coincident with the 0V foil. Alternatively, where the 0V rail is not to be taken to chassis ground, it will be necessary to ensure that the p.c.b. mounting holes occur in an area of the p.c.b. which is clear of foil.

(c) Track widths should be chosen in relation to the current which is expected. The following should provide a rough guide:

Current (d.c. or r.m.s. a.c.)	Minimum track width
less than 500mA	0.6mm
500mA to 1.5A	1.6mm
1.5A to 3A	3.0mm
3A to 6A	6.0mm

(d) As a general rule of thumb, the width of the 0V track should be at least TWICE that used for any other track.

(e) Conductors which will be handling high voltages (i.e. those in excess of 150V d.c. or 100V r.m.s. a.c.) must be adequately spaced from other tracks. The following should provide a rough guide:

Voltage between adjacent conductors (d.c. or peak a.c.)	Minimum track spacing
less than 150V	0.6mm
150V to 300V	1.6mm
300V to 600V	2.5mm
600V to 900V	4.0mm

(f) Identify the point at which the principal supply rail is to be connected. Employ extra wide track widths (for both the 0V and supply rail) in this area and check that suitable decoupling capacitors are placed as close as possible to the supply. Check that other decoupling capacitors are distributed at strategic points around the board (as for the stripboard layout procedure).

(g) Fill unused areas of p.c.b. with "lands" (areas of foil which should be linked to 0V). This helps ensure that the 0V rail is effective as a common rail, minimises use of the "etchant", helps to conduct heat away from heat producing components, and furthermore, is essential in promoting stability in high-frequency applications.

(h) Lay out the 0V and positive supply rails first. Then turn your attention to linking to the pads or edge connectors used for connecting the off-board components. Minimise, as far as possible, the number of links required. Do NOT use links in the 0V rail and avoid using them in the positive supply rail.

(i) Be aware of the pin spacing used by components and try to keep this consistent throughout. With the exception of the larger wirewound resistors (which should be mounted on ceramic stand-off pillars) axial lead components should be mounted flat against the p.c.b. (with their leads bent at right angles). Axial lead components should NOT be mounted vertically!

(j) Minimise track runs as far as possible and maintain constant spacing between parallel runs of track. Corners should be radiused and acute internal and external angles should be avoided. In exceptional circumstances, it may be necessary to run a track between adjacent pads of a d.i.l. integrated circuit. In such cases, the track should not be a common 0V path neither should it be a supply rail!

(k) Finally, don't forget that tracks may be conveniently routed beneath other components. Supply rails, in particular can be routed between opposite rows of pads of d.i.l. integrated circuits; this permits very effective supply distribution and decoupling.

As with stripboard layouts, it is well worth devoting some time to checking the final draft p.c.b. layout before starting on the master artwork. Again, this can be instrumental in saving much agony and soul searching at a later stage!

Printed circuit board assembly

Several methods can be used for prototype and small-scale production of printed circuit boards including the use of etch resist drawing pens and transfers applied directly to the copper surface coating. The most versatile method, however, involves producing a 1:1 transparency (from the orginal master artwork generated by a CAD package or from transfers of pads linked by hand-drawn tracks). This positive master transparency is used in conjunction with copper clad board which is coated with a photosensitive film.

The board is exposed under an ultraviolet light source (the positive master transparency is placed on top of the board whilst it is exposed). Small ultraviolet light units are available which permit exposure of boards measuring 250mm x 150mm whilst larger units are suitable for boards of up to 500mm x 350mm. The more expensive exposure units are fitted with timers which can be set to determine the actual exposure time. Low cost units do not have such a facility and the operator has to refer to a clock or wristwatch in order to determine the exposure time.

In use, the 1:1 master artwork (in the form of opaque transfers and tape on translucent polyester drafting film) is placed on the glass screen immediately in front of the ultra-violet tubes (taking care to ensure that it is placed so that the component side is uppermost). The opaque plastic film is then removed from the photo-resist board (previously cut roughly to size) and the board is then placed on top of the film (coated side down). The lid of the exposure unit is then closed and the timer set (usually for around four minutes, but see individual manufacturer's recomendations). The inside of the lid is lined with foam which exerts an even pressure over the board such that it is held firmly in place during the exposure process.

The specially coated copper board (in common with most photographic materials) has a finite shelf-life. Boards should be stored in a cool place at a temperature of between two degrees C and 10 degrees C. The shelf-life of boards is limited to around 12 months when stored at a temperature of 20 degrees C and thus boards should be used as quickly as possible after purchase.

Alternative method

If the outlay associated with the purchase of a dedicated ultraviolet light box is somewhat daunting, readers may like to know that it is not absolutely essential to have access to an ultra-violet light box since we all have occassional access to an entirely free source of ultraviolet light! Provided one is prepared to wait for a sunny day and prepared to experiment a little, boards can be exposed under ordinary sunlight.

As a guide, and with the full sun present overhead, exposure will take around fifteen minutes. Alternatively, one can make use of a sun-ray lamp. Again, some experimentation will be required in order to get the exposure right. With a lamp placed approximately 300mm from the sun ray source (and arranged so that the whole board surface is evenly illuminated) an exposure time of around four minutes will be required.

Note that, if you use this technique, it is important to follow the sun-ray lamp manufacturer's instructions concerning eye protection. A pair of goggles or dark sunglasses can be used to protect the eyes during the exposure process however one should NEVER look directly at the ultraviolet light source even when it is "warming up"!

It must be stated that neither of the foregoing techniques is suited to anything other than the casual "one-off" production of printed circuit boards. One further option for the d.i.y. enthusiast is that of constructing a purpose built ultraviolet light box using low-power ultraviolet tubes. Whichever method of exposure is used some experimentation may be required in order to determine the optimum exposure time. *(A UV Exposure Unit design will be published in EE next month – Ed).*

Development

After this time has elapsed, the board should be removed and immersed in a solution of sodium hydroxide which acts as a developer. The solution should be freshly made and the normal concentration required is obtained by mixing approximately 500ml of tap water (at 20 degrees C) with one tablespoon of sodium hydroxide crystals.

A photographic developing tray (or similar shallow plastic container) should be used to hold the developer. Note that care should be taken when handling the developer solution and the use of plastic or rubber gloves is strongly recommended! This process should be carried out immediately after exposure and care should be taken not to allow the board to be further exposed under room lights.

Whilst immersed in the developer, the board should be gently agitated and the surface of the board carefully watched. The board should be left for a sufficiently long period for the entire surface to be developed correctly but not so long that the tracks start to lift.

Development times will depend upon the temperature and concentration of the developer and on the age of the sensitised board. Normal development times are in the region of 30 to 90 seconds and after this period the developed image of the track layout (an etch-resist positive) should be clearly seen.

After developing the board it should be carefully washed under a running tap. It is advisable not to rub or touch the board (to avoid scratching the surface) and the jet of water should be sufficient to remove all traces of the developer.

Etching

Finally, the board should be placed in the etchant which is a ferric chloride solution ($FeCl_3$). For obvious reasons, ferric chloride is normally provided in crystalline form (though at least one major supplier is prepared to supply it on a "mail order basis" in concentrated liquid form!) and should be added to tap water (at 20 degrees C) following the instructions provided by the supplier. If no instructions are given, the normal quantities involved are 750ml of water to 500g of ferric chloride crystals.

Etching times will also be very much dependant upon temperature and concentration but, for a fresh solution warmed to around 40 degrees C the time taken should typically be ten to fifteen minutes. During this time the board should be regularly agitated and checked to ascertain the state of etching.

The board should be removed as soon as all areas not protected by resist have been cleared of copper; failure to observe this precaution will result in "undercutting" of the resist and consequent thinning of tracks and pads. Where thermostatically controlled tanks are used, times of five minutes, or less, can be achieved when using fresh solution.

Great care should be exercised when handling ferric chloride. Plastic or rubber gloves should be worn and care must be taken to avoid spills and splashes. After cooling, the ferric chloride solution may be stored (using a sealed plastic container) for future use. In general, 750ml of solution can be used to etch around six to ten boards of average size; the etching process taking longer as the solution nears the end of its working life. Finally, the exhausted solution must be disposed of with care – it must not be poured into an ordinary main drainage system.

Drilling

Having completed the etching process, the next stage involves thoroughly washing, cleaning, and drying the printed circuit board. After this, the board will be ready for drilling. Drilling will normally involve the services of a 0.6mm or 1mm twist drill bit for standard component leads and i.c. pins. Larger drill bits may be required for the leads fitted to some larger components (e.g. power diodes) and mounting holes.

Drilling is greatly simplified if a special p.c.b. drill and matching stand can be enlisted. Alternatively, provided it has a bench stand, a standard electric drill can be used. Problems sometimes arise when a standard drill or hand drill is unable to adequately grip a miniature twist drill bit. In such cases one should make use of a miniature pin chuck or a drill fitted with an enlarged shank (usually of 2.4mm diameter).

Having dealt with the manufacture of circuit boards, it is worth considering two further items which are important in the production of a finished item of electronic equipment: connectors and enclosures.

Connectors

Connectors can be categorised in various ways however the circuit designer will probably be concerned with the following types:

(a) Mains connectors which are intended for use in conjunction with the a.c. mains supply. Standard IEC connectors (with integral fuses and/or filters as appropriate) should be used whenever possible.

(b) Single-pole connectors of the 2mm, 3mm or 4mm variety should be used for test leads at d.c. and low frequencies and also for the outputs of bench d.c. power supplies. Where necessary, connectors can be colour coded to indentify polarity, etc.

(c) DIN audio connectors (3-way, 5-way, 7-way etc). These are ideal for use with audio equipment but also make excellent low-cost general purpose connectors.

(d) Multi-pole connectors for p.c.b. and stripboard connection. These include the popular DIN41612 types (having 32, 64 or 96 ways) which are highly recommended for cards mounted in frames.

(e) D-connectors. These are commonly associated with computers and are available in 9, 15, 25, and 37-way versions.

(f) IDC connectors for solderless termination of ribbon cables. These connectors are ideal for linking printed circuit boards together but can also be used in many other applications in which a large number of connections are required.

(g) Coaxial connectors (BNC, PL259/SO239, etc). These connectors are used in conjunction with screened cables. BNC connectors can be used reliably at frequencies up to 4GHz (note that they are available in both 50 ohm and 75 ohm varieties) whilst the PL259/SO239 combination (also known as "UHF" connectors) are only fully rated at up to 250MHz. If you need a cheap and simple coaxial connection, the humble TV connector (Belling-Lee connector) is quite suitable for use at frequencies up to 800MHz in systems which exhibit a 75 ohm impedance.

Enclosures

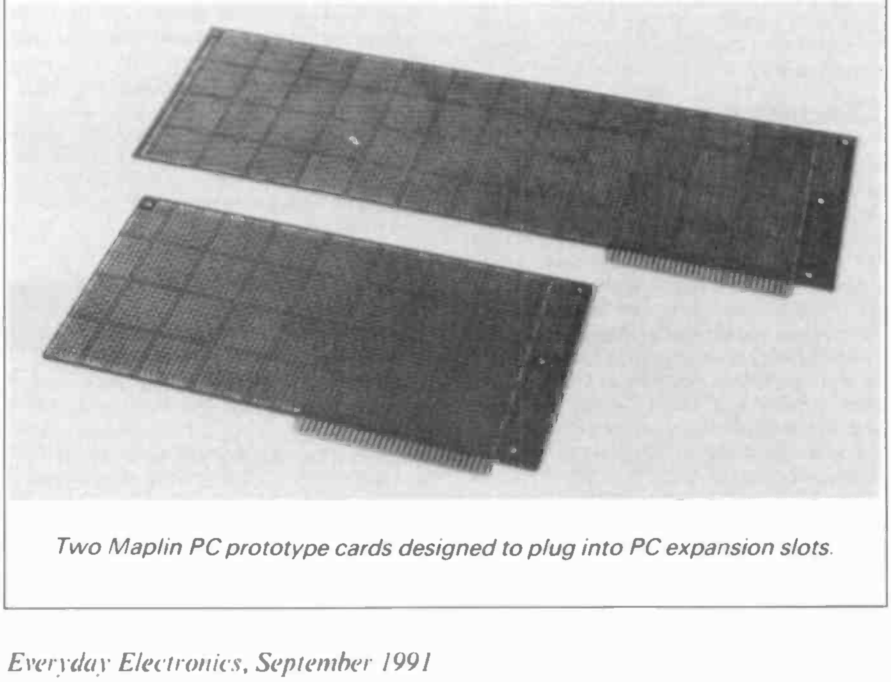
Enclosures not only provide protection for electronics equipment but should also add to its functionality and attractiveness. As with connectors, there are a number of types to consider:

(a) Instrument cases which are ideal for small items of test gear (such as meters) and are available in a variety of styles and sizes. Such enclosures are generally manufactured from plastic (ABS) but may be fitted with metal front and/or rear panels. Larger instrument cases have sufficient size to accommodate power transformers and are thus ideal for building power supplies, amplifiers, etc.

(b) Plastic and diecast boxes. These enclosures comprise a box with removable lid secured by means of four or six screws. Boxes are available in a range of sizes and the diecast types (which are ideal for use in hostile environments) are available both unpainted and with a textured paint finish.

(c) Rack systems designed to accept standard cards (e.g. Eurocards). These are ideal for modular projects but are relatively expensive. Outer cases comprise an aluminium framework fitted with covers which may be fitted with an internal card frame comprising a series of connectors at the rear from which the modules derive their power and by means of which they exchange signals.

Individual circuit cards (which may be stripboard or p.c.b.) are



Two Maplin PC prototype cards designed to plug into PC expansion slots.

fitted to a small supporting chassis and anodised aluminum front panel (available in various widths). The card assembly slides into the rack using appropriately positioned clip-in guides.

(d) Desk consoles represent the most attractive (and probably the most expensive) method of packaging electronic equipment. Desk console enclosures are intended for desktop equipment and generally have sloping surfaces which are designed for mounting keyboards and keypads.

When deciding upon which type of enclosure is required, it is important to consider a number of factors including size, physical construction, ventilation and dimensions of the front panel (which must be sufficient to mount the various controls and indicators required).

In any event, careful consideration should be given to the layout of the controls and indicators. The front panel layout should be logical and controls with related functions should be grouped together and clearly labelled. Consideration should also be given to the type of controls used (e.g. slider versus rotary potentiometers, push-button versus toggle switches, etc).

Furthermore, it is important to connect controls so that their action follows the expected outcome. Rotary "gain" and "volume" controls, for example, should produce an increase in output when turned in a clockwise direction. Indicators should operate with adequate brightness and should be viewable over an appropriate angle.

Indicators and controls should be arranged so that it is possible to ascertain the status of the instrument at a glance. If necessary, a number of opinions should be sought before arriving at a final layout for the front panel; one's own personal preferences are unlikely to coincide exactly with those of the "end user"!

Further projects

Readers who have followed the series this far may now be looking for some further projects to test out their skill as circuit designers. Here are just four ideas for further development:

1. A high current 12V to 13.5V stabilised power supply based on an LM338K (or similar) regulator (see Part 1). Fig. 1.16 could make a starting point.
2. A high-power, high-quality stereo amplifier based on the high quality power amplifier module but modified for a MOSFET output stage. Maplin's MOSFET power amplifier kit (LW51F) should provide you with a few clues!
3. A low-distortion audio signal generator based on the stabilised Wien bridge oscillator shown in Fig. 4.10. The circuit would benefit from a low-power output stage so that it can drive a low impedance load (Fig. 3.19).
4. An improved optical communication system in which pulse-width (rather than amplitude) modulation is employed. A pulse width modulator can be constructed around a 555 timer and the demodulator could feature a 567 phase-locked loop i.c.

Readers' feedback

Many of you have taken the time to write with suggestions and queries based on the series. The following points made by readers are worthy of a wider audience and thus I have included them in this final part.

Coil winding nomograph

Andrew Ross writes from Worcestershire pointing out some discrepancies between the coil data published in Part 7 and that given in the *Radio Designer's Handbook*. Unfortunately, Andrew, the reason for the worrying difference in results when applying the formula in the *Radio Designer's Handbook* and when using the nomograph (Fig. 7.27) are simply due to the fact that I stupidly marked the wire gauges incorrectly! To put the record straight, the following changes should be made to Fig. 7.27:

Existing marking	Corrected marking
26 s.w.g.	46 s.w.g.
24 s.w.g.	40 s.w.g.
22 s.w.g.	34 s.w.g.
20 s.w.g.	26 s.w.g.

I sincerely apologise for any problems this may have caused!

More stripboard layouts

Mr Parkinson writes from South Yorkshire to make a plea for more information concerning stripboards. Mr Parkinson writes:

"I feel that at least some of the projects ought to have been shown laid out on stripboard. It would then have cost less to build the projects, modifications would also have been more easily possible. I am sure that youngsters following the series have to count their coppers before deciding to go ahead with a project, just as I do."

Mr Parkinson has made an interesting point and one which gave rise to a little soul searching when I first put together an outline for the series. I know that beginners do have problems with stripboards (it is probably *easier* to make mistakes when wiring a stripboard layout than with a printed circuit). I can speak with some experience on this point – having spent many frustrating hours trying to help GCSE Electronics students get their projects working only to find that they have missed a single all-important track break!

In any event, perhaps the pointers given in this article will help some of those who do have to work on a restricted budget get their own circuits laid out on stripboards. In fact, I regularly use this form of construction myself!

Oscillator design

Mr F. Clifford writes from South Africa with some interesting information on the design of oscillators. Mr Clifford writes:

"At the start of the war I was working on RC filters and realised that they could form the frequency determining network in oscillators. I used a small electric light bulb for the amplitude stabiliser and a Vien network somewhat similar to that shown by Mr Tooley. I took out UK patents on this oscillator around 1944 when I was less busy and showed that equal values for the capacitors and resistors, as shown in Mr Tooley's Figs. 4.8, 4.9 and 4.10, do not provide the best frequency stability.

The frequency stability of RC oscillators is not as good as LC types because the operating Q value is much lower thus increasing the level of the fed-back harmonics. In the case of single circuit L-C oscillators and RC types these signals are shifted by nearly 90 degrees relative to the fundamental which is the worst case for frequency stability. I have taken out UK patents on LC oscillators that avoid this trouble.

The parallel T networks shown in Figs. 4.11 and 4.12 are equivalent to what we call a full Vien network where R1 and R2 in Fig. 4.8 are replaced by R in parallel with C and R in series with C respectively. With the values shown in Fig. 4.12, no oscillation can occur and, with respect, I suggest that it would have been better to have omitted the component labelling.

It would appear that there are errors in the values of the components shown in Fig. 4.13 and the transistor is saturated. Thus R1 and R2 should be around 470k and not 47k and the other components amended suitably.

We usually use the parallel T network in the negative feedback path of the maintaining amplifier and arrange for the positive feedback to be applied through an amplitude stabiliser, a simple matter if an operational amplifier is used."

Thank you Mr Clifford for making these interesting points and for throwing some light on the history of the twin-T and Wien (Vien) oscillators. In my defence, I must say that I have not found the twin-T oscillator to be particularly critical concerning component values although I would certainly agree with the points which Mr Clifford makes concerning stability.

That said, the circuit of Fig. 4.13 certainly *does* work! The transistor is not saturated (despite the relatively low value of R1 and R2 resistors – perhaps all my BC109 transistors exhibit unusually low current gain?).

It should be noted that the values of C1 to C4 in the module have been all made equal in order to assist readers in obtaining the necessary components and, in fact, C3 and C4 in series result in a somewhat different set of conditions when compared with those in Fig. 4.12 (in which the shunt element is 2C). I am not sure whether any other reader has experienced difficulties with this circuit but I have not, as yet, received anything to indicate that this circuit is not functional!

Audio circuits reference

Stan Taylor writes from Birmingham to ask for some suggestions and further circuits. Like many readers, Stan is involved with designing audio amplifiers and preamplifiers and is keen to further develop some of the circuits provided in Part 3 of the series. One of the best all-round reference books is Ian Sinclair's *Audio Electronics Reference Book* (BSP Professional Books ISBN 0-632-01929-8) and this would be well worth acquiring, or borrowing from your local library.

Assessment test

The following multiple choice assessment test has been designed for readers who may, at the conclusion of our series, welcome the opportunity to assess their understanding of the series as a whole. The test comprises twenty multiple-choice questions (note that there is only one correct answer to each question):

ASSESSMENT TEST

1. A low-voltage d.c. power supply is to provide an output of 1A at 20V. Which one of the following rectifier specifications is most appropriate for use in this application?

	Maximum forward current I_{FM}	Maximum reverse voltage V_{RRM}
(a)	0.5A	50V
(b)	1.0A	50V
(c)	2.0A	100V
(d)	4.0A	200V

2. A power supply has to provide positive and negative power rails rated at +12V, 0.75A and −12V, 0.75A. Which one of the following regulator types is most appropriate?

(a) 7805 and 7905
(b) 7812 and 7912
(c) 2 × LM723
(d) 2 × L200

3. The purpose of a crow-bar circuit in a power supply is to:

(a) limit the input voltage to a safe value
(b) limit the input current to a safe value
(c) limit the output voltage to a safe value
(d) limit the output current to a safe value.

4. A typical value for the output impedance of a bench power supply is:

(a) 0.1 ohm
(b) 10 ohm
(c) 1kilohm
(d) 100kilohm.

5. Which one of the following transistor amplifier configurations provides high voltage gain coupled with a low input impedance?

(a) common base
(b) common collector
(c) common emitter
(d) emitter follower.

6. Which one of the following refers to the properties of an operational amplifier?

(a) very low input impedance and very low voltage gain
(b) very low input impedance and very high voltage gain
(c) very high input impedance and very low voltage gain
(d) very high input impedance and very high voltage gain.

7. An amplifier has a large amount of negative feedback applied. Which one of the following statements is correct?

(a) Its gain and bandwidth will both be reduced
(b) Its gain will be increased and its bandwidth reduced
(c) Its gain will be reduced and its bandwidth increased
(d) Its gain and bandwith will both be increased.

8. Non-linearity at the zero-axis crossing point in a power amplifier results in:

(a) noise
(b) instability
(c) low gain
(d) cross-over distortion.

9. One of the principal advantages of MOSFET power transistors for use in the output stages of an audio amplifier is:

(a) immunity from thermal runaway
(b) negligible supply current required
(c) ability to work without a driver stage
(d) complete freedom from distortion and instability.

10. The high frequency response of an inverting operational amplifier stage can easily be "rolled off" by connecting a capacitor of appropriate value:

(a) in series with the inverting input
(b) in series with the non-inverting input
(c) between the output and inverting input
(d) between the output and non-inverting input.

11. The output of an single operational amplifier supplied in an 8-pin dual-in-line package is usually:

(a) pin-1
(b) pin-2
(c) pin-3
(d) pin-6

12. The output from the collector of a blocking oscillator comprises:

(a) a sine wave
(b) a triangle wave
(c) a train of pulses
(d) a positive going ramp.

13. The output frequency of a C-R ladder oscillator is:

(a) directly proportional to the ratio, C/R
(b) inversely proportional to the ratio, C/R
(c) directly proportional to the product of C and R
(d) inversely proportional to the product of C and R.

14. The output of a two-input NAND gate is only a logic 0 when:

(a) both inputs are logic 0
(b) both inputs are logic 1
(c) input A is at logic 1 and input B is at logic 0
(d) input A is at logic 0 and input B is at logic 1.

15. The normal supply voltage range for a TTL gate is in the range:

(a) 3V to 15V
(b) 5V to 15V
(c) 9V to 12V
(d) 4.75V to 5.25V.

16. The typical value of high state source current from the output of a standard TTL logic gate is:

(a) 40µA
(b) 1.6mA
(c) 4mA
(d) 16mA

17. An integrated circuit is marked "4069BE". The device is:

(a) a standard TTL device
(b) a buffered TTL device
(c) a standard CMOS device
(d) a buffered CMOS device.

18. The monostable output period of a 555 timer with timing components C and R is:

(a) directly proportional to the ratio, C/R
(b) inversely proportional to the ratio, C/R
(c) directly proportional to the product of C and R
(d) inversely proportional to the product of C and R.

19. The normal intermediate frequency (i.f.) for an a.m. receiver is in the range:

(a) 150 to 170kHz
(b) 450 to 470kHz
(c) 550 to 570kHz
(d) 950 to 970kHz.

20. The typical gate trigger voltage for a thyristor is in the range:

(a) 0.5V to 1.5V
(b) 1.5V to 3V
(c) 3V to 5V
(d) 5V to 18V

Answers are given on the next page

Scores:

If you scored 16 or more, you are already well on the way to designing your own circuits! A score of 11 to 15 indicates that you already have a good grasp of many of the principles of electronics but there may be a few gaps in your knowledge worth "brushing-up" on. If you scored 10, or less, then it would be worth checking your answers against the relevant parts of our series. You should find all of the answers and underlying theory in the text.

Further Reading

For those readers who would welcome the opportunity of following the series up (and for whom a conventional course of study at a Further Education college may not be feasible), the following books are recommended as the basis for further reading and experimentation:

Analog Electronics, by Ian Hickman, Heinemann Newnes, ISBN 0-434-90723-5. This is an excellent book for those wishing to specialise in the design and development of analogue circuits. The book contains a wealth of practical tips (including a chapter entitled "Tricks of the Trade") and has a series of very useful appendices.

Logic Designer's Handbook by E. A. Parr, BSP Professional Books, ISBN 0-632-02024-5. This is an invaluable book for anyone concerned with the design of digital circuits. The book develops several of the topics which have been introduced in this series. Highly recommended.

The Art of Electronics, by Horowitz and Hill, Cambridge University Press. This book must be considered essential reading for anyone involved with electronics at any level! The book is probably the most comprehensive source book of electronic design theory available.

The Maplin Electronic Circuits Handbook, Mike Tooley, Butterworth-Heinemann, provides an inexpensive introduction to electronic circuits and further develops many of the themes introduced within this series. Sections are included on Computer Interfacing, Test Equipment, Soldering and De-soldering and a variety of practical projects (supported by kits and printed circuit boards available from Maplin Electronics) are included.

In conclusion

This ten part series has aimed to provide readers with a broad introduction to electronic circuit design. If you have followed the series over the past ten months, or so, then I sincerely hope that you have found it useful and that you have already embarked on "designing your own circuits".

Finally, I would like to extend sincere thanks to all those readers, too numerous to mention, who have written (or telephoned!) with comments, suggestions and advice. Please forgive me if you have not always received a written reply to your letters – hopefully I have, by now, covered all of the points which you have raised.

Answer to last month's design problem:

An automatic porch light is to operate up to 300W of mains lighting whenever the ambient light level falls below a pre-set threshold point. Devise a suitable circuit arrangement based on an LDR and solid-state relay.

One solution to last month's design problem is shown in Fig. 10.1.

Test Answers

1. c	11. d
2. b	12. c
3. c	13. d
4. a	14. b
5. a	15. d
6. d	16. a
7. c	17. d
8. d	18. c
9. a	19. b
10. c	20. b

Index to modules

For the benefit of those readers who may only recently have discovered our series, the following list briefly describes the modules which have been described (each module is provided with a full component list and printed circuit board):

Title	Part	Function/specification
Dual output power supply module	1	Dual ±5V, ±12V or ±15V regulated power supply rated at 1A max. output
723 variable power supply module	1	Single variable output of +2V to +37V at up to 5A max. Output voltage and current limit are set by means of preset controls.
L200 variable power supply module	1	Single variable output of +2.7V to +35V at up to 2A max. Inutput voltage and current limit are set by means of variable controls.
General purpose transistor amplifier module	2	Pre-defined voltage gain and frequency response. Low/medium input impedance, low output impedance. Requires a single 9V d.c. supply at 2mA nominal.
General purpose operational amplifier module	2	Pre-defined voltage gain and frequency response. Two stages may be used independently (e.g. for stereo operation) or connected in tandem. Requires a dual supply of between ±5V and ±15V at 10mA nominal.
High-quality power amplifier module	3	Fixed gain medium/high power class AB audio amplifier capable of operating with very low distortion. Recommended load impedance 8ohm. Requires a dual supply of between ±12V and ±20V at up to 2A.
TBA820 i.c. amplifier	3	Versatile i.c. low/medium power for general purpose applications. Requires a single supply rail of between +5V and +15V.
Sine wave oscillator	4	Low distortion sine wave oscillator capable of providing outputs over the range 50Hz to 50kHz. Frequency and amplitude adjustable. Requires +12V to +15V supply at 10mA (nominal).
8038 waveform generator	4	Provides sine, square and triangle outputs adjustable the range 0.01Hz to 20kHz. Requires ±9V supply at 10mA.
Digital counter module	5	Single stage decade counter with seven-segment l.e.d. display. Standard TTL input levels. Requires +5V supply at 90mA.
General purpose timer module	6	Astable or monostable mode timer circuit configured by wire links. Extenal trigger (both a.c. and d.c.) and reset inputs. Output up to 12V at 200mA. Requires a single supply rail of between +5V and +15V.
RF amplifier module	7	High gain r.f. amplifier module which can be used in a variety of applications, including receivers (both TRF and superhet) and test equipment. Requires a single supply rail of +9V.
Solid-State switch module	8	Solid-state switch capable of controlling a.c. mains loads rated at 240V 1kW maximum. The switch operates from an input of less than 100μA and requires a supply of between 5V and 24V.
Light sensitive switch module	9	Light sensitive switch capable of controlling loads rated at up to 280W at 28V d.c. or 1.2kVA at 240V a.c. The circuit may be configured for operation on either increasing or decreasing light levels. Requires a supply of between 10V and 15V and requires 1mA (standby), 60mA (operating) when operating from a 12V supply.

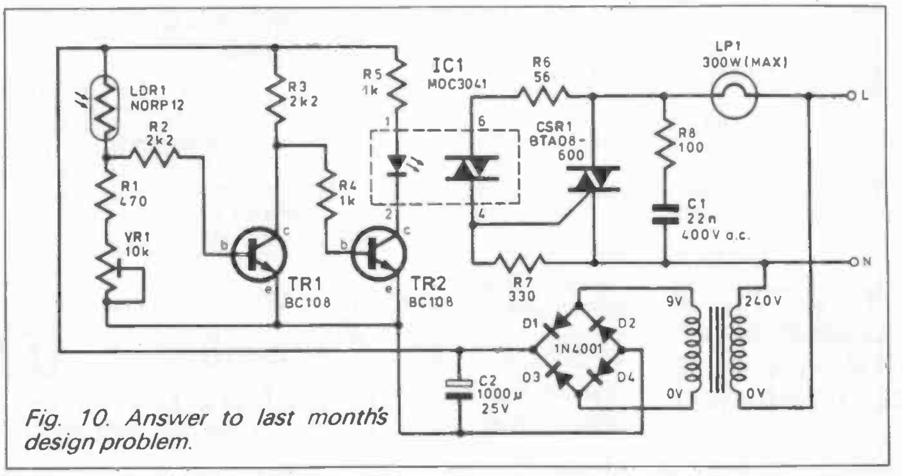


Fig. 10. Answer to last month's design problem.

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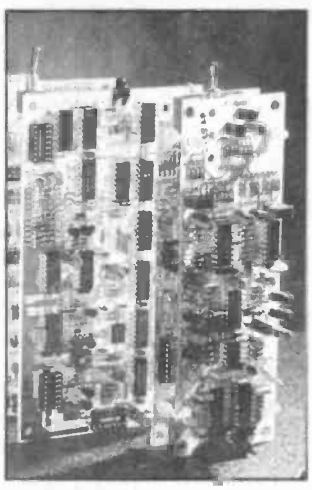

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12V LAMP DIMMER

T. R. de VAUX-BALBIRNIE

A touch of luxury for caravans and boats. Controls up to 20W of filament lamp lighting.

THE DIMMER circuit described here serves the same purpose for low-voltage lighting as the familiar mains dimmer switch used at home. It may thus be used for dimming filament lamps used in caravan table and bunk lights operating from a 12V d.c. (car battery) supply. Bulbs up to 20W rating may be used (for example 2 off 10W bunk lights connected in parallel) but note that this circuit is NOT suitable for dimming *fluorescent* lights.

The unit is built in a small aluminium case with the brightness control knob mounted on the end panel. The on-off switch is part of the brightness control so that the unit switches on when the knob is moved from its rest position. Alternatively, a separate on-off switch could be used.

The unit may be mounted "in-line" which would be appropriate to table lamps, or built into a cupboard with only the control knob showing. This method would be suitable for bunk lights. Although the main purpose of the circuit is to provide a touch of luxury to caravan and boat lights, there is also a bonus in terms of energy saving.

HOW IT WORKS

Although the 12V Lamp Dimmer behaves like a dimmer switch used for mains lighting, the circuit is very different. This is because household dimmer switches use a high-voltage a.c. (alternating current) supply while the present one operates from a low-voltage d.c. (direct current) source.

The most obvious way of dimming a lamp is to connect it in series with a battery and variable resistor (potentiometer), see Fig.1. With the sliding contact (w) at the bottom of the track (Fig.1a) the variable resistor presents virtually no resistance to the circuit and the lamp operates at full brightness. When the sliding contact is at the top of the track (Fig.1b) the variable resistor has maximum resistance and the lamp will then operate at minimum brightness.

Intermediate positions of the sliding contact would provide varying degrees of brightness. When used in this way, a variable resistor is often called a rheostat.

Although this idea is sometimes used for dimming car dashboard lights and was used until fairly recently for dimming high-power stage lighting, it is a poor method. This is because the variable resistor becomes hot in operation and not only does this waste power, but the heat must be dissipated into the air without doing any harm. Old stage lighting hands often tell stories of frying eggs on the dimmer casings.

The 12V Lamp Dimmer circuit operates instead by switching the supply to the bulb on and off rapidly. By using a frequency faster than the human eye can follow, the lamp does not appear to flicker.

By adjusting the ratio of "off" to "on" times, the degree of dimming may be controlled. Thus, if the supply is on nearly all the time, the lamp will appear at full brightness and when off for most of the time it will be very dim. The advantage of using this method is that little power is wasted and the excess heat which is produced is easily removed.

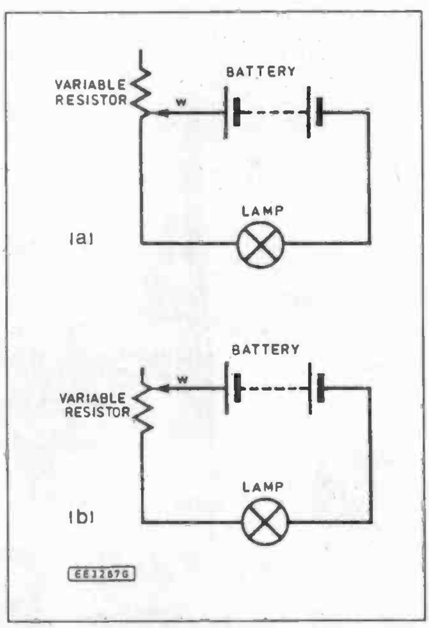


Fig. 1(a). Sliding contact (w) bottom of track (low resistance) – full brightness and (b) top of track (high resistance) minimum brightness.

CIRCUIT DESCRIPTION

The full circuit diagram for the 12V Lamp Dimmer is shown in Fig.2. IC1 is a 555 timer integrated circuit which is connected here as an astable multivibrator.

With double-pole switch S1 on, a supply is established from the 12V battery, B1, through fuse, FS1, to the rest of the circuit. The purpose of capacitors C3, C4 and radio-frequency choke, L1 will be explained later.

With power supplied, IC1 output, pin 3 switches repeatedly between high and low states (that is, it switches on and off) at a rate dependent on the values of fixed resistors R3 and R2, potentiometer VR2 and capacitor, C1 (R1 and VR1 may be ignored for the moment). Additionally, and more importantly, the ratio of "on" to "off" time (called the mark to space ratio), varies with the adjustment of VR2.

With the values specified, the mark to space ratio varies between approximately 100:1 (on for 100 times longer than it is off) and 1:20 (off for 20 times longer than it is on). In the first case the lamp appears at near full brightness while in the second, it is practically off. At the same time, the frequency varies between 250Hz and 1.5kHz approximately — this is high enough for the light to be flicker free.

These figures were obtained by taking oscilloscope measurements on the prototype unit and are only approximate. They will also vary to some extent from one unit to another due to component tolerances.

TRANSISTOR DRIVER

The output from IC1 is insufficient to operate a filament lamp direct so transistor TR1 acts as an amplifier for this purpose. TR1 is actually a Darlington device and is normally used in audio applications. A Darlington is really two transistors in one case and has an exceptionally high current gain.

The transistor drive current flows from IC1 pin 3 through current-limiting resistor, R4, to the base of TR1. The transistor, hence the lamp LP1 connected in its collector (c) circuit, therefore switches on and off in sympathy with IC1 output.

In operation, there will always be a small voltage appearing between TR1 collector and emitter — approximately 0.7V to 1V and this is "lost" as far as the lamp is concerned. However, there will be some heat produced by TR1 and this will make it warm especially when operating a lamp of the maximum specified power at full brightness. For this reason, the 12V Lamp Dimmer is built in an aluminium box which then acts as a heatsink. It also helps in reducing radio-frequency interference — see later.

Diode, D1, increases the range of mark to space ratio provided by IC1. Without this, the output would be limited to a 1:1 ratio approximately — that is, equal on an off times and this would provide only moderate dimming.

The purpose of preset VR1 is to set the minimum brightness required — this component, in combination with R1, effectively reduces the value of VR2 by an amount dependent on VR1 adjustment. This adjustment will be made at the testing stage.

INTERFERENCE

It is a consequence of the rapid switching action of this type of circuit that some radio-frequency interference (r.f.i.) will be produced. This will be heard as clicking or whining sounds from a radio operating nearby — the frequency will vary as VR2 is adjusted.

Tests on the prototype show that r.f.i. is only evident if the radio is tuned to a weak station on the long or medium waveband and is placed very close to the unit or to some of the wiring. There is no effect on f.m. radio or to TV reception.

COMPONENTS

See SHOP TALK Page

Resistors
- R1 1M
- R2 10k
- R3 47k
- R4 2k2
- All 0.25W 5%. carbon film

Potentiometers
- VR1 4M7 miniature preset, horizontal
- VR2 470k rotary carbon (lin.), with switch

Capacitors
- C1 10n polystyrene
- C2 10n ceramic
- C3, C4 2µ2 polyester (2 off)

Semiconductors
- D1 1N4001 50V 1A rectifier diode
- TR1 TIP120 *npn* power Darlington
- IC1 555 bipolar timer

Miscellaneous
- L1 Radio-frequency choke — preferably toroidal construction (see text). 150µH minimum
- FS1 3A 20mm fuse and chassis fuseholder
- TB1 3A 4-way terminal block
- S1 DPST switch, part of VR2

Stripboard 0.1in matrix, size 9 strips x 21 holes; aluminium case, size 102mm x 70mm x 38mm; plastic control knob for VR1; 3A minimum auto-type wire; multi-strand connecting wire; stand-off insulators (2 off); TO220 mounting kit for TR1; nut, bolts and washers; solder etc.

Approx cost guidance only **£12**

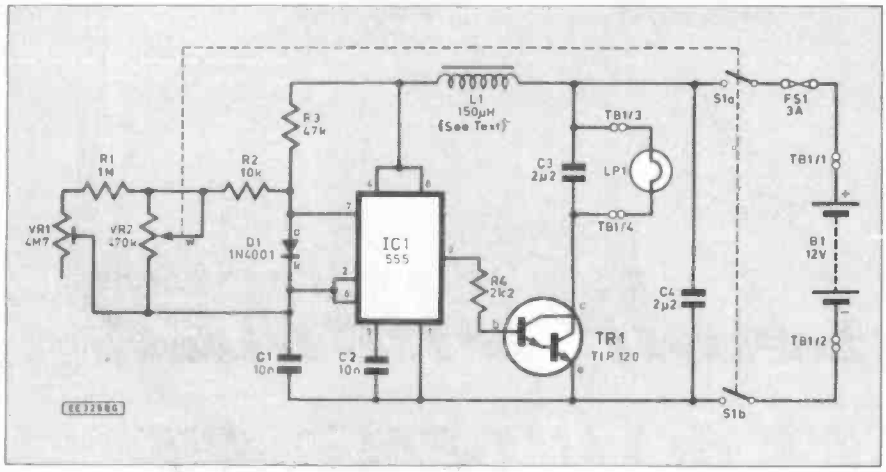


Fig. 2. Complete circuit diagram for the 12V Lamp Dimmer.

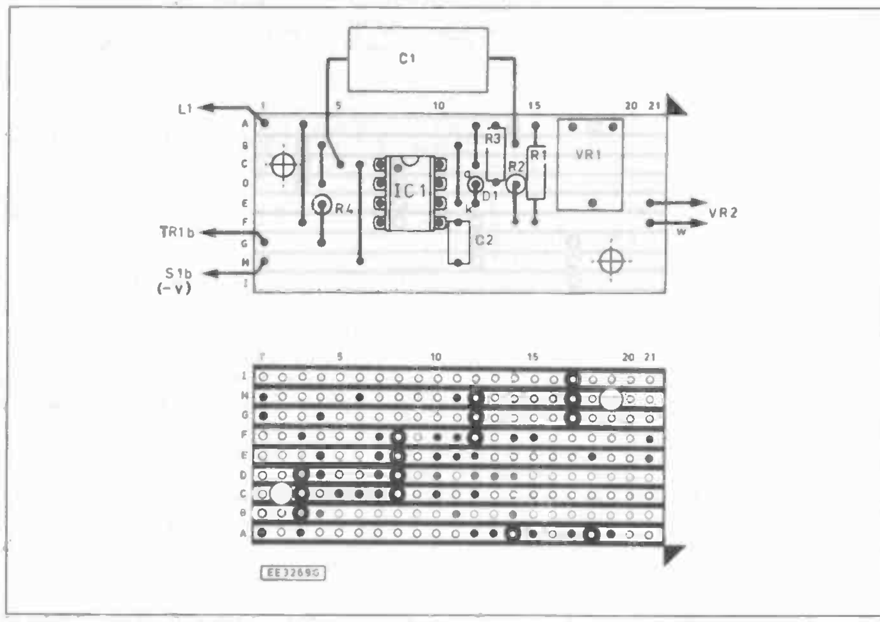
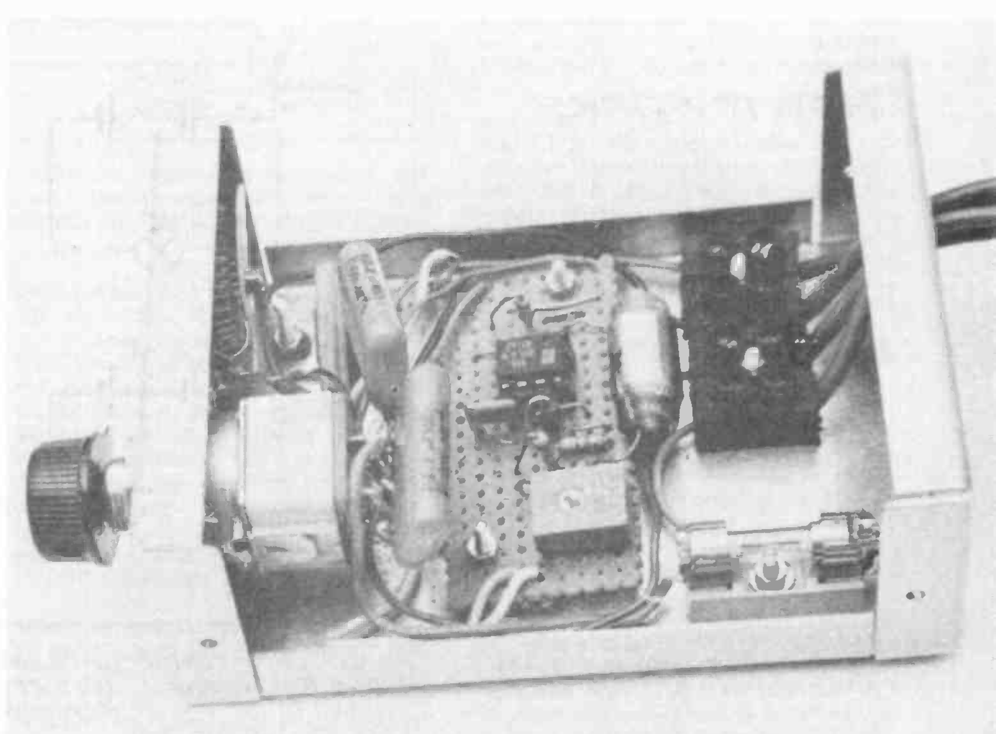
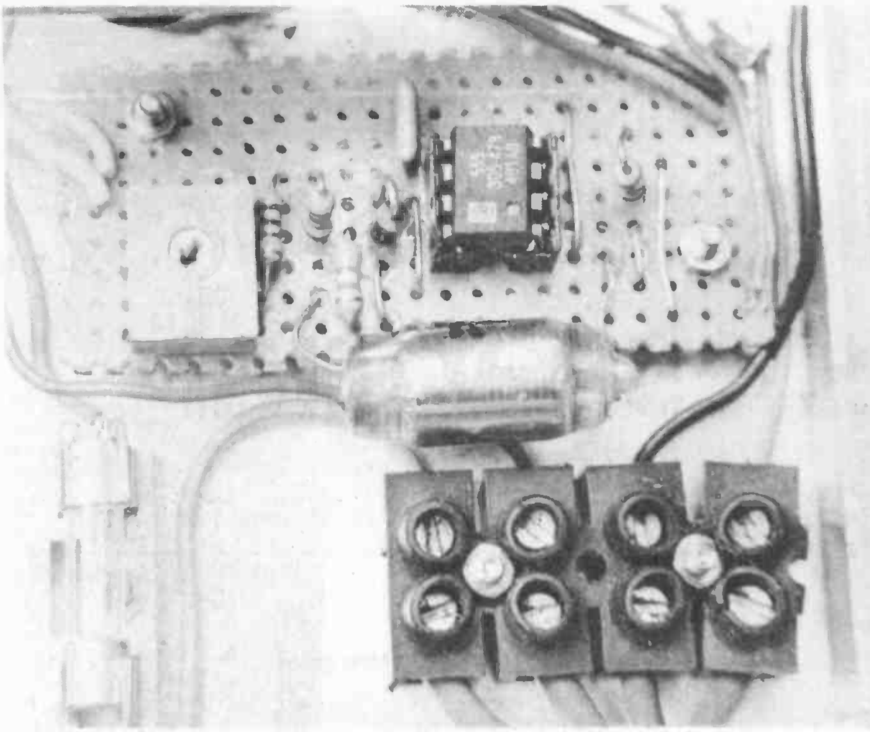


Fig. 3. Stripboard component layout and details of breaks required in the underside copper tracks. The mounting of components inside the metal case is shown below.





The completed circuit board showing wiring to the 4-way terminal block and the fuseholder bolted to the base of the case.

will also need to drill a hole for the separate toggle or rocker switch.

Mount these components with the circuit panel placed on short stand-off insulators to keep the copper strips 3mm clear of the metalwork. Note that transistor TR1 requires a mounting kit consisting of a thin mica washer and a plastic bush (see Fig.5) to isolate it from the case.

Press the rubber grommets into the holes drilled for the input and output wires then, referring to Fig.4, mount the remaining components and complete all wiring. Fit the control knob to VR2 spindle. The on-off switch can be made to operate the circuit so that the lamp comes on at either minimum or maximum brightness depending on the sense of VR2 outer connections.

Adjust preset VR1 sliding contact to approximately mid-track position. Insert IC1 and fuse into their holders taking care over the orientation of IC1. Check that the link wire at matrix position *A3/F3* is clear of the nearby fixing.

INSTALLATION AND TESTING

***Important:** To avoid short circuits, disconnect and remove the 12V battery before proceeding to test the finished unit.*

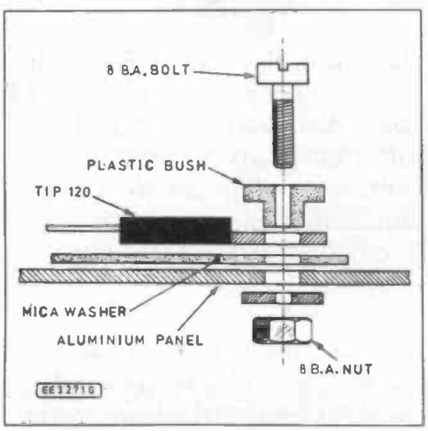


Fig. 5. Method of mounting the transistor in the case is accomplished by using an insulating mounting kit. The transistor is mounted on the base of the case.

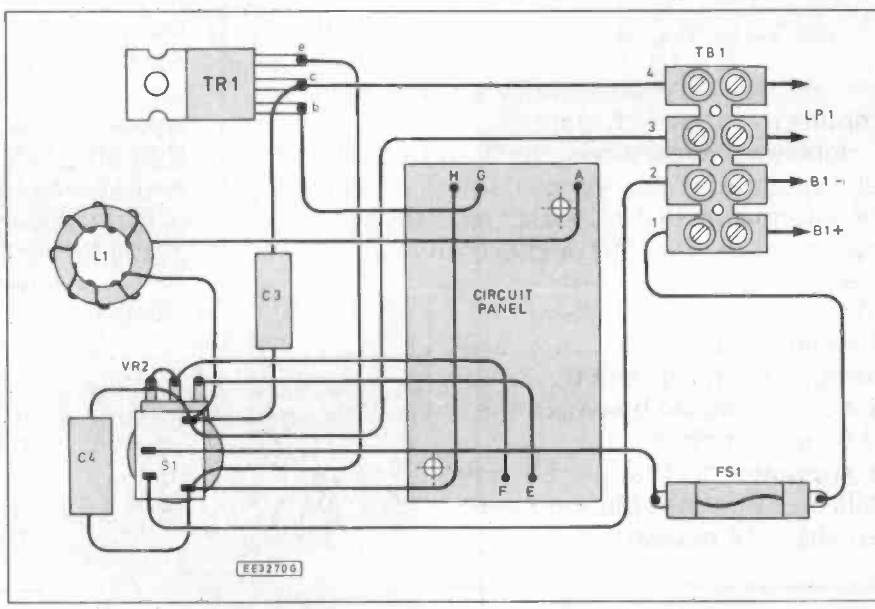


Fig. 4. Interwiring between the circuit board and all off-board components. Note that the radio interference choke L1 is bolted on the same side panel as the On-Off switch/Brightness control – see photograph on previous page. The choke is wound on a ferrite ring.

Capacitors C3 and C4 in conjunction with the radio-frequency choke, L1, are suppression components which help to reduce r.f.i. To save costs, it would be possible to make L1 instead of using a ready-made component. To do this, wind 50 turns of 20s.w.g. enamelled copper wire on to a short piece of ferrite rod or, better, a ferrite ring.

CONSTRUCTION

The prototype 12V Lamp Dimmer was based on a circuit panel made from a piece of 0.1in. matrix stripboard, size 9 strips x 21 holes. Details of component layout, breaks required in the underside copper tracks and inter-strip link wires is shown in Fig.3.

Begin by cutting the material to size, drilling the two mounting holes and making the track breaks and links as indicated. Solder into position all on-board components taking care over the polarity of diode D1. Note that capacitors C3, C4 and choke L1 are mounted separately off-board. Solder 8cm pieces of light-duty stranded connecting wire to copper strips *A*, *G* and *H* on the left-hand edge and to strips *E* and *F* on the right-hand edge of the circuit panel.

Cut the spindle of potentiometer VR2 to a length of 8mm approximately (or longer if the box is to be mounted behind a wooden panel). To do this, grip the spindle — not the potentiometer body — in a vice and, supporting the body, cut the spindle using a small hacksaw. Smooth the end and check that the control knob fits correctly. Drill a hole in the end panel of the box and mount VR2 — see photograph.

Drill holes for the rubber grommets used for the input and output wires to pass through also for transistor TR1, terminal block TB1, fuseholder (FS1), r.f. choke (L1) and circuit panel mounting. If using a non-switched potentiometer you

Connect the supply wires to the terminal block at points TB1/1 (positive) and TB1/2 (negative). Connect the lamp wires to TB1/3 and TB1/4 (polarity unimportant).

For all external connections use auto-type stranded wire of 3A rating minimum. Any switch already present in the lamp should be simply bypassed. Note that both lampholder connections MUST be *isolated from ANY metalwork* which connects to supply negative (vehicle chassis) Connect the supply and rotate VR2 control knob — the brightness of the lamp should vary smoothly. Adjust VR2 for least brightness then adjust preset VR1 to give the desired minimum brightness.

After a check for r.f.i. and any final adjustments have been made, the 12V Lamp Dimmer may be put into service. □

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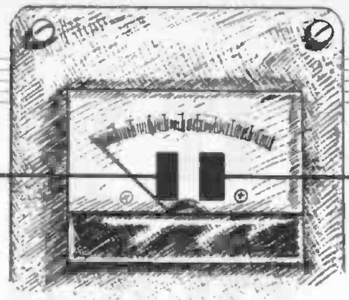
Constructional Project



LOW-COST CAPACITANCE METER

STEVE KNIGHT

A simple and inexpensive piece of test gear that can prove invaluable to the hobbyist

THERE are a great variety of ways in which capacitance can be measured. Many of these are sophisticated pieces of laboratory equipment and very expensive and as a consequence can find no home on the work benches of us project builders, experimenters and downright dabblers, who just like messing about with electronic gadgetry but have to keep a sharp eye on the finances.

This little piece of test gear enables the values of capacitors from about 10p up to 1µ to be measured in five decade ranges and, apart from the meter (which may be one you already have in the shape of an Avometer or any of the popular multimeters now available), will cost no more than about a tenner. Even for something which isn't going to be used "all the time", this outlay is not likely to prove a hardship.

USES

Now it may well be that you might think the capacitance range of 10p to 1µ is a bit restrictive, but if you think about things associated with home project building, most of the capacitors used in the majority of circuits outside of the power supply sections fall within this range. Go through your store of capacitors or look up the circuits described every month in *Everyday Electronics* and see if this isn't the case.

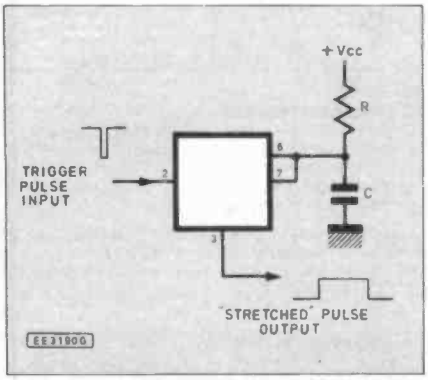


Fig. 1. The 555 used in monostable mode.

Often these capacitors get used a number of times in experiments and they tend to gather in what used to be called the "junk box" (perhaps it still is) for future use, very often finishing up with the original markings rubbed off or with no means of checking their values or indeed their actual condition. A lot of manufacturers' surplus capacitors which are sold in cheap lots are often unmarked, out of tolerance, or coded in some unreadable form. A simple checker such as this project is, is a good investment.

The project gives a direct and steady reading of the capacitance value on an analogue 1mA panel meter (which may be an appropriately switched multimeter), with no adjustments except a meter zero control which is only needed on the lower range in any case. It operates from a 9V battery supply, although if you feel enthusiastic enough, a simple mains power supply will be described later, and it fits into an ABS plastic case measuring 150mm by 80mm by 50 mm.

PRINCIPLE OF OPERATION

The instrument works on the principle that the output pulse of a monostable or one-shot multivibrator depends upon the values of the resistance and capacitance used in its feedback coupling path. Multivibrators can be easily constructed using a couple of discrete transistors, but the popular 555 integrated circuit is a much superior system where everything is already taken care of and where the monostable, bistable and astable forms of the multivibrator are available by simple external variations in resistance and capacitance feedback values.

The monostable mode of the 555 is shown in Fig. 1, where only the relevant pin numbers and components are indicated. Initially, the external capacitor *C* is kept in a discharged state by the internal circuitry and the output at pin 3 is low.

A short negative-going trigger pulse applied to the input at pin 2 enables the capacitor to start charging up by way of resistor *R*. The voltage across *C* then rises exponentially with a time constant *CR* as current flows into it through *R*, and the output at pin 3 simultaneously goes high and remains high all the time the charge is going on.

When the voltage across *C* reaches a predetermined level (two-thirds of the applied Vcc), the capacitor is abruptly discharged and the output returns to its original low state. The related waveforms for this sequence of events is shown in Fig. 2, hence for each input trigger pulse, the output is an extended or "stretched" pulse

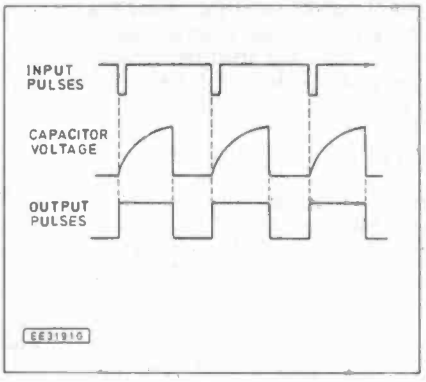


Fig. 2. Waveform sequence for the monostable circuit.

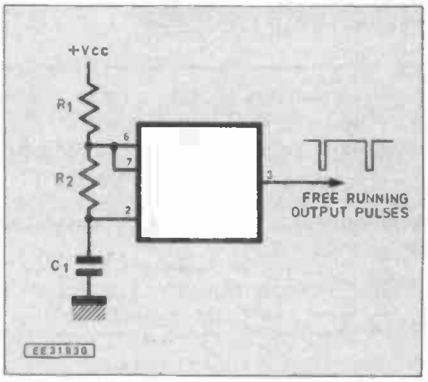


Fig. 4. The 555 timer used in the astable or free running mode.

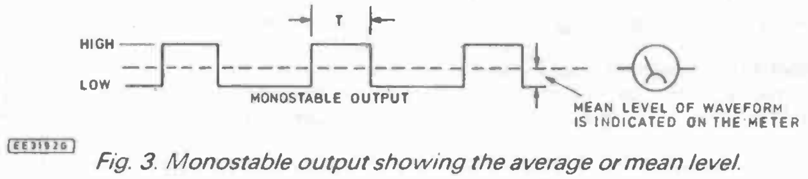


Fig. 3. Monostable output showing the average or mean level.

whose duration depends solely upon the values of external components *C* and *R*.

Since the duration of this pulse can be expressed by the simple formula $T = 1{\cdot}1CR$, then for a fixed value of *R*, the time *T* is a direct function of the value of *C*; if *C* is halved, for example, *T* is halved, and so on. For a continuous series of output pulses, therefore, if these drive current through a milliammeter, the meter will indicate the mean or average value of the resultant current flowing through it, and this reading will, in turn, be directly proportional to the pulse length and hence proportional to the value of capacitor *C*, see Fig. 3.

TRIGGER PULSES

So much for the principle of measurement; what we want now is a train of trigger pulses at the input of the monostable. We can get these from another 555 connected in astable or free-running mode. This time the connections are made as shown in Fig. 4, where the values of R1, R2 and C1 determine the pulse duration and its repetition rate.

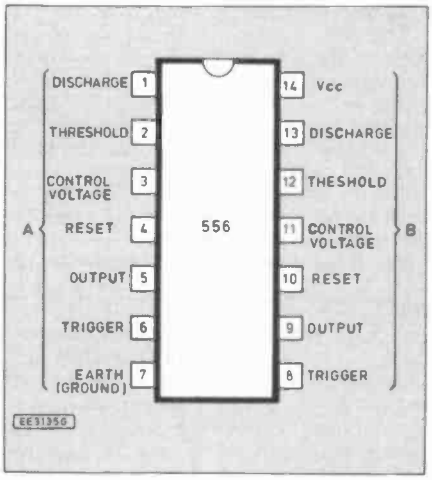


Fig. 5. Pin connections for the 556 i.c. showing the two individual timers.

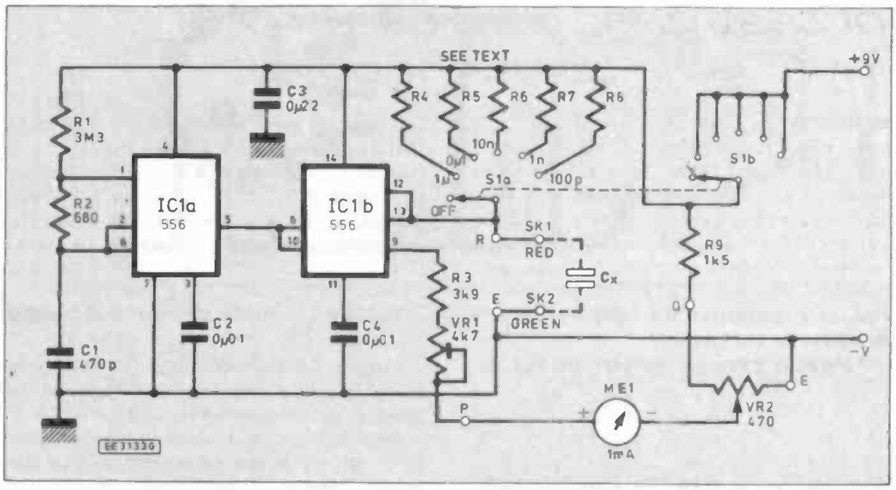


Fig. 6. Complete circuit diagram for the Low-cost Capacitance Meter. The lettered circles indicate connections to off-board components.

The triggers need to be of very short duration; they cannot be greater in duration than the stretched pulses from the monostable, and as these pulses will themselves be very short for small values of test capacitance *C*, the trigger must be as short as we can practically make it consistent with reliable operation of the astable. By making R1 = 3M3, R2 = 680 and C1 = 470p, a pulse width of about 200ns is secured with a spacing of about 950µs. These are measured values which differ slightly from the theoretical values, as is to expected.

By connecting the two forms of multivibrator in series, therefore, and measuring the mean current through a meter connected to the output of the monostable, a direct measurement of test capacitor values can be made.

CIRCUIT

To make a more compact assembly, the two 555 i.c's mentioned in the operating principles above are replaced by the 556, which contains two independent 555's in one 14-pin d.i.l. package but with common supply voltage rails. Those constructors who might wish to use separate 555's may, of course, do so, but the printed board layout shown later caters for the single 556. The connection diagram for this i.c. is given in Fig. 5 which shows how the two timers are separated along each line of pins.

The current consumption of the circuit using a standard 556 is about 14mA, but this chip is available (as is the 555) in a low power version and for battery operation this gives an edge over the standard version. I have not tried the circuit with the low power chip but I imagine it would reduce the current consumption to something below 10mA.

The full circuit diagram is given in Fig. 6; the pin numbers here apply of course to the 556 package. All components, with the exception of the Set Zero control VR2, the meter ME1 and the test terminals SK1, SK2, are mounted on the board.

The Range switch S1, which is a miniature Lorlin 2-pole, 6-way type, is mounted directly on the board. This arrangement is preferable to having the switch connected to the board by hard wiring as it helps to keep the stray capacitances associated with the circuit at a minimum.

The range resistors R4 to R8 are all one per cent tolerance, these now being readily available from most outlets. There is a chance that a one per cent 10M for R8 may be more difficult to obtain; if so, use a five per cent, though if you can lay your hands on a closer tolerance, use it. None of the other resistor values is critical. An i.c. holder is recommended for the 556.

COMPONENTS

See SHOP TALK Page

Resistors

R1	3M3
R2	680
R3	3k9
R4	1k ± 1%
R5	10k ± 1%
R6	100k ± 1%
R7	1M ± 1%
R8	10M ± 1%
R9	1k5

All 0.25W 5% carbon, except where indicated

Potentiometers

VR1	4k7 min. preset (horizontal)
VR2	470 linear carbon

Capacitors

C1	470p polystyrene
C2, C4	10n min. ceramic (2 off)
C3	0µ22 min. ceramic

Semiconductors

IC1	556 dual timer

Miscellaneous

ME1	1mA f.s.d. moving coil meter
S1	2-pole 6-way min. rotary switch

Case, ABS plastic 150x80x50mm; p.c.b. available from the EE PCB Service, order code EE751; 14-pin d.i.l. socket; control knobs (2 off); socket/terminals (2 off); connecting wire; solder; PP3 battery or similar.

Approx cost guidance only **£12** *excl. meter*

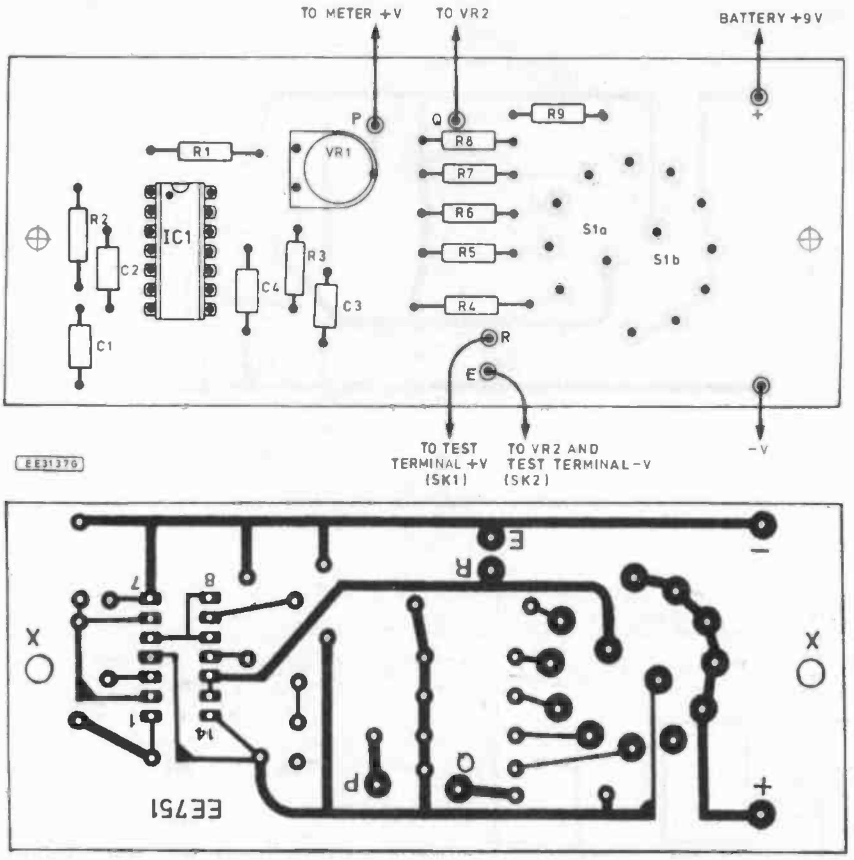


Fig. 7. Printed circuit board component layout and full size copper foil master pattern.

CONSTRUCTION

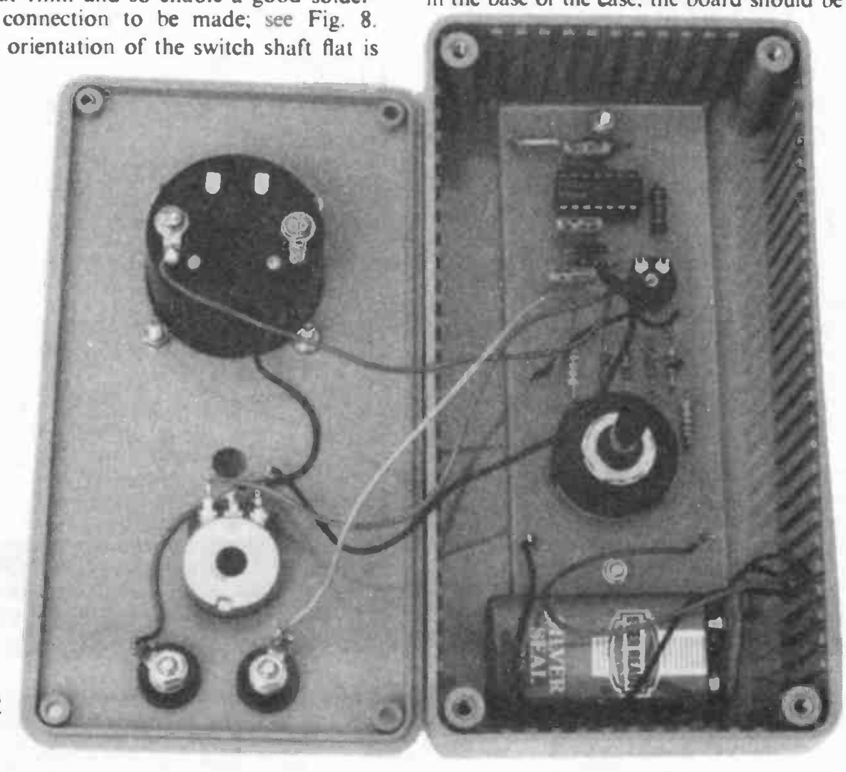
The Low-Cost Capacitance Meter is built on a small printed circuit, including the range switch pads. The component layout and full size copper foil master pattern is shown in Fig. 7. This board is available from the *EE PCB Service*, code EE751.

Stick to all the usual precautions when soldering your components to the board as shown in Fig. 7, especially to those pads associated with the i.c. and the range switch. This switch must be prepared by snipping off the tag ends of all the contacts (expect pin 7 which is snipped off completely at its base), leaving as much of the "stumps" as possible so that these will protrude on the copper side of the board by about 1mm and so enable a good soldering connection to be made; see Fig. 8. The orientation of the switch shaft flat is automatically correct when the switch is mounted for a grub-screwed knob to be fitted. Do NOT shorten the shaft.

The four outgoing wires from the points *E, P, Q* and *R* should be soldered to the board, allowing about 130mm in length for each of these. The battery leads can also be connected, these should have battery snaps to clip on to the appropriate battery terminals and need be no more than 75mm in length.

ASSEMBLY

The lid of the specified ABS plastic box should be removed and the four fixing screws retained. You will probably find it best to assemble the circuitry into the case in the following order. First, mount the board in the base of the case; the board should be positioned on the floor of the case shown in Fig. 9, and the two fixing holes at X-X marked through on to the case bottom using a scriber or a sharp pencil point. Make sure that the range shaft is central between the sides of the case.



Drill two 6BA holes through the case bottom at these marked positions and mount the board on two 6BA screws with ¼in. (6mm) intermediate spacers to lift it off the case floor and allow enough of the range shaft to protrude through the lid to accept a suitable knob. Knowing the position of the range shaft, drill a 5/16in. (8mm) clearance hole in the lid so that the shaft passes comfortably through it when the lid is placed in position.

We can now do the rest of the work on the lid. Additional to the hole we already have, this is drilled to the dimensions given in Fig. 10. The 1½-inch hole is only needed if you are going to use the specified meter; if you are going to use an external meter, simply provide two terminals or socket holes in the position which would have been taken by the 1½in. hole.

The test terminal holes at the lower edge of the lid should suit the terminals you have; if these are the standard 4mm types, a 5/16in. hole is wanted for each together with a small "notch" to accept the anti-rotation protrusion on the terminal assembly. Having drilled the necessary holes, the artistic among you might like to label the lid appropriately, using a pen or preferably rub-down lettering.

The front panel layout is shown in the photographs. Notice that the six switch positions start off at 15 degrees to the horizontal and are then spaced at 30 degree intervals. This way they will coincide with the switch shaft orientation when a knob is fitted. Now the meter (if used), the Set Zero potentiometer (with its shaft cut to the right length to take the knob) and the test terminals can be fitted into place.

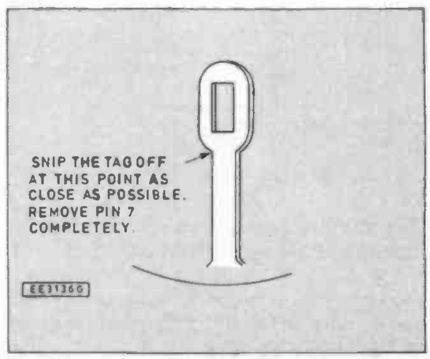


Fig. 8. Preparing the range switch S1 for the p.c.b.

WIRING-UP

Returning to Fig. 9, wire up the lid components to the four board leads as the diagram shows. Adjust the lengths of these wires so that the lid can rest alongside the case bottom while the initial setting-up procedure is done; after that, which involves only the adjustment of preset VR1, the lid can be screwed onto the box and knobs fitted to the two control shafts.

The battery fitting hasn't been mentioned, the reason being that this is a simple job which should not require any specific instructions. A simple metal clip might be used or the battery could be "stuck" down to the base of the box by a couple of the self-adhesive pads available from most d.i.y. stores. Its position is shown in Fig. 9.

CALIBRATION

Calibration is very simple but you need an accurate capacitor within the range 0μ05 to 0μ1 if you are to get the best out of this project. A range of one per cent capacitors is generally available and if you choose a couple from these, there should be no problems. This aspect is discussed at the end of this article.

With the range switch set to OFF and the battery installed, turn the Set Zero control full *clockwise*, then switch to position 3 (the 0μ1 range) and if necessary adjust the Zero control to give zero meter reading. Connect the known capacitor across the test terminals and adjust VR1 on the board until the meter indicates the value of this capacitor; for example, if you use two accurate 39000p capacitors in parallel (that is, equivalent to 0μ078), you would set the pointer to 0·78 on the 0-1 scaling. If you have an accurate 0μ1, of course, you would adjust VR1 to give full scale deflection.

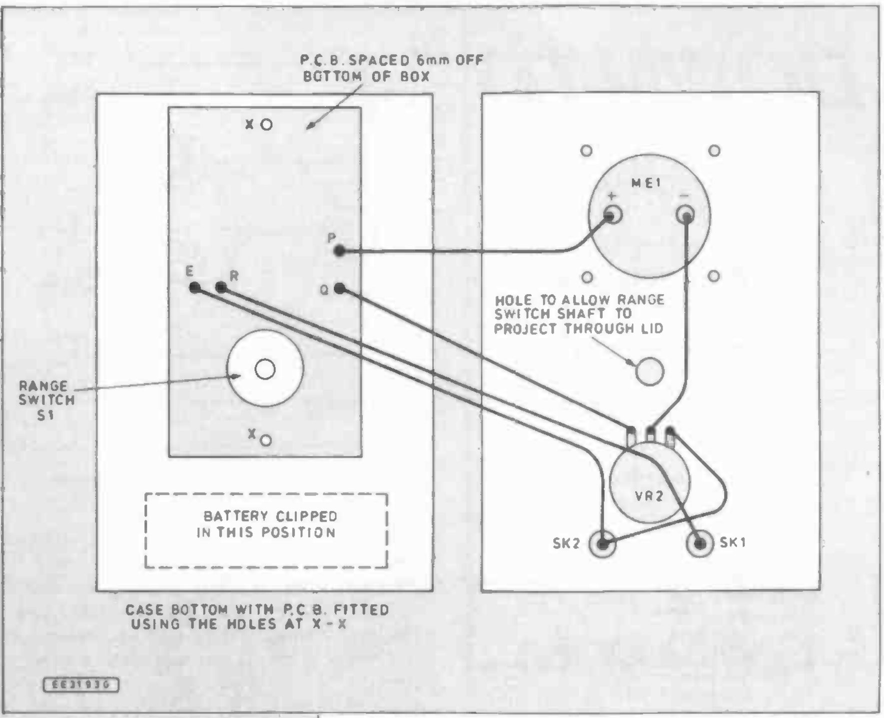


Fig. 9. Wiring from the circuit board to the components mounted on the case lid.

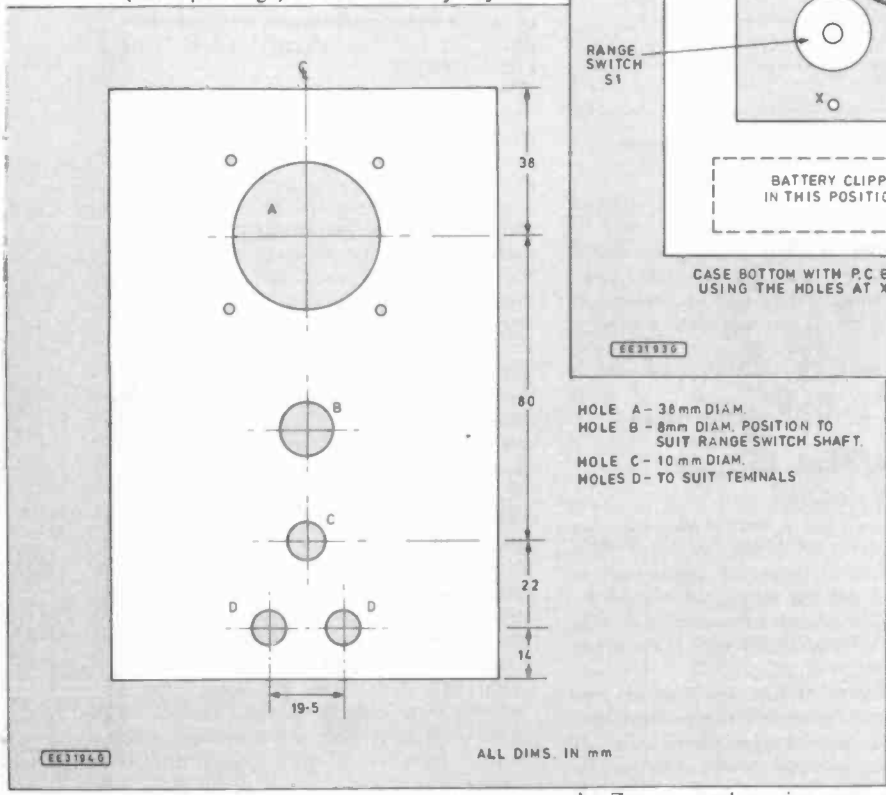
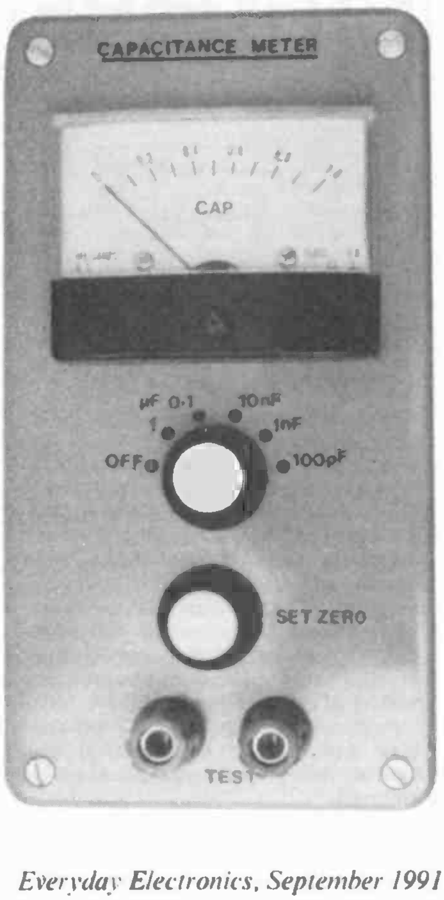


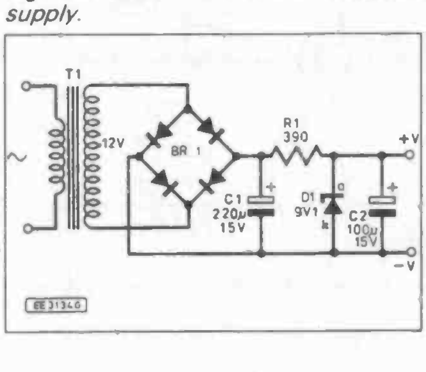
Fig. 10. Drilling details and (below) lettering of the front panel of the meter.



This completes the calibration procedure; the other ranges will be automatically correct if the circuit has been built to the specification given. The other ranges can of course be checked by connecting known capacitors for each range and noting that the meter reading is within the tolerance of the capacitors used. Five per cent types are good enough for these checks.

For the first three ranges i.e. 1μ, 0μ1 and 10n (0μ01) the Set Zero control will probably need no adjustment. For the other two ranges i.e. 1n and 100p, adjustment is needed, particularly on the 100p range. The scale should be zeroed before connecting the capacitor.

Fig. 11. Circuit for a mains power supply.



If you have no idea of the value of a capacitor, always start off on the 1μ range and work downwards.

PRECISION CAPACITORS

An accurate 0μ1 can be made up from two 39000p and one 22000p all in parallel. These values are available in the one per cent tolerance range. If you cannot get hold of any of these close tolerance types, five per cent types may be used without seriously affecting the usefulness of the project; most capacitors do not need to be known to any better accuracy than five per cent anyway.

Electrolytic types are not common below 1μ in value; these *can* be measured on this instrument, but observe the polarity at the test terminals. The terminal on the left (looking at the front) which is wired to point *P* on the board is the positive; use a red terminal here and make the other black or green for convenience.

The battery should give a long operation in this usage, but as its output falls, there will be a small change in the meter indication. Check at regular intervals using the precision test capacitor on the 0μ1 range, and adjust VR1 if necessary.

MAINS POWER SUPPLY

Some of you may prefer to use a larger box and build in a mains power supply. The general assembly can follow the battery version, the power unit taking the place of the battery position. A suitable circuit is shown in Fig.11. A miniature 3VA transformer is sufficient having a 12V or two 6V secondaries.

The range switch may still be used as the ON-OFF switch on the secondary side exactly as it is for the battery version, but the primary *must* be separately switched by way of a toggle or slide switch of proper mains rating. □

DOWN TO EARTH

George Hylton

ZENERLESS VOLTAGE STABLISERS

CONVENTIONAL voltage stabilizers usually contain a Zener diode to provide a reference voltage. A similar job can be done by an ordinary transistor.

The working base-emitter voltage (V_{BE}) of a silicon transistor varies, but within fairly narrow limits. For any particular transistor it varies with collector current and with temperature. If the temperature doesn't change much and the current is fairly constant then V_{BE} can be used as a reference voltage of 0.6 to 0.7V.

The idea is elaborated in band-gap voltage references, i.c.s where a special combination of transistors gives a very stable voltage (usually about 1.2V). However, this article deals only with the simple V_{BE} case, which lends itself to d.i.y. applications.

TWO-TRANSISTOR STABILIZERS

In the simplest case (Fig 1), the base-emitter voltage of TR1 provides the reference. The second transistor TR2 delivers output current. The voltage drop across R2 (which is the output voltage) turns on TR1. If this voltage tries to increase, the resulting increase in TR1's collector current through R1 pulls down the base voltage of TR2 and so counteracts the rise. This is a negative feedback process. It is most effective when the voltage gain of TR1 is high. The gain is roughly 40 times the number of volts dropped by R1, and can be quite high.

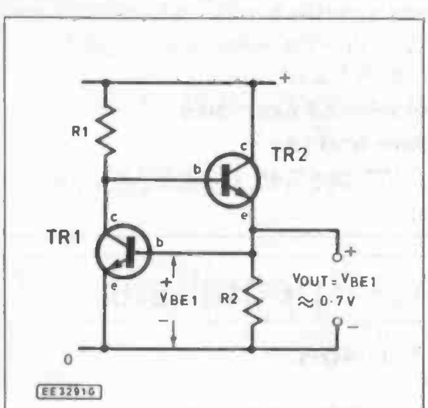


Fig 1. Basic stabilizer

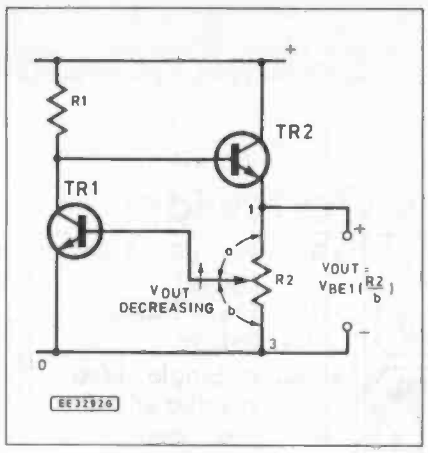


Fig 2. Variable output voltage

VARIABLE VOLTAGE

The basic circuit is fine, if you want an output of about 0.7V. But who does? One way to provide an increased output voltage (Fig.2) is to tap the output with a potentiometer. The output voltage is then V_{BE} (R2/b) where b is the resistance of the lower end of the pot.

Unfortunately, if the slider moves upwards when the spindle is turned clockwise the voltage control works "backwards". If R2 is a linear pot this can be remedied by reversing connections "1" and "3". This is impracticable with a log. law pot, because the voltage control is then too fierce.

To use a log. law pot (Fig.3), add a resistance R3 and connect the pot as a variable resistance R2. Voltage can now be made to increase smoothly with clockwise rotation, and is V_{BE} (R2/R3).

FIXED VOLTAGE

It is easy to fix the voltage by using a preset R2. If a more precise control is needed you can add a Zener diode (Fig.4). The output voltage is $V_z + V_{BE}$ and can be fine-trimmed by R2. This circuit is useful where more output current is needed than a simple Zener stabilizer can supply.

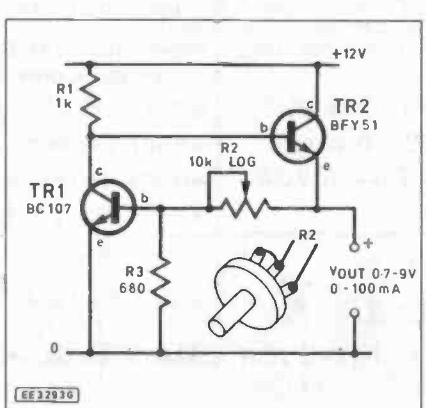


Fig 3. Practical variable output

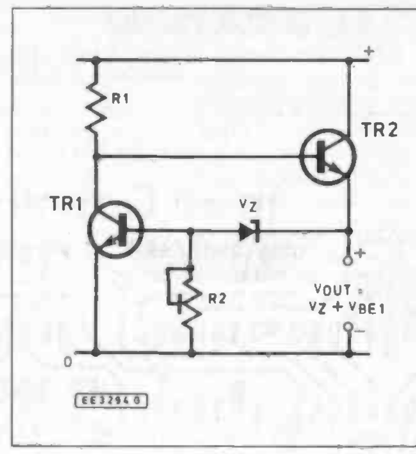


Fig 4. Fixed voltage

By using a power transistor for TR2 you can obtain large output currents. However, when no output is drawn the standby drain is low. In a simple Zener circuit, on the other hand, the drain is constant even when no output current is drawn.

The value of R2 in all these circuits (R3 in Fig.3) should be chosen to pass at least ten times the expected base current of TR1. Since the voltage across R2 is V_{BE}, which is likely to be about 0.65V (650mV) the required R2 value is easily calculated: $R2 = 650/(10.I_B)$. With I_B in micro-amps R2 is in kilohms; with I_B in milliamps R2 is in ohms.

These simple stabilizers can be elaborated to provide much better performance, and with added overload protection, but they can't then compete in cost with integrated stabilizers. They do have the advantage of being able to provide low output voltages (under 1V) from a single positive input voltage, which some variable voltage i.c. stabilizers cannot.

Special Feature

BLUMLEIN
THE FORGOTTEN GENIUS
BARRY FOX

A true mystery story that is stranger than fiction and reads like a Hollywood movie script.

Next year, 1992, sees the unification of Europe. For a very few people 1992 also means the fiftieth anniversary of the death of Alan Blumlein – arguably the most significant electronics engineer to be born, live and work in Britain. It was on 7th June 1942 that the plane carrying Alan Blumlein and his experimental radar crashed near Ross-on-Wye, killing all on board.

Despite the importance of his work on stereo sound, television, telecommunications and radar, only electronics engineers know enough of the man's achievements to respect his memory. The public at large will have heard of Edison, Bell and Baird, but not Blumlein.

Victim Of Circumstance

This is curious because Blumlein's life story reads like a Hollywood movies script. The picture his family paints is of an absent-minded genius who died young in mysterious circumstances, who couldn't read until he was twelve years old and would not read complete books until after he was married. In all Blumlein filed 128 patents, one for every six weeks of his working life. And he wasn't just an armchair inventor. He built what he patented.

But, in death, Alan Blumlein has been a victim of circumstance. When he died, he was engaged in secret war work. The government postponed even a brief announcement for three years.

Before the war, Blumlein had been working with EMI, now Thorn-EMI, and the company has done pitifully little to publicise his achievements. For a quarter of a century there has been talk of a biography, but the first biographer fell sick and died early in the project. His successor, Francis Thomson, has still not produced anything after nearly twenty years of promises. It now looks as if even the fiftieth anniversary will be missed.

The whereabouts of large quantities of biographical papers is now shrouded in mystery. Colleagues of Blumlein who provided it have since died. Every year, first-hand memories of Blumlein fade further into the mists of time. The story of the missing biography would make a book of its own.

The Man

Alan Dower Blumlein was born in Hampstead, North London on June 29th, in 1903. He went to Highgate School, where he studied science. From there he went on to City and Guilds where at the age of twenty he was awarded a first class honours degree in heavy electric engineering. He stayed on at City and Guilds for a while as a demonstrator. At the age of twenty-one he wrote an award winning paper for the Institution of Electrical Engineers on measuring electrical resistance.

In 1924 Blumlein joined International Western Electric, owned by Bell Laboratories who ran the North American telephone system. Later the company became Standard Telephones and Cables, now known as STC. Blumlein's job was to improve the sound quality on long distance telephone lines. But in 1929 he grew restless and joined the record company known as Columbia Graphophone.

Blumlein's boss, Isaac Shoenberg, later Sir Isaac, asked him to find a way round a string of patents owned by Bell and Western Electric on their new method of recording sound electrically. Until then, records had been made mechanically, with sound waves vibrating a diaphragm which moved a stylus to cut a groove. Bell and Western had come up with a way of using a microphone to produce electric signals which, when amplified electronically, moved the stylus. It was so successful that all the record companies wanted to use the system. But they all had to pay the Americans up to a penny royalty on every record pressed.

The Western Electric patent on the disc cutter monopolised the use of a lossy rubber transmission line connection to a moving iron. Around 1928 H.E. Holman of Columbia got round the patents by putting rubber mounts at the side of the moving iron. The results were poor. By June 1930, within a year of joining the company, Blumlein had made a moving coil cutter which needed no rubber at all and thus steered well clear of the Western patents while giving improved reproduction.

The cutter moving coil was a single turn of metal which carried very heavy currents. Blumlein used neoprene for the bearing instead of rubber. He made it work with relatively low power radio receiver valves instead of the very high power transmitter valves previously needed.

His system not only avoided the patents – it did the job better. He also built a moving coil microphone because Westrex claimed royalties on condenser mics too.

Hot and Bothered

In 1931 Columbia Graphophone merged with the Gramophone Company, which owned the His Master's Voice record label and the famous Nipper dog trademark. The result was a new company, Electrical and Musical Industries, later to be known just as EMI.

Scientists working at EMI's Lab in Hayes were given a very free hand. The company was always looking to the future. Blumlein held a special position at EMI. At the Hayes labs he worked in an odd way, holding a privileged position. He could go anywhere he liked in the labs and settle on any task he thought appropriate. He would flit around, looking over people's shoulders and when he saw a tough problem he would help.

In a tape recorded a few years before her recent death, Blumlein's wife, Doreen, remembers the time when Alan was doing the work on disc cutters:

"He had started in Standard Telephones and Cables. Then Columbia wanted someone to help with a recording system. They were paying Western Electric a halfpenny a record. So he went to Columbia and made this recording system which he called "Hells bells, hot and bothered", HB for short.

"He was very proud of saying he was never in HMV; he went straight to EMI. He was very worried about his recording system. He was very modest.

"He said to me, 'Oh dear, what if their system is better than mine', and I said "Wait and see darling, it doesn't matter. Probably yours is better".

"Of course the HMV system never worked so they took Alan's system. He came home one day and said, "Well really", and I said, "What is it?", and he said, "HMV have put out a big notice, 'After years of patient research we have perfected the best method piano recording'. And of course it was Alan's, you see."

Stereo Shuffler

After improving the quality of disc recording, Blumlein turned his attention to stereo. He made a stereo cutter and pick-up with a pair of moving coils. Although he constructed a ribbon stereo mic most of the historic stereo test recordings were made with twin mics and "shuffler" circuits, onto 10 inch 78rpm discs. Thankfully, much of this equipment is now on display at Thorn-EMI's new Central Research Laboratories near the old Labs in Hayes.

In nature our two ears hear a natural spread of sound from a limitless number of sources all round. At home or in the studio, we are listening to sound from just two loudspeakers. But we don't hear two loudspeakers, we hear the illusion of sound spread between and around the speakers.

It was Blumlein who thought up the trick that makes this work. While other engineers, for instance at Bell Labs in America, were trying to mimic nature with numerous loudspeakers reproducing subtle variations in the phase of the sound, Blumlein did some lateral thinking. Instead of trying to recreate the original sound field, he found a way of fooling the ear and brain. His shuffler circuit converted phase changes into amplitude variations. Later he achieved the same effect with a crossed pair of directional microphones.

During reproduction, each of our ears hears a mix of sound from each loudspeaker. When both loudspeakers are reproducing the same sound (in the same phase) at the same volume level, our brain is fooled into thinking the sound is coming from halfway between the two loudspeakers. When the sound from one loudspeaker is slightly louder than the other, the apparent source shifts sideways.

In the Groove

By far the most important of Blumlein's 128 patents was the one (number 394 325) which described this stereo technique. The same patent also tells how to record two channels of sound in the single groove of a gramophone record - or a single soundtrack down the side of a reel of cinema film. British patent 394 325 has become a Bible for audio engineers.

Recently, at the University of Keele, Reg Williamson has been working with students to build a complete Blumlein stereo shuffler system, following the patent specification and drawings.

The first draft of the seminal patent was filed on December 14, 1931, and (in accordance with the patent laws of the time) the "complete" or final specification was lodged on November 10, 1932. The papers were examined by the Patent Office and formally approved and "accepted" on June 14, 1933.

In July 1933 Blumlein started making test stereo recordings. By December 1933 he had made a record which is now famous amongst sound engineers as the "walking and talking" stereo experiment. Engineers walk backwards and forwards across a room, in front of a stereo microphone.

In January 1934 Blumlein took his equipment to EMI's recording studios at Abbey Road and there cut discs of Ray Noble's dance band and Sir Thomas Beecham conducting Mozart.

There was no market for stereo then. Few people could afford one loudspeaker, let alone two. Blumlein's stereo only came into its own in the fifties, long after the inventor's death. He never lived to see how successful it was and hear how wonderful it sounds on a good hifi system.

Matter of Standards

In March 1958 the record industry set a standard for stereo recording – and then the press referred to it as an American system. In a thundering Editorial, in the April 1958 issue of The Gramophone, the technical editor Percy Wilson reminded the world that it was Blumlein who had invented and patented the system.

Engineers at EMI's main rival, Decca, spent five years working on stereo in the early 50s. Arthur Haddy, who was in charge of all Decca's technical services, later told how it was only when they filed a patent of their own, that they found out that everything had already been invented and claimed by Blumlein in the 30s.

Neither Blumlein, nor his family, nor EMI, ever benefited financially from the patent, even though the company's lawyers were able to keep it in force until December 1952, (thanks to special provisions that compensated inventors for the lost war years).

His wife remembered:

"One day at EMI's AGM, when I had some of the shares, Sir Joseph Lockwood said to me, 'We still live on Alan's work, you know'. And I thought, well a pity you don't pay me for it.

"And he said, 'We are resurrecting his binaural'. And of course they called it stereo. But the patents had lapsed so they didn't get anything out of it, or me. Of course, I had already signed all the patents away because he was under contract."

Gone Missing

Much of the recording apparatus which Blumlein built has either been lost or destroyed by people who did not recognise its historical value. Papers documenting his work are missing. EMI does not have access to Shoenberg's personal papers. Philip Vanderlyn, who worked with Blumlein at EMI, told the BBC (for the Radio 4 documentary, *Move the Orchestra*) how he was still puzzled about this:

"Every day he would come round the Research Labs and talk with everyone. He kept in touch that way. Going back through his papers I would have expected to find a lot of theory, thoughts and calculations. But they didn't emerge and I often wondered where the devil they were. I would have expected some sort of master plan. But the core of his work was missing."

Forgotten Footage

Blumlein's stereo sound film system was forgotten for forty years after it was invented. His wife later recalled how he described what he wanted to achieve:

"One day before the war we were in the cinema and he said to me, 'Do you realise that the sound only comes from one person?'. Well I didn't. I'm not clever or musical. I said, 'Oh does it?'. He said, 'Yes, I've got a way', he said 'to make it follow the person'. And he called it binaural, and because the war came it was shelved."

In the seventies Dolby Laboratories finally convinced the Hollywood film studios that they it should start taking stereo sound seriously.

Dolby Labs, working with EMI, produced the first 35mm optical stereo films (since Blumlein) in 1975. Like Blumlein the Dolby optical system splits a variable area track, but adds noise reduction to make up for loss of signal. Dolby Labs found that Blumlein's stereo films will run on a modern Dolby stereo film system. The tracks sit in the right location, left and right.

The stereo sound film recordings were made in 1933. After years of nagging, Thorn EMI (with the help of dedicated outsiders working for love) finally transferred them from old nitrate stock onto one inch video. There is a classic shot of a train going past the EMI Labs, filmed from the building roof. The stereo mic was mounted on a lamp post down below near the railway lines. There is also a piece of film shot inside the labs, which has Blumlein, Vanderlyn, Holman and Westlake walking backwards and forwards across a crude stage while talking to give a mobile stereo image.

One famous film is a playlet performed by the Hayes Amateur Dramtic Society. It was shot with a single camera, from a single viewpoint, to avoid the need for editing. Set in a cafe, waiters run on and off, noisily dropping plates to the extreme left and right off screen. An orchestra plays off set to the extreme left. At one point one of the waiters asks the musicians to move. Their sound pans across, apparently still in stereo.

No-one has ever been able to explain how this modern effect was achieved in 1933.

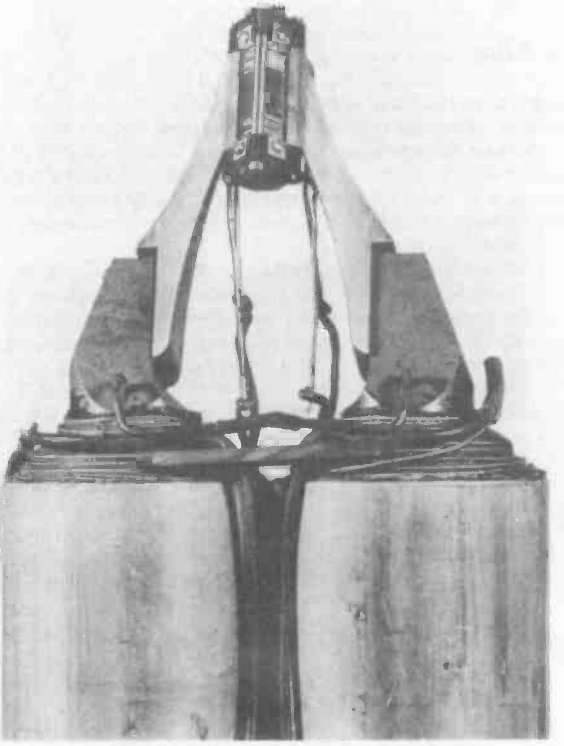
Contrary to popular belief Blumlein did not invent surround sound. He was more interested in height than back to front depth. For his cinema system he proposed using the amplitude channel for left/right modulation, from the left end of the screen to the right, with the other channel, the phase difference channel, for vertical signals from the bottom of the screen to the top of the screen.

Television – The Impossible

It was a logical step from sound and film, to television. John Logie Baird, whose largely mechanical TV system was abandoned in favour of the far superior all electronic system developed by Blumlein and a team of engineers at EMI's Research Laboratories in Hayes, was a highly successful self publicist. So although it was Blumlein's work that gave Britain a regular TV service, the public thinks of Baird as the inventor.

In 1935 a Government committee under Lord Selsdon recommended that Britain should have a TV service with pictures made up from 240 horizontal scanning lines.

Original experimental microphone
All photos courtesy of Thorn-EMI Central Research Labs.



Baird had been promoting a mechanical system with just 30 lines. He might just manage 240. Isaac Shoenberg decided that EMI should develop something that was so obviously so much better, that Baird's system would quickly sink without trace. He committed Blumlein, and his fellow researchers, to the development of a 405 line standard.

Although 405 line black and white pictures would today look poor alongside 625 line colour pictures, fifty years ago Schoenberg's target looked impossible.

Blumlein thrived on the impossible. It took him and his colleagues just eighteen months to design, develop and install a working TV system ready for the BBC to install at Alexandra Palace for transmissions to begin in November 1936.

EMI engineers had made the transition from film sound to TV after trying to make movies on paper for home display. Their first TV system, built around 1930, used 150 lines per picture.

The first public demonstrations of the EMI system were at the *Radiolympia* show held in late August 1936, and the regular BBC TV service began from Alexandra Palace on November 2, 1936. For political reasons Selsdon had recommended a public test, with the BBC transmitting the same programme alternately on both the Baird and EMI systems.

The unwieldy Baird system was a clumsy mix of film and mechanical scanning technology. One contemporary described Baird's system as "clockwork" compared to the EMI all-electronic technology, but Lord Selson and his committee just plain didn't dare freeze Baird out. The public TV test of winter 1936/37 was probably the first and last time that any government decided against deciding on what technology to use and let the protagonists fight it out in public.

Just as Shoenberg had planned, Blumlein's all electronic TV killed Baird's system stone dead. After a few months of running both systems side by side, with the same programmes transmitted twice. The corporation finally dropped the Baird system in February 1937.

By May 1937 the EMI team had produced outside broadcast equipment which was capable of transmitting King George VI's coronation, the first ever all-electronic TV broadcast from outside a studio. The pictures were clear, despite an overcast day and very poor light. Blumlein had designed cables and amplifiers to carry the signals eight miles across London.

Few people had TV sets. His son, Simon, who now runs a record shop in Petersfield (called Blumlein's) was one of the few people to see the results. He still remembers watching the Coronation on the 12th May 1937, even though he was only just over a year old. This makes him one of the very few people in the UK to have seen two Coronations on television.

Absent Minded

The tape of Doreen Blumlein contains some fascinating insights into the man.

"There wasn't a single subject that you could mention that he didn't know something about, even if it was only one word. I don't think I ever mentioned anything and he ever said, 'What's that?'.

"If we went to look up a word in the encyclopaedia, he'd be there for about an hour and a half because he'd found lots of other words.

"When I first met him he wouldn't read any books. He didn't really read until he was twelve. His nurse used to read everything to him because he hated reading. Then he went to a crammers when he was about twelve"

Doug Birkinshaw (BBC Superintendent Engineer), with Emitron Camera at Alexandra Palace 1936.

"I used to say to him, you couldn't read properly until you were twelve, and he said, 'No, but I knew a hell of a lot of quadratic equations'.

"I got him to read library books. But he couldn't read poetry himself. I would have to read it or say it to him. Sometimes in bed he would say to me, say that speech from Shakespeare, the one from Hamlet. At that time I had a photographic memory and I would say it to him. He would say to me, 'Say it again, and I shall know it'.

"He got to like poetry through me, but he couldn't read it to himself ever. I would have to do all the reading to him. He had that type of brain that he couldn't read poetry.

"He couldn't spell. Two days before he died he wrote me a letter of two pages and nine spelling mistakes. Rotten was wrotten. I used to say, 'No W'. He'd say: 'Well you spell wrong "wr", why can't I spell it "wrotten"'. Kipper was kippa - I'll have kippas for breakfast.

"His mind would be so full, he didn't remember whether he was dressing or undressing. I remember once we went out to dinner and we were sitting in a friend's drawing room after dinner and he whispered to me, he said 'Have we had the meal?' I said, 'Yes, don't you remember?' 'No....'

Paperwork

Blumlein's patents would have been drafted with the help of EMI's patent agent; likewise the papers which he wrote for the Institution of Electrical Engineers in 1937/8. These show how the electronic TV system was put together and there is here a clear lesson for today.

Instead of building hardware by trial and error, and then using it as a basis for paper circuits and published theory, Blumlein started out by defining the TV waveform and then building technology to produce and process the defined waveform. The 405 line TV waveform described in the IEE papers became the basis of all television transmission throughout the world.

Blumlein rejected the idea of scanning the TV lines in zig-zag fashion, and changing the scanning speed with picture brightness. Instead he chose unidirectional scanning at uniform speed. Double sideband amplitude modulation was chosen, along with line and picture synchronization by pulse control signals transmitted along with the picture information.

Reference signal levels define full white and full black values of picture brightness. Peak signal level represents white. The synchronizing signals are at three sevenths the vision signal value. To prevent flicker from the display of 25 bright pictures a second, each picture is broken down into two half pictures – made up from half the total number of lines. These half pictures or fields are then displayed at a rate of 50 a second so that they interlace and merge on screen to give 25 full pictures, but without noticeable flicker.

Later Blumlein admitted that EMI had gambled on recommending a 405 line system to Selsdon's committee long before they had made it work. The recommendation was given, said Blumlein, "with considerable misgivings".

Although details, such as the number of lines and later the addition of colour coding, have of course been changed for modern systems, the basic parameters remain the same. Indeed some people in Britain were still receiving 405 line programmes in the 1936 waveform until January 1985, when the last transmitters closed down and the VHF service was terminated. The transmitters went to hospitals to help cure cancer by radiation therapy. The VHF bands released by the shutdown have been allocated to new public mobile radio services.

War Years

The TV service was temporarily shut down in September 1939 because the military feared that German bombers might home in on Alexandra Palace.

But by then Blumlein was deep into war work. His design for the airborne interceptor, or AI, system was the first successful high frequency centimetric radar. His next and final work, was on the H2S system – known at the time as blind bombing or bombing without seeing. The object was to get a plot of the target onto a cathode ray tube. The bomb aimer was then able to bomb very accurately.

At the time not even Blumlein's wife knew what he was doing:

"I didn't know anything about his working on radar. When the war started he said to me, 'I shall not be telling you anything of what I am doing because I am not allowed to speak about it, and if I tell anyone I shall tell you. If I haven't told you I shall never be tempted to tell anyone else'.

"He did tell me that his name was on a list and that he would be taken to Germany if the Germans came. He told me exactly what I was to say so the boys and I would be all right.

"If he brought work home he always burned it at the end of the day, so of course I didn't know anything until after the war when they told me. I had no idea he was working on night fighters or H2S or anything, because they weren't allowed to say".

We now know that Blumlein's war effort began with a clever use of his stereo sound system to help gun crews pinpoint incoming aircraft. Spaced microphones in parabolic reflectors collected the sound, which was then piped to the operator's ears down stethoscope tubes, similar to those horrid gadgets used for inflight entertainment by some airlines. By moving the microphone pair, until the sound level peaked, the operator could pinpoint the sound source. Two operators could work together with two microphone pairs, one horizontal and one vertical.

Philip Vanderlyn told the BBC about the practical snag with the system:

"Sound location was an adaptation of his stereo system. They brought sound locators into the gun sites because the early radio devices didn't have any height finding. They used the sound locators for height. But they were very close to the guns. The operators had a mechanical tap in the pipes that they could turn off, but of course they had to hear the orders to fire before they could turn the darn thing off. And there was always confusion on those sites. The poor devils that were sitting on the locators often had their eardrums shattered.

To cure this problem Blumlein developed electrical limiting circuits, like those used in modern ear muffs, and tried to display the signal visually on a cathode ray tube.

Radar

From there, and from television, it had been a logical step to radar. The two systems have a lot in common. For TV, a camera converts light into electrical signals which paint a luminous image on the screen of a cathode ray tube. For radar, a radio wave is transmitted and any reflection from a solid object – whether an aircraft or the ground – is displayed as luminous blips on a similar screen. Careful calculation of the time it takes for the signal to bounce back to the transmitter, gives a telltale of the distance.

The government had in fact given the go-ahead for secret work on radar to begin, in 1935, after Robert Watson-Watt proved that radiowaves from the BBC's transmitter at Daventry could be bounced off a bomber, detected and displayed on a cathode ray tube screen.

It is surely no coincidence that the British Government simultaneously encouraged Baird and EMI to race on the development of a high frequency TV system which relied on cathode ray tube display screens. Crash research into TV had the happy side effect of stimulating the production of radar screens, and high frequency, high power valves.

Colleagues recall that Blumlein had an idea for producing a visual indication by acoustics. But the speeds of the aircraft got to high. Then he had an idea for a radar that got not only the direction of the aircraft but its height. This was done by having a single transmitting aerial and three receiving aerials spaced around it at a distance of about 50 yards in a triangular formation.

EMI gave a demonstration of this in December 1939 to the Telecommuniations Research Establishment at Malvern. This lead the Ministry of Defence to contract EMI to improve existing radars and develop new ideas.

In January 1940 Blumlein and colleagues from EMI went to Dundee to pick up an early model of an airborne flight interception radar which would not work at a range of less than about 1,000 feet. At night this was too far away for the pilot to be able to see the plane he was chasing. Blumlein's team at EMI produced a system that worked down to about 400 ft. It was known as AI Mark IV.

Next came Mark VI AI, which was originally intended for two seater fighters, but was later used in single seaters because it was very easy to operate. But by the time the system was in production centimetric radar, which had very much better angular resolution, was available. This relied on the magnetron which had recently been developed at Birmingham.

A narrow beam is needed to get the direction accurately, and this either required a very large parabolic mirror (like a modern satellite dish aerial) or a very short wavelength. Obviously an aeroplane cannot carry a mirror bigger than three or four feet. But if the wavelength can be reduced to about 10 cms the mirror can be smaller.

Valves could generate radio waves down to a metre, but not much below that. The breakthrough at Birmingham was in producing an improved magnetron which was capable of handling kilowatts at centimetre wavelengths.

Home Sweet Home

H2S (Home Sweet Home) was a centimetric Airborne Plan Position radar. The Telecommunications Research Establishment (TRE) at Malvern had noticed that AI radars could pick up echoes from the ground down below. So they had the idea of modifying the system to display a map of the ground down below. This would then be used to help bomber crews find their targets at night and in bad weather.

Blumlein was seconded from EMI at Hayes to TRE in Malvern. TRE is now the Royal Signals Radar Establishment, RSRE. Here the records become hazy. RSRE has none of his original notes. In the war years, TRE boffins had more pressing things to do than keep notes of everything they did. Because Blumlein was employed by EMI, not TRE, any reports he wrote would have gone back to EMI. If so, they are lost. Although he filed patents in the late 30s, which for security reasons were not published until after the war, they give only the barest technical details.

But the history of radar shows how, by 1940, Blumlein's Air Interception Mark IV radar operated automatically and thus enabled the air gunner in a *Defiant* night fighter to man both his gun and radar at the same time. By the spring of 1941, the accuracy of the system had improved sufficiently for one aircraft to detect another in the air several miles away.

EMI at Hayes and TRE at Malvern worked separately on H2S Plan Position radar. By early 1942 things were looking hopeful. Sir Bernard Lovell, later famous for his work with radio telescopes at Joddrell Bank, was brought in to head the team. The Secretary of State for Air gave instructions for six Blenheim bombers flights to be made to find out once and for all whether objects of interest on the ground could be distinguished from unwanted clutter. Halifax bombers were chosen for the next round of tests and on May 14th the team from EMI arrived at Hurn after a modified Halifax bomber had been delivered by Handley Page. At the end of the month everyone decamped from Hurn to Defford, near Malvern, because it was feared that Hurn was too vulnerable to parachute attack.

Flight Of Destiny

On June 7th 1942 Halifax number V9977 took off from Defford, crammed with experimental radar gear. It was a Sunday, the one day of the week on which the aircraft could be spared from other tests. Although there was no EMI gear on V9977, a team of EMI scientists including Blumlein flew on the test mission to see how the TRE equipment, powered by a magnetron, performed. One EMI man, Felix Trott, missed the flight because he went for a cup of tea. He was a very lucky man.

The cause of the accident has always been a mystery. The only crash report was a Ministry of Defence index card which blames a fire in the starboard engine which started because the crew tried to start it after it failed, and the fire extinguishers on the plane were empty. The MoD card suggested that the extinguishers had "probably" left the makers empty. This led Blumlein's wife to suspect sabotage. So did Sir Isaac Shoenberg, who headed EMI's research department.

In the mid eighties, RSRE scientists set about piecing together what actually happened. They searched old service records and notebooks, interviewed the makers of the aircraft, an engineer who had investigated the failed engine and even a farmer who had narrowly escaped being hit by the crashing plane.

The Halifax had only recently been built, by English Electric at Preston in Lancashire. It had four Merlin engines, three made by Rolls Royce at Crewe and the fourth in the US.

The plane took off at 14.50 hours on the Sunday afternoon. All eleven people on board, five crew and six scientists, were at the front of the aircraft, either flying it or peering at the radar screen. The pilot was experienced, but had only flown for thirteen hours in a Halifax. His crew members were inexperienced.

The Merlin engines had recently undergone a safety check. Rolls had found that the valve tappets tended to increase their clearance under running conditions. So Rolls advised a slight reduction in initial clearance. Each engine had 48 lock nuts and there were four engines. So fitters in the field had to loosen a total of 192 lock nuts, adjust all the tappets and then tighten all the nuts again. Inevitably some nuts were not fully tightened.

As the Halifax flew over the South West of England, a tappet nut in the starboard outer engine (one of the three Merlins on the plane which had been made in Britain) started to come loose. This put excessive strain on its valve which fractured. Once the inlet valve failed, it was only a question of how long the aircraft could stay in the air.

Fire

The aircraft was at 15,000ft over South Wales when fuel started to spill and catch fire. The propellor continued to turn, like a windmill, pumping fuel to worsen the fire. The fire flashed back towards a main tank containing 247 gallons of unused petrol. The pilot had no way of knowing whether the automatic fire extinguishers and fuel valves had successfully isolated the fire in the engine bay. They had not. The engine fitter would not have had time to crawl down the aircraft to the main fuel cocks, to isolate the tanks.

Once the fire had flashed back to the main fuel tanks the aircraft only had a few minutes of survival time left as its structure burned away. Although the aircraft was still at sufficient height for parachute escapes, no-one bailed out. Immediately after the accident the authorities tightened up on the requirement that all scientists must carry parachutes. The implication was clear. There were not enough parachutes on board for the scientists as well as the crew.

The burning aircraft was over rough terrain. It still had 1,600 gallons of fuel on board. The pilot descended over the Forest of Dean towards Goodrich where there was some flat land.

But as the plane flew low over the Wye near Welsh Bicknor, at around 4.20pm, the starboard wing burned through and broke off. The remainder of the aircraft rolled over and fell out of the sky exploding as the petrol tanks ruptured and ammunition on board detonated.

In wartime, no one is indispensable. On July 3rd 1942 Winston Churchill ordered that two squadrons of aircraft be fitted with Blumlein's radar by October. EMI produced fifty complete sets by the end of the year. The first bombing raid which used the equipment was on Hamburg, on the night of January 30th 1943. The returning pilots enthused over the equipment. One estimate is that Blumlein's radar reduced U-boat losses in the North Atlantic from 400,000 tonnes a month in March 1943 to less than 50,000 tonnes just three months later.

It is not hard to see why the Government postponed any announcement of Blumlein's death for three years.

Even if there is no biography ready for the fiftieth anniversary of the Halifax crash, RSRE plans to unveil a memorial in June 1992. English Heritage has offered a site for the memorial at Goodrich Castle, two miles north of the crash site. RSRE's library at Malvern is collecting contributions for the memorial.

Biographical Concern

Alan Blumlein's son, Simon, has waited patiently for a biography but now says he is "very concerned".

The bizarre story began with a 1967 article by B.J. Benzimra in which the author called for reminiscences from those who knew Alan Blumlein to be sent to the inventor's son Simon. Benzimra's dream was to "raise this forgotten man from the dead". The next year, at a seminar on Blumlein's life organised by the British Kinematograph Sound and Television Society (BKSTS), Simon Blumlein spoke about his father and said he hoped with Benzimra to write a biography.

Unfortunately Benzimra had to abandon the project through ill health (he later died) and it was then taken over by a Mr Francis Paul Thomson of Watford.

Francis Thomson began making private and public calls for biographical material, in 1972, using son Simon Blumlein's name and with the Blumlein family's blessing. Because no book has appeared Thomson still holds the material collected. Please reply by 30 November, 1972, recipients of a letter from Thomson were asked and given eighteen points on which to respond.

In September 1973 "Wireless World" carried a letter from Rex Baldock, organiser of the BKSTS seminar, suggesting that anyone with information on Alan Blumlein should send it to Mr. Thomson at his Watford address.

Extraordinary Events

At the 1977 unveiling of a plaque on the house in Ealing where Blumlein once lived, Mr. Thomson gave a speech in which he told how he had been "persuaded to write a biography". By 1981 he said he had accumulated about one and a half hundredweight of material and traced Blumlein's ancestry back to the early 15th century.

In 1982, in the fortieth anniversary year of Blumlein's death, "Wireless World" reported Mr Thomson as saying that he expected his biography on Blumlein to be published in mid-1984 and had "found some very interesting material about Blumlein's father and maternal grandfather who had much influence on him" and that "research into the family has taken him into such fields as mediaeval tapestry when he found the coat of arms of the Blumlein family of Strasbourg in a 500 year old tapestry."

In the 1982 edition of Who's Who, the entry for Francis Thomson lists books on banking and tapestry, and a biography (with Simon Blumlein) entitled "*A.D. Blumlein, Inventor Extraordinary*". Publication date was given as 1977.

The next edition of "Who's Who" referred to "Engineer Extraordinary: a Biography of Alan Dower Blumlein", omitted any mention of Simon Blumlein and gave the publication date as 1983. By 1984 all reference to Blumlein had disappeared from Thomson's entries.

Last year Thomson blamed an un-named publisher for the delay. Later he said that unification of the EC in 1992 will "so completely turn the public's attention away" as to make publication of a biography in 1992 "a wasted effort". He then promised a "bang" in "virtually every country globally at a time suitable". Next he claimed to have written "five biographies of Blumlein" and that "the Mark IV version went to the publishers months ago". Then (June 1990) he said he would publish an "abridged autobiography" (whatever that may mean) "internationally in 1991/92".

Simon Blumlein, like his mother who died recently without ever seeing the biography of her late husband, has become progressively less happy about the biographer's interest in distant and tenuous links between the two families. Parallels being drawn at great grandfather and junior school level which, as Thomson puts it, have "enabled me to piece together an important basis to account for his genius".

Simon Blumlein does not know what biographical material has been supplied to Thomson, and by whom, and what will happen to it in the future. This is because the Blumlein family agreed in 1972 that all material received from those who knew Alan Blumlein should for convenience be sent to and held on behalf of the Blumlein family by Francis Thomson. Some of the people who supplied material for the book are believed now to be dead.

While the book remains unfinished, other researchers are unable to access whatever historical material Thomson was supplied.

"I hold the world copyright of very many of the photos and illustrations of Blumlein from circa the early 1900's; I hold the negatives of very many Blumleinalia materials" confirmed Francis Thomson last year, warning that anyone thinking about publishing their own biography "should ensure... copyright clearance of both illustrations and text".

Help Simon

Simon Blumlein now runs a record shop in Petersfield. He would welcome hearing from anyone about original material and may be contacted at his shop ***(Blumlein's, 9a Dragon Street, Petersfield GU31 4JN)***.

Says Simon Blumlein: "I just want to see my father's achievements more widely recognised, which was the original aim of the biography. One of the last things my mother told me was that she wanted that too.

We want to be sure that material submitted in good faith to Francis Thomson and myself by people who knew my father is safe and secure and that bona fide researchers can eventually be guaranteed access to it. We do not want to see the Blumlein and Thomson families tenuously linked by ancestral coincidences. Apart from anything else, it's hard to see who, other than the biographer, could possibly be interested in such matters."

The latest twist in the tale is that now, nearly twenty years on, Thomson is calling for yet more material. He asks for copies of papers and articles in a form "suitable for direct production of printing plates". This suggests that the long-awaited biography may depend heavily on re-prints of previous material. Thomson now writes of the biography "being ready for publication in 1992-3". This confirms what many people have long feared, namely that the 50th anniversary date will be missed.

The Institution of Electrical Engineers, of which Francis Thomson is a member, now says it is "concerned" but admits that "it is difficult to exert other than moral pressure where records are held by a private individual".

A Lancaster bomber fitted with H2S, the airborne radar system used to provide a plan position indication (PPI) of features of the ground below and used as aids to navigation and "blind" bombing.

POLARITY CHECKER

C. H. GREAVES

A simple and inexpensive lightweight tester for speaker leads, car wiring etc. Various methods of construction are described.

When wiring up a PA system with two sets of speakers, the problem of identifying which wire was which of an uncoded twin cable, arose. Balancing a multimeter, at the top of a ladder, in a position that made for easy reading, was not feasible. Something was needed that was light enough to dangle from its own croc clips.

THEORY

An l.e.d. is a one-way device and will only light up if the polarity is correct. So, any l.e.d. with suitable series resistor should do the trick. Better to use two, back to back. Then the polarity will be indicated by whichever of the two lights up. If the l.e.d.'s each emit a different colour, polarity will be obvious at a glance. It is possible to obtain a red and a green l.e.d. encapsulated together and this yields the neatest result.

CIRCUIT

There are just two types of component used in this circuit; an l.e.d. and a dropping resistor. See Fig. 1. The supply to the far end of the cable is a PP3 battery – **the circuit must not be connected to a high voltage.**

In the prototype a 270 ohm resistor was used with a further 150 ohm in series which could be shorted with a switch. The purpose of this was to enable the device to be used with either a 9V or 12V supply. In practice it was found that a single 430 ohm resistor can be used for both supplies without drastic drop in brilliance when the supply is only 9V.

The l.e.d. can either be a bi-colour device or two different colour l.e.d.s.

CONSTRUCTION

A matchbox would be more than adequate in size to house the components, but does anyone make so small a box? You can obtain a potting box which is somewhat less than 25mm cube but this is uneconomic unless you are potting something else at the same time. A box roughly 125 × 30 × 30mm was used for the prototype. Since then, a variety of enclosures have been used, e.g. adhesive plaster stripping spool (Fig. 2); "Tic-Tac" box (Fig. 3); ball point pen (Fig. 4).

If you look around you will probably find other suitable containers (like the boxes inside "Kinder Eggs"). Where the container is of clear plastic, the l.e.d.(s) may be housed inside it.

The "pen" version is by far the most difficult to construct due to the tight fit of wires and components. The green lead is passed through the hole in the side and out of the pen top and soldered to the

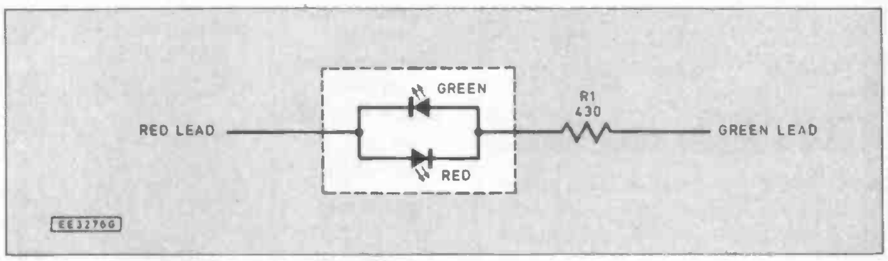
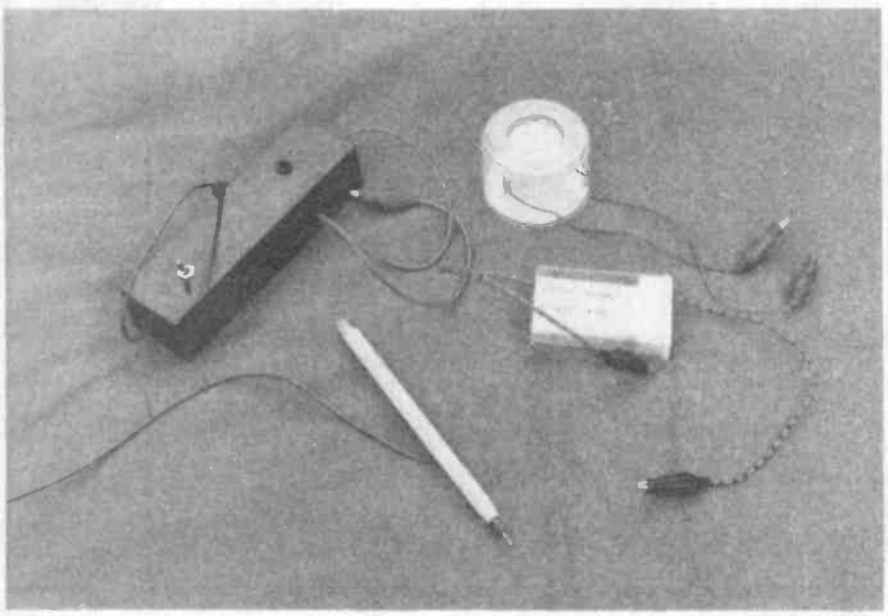


Fig. 1. Complete circuit diagram for the Polarity Checker.



The various methods of construction are shown left.

COMPONENTS

D1	Bi-colour l.e.d. or red and green l.e.d.s. (D1a and D1b)
R1	430 ohm ¼W carbon resistor

L.E.D. clips; small grommets; red and green croc-clips (4 off); PP3 battery clip; PP3 battery; case – see text.

See SHOP TALK Page

Approx cost guidance only
£1 to £2.50
excl. battery

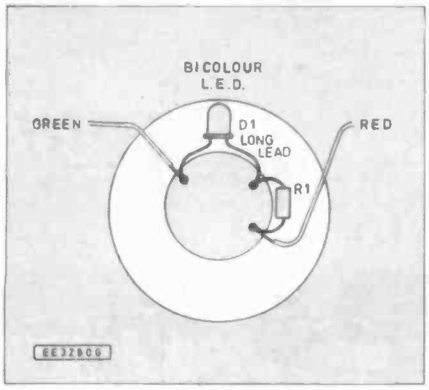


Fig. 2. Construction in an adhesive plaster spool.

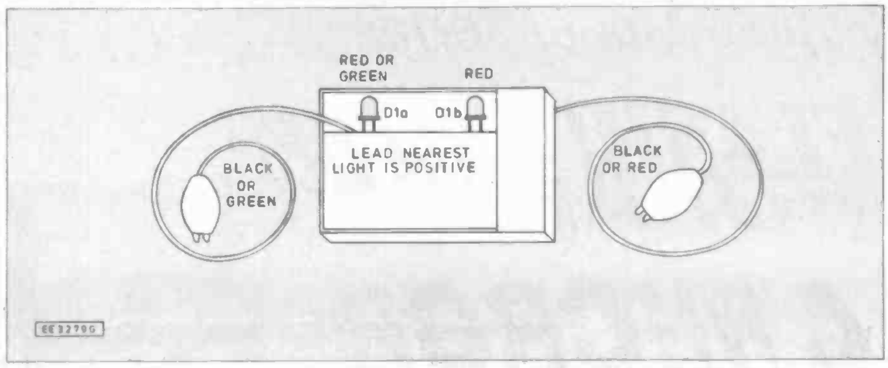


Fig. 3. Construction in a "Tic-Tac" box.

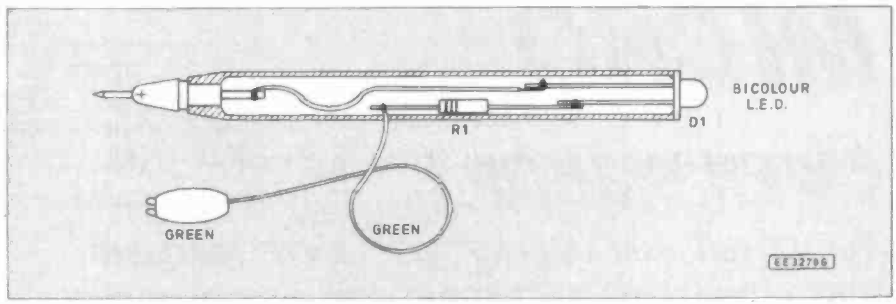
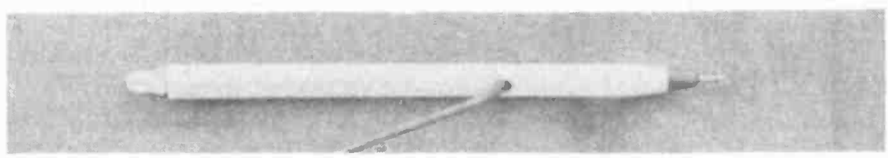


Fig. 4. Construction in a pen case.



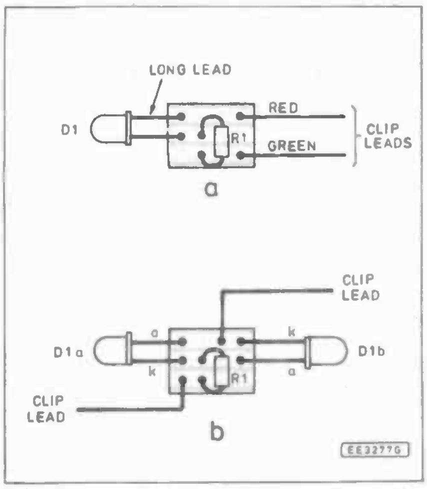


Fig. 5. Veroboard wiring for a bi-colour l.e.d. (a) and for two separate l.e.d.s (b). No breaks are required in the copper strips.

resistor wire. At the same time the flexible wire for the probe is fed up to the pen top and soldered to the long lead of the l.e.d. One or other of these leads will need insulating to prevent the l.e.d. being shorted out. This would not harm the device but might give a misleading result if you were checking for the presence of a voltage. A short length of heavy gauge copper wire was used for the probe. Brass would be better.

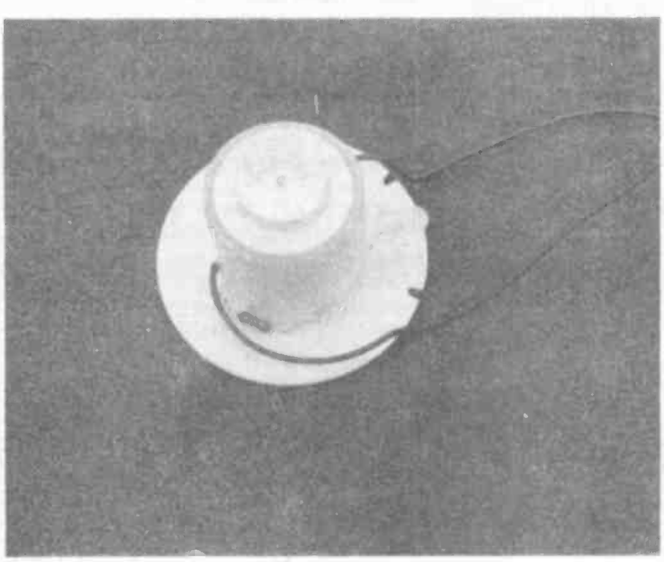
For those who like everything on a board, a small piece of stripboard will suffice. Fig. 5a shows the arrangement for a bicolour l.e.d. The "Tic-Tac" version uses two l.e.d.s and a board connected as shown in Fig. 5b. This is not visible in Fig. 3 as the bottom part of the box has an insert of stiff card to hide the "works" and bear the legend "Lead nearest light is positive", or similar. This is the "junk-box" version, so I actually used a couple of second-hand 220 ohm resistors in series and the wire came from interconnecting wire from an old TV.

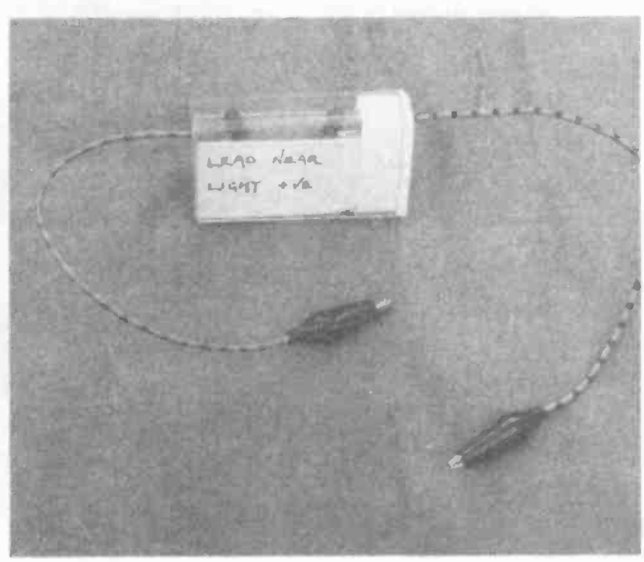
In the bi-colour l.e.d. versions the leads and croc clip insulation were colour-coded. (When the long lead of the bicolour l.e.d. is positive the colour is red.) The "plaster" box uses this type of arrangement and in addition the croc-clip leads emerge via a slot so that when not in use they may be wrapped round the spool in the spare space inside. This is the version I like best.

IN USE

The PP3 is applied to one end of the pair of wires with croc-clips. At the remote end the tester leads are attached and the colour, or position of the light, indicates which lead is positive. There should be no trouble with volt-drop in the cable as the tester will indicate with only 3V across its leads.

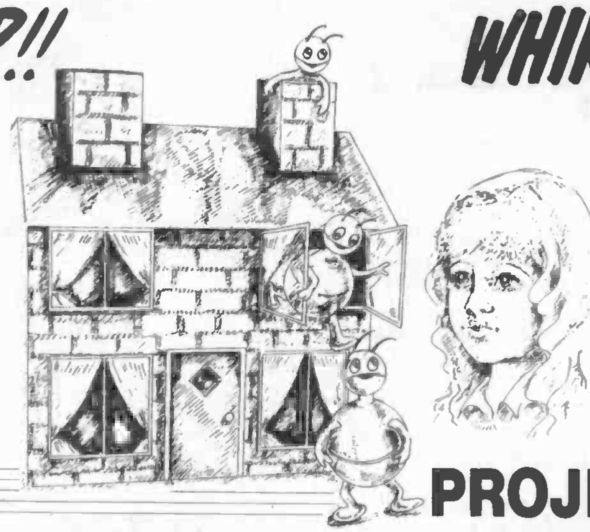
Since the device was made, it has also frequently been used for detecting live wires (or vice versa) in car wiring. There should be no problem here even if the alternator is charging as the maximum l.e.d. current of 30mA corresponds to about 14.5V across the leads. □





Simple Model Series

FLASH! BLEEP!! WHIRR!!!



A MICRO MICRO

OWEN BISHOP

PROJECT 3

A novel series which combines two hobbies in one – electronics and model-making. Simple electronics circuits combined with easy-to-assemble models will cover a wide range of interests. There will be whimsical models and realistic scale models. There will be models for the railway enthusiast, miniature furniture for the doll's house, and toys for all ages. The models that form the first six parts of the series are: Police Car; Musical Roundabout; Micro Micro; Centurion Tank; Mini Microwave; Christmas Novelty.

In this series we use integrated circuits as much as possible to keep the wiring simple and to cut down on the size of the circuit boards. Assembly by the Vero Easiwire wire-wrapping system means that model-makers need not worry about soldering.

Circuit-boards made of card are provided by us. They show where all the components should go, so there should be no problems with getting everything to work first time. All projects are battery- powered for safety.

Models are made of easily handled materials such as cardboard, plastic, modelling compound and other inexpensive items that can be obtained from any modelling shop. You will also need some adhesives and paints or crayons.

Few tools are required other than a pair of scissors, a steel ruler and a craft knife.

THIS month we announce a major breakthrough in microcomputer architecture – the single-chip Micro micro. This is a working model micro, made to twelfth-scale, to add an up-to-date touch to a doll's house. It stands on a miniature computer desk, and has a colour monitor and a touch-sensitive keyboard.

When we state that it is a working model, we do not mean that the micro is actually able to run your favourite computer game but, nevertheless, it looks as if it is in the process of doing so. When the power is switched on, the red pilot l.e.d. on the computer glows and the screen of the monitor lights up, displaying a frame from a chosen program in full colour. If you touch the keyboard, a cursor begins to blink, flashing continuously for about half a minute.

Dolls' house enthusiasts will know that, although there is a wide range of ready-made doll's house furniture available, almost all of the best quality items are based on Victorian styles. This is understandable, because dolls' houses first became fashionable in Victorian days.

When we began to furnish our dolls' house, which has a Georgian exterior, we decided that we would furnish it as a modernised Georgian house, lived in by 20th century people. Instead of a parlourmaid's room with feather dusters, a coal scuttle, and mid-19th Century bric-a-brac, our house has a teenager's bedroom with posters on the wall, a duvet on the bed, and a micro for helping with the A-Level Maths homework.

MATERIALS AND TOOLS

The model is built from thin card or, better, from plastic sheet and extrusions available from a modeller's store. A cutting list is given later in the article. Our plastic was coloured in various shades of "computer-grey", which means that there is no need to paint the model. The pieces are cut to size using a craft knife, junior hacksaw or stout (but sharp) scissors, finished with sand-paper or a fine file, and stuck together with modeller's plastic cement.

It is useful to have a steel rule graduated in millimetres for marking out the pieces. A sharp steel point is used to rule the lines. We have also found that a sub-miniature electric drill is a great asset. These are available from electronics mail order suppliers. The one we use works on 6V to 18V d.c., and has bits ranging in size from 0.6mm to 1.6mm diameter, a small (15mm diameter) circular saw, and various other useful tools.

Plastic cement takes about two hours to set hard, so an assortment of small clamps, bulldog clips and similar devices is invaluable for holding the pieces together while the glue dries.

POWER SUPPLY

Many dolls' house owners have installed a low-voltage electricity supply, even though it may be used to light replicas of Victorian gas lamps. This project operates on a power supply in the range 6V to 12V. However it is essential that the power supply unit is one that produces direct current (d.c.). A p.s.u. that is simply a low-voltage transformer producing alternating current (a.c.), is unsuitable for this model. If your house has an a.c. supply, instal a separate circuit for the micro and power this from four "D" type cells in a 6V battery holder.

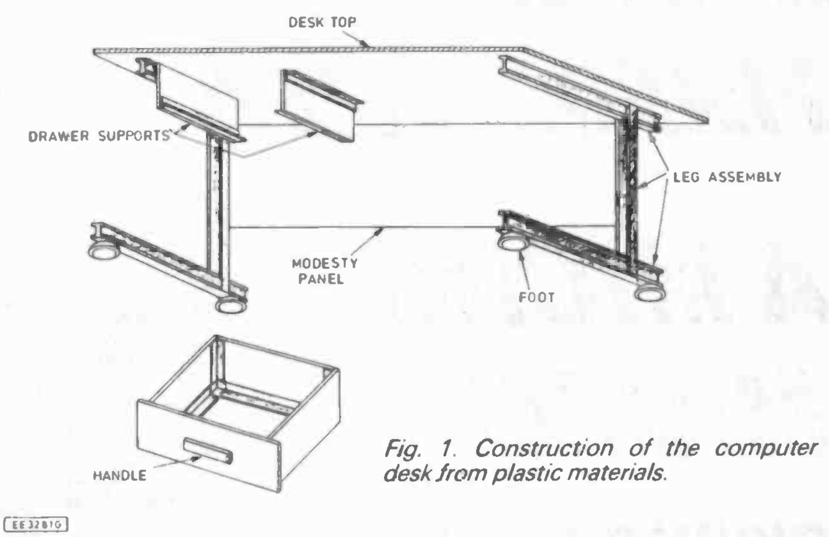


Fig. 1. Construction of the computer desk from plastic materials.

MONITOR SCREEN

The most realistic way of simulating a monitor screen is to use a 35mm colour transparency. You could use any suitable photograph but it is obviously better to photograph the screen of a real computer. Load and run a program on the computer to obtain a suitable static display. You need a camera that focusses at short distances, so that the computer screen almost fills the viewfinder. A single-lens reflex camera is ideal as this can be aimed accurately at close range.

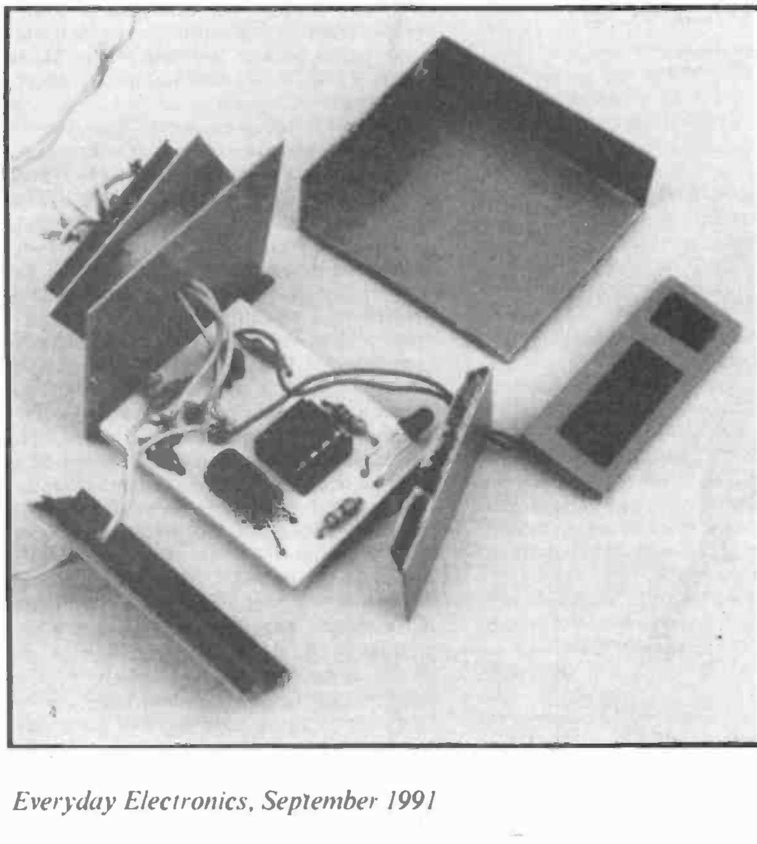
Darken the room to avoid extraneous reflections from the computer screen. Adjust the aperture so that an exposure of at least 1/5 of a second is required. This allows the raster to be displayed 10 times or more during the exposure, and the image will be equally bright all over the screen. With a shorter exposure you tend to get a bright band on part of the screen and dark bands on the remainder.

While on the subject of photography, a finely detailed keyboard can be obtained by photographing the keyboard of a real computer. We did not use this technique for our prototype but it adds a further touch of realism to the model. Use a colour print film for this and take the photograph at as short a range as possible. Have a colour enlargement made so that it shows the keyboard exactly one-twelfth its actual size. Stick this on the keyboard base.

THE COMPUTER BENCH

Although we deal with the units of the model separately, the lengthy drying time of the glue means that you will have all of the units under construction at once, all at different stages of completion.

The computer desk is shown in Fig.1 this can only sensibly be made using plastic from a model shop. Each leg assembly consists of two horizontal members and one vertical member cut from 5mm I-girder plastic. The vertical members have a 5mm slot cut at each end, to fit over the horizontal members. Glue the horizontal members in place so that they project 14mm be-



WIRE-WRAPPING

To mount the components, use a sharp point, such as the point of a drawing-compass or the pointed Vero utility tool, to pierce the circuit card where indicated. Push the leads of components (or the i.c. terminal pins) through the holes, so that the components lie flat against the component side of the card. Turn the card over to the wiring side and, if necessary, cut the leads to about 3mm long.

Plan the wiring so that, where several points have to be connected together this is done with a single long run of wire, not with separate lengths of wire for each connection.

The wrapping wire has no insulation. Where wires cross (e.g. between the i.c.s on the main board) first lay one wire in place. Cut a small rectangle of p.v.c. insulating tape and press this down over the wire, at the crossing point. The second wire may then be laid in place on top of the tape.

Off-board connections are made using eyelet terminals. Push the "legs" through the hole in the board and splay them out slightly to hold the eyelet in place before wire wrapping. To connect the flying lead simply wrap the joint between the lead and eyelet.

Wire-wrapping joints are surprisingly strong and survive normal handling. To make them more secure, spray the completed board with a printed circuit lacquer.

hind the vertical members. Give the assemblies plenty of time to harden, then glue them to the underside of the table. The upper horizontal members are 5mm from the ends of the table top, and set back 2.5mm from the front edge. Glue the ends of the modesty panel to the vertical members of the leg assemblies.

The drawer supports consist of rectangles of 0.5mm sheet plastic with lengths of 2mm angle plastic glued to their edges. The upper angle piece turns out and the lower one turns in on each support. To ensure a good fit, make the drawer before gluing the supports to the underside of the table top.

Glue the four 32.5mm lengths of angle plastic to the bottom of the drawer, so that they run exactly along the edges of the bottom, with their corners neatly mitred together. Then glue the sides and back to the angle plastic. Glue the four 6mm angles in the corners, and glue the handle to the centre of the drawer front. Finally glue the drawer front to the rest of the drawer, so that its top edge is about 1.5mm above the top edges of the sides and back.

The feet are made by cutting the threaded parts away from four round-headed nylon bolts. Paint the heads black before sticking them to the leg assembly. The feet do not project beyond the ends of the horizontal members.

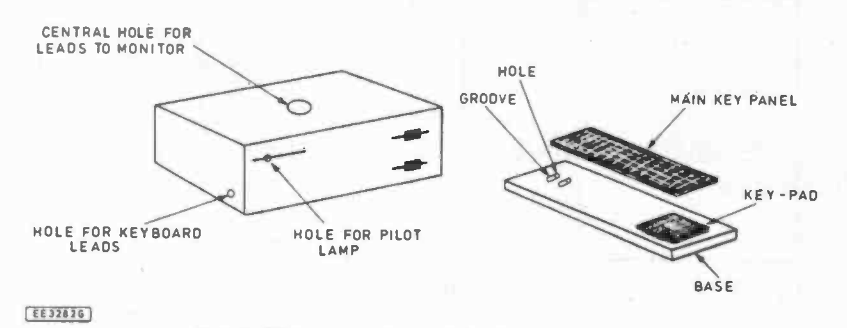


Fig. 2. The computer and keyboard.

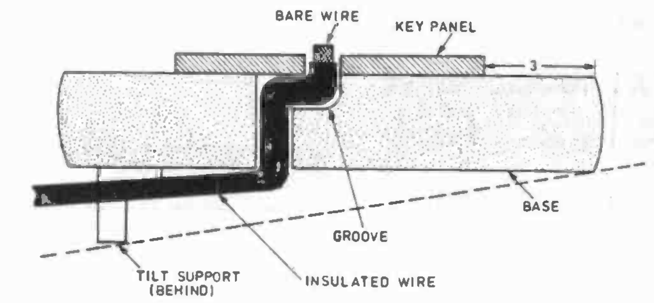


Fig. 3. Keyboard wiring.

THE COMPUTER

The bottom of the computer is made from 2.5mm sheet but the sides and top are cut from 0.5mm sheet. Bore a hole in the left side, to take the twin leads that go to the keyboard (Fig 2). Bore a 1mm hole near the top left corner of the front for the pilot lamp. This can be left as a hole but, if you can obtain a piece of 1mm optical fibre about 3mm long and glue this into the hole, projecting about 0.5mm at the front, the pilot light looks more realistic. Light is channelled from the l.e.d. inside the computer and the luminous point then appears at the front end of the fibre.

The front is marked to resemble the front of a PC with twin disc drives. The "slots" are 11mm long. Selected portions cut from a sheet of rub-down lettering give the disc drives a neat appearance.

Glue the front and side panels to the edge of the computer bottom. Use 8mm lengths of angle plastic at the corners to fix the front to the sides. Glue the mitred angle plastic around the top edges of the box, ready to support the top panel. Before fixing the top panel in place, it is advisable to build and instal the circuit board (see below). Thread the keyboard leads through the hole in the side panel and wrap them around the terminals on the circuit board. Adjust the position of D2 so that it is close behind the pilot lamp hole, and touches the end of the optical fibre, if present.

Bore a 2.5mm hole in the centre of the top panel, thread the three monitor leads through this and glue the panel to the angle pieces. Bore a hole in the back panel to take the twin power leads. Stick a 39mm angle-piece along the top and bottom edges of the back panel, about 0.5mm from each edge. Thread the power leads though the hole and push the back panel into place.

THE KEYBOARD

Cut the base from 2.5mm sheet, rounding the edges and corners slightly with a file (Fig.3) Cut the key panels from 0.5mm sheet, preferably of a contrasting tone, or use rectangles cut from colour prints, as described earlier.

Bore two holes in the base and in the main key panel about 2mm apart. The holes are different distances from the front edge of the panel, so that the leads have to be bent twice, holding them firmly in position (Fig.3). Cut the wires about 80mm long, strip their ends and thread them through the holes, bending them as you stick the key panels in position. Clip the exposed bare ends almost flush with the key panel. Glue the keyboard tilt support to the underside of the base, about 1mm from the rear edge.

THE MONITOR

File the pedestal base to give it bowed and bevelled edges. Glue it to the top of the computer so that the hole in the base coincides with the hole in the top panel. The monitor is supported on a tripod of three short lengths of I-girder, but these are concealed within a circular collar (Fig.4). Wind the 65 x 5 rectangle around a cylindrical object about 18mm in diameter, so that its ends overlap. Immersing the plastic in hot water or exposing it to steam helps to put a permanent curl into it. Glue the overlap and clamp the ends firmly (crocodile clips work well) until it is fully dry. Glue the I-girders to the inside of the collar, then fix the assembly centrally on the base.

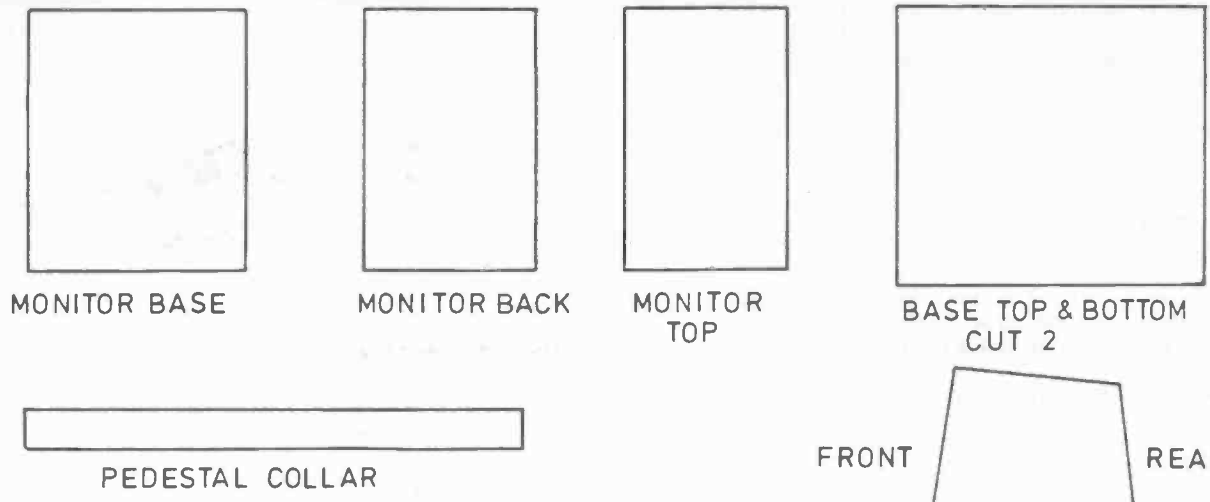
The monitor frame may have slightly bowed edges. The aperture is cut by drilling a row of fine holes just inside a 26 x 18 rectangle drawn on one surface. Cut the plastic between the holes with a finely pointed knife and remove the central rectangle. File its edges to make them smooth and to bevel the edges out at 45 degrees to a 31 x 23 rectangle at the front. Note that the lower side of the frame is 3mm wide but the other sides are 2mm wide. As with the pedestal base, the aperture can have a bowed shape, as in most TV sets and monitors.

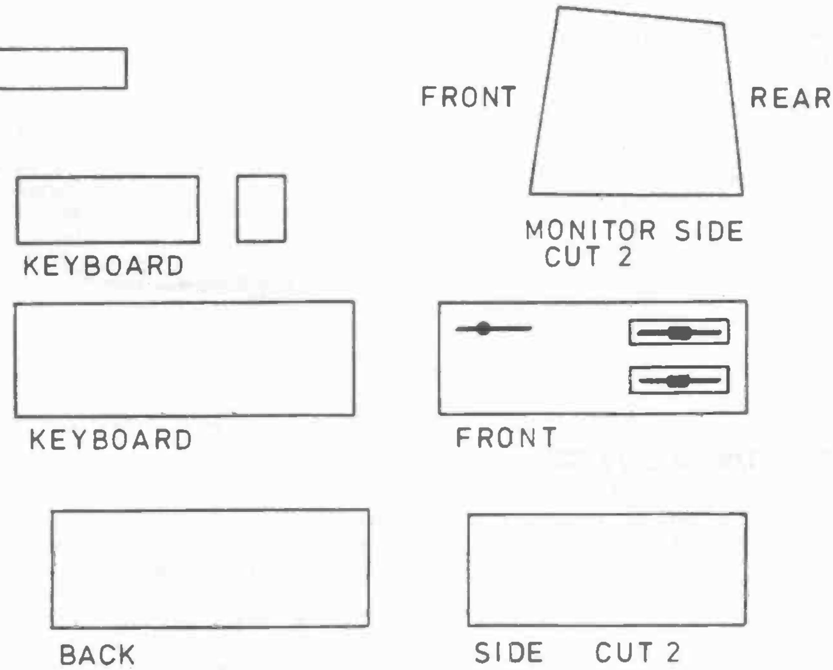
Glue the mitred angle-pieces to the rear of the frame, so that their outer edges are about 1mm from the edges of the frame, or 2mm from the bottom edge, and they form a rectangle measuring 33mm x 25mm. Glue the side panels and bottom panel to the angle-pieces, and strengthen the bottom left and right corners with 2mm angle-pieces.

Remove the screen transparency from its plastic mount. Trimming the edges of the transparency a little at a time, reduce it to the exact size to fit behind the frame. Check that it is a good fit before gluing it in place. Place a small spot of clear adhesive (e.g. Bostik) at the four corners of the frame and press the transparency gently into place. There is to be a diffusing screen behind the transparency to scatter the light coming from the filament lamp. We used matt-surfaced plastic drafting film, but thin paper could be used instead. This too is fixed in place by four small spots of glue at the corners.

Bore four 1mm holes in the lamp-mount (Fig.5) and glue it in position. Thread a 10mm piece of sleeving (or plastic tube) over one lead of the filament lamp LP1; thread the wires of the lamp through the two holes on the left, and use clear adhesive to glue the sleeving to the mount, so as to support the wire vertically, and hold the lamp about 12mm above the bottom of the monitor case. Push the leads of the flashing l.e.d. through the other two holes (anode wire to the right). Push the l.e.d. toward the screen and use a small amount of clear adhesive to glue its tip to the rear of the diffuser. This glued contact makes the l.e.d. show more distinctly, simulating a cursor.

Thread the leads from the circuit board up through the hole in the base of the monitor. Glue the monitor to the tripod girders of the pedestal. Make the connections shown in (Fig.5). Test the operation of the circuit, viewing the screen from the front to check that the illumination is satisfactory. It may be that the plastic used for the monitor case is not completely light-proof. If this is so, line the top, sides and rear with thin white card or self-adhesive





CUTTING LIST

All dimensions in millimetres

Plastic sheet, 2.5 thick
- Table top, 100 x 55
- * Computer bottom, 40 x 36
- * Keyboard, 44 x 15
- * Monitor frame, 35 x 28
- * Monitor pedestal base, 22 x 22

Plastic sheet, 0.5 thick
Can be cut with sharp scissors
- Drawer bottom, 32.5 x 32.5
- Drawer sides and back, 32.5 x 10 (3 off)
- Drawer front, 38 x 15
- Drawer supports, 32 x 12
- Modesty panel, 95 x 32
- * Computer front, 40 x 14
- * Computer back, 41 x 15
- * Computer top, 40 x 36
- * Main key panel, 24 x 8
- * Key-pad panel, 6 x 8
- * Monitor sides (2 off)
- * Monitor top, 34 x 21
- * Monitor back, 34 x 22.5
- * Monitor bottom, 34 x 28
- * Monitor pedestal collar, 65 x 5

Plastic I-girder, 5 x 2.3
- Table leg assemblies, horizontal members, 50 (4 off)
- Table leg assemblies, vertical member, 47.5 (2 off)
- Monitor pedestal supports 5 (3 off)
- Lamp mount 27

Plastic angle, 2 x 2
★indicates mitred both ends unless otherwise stated
- Drawer, 32.5★ (4 off)
- Drawer, 6 (4 off)
- Drawer supports, 32 (4 off)
- Drawer handle, 13
- COmputer, 40★, 39 (2 off), 34★ mitred one end (2 off), 8 (2 off)
- Keyboard tilt support, 25
- Monitor, 33★ (2 off), 33 (2 off) 25★ (2 off), 22 (2 off), 16 (2 off)

Miscellaneous
Nylon bolts with round heads approx 7mm diameter (4 off)

If using cardboard for the construction of the computer the items marked* are not required. These are replaced with the card available from EE or with the kits (See *Shop Talk* and the special offer page) or with card photostatted with the diagrams shown on this page. Various thicknesses can be made up by laminating the card.

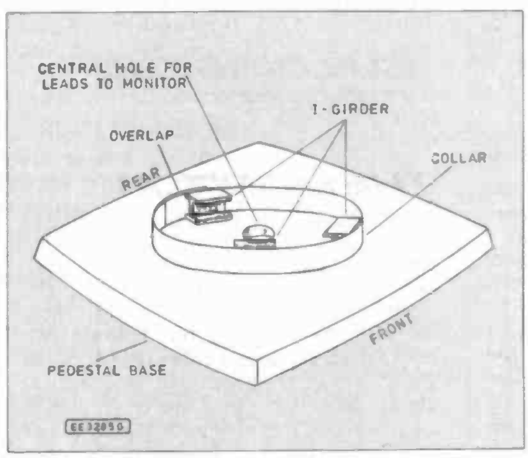
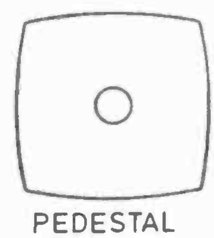
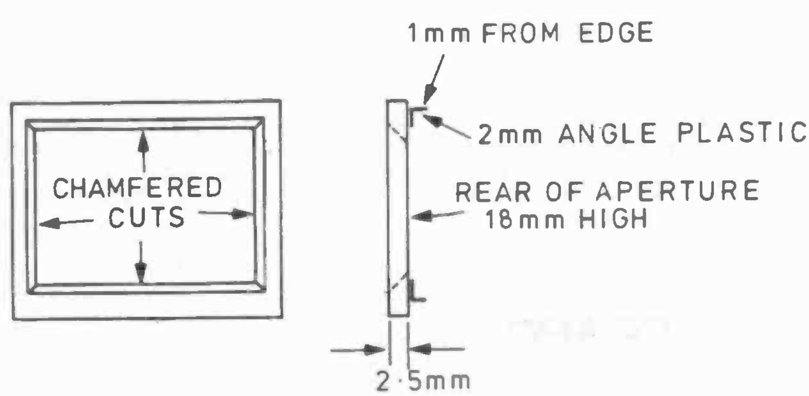


Fig. 4. Construction of the pedestal.





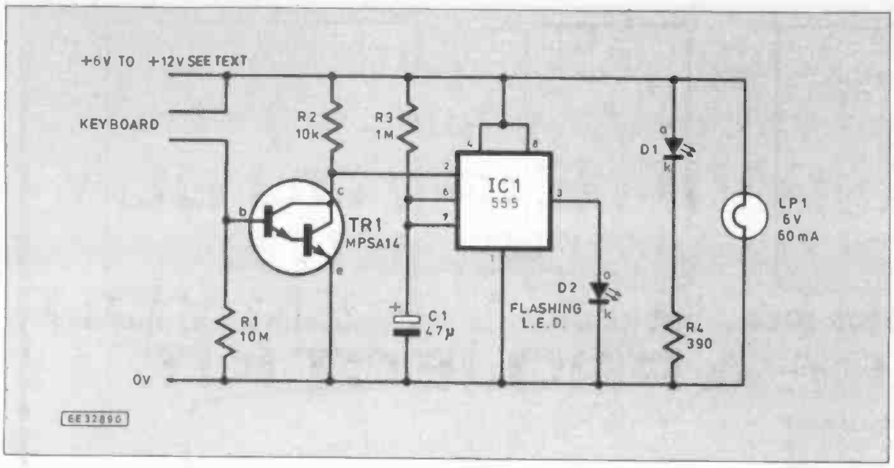


Fig. 6. Circuit for the Micro Micro.

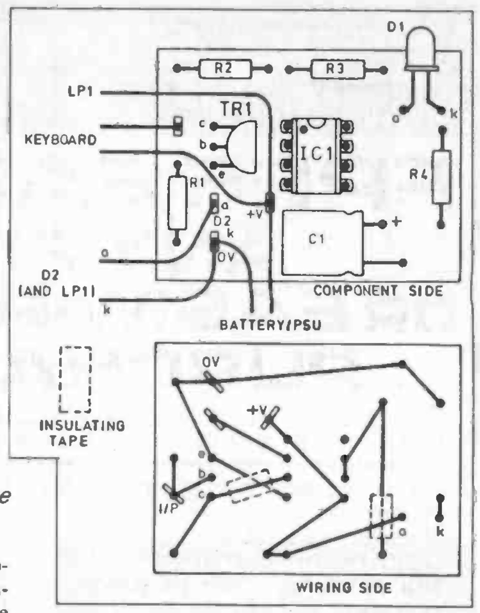


Fig. 7 (right). Circuit board for the Micro Micro.

plastic sheet (e.g. Fablon, Contact). Glue the top panel in place, using the 16mm angle-pieces. The rear panel is a push-fit into the back of the monitor case; a small lump of Blutack will help to keep it in place if the fit is not tight enough.

HOW IT WORKS

The red l.e.d. D1 (the pilot lamp) and the filament lamp LP1 (Fig.6) are powered directly from the 6V supply and are on for as long as power is supplied. The flashing l.e.d. D2 is one that has an internal circuit which makes the l.e.d. flash on and off whenever power is applied.

Power for D2 comes from the output (pin 3) of IC1. This i.c. is the CMOS version of the well-known 555 timer. Here it is connected in monostable mode, with an "on" period of about one minute. The timer is triggered into action by a low-going voltage at its input terminal, pin 2. This is provided from two transistors connected as a Darlington pair. The device used in this circuit, the MPSA14, has the two transistors already connected in a three-terminal package.

Normally, the base of the first transistor is held low at 0V because of the connection through R1. This transistor is off and supplies no base current to the second transistor, which is also off. As a result of this, the collector of the second transistor and the trigger terminal of IC1 are at +6V.

The base of the first transistor is connected briefly to the +6V rail by touching both probe wires to short-circuit them. A current flows to the base and the transistor is turned on. The current flowing through this transistor turns on the second transistor, and the voltage at its collector falls sharply. This low-going voltage triggers the timer.

Since the emitter current of the first transistor becomes the base current of the second transistor, this combination of transistors has very high gain. Typically it is around 10,000. Thus a very small current, such as that flowing when your finger-tip is bridging the probe wires, is sufficient to trigger the timer.

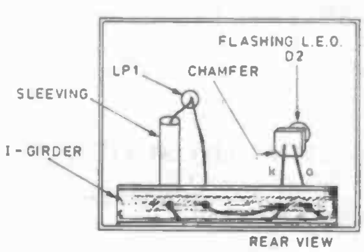
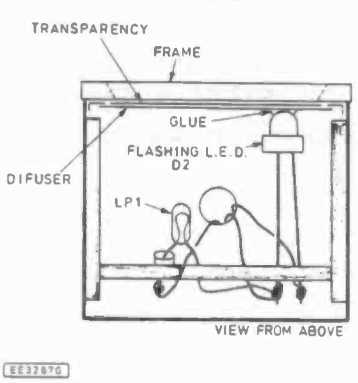


Fig. 5. Arrangement and wiring of the monitor components.



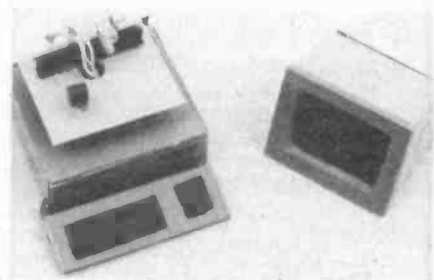
BUILDING THE CIRCUIT

The circuit is assembled on a piece of thick (2mm) card, which is a loose fit in the computer case. Make the holes for the wires and leads, using a sharp point or a 1mm drill (Fig.7). It is better to stick the i.c. socket and the capacitor to the board with clear adhesive. Wiring up is simple as there are only two places where the wires cross. A small rectangle of p.v.c. insulating tape is used to keep the crossing wires from contacting each other.

To test the circuit, connect the flashing l.e.d. D2 to the board observing polarity. The cathode is usually indicated by a chamfer on the body of the l.e.d. and having the shorter of the two leads. When power is applied, the red l.e.d. D1 lights and the red flashing l.e.d. D2 begins to flash about twice a second. It continues to flash for about a minute, then stops. To make it start flashing again, the keyboard terminals must be shorted. Either attach the keyboard and touch the bare wires with a finger-tip, or touch the two terminals with your thumb and with a finger of the same hand.

It helps to make the assembly permanent if the wiring side of the board is sprayed with p.c.b. lacquer once the circuit has been checked.

When the circuit is installed in the computer, only one wire goes from the board to the lamp LP1. The return connection from the lamp is by way of the lead that goes to the cathode of D2. (See Fig.5).



Place the computer on the right-hand half of the table, with the keyboard in front of it. The micro is now ready for its place of honour in the Teenager's Room, or perhaps the Study, in the dolls house. If you need a chair for the operator, there should be plenty of plastic scraps left over with which to make a 5-castor office-type chair. Perhaps you can model a printer and a mouse too, to complete the system. □

COMPONENTS

Resistors

R1	10M
R2	10k
R2	1M
R4	390 (560 for 12V supply)

All carbon, 0.25W, 5%

See SHOP TALK Page

Capacitors

C1	47μF elect. 12V

Semiconductors

D1	light-emitting diode, 3mm, red
D2	flashing light-emitting diode, 3mm, red
TR1	MPSA14 Darlington
IC1	7555 CMOS timer

Miscellaneous

LP1	6V (or 5V) 60mA wire-ended filament lamp (6.3mm long); 12V type for 12V supply

8-way d.i.l. socket; p.c.b. eyelet terminals (4 off); printed circuit card available from EE or with model kits – see *Shop Talk* or special offer page.

Approx cost guidance only **£2.50**

SIMPLE MODEL SERIES SPECIAL EASIWIRE OFFER

FREE EASIWIRE IF YOU BUY ANY FOUR MODEL KITS OR EASIWIRE FOR £5 WHEN YOU PURCHASE A PROJECT KIT.

The two companies mentioned below have large stocks of Easiwire solderless wire wrapping systems, as used to build all our *Simple Model Series* projects. They have agreed to make these available to EE readers who purchase complete kits of components for the projects, **INCLUDING** printed cards to cut out and assemble for each model. If you are prepared to buy *any four* of the six model kits that kick off the series then you can get your Easiwire **FREE**.

If you buy *any one* model kit you can purchase an Easiwire kit for just **£5**. (These kits were previously advertised by BICC-Vero at £15, including p&p). To get your kit and Easiwire simply fill in the appropriate coupon and send it with your cheque (or credit card details) to *either of the companies*.

The six projects that kick off the series are: Police Car (July 91); Musical Roundabout (Aug 91); Micro Micro – a dolls house microcomputer (Sept 91); Centurion Tank (Oct 91); Mini Microwave - dolls house microwave oven (Nov 91); Christmas Novelty Decoration (Dec 91). These models all play tunes or make noises or flash lights etc. They will each cost about £8 or less to build, *the prices charged will be as given by EE in the "approximate cost box."*

All prices include VAT

All the kits will be available separately as the projects are published and the £5 Easiwire offer will be available with each kit when each project is published.

Please fill in the appropriate coupon below, tick the relevent boxes and send your cheque/PO/credit card number with *one* of the coupons to:

BULL ELECTRICAL
250 PORTLAND ROAD,
HOVE, SUSSEX
BN3 5QT
Tel: 0273 203500
Fax: 0273 23077

OR

GREENWELD ELECTRONIC COMPONENTS
27 PARK ROAD,
SOUTHAMPTON S01 3TB
Tel: 0703 236363
Fax: 0703 236307

SEND EITHER COUPON TO EITHER COMPANY - YOU CHOOSE YOUR SUPPLIER

Overseas readers please add £3 to cover the extra postage charge.

FREE EASIWIRE

Please send me my FREE Easiwire kit. I understand that I must buy four model kits at the price given by EE -
I enclose a cheque/PO for £20 for the kits ticked below *and* as a deposit on further kits ☐
Please debit my credit card as each kit is sent ☐

Card No. ....

Ex. Date.................. Signature....................

The kits I require are: (Tick four *or more* boxes.)

- Police Car (July '91)........ £5.95 plus £1 p&p ☐
- Musical Roundabout (Aug '91)........ £7.95 plus £1 p&p ☐
- Micro Micro (Sept '91)........ £2.50 plus £1 p&p ☐
- Centurion Tank (Oct '91)........ plus £1 p&p ☐
- Mini Microwave (Nov '91)........ plus £1 p&p ☐
- Christmas Novelty (Dec '91)........ plus £1 p&p ☐

Name....................
Address....................
....

£5 EASIWIRE

Please supply the Micro Micro Kit on its own at £2.50 plus £1 p&p ☐
Please supply an Easiwire at £5 with the above kit ☐
Overseas readers please add £3 to cover the extra postage charge.
I enclose a cheque/PO for £.............. (£3.50 or £8.50) ☐
Please charge my credit card - ☐
Card No. ....
Ex Date ....
Signature ....
Name ....
Address ....
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ACTUALLY DOING IT!

by Robert Penfold

IN A recent editorial in *Everyday Electronics* (April 1991 issue), Mike Kenward remarked on how the sale of books and p.c.b.s had fallen off during the long hot summer. Normally the flow of readers' letters would also be expected to fall away substantially with such good weather for outdoor pastimes. For some reason, and I can offer no explanation, the number of readers' letters that were passed on to me from various sources actually increased.

Whatever the reason, I suppose it does demonstrate two things. Not everyone is interested in sunshine and outdoor pursuits, and a small percentage of constructors will inevitably run into difficulty with a project from time to time. So what can you do if your latest project fails to burst into action at switch-on?

SPLASHING OUT

I live close to the main office and workshop of a well known electronics retailer which sells many thousands of kits each year. When talking to members of the service department about non-operational kits that are returned for checking, there is never any doubt in their minds about the main cause of problems. By far the most common fault is poor quality soldering of one kind or another.

Apparently most of the returned units can be made to function properly simply by stripping off all the solder and resoldering all the joints! Many constructors seem to think that this sort of claim is an attempt to "pass the buck", and feel that it is unlikely that it is anything that they have done wrong which is causing the problem. The evidence would suggest otherwise though, and in my own experience, when a newly constructed project fails to work it is almost invariably due to a problem with the soldering.

Modern circuit boards tend to be very crowded, with a lot of components packed into a small space. This means that in at least a few parts of the board there will be many soldered joints crammed into a small area. This gives a major problem with blobs of excess solder bridging adjacent connections, and almost certainly preventing the circuit from functioning properly.

There is a similar problem in the form of solder splashes. This is where some excess solder falls from the bit and onto the board. It may leave a large circular disc of solder, or there could be thin trails of solder. Although you might expect to be able to see these solder blobs or splashes without any difficulty, this is not always the case.

Apart from the fact that everything is on a very small scale, there is often a fair amount of excess flux from the solder around joints. This can tend to hide the smaller solder blobs and splashes, although the larger ones should be self evident.

CLEANING-UP

A magnifying glass is a useful item to have in the electronics toolkit, and a careful inspection with the aid of one of these will often reveal any minute pieces of solder in the wrong places. Excess flux might still hide the offending pieces of solder, and it is helpful to remove this flux. Special fluids and aerosols for cleaning p.c.b.s. can be obtained, or methylated spirit will do the job. Methylated spirits and some of the special cleaners are highly inflammable, and should therefore be treated with due caution.

In my experience a quick visual inspection, even with the aid of a magnifier, will not always reveal any accidental short circuits. Going over the board a couple of square millimetres at a time would presumably do so, but could be very time consuming.

It is best to concentrate the search at likely parts of the board. This is wherever there are a lot of joints in a small space, which usually means in the vicinity of integrated circuits, and other multi-pin components such as certain types of connector, s.i.l. resistor assemblies, etc. With stripboard there seems to be a tendency for short circuits to occur at the ends of copper strips, and these are often very difficult to spot visually.

Rather than rely totally on a visual search, I prefer to make a brief visual inspection, followed by checks for short circuits using a continuity tester. This second method of testing will often reveal short circuits that were not previously apparent. However, once you know they are there, it is not usually too difficult to track them down precisely by looking very carefully at the two tracks in question.

CONTINUITY TESTS

Continuity tester designs are featured in *Everyday Electronics* from time to time, or a multimeter set to a (more or less) middle resistance range will do the job quite well. I have warned previously against using a home-made continuity tester consisting of a torch bulb and a battery. The currents consumed by most torch bulbs are high by semiconductor standards. A tester of this type may well track down the short circuits, but it could easily destroy a number of semiconductors in the process!

Note that some multimeters when set to a low resistance range have quite high test currents, and could also cause damage. It is for this reason that I recommend using a middle resistance range, even though a low one would more clearly show up the difference between a low resistance in the circuit and a short circuit.

DRY JOINTS

If the problem is not due to excess solder, then it may be due to inadequate or old solder. With the larger boards in particular, it is quite easy to overlook a joint. Presumably a visual check for solder blobs would also bring to light any joints where soldering is totally absent. It should also show up any joints where inadequate solder has been used, resulting in no connection between the leadout and the pad.

So-called "dry joints" were once a common problem, but are (thankfully) something of a rarity these days. Modern components are designed for use in automated production lines, and as a result of this they take solder very readily. This greatly reduces the risk of dry joints. In fact, a few years ago when I tried to produce a dry joint so that it could be photographed and used to illustrate an article, I found it impossible to produce one! I had to resort to some trickery in the end. However, this is not to say that dry joints can never occur - they are just much rarer these days.

The standard method of producing a dry joint is to leave the soldering iron in its stand for a period of time with a lot of solder on the tip of the bit. When you then try to produce a joint, this solder tends to fall off the bit and onto the leadout wire and pad.

The flux will have burned off long before the solder reaches the joint, and there will consequently be no flux to help the solder flow properly and produce a good joint. Furthermore, the solder will probably have oxidised to some extent while it was on the iron, and will lack physical strength. The fresh solder applied to the joint might alleviate the situation, but it will probably be too late to do any good. In fact the flux often seems to end up acting as a layer of insulation between the pad and the leadout wire.

A dry joint of this type will normally exhibit some tell-tale signs, one of which is a rather rounded, globular appearance. The solder will also tend to look dull in appearance instead of having the usually glossy finish. The surface may well have a cracked and crazed appearance.

EXCESS FLUX

There is another version of the dry joint, which seems to occur when the mix of the solder goes slightly awry. An excessive flux content results in a joint which is spoiled by masses of half burned flux. As in the previous example, the flux usually ends up providing a layer of insulation between the pad and the leadout wire.

With this type of joint the solder will again be much more rounded than normal, but it will usually be shiny in appearance. At least, it will if you can actually see it. It is quite normal for the joint and a small area of the board around it to be covered with a thick layer of blackened flux.

Where a dry joint is suspected it is advisable to clean away the solder using any form of desoldering equipment. Then clean up the pad and leadout wire by scraping them with the blade of a pen knife, after which a new attempt can be made at completing the joint.

If the joints all seem to be all right, and no short circuits due to excess solder can be found, it is worth going back and rechecking all the wiring and component placements again before assuming that a faulty component is the problem. Quite frankly, faulty components are extremely rare these days. The problem is much more likely to be due to a bad joint, short circuit, component fitted the wrong way round, or something of this general type. An occasional cause of problems is the use of substitute components. Unless you really know what you are doing, only use the specified components.

SOS

If your attempts to get a project to work fail, then you can always write in for advice. Here are a few rules that will help us to give you a speedy and (hopefully) useful reply:

1. If you cannot type or word process the letter, write as clearly as possible. I have received several letters over the years that could not be fully deciphered even with the aid of several assistants.
2. Enclose a stamped addressed envelope.
3. Try to be concise and to the point. Give a brief description of the problem, and what the unit actually does. Even if the project does absolutely nothing, say so.
4. If you have a multimeter, give a small list of test voltages taken at various points in the circuit (e.g. collectors of transistors, outputs of integrated circuits, etc.). Mention the type of meter you are using (digital, 20k/V analogue, etc.). In fact the results of any tests that you have made could be very helpful in trying to make a diagnosis.
5. If you have any comments to make about the magazine, or a particular article, we are always interested. However, please keep this type of thing separate from the main query.
6. Make it clear which particular project you are enquiring about. If the project was published more than a few months ago, it helps if you specifically mention which issue it was in.

These are a few things to do if you would like to make our day.! Fail to enclose a stamped addressed envelope with your letter, and write so badly that neither the name or address can be read with any degree of certainty. Write a long list of vague questions about a project published in the second issue of *Everyday Electronics*. Write a long list of vague questions about a project published years ago in some other publication.

Ask a trivial question about a project, and then request detailed modifications for the project. Incidentally, this type of thing seems to be the most common transgression these days. Around half the letters I receive seem to be basically about modifying a project, modifying ready-made equipment, or producing a design from scratch – none of which can we offer any assistance with.

Request information that is included in the article or elsewhere in the magazine (in the *Shop Talk* feature for example). I know it is tempting to simply follow the drawings and ignore the boring instructions, but this usually leads to problems.

Say that you built XYZ project, that it does not work, and ask what to do next without supplying any further information. Ask numerous questions about several projects which you will make one day, maybe, if you get around to it!

SHOP TALK

with David Barrington

Capacitance Meter

The one percent resistors needed for the *Capacitance Meter* can be the 0.25W or 0.6W metal film types. These are common "off-the-shelf" ranges and should be available generally.

The meter used in the prototype model is an Altai T-series type and was purchased from **Electrovalue** (☎ ***0784 33603***), stock no. T24. This moving coil meter is rated at 1mA full scale deflection (f.s.d.) and has a 100 ohm internal resistance. Other meters can be used, provided they have an identical specification and will fit the case cutout. You can, of course, use a different size case.

The "Lorlin" enclosed type rotary switch, or one very similar, appears to be stocked by most of our components advertisers. The small printed circuit board is available from the *EE PCB Service*, code EE751 (see page 604).

Micro Micro – Simple Model Series

The model and circuits for this month's *Simple Model Series – Micro Micro –* are built on printed card, which can be obtained from the EE Editorial Offices for the sum of £1 (including postage). The actual circuits are wired up using the solderless Easiwire wire-wrapping system.

To help with assembly, **Greenweld Electronic Components** (☎ ***0703 236363***) and **Bull Electrical** (☎ ***0273 203500***) have put together a complete kit, including cards but excluding the plastic parts, for the sum of £2.50 plus £1 p&p. They are also making a Special Offer on the Easiwire kit, see page 589.

The plastic sheet, angle pieces and girders should be available from most good model making shops.

Brainwave

All the components required to build the *Brainwave* project are standard "stock items" and should not pose any buying problems. Make sure a "logarithmic" type potentiometer is asked for when ordering the combined Brilliance/On-Off control.

The glasses used in the prototype model, which carry the l.e.d.s, should be available from most DIY stores and are usually sold as "safety glasses".

It is most important that ***ALL*** constructors and possible users of the unit pay careful attention to the warning at the start of the article. On a personal observation, it might be wise to start from a very low setting on the "brilliance" or l.e.d. brightness control until familiar with the unit.

Modular Disco Lighting System

The only listing we have been able to find for the DG308 quad analogue switch used in the *Theatrical Dimmer Inteface*, this month's *Modular Disco Lighting System* project, is from **Electromail** (☎ ***0536 204555***) code 303-551.

The Bulgin type plugs and sockets are stocked by most of our component advertisers, but the circular 10-pin video chassis plug and socket may prove difficult to locate. One source is Electromail. The case is the **Maplin Blue case 233**, code XY48C.

To some readers, the video sockets and case may appear fairly expensive. Alternatives can be used, but, for safety, the case MUST be all-metal and "Earthed".

The electrolytic capacitors used in the model are rated at 15,000µ at 16V working and came from Electromail, code 104-348. The 25V 10,000µ (code 106-192) type can be used but may be difficult to mount on the p.c.b.

The 4-pole changeover toggle switch is currently listed by **Cricklewood** and **Maplin**. The printed circuit board is obtainable from the *EE PCB Service*, code EE765 (see page 604).

12V Lamp Dimmer

There could be a problem locating a suitable r.f. choke for the *12V Lamp Dimmer* with the recommended rating. The only 150µH choke we have been able to locate is listed under "High Current Toroids" and obtainable from **Maplin**, code JL72P.

To save costs, it might be better to follow the designer's suggestion and make your own choke instead of using ready-made components. To accomplish this, wind 50 turns of 20 s.w.g. enamelled copper wire on a ferrite ring of about 24mm outside diameter.

The Darlington power transistor type TIP120 should be fairly easy to locate. If however sourcing problems do arise, it is currently listed by **Greenweld**, **Cricklewood**, **Omni** and **Marco**.

It is most important that 3A minimum auto-type stranded wiring be used for all external connections. Also, it is vital that the lampholder (to be dimmed) wires are COMPLETELY *isolated* from ANY *metal* which connects to the vehicle chassis (negative supply).

Dry Cell Charger

The components required to build the *Dry Cell Charger* are all stock items and should be obtainable from any good component stockist.

It is most important to ascertain, before commencing construction, which type of cells you wish to charge and select the appropriate "wattage" resistors as outlined in the table. The choice of resistors will range from ¼ watt up to 5 watt types and selecting the wrong one could prove disastrous.

Polarity Checker

We would be most surprised if any reader had trouble obtaining parts for the *Polarity Checker*. Almost all component suppliers advertising in EE now carry stocks of bi-colour l.e.d.s. If they do not they will certainly be able to offer single devices, colour to choice.

REPORTING AMATEUR RADIO

Tony Smith G4FAI

NOT ENOUGH FREQUENCIES

In preparing for the *World Administrative Radio Conference*, 1992, an FCC Industry Advisory Committee Informal Working Group (IWG–1) came up with some interesting information, as reported recently by the W5YI REPORT.

The IWG commented that the broadcasting requirements of ITU member countries have greatly exceeded the number of available channels in the allocated spectrum. Congestion in the h.f. bands has reached the point, it says, where effective use can only be made by the use of excessive transmitter power and multiple transmitters broadcasting the same programme.

Since 1979, the total world broadcasting on h.f. bands (excluding tropical zone bands) has increased from about 28,000 frequency hours daily to a present level of about 40,000 hours. The Soviet Union and the USA are the largest users of h.f. broadcasting spectrum. In terms of listeners, a 1986 *Voice of America* study concluded that there are more than 500 million shortwave receivers in the world, not including North America, with Asia having the most with over 168 million.

With its suspension of jamming US-operated broadcasters, the USSR has increased its in-band broadcasting by more than 1,300 frequency hours. There are numerous new USSR broadcasting transmitters at 20kW which apparently were used as jammers before 1989. The conclusion of the IWG is that jamming has now given way to another form of interference, i.e., "increased interference to broadcasters by other broadcasters".

S.S.B. PROPOSALS

The IWG examined the proposed conversion to s.s.b. (single sideband) from d.s.b. (double sideband)-a.m. for h.f. broadcasting which would mean stations taking up less frequency space. While supporting proposals from the FCC to the WARC for expanding the broadcast allocations in the 40 metre band, the IWG recommended that priority be given to s.s.b. broadcast stations operating in the expanded band.

In this connection, I was interested to see a report in *Monitoring Times* for May that Radio Netherlands would be testing "compatible" reduced-carrier upper sideband transmissions from its Bonaire station throughout June on 15560kHz; and asking for listeners comments on the audio quality of the broadcasts. If any SWL readers of this column heard some of these transmissions I too would be interested to receive their comments.

220-222MHz LOST TO AMATEURS

Back in September 1989 I reported a decision of the American licensing authority (FCC) to allocate 2MHz of the 220MHz amateur (shared) band exclusively for commercial use. Despite a hard fight all the way, including the involvement of a Congressional House Sub-Committee and a request to the Federal Court of Appeals to review the FCC decision, the amateurs have finally lost the day. At the end of May the FCC announced that amateur operation in the band 220-222MHz will be prohibited after August 27th, 1991. The previously shared frequency band of 222-225MHz will then be exclusively allocated for amateur use.

The W5YI REPORT reveals that the new commercial band will provide 200 narrow band paired business channels. Due to mileage separation permitting co-channel use thousands of stations are expected to make use of these new bands. In the first 30 days nearly 50,000 applications were received from potential users.

This is an increasingly common story. Philippine amateurs recently lost satellite frequencies in the 430-440MHz band to commercial users, and New Zealand amateurs have lost 2300-2396MHz which has been divided up into twelve 8MHz wide TV channels for sale by tender. Since governments discovered that radio frequency spectrum is a highly lucrative marketable commodity the pressure has been mounting on the amateur bands and, as these examples show, it would be unwise to assume that any frequency is safe in the future.

BUSY WEEKEND

April 27-28 saw the Radio Society of Great Britain's annual convention and exhibition at the National Exhibition Centre, Birmingham, with "The Year of the Novice" as its theme. Over 6,000 visitors attended, including many youngsters, and the Society's special Novice stand was inundated with enquiries about the new Novice licence.

In the States, at the same time, the annual Dayton *Hamvention* was held, with around 35,000 attending. Every hotel was booked solid within fifty miles. There were over 300 exhibitors and 51 forums/lectures. Apart from the huge indoor Convention Center, there were around 2,200 spaces in a 25 acre flea-market area. At a banquet attended by 1300 people, astronaut Tony England, W0ORE, described the operation of amateur radio aboard the space shuttles. Dayton is *the* event of the American ham radio calendar, with many amateurs from other countries around the world making it the high spot of their year also.

HOME-BREW AT NORWICH

In contrast to the big national event, I recently attended the annual mini-convention of the Norwich and District QRP Group. This is a group of enthusiasts whose main interest is in the home-construction of amateur radio equipment suitable for use in QRP (low power) operating.

The equipment on display at the convention included transmitters and receivers, as well as transceivers, antenna tuning units (ATUs), SWR and power meters, electronic Morse keyers, power supplies, in fact all the bits and pieces necessary to put an amateur station on the air.

Some of these items were made from commercially available kits, with some of them heavily modified by their constructors. Others were taken from published articles, and some were designed by the constructors themselves. Exactly the same approach, in fact, as that taken by many of the electronic constructor readers of EE.

The quality of construction was very good, and in some cases superb, and it showed very clearly that despite the large number of radio amateurs today who are "black box" operators and who never make anything, the art of home-construction is not lost and that there are still enthusiasts around who like to know what is inside their equipment and are able to service or modify it themselves to get the best possible performance from it.

The beauty of QPR is that some designs are quite simple and even a beginner can get on the air with home-made equipment, progressing to more sophisticated designs later. One transmitter kit available from the G-QRP Club, for instance, is the "Oner" with a one inch square p.c.b. containing just 11 components with two more external to the board, giving an output of one watt r.f. power. There's a little more to it than that, of course, before it can be put on air, but it is all within the capability of a beginner.

The Norwich QRP Group offer a warm welcome to new members at any time. This includes those who are currently non-amateurs but who are interested in the possibility of making their own equipment as a route into amateur radio. Further details are available from Mike Coan G4EOL, 4 Vera Road, Hellesdon, Norwich NR6 5HU. ☎ 789792.

LOTHIANS "OPEN NIGHT"

North of the boarder, Lothians Radio Society will be holding its annual "open night" at the Orwell Lodge Hotel, Polwarth Terrace, Edinburgh, at 7.30pm on Wednesday 25 September 1991 where non-members, including radio amateurs, short wave listeners and other enthusiasts will be very welcome.

This year's event will feature a flea-market and a bring-and-buy sale. The Society's registered Novice Licence instructor will have details of proposed Novice and Morse classes for those interested. Local traders will be present and there will be a display of members' "home-brew" equipment. Further information is available from Mel Evans on ☎ 031 664 5403.

Constructional Project

MODULAR DISCO LIGHTING SYSTEM

Part Five: DIMMER INTERFACE MODULE

CHRIS BOWES

Light up your party or disco road show with these easy-build effects modules.

THIS output module for the *Modular Disco Lighting System* is designed to enable a maximum of three input modules from the system to be used to provide signals capable of driving remote control theatre lighting systems. The main advantage of this method of control is that theatre lighting systems are designed to handle very large lighting loads. If access to such a system is available in a hall where the Modular Disco Lighting System is being used then this can be used, in conjunction with the normal lighting rig, to provide very substantial amounts of light to illuminate the dance floor.

CONTROL VOLTAGE

Modern remote control theatre lighting systems work by applying a control voltage, generally between zero volts (0V) and ten volts, obtained from a lighting control "desk" which is generally mounted at the rear of the theatre or hall, to a dimmer "rack", which then controls the profile of the alternating current mains voltage fed to the theatre lanterns. Thus the "rack" is used to actually provide all the necessary high current switching to the lanterns. As a rule each dimmer channel is usually designed to control a load of between 1kW and 5kW.

Theatrical dimmer racks use the control signal voltage to trigger high speed switching of the a.c. mains waveform so that the length of time during which the a.c. waveform is allowed to pass through the thyristors or triacs in the output circuit of the dimmer rack governs the brightness of the lanterns connected to the channel. Thus the light output from each lantern is controlled by the magnitude of the input voltage fed to the appropriate channel of the rack.

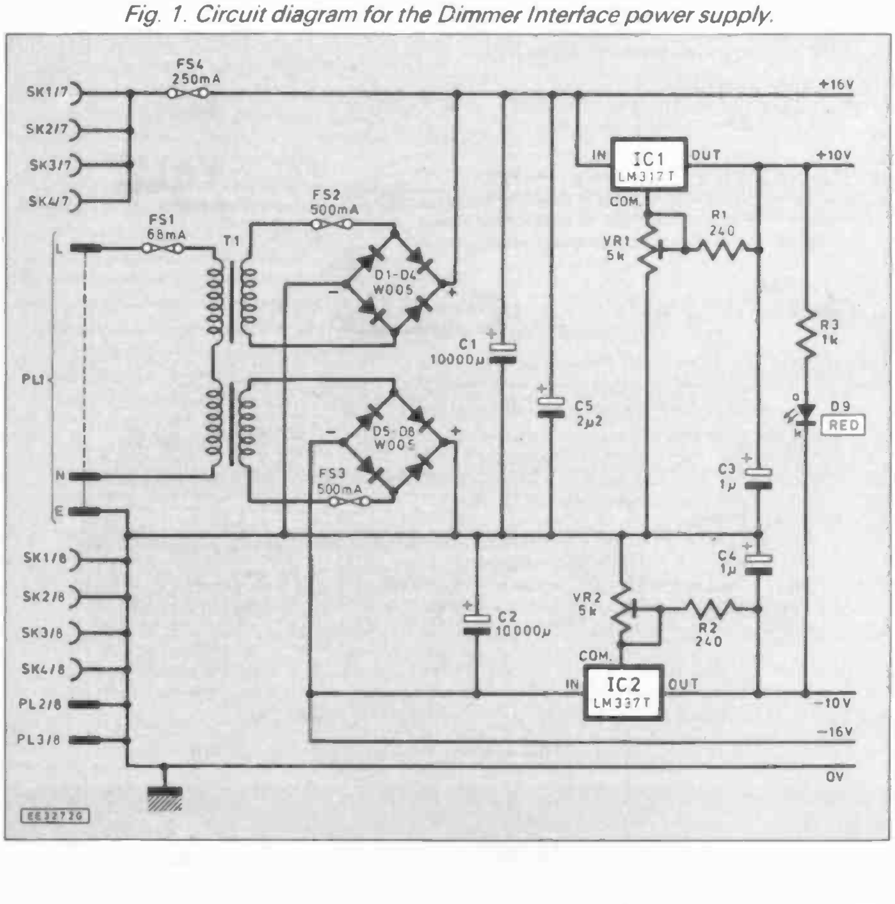
Most theatre lighting racks are designed to control six channels although other systems, usually of a permanently installed nature, may be designed to control a larger number of channels. The Dimmer Interface Module described here has been designed to allow up to three modules (12 circuits) to be interfaced with two, six-way dimmer racks (also 12 circuits) and to accommodate the input signals normally used by most of the common makes of control systems.

One complication in this respect lies in the fact that some theatre lighting systems use a control voltage which has a range of 0V to minus ten volts (−10V) (notably systems made by Rank Strand) whilst most other systems use a control voltage ranging from 0V to +10V (notably Zero-88 and Eltec systems).

The Dimmer Interface Module has therefore been designed to allow signals from any module to operate both systems, which will be controlled both in respect of the signal voltage and polarity. In this respect it is not only fully compatible with all conventional systems but is also able to accommodate a mixed system made up of dimmer racks which operate on different polarities.

A further refinement incorporated is the ability for input one of this module to be switched so that the outputs to the dimmer rack may be connected to be operated either by an "on/off" module or by direct connection of the output to a proportional signal (e.g. the output of a Sound-to-Light module, or even the systems own control desk). It is important to note, however, that the Dimmer Interface Module provides no inverting function and it is essential that the proportional output unit should provide a signal which is compatible with the dimmer-rack to which the first six channels of the interface are connected.

Fig. 1. Circuit diagram for the Dimmer Interface power supply.



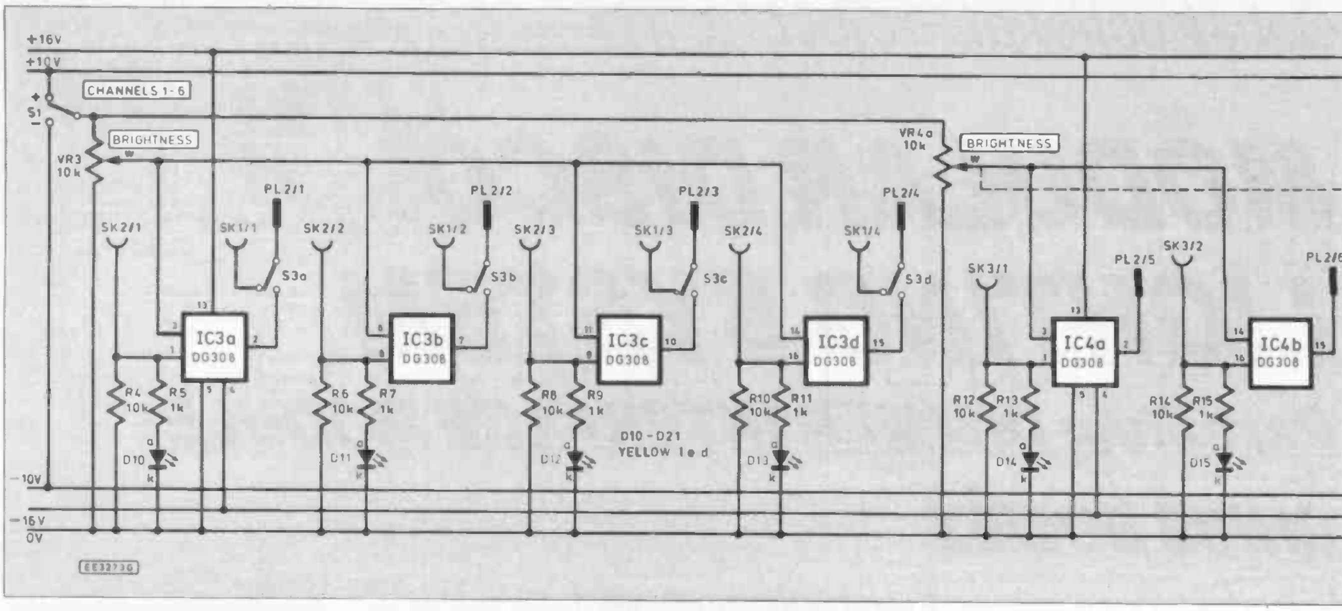


Fig. 2. Circuit diagram for the input/output channels of the Dimmer Interface Module.

COMPONENTS

Resistors

R1, R2	240 (2 off)
R3	1k
R4, R6, R8, R10, R12, R14	10k (6 off)
R5, R7, R9, R11, R13, R15	1k (6 off)
R16, R18, R20, R22, R24, R26	10k (6 off)
R17, R19, R21, R23, R25, R27	1k (6 off)

All ½W 5% carbon film or 0.6W 1% metal film

Potentiometers

VR1, VR2	5k skeleton preset, horizontal (2 off)
VR3, VR5	10k rotary carbon, linear (2 off)
VR4	10k dual (stereo)-ganged rotary, linear

Capacitors

C1, C2	10,000µ p.c.b. radial elect., 25V (2 off)
C3, C4	1µ tantalum, 16V (2 off)
C5	2µ2 tantalum, 16V

Semiconductors

D1-D4, D5-D8	W005 1A 50V bridge rec. (2 off)
D9	Standard Red l.e.d.
D10-D21	Standard Yellow l.e.d. (12 off)
IC1	LM317T positive voltage regulator
IC2	LM337T negative voltage regulator
IC3, IC4, IC5	DG308 quad analogue switch (3 off)

See SHOP TALK Page

Switches

S1, S2	S.P.C.O. min. toggle switch (2 off)
S3	4-pole changeover toggle switch

Miscellaneous

T1	Mains 12VA p.c.b. mounting transformer; 12V 0.5A, 12V 0.5A secondaries
PL1	Mains inlet chassis mounting plug, with matching cable socket (Bulgin)
PL2, PL3	10-pin circular video chassis mounting plug, with matching cable socket (2 off)
SK1, SK2, SK3, SK4	10-pin circular video chassis mounting socket, with matching cable plug (4 off)
FS1	63mA 20mm anti-surge fuse and p.c.b. fuse clips
FS2, FS3	500mA 20mm anti-surge fuse and p.c.b. fuse clips (2 off)
FS4	250mA 20mm fuse and p.c.b. fuse clips

Aluminium instrument case (Maplin "Blue Case 233"), size 250mm x 150mm x 75mm; 16-pin d.i.l. socket (3 off); plastic knobs (3 off); l.e.d. clips (13 off); p.c.b. stand-off pillars (4 off); connecting wire; solder pins; solder etc.

Printed circuit board available from the EE PCB Service, code EE765.

Approx cost guidance only **£62** *excl. case*

CIRCUIT DESCRIPTION

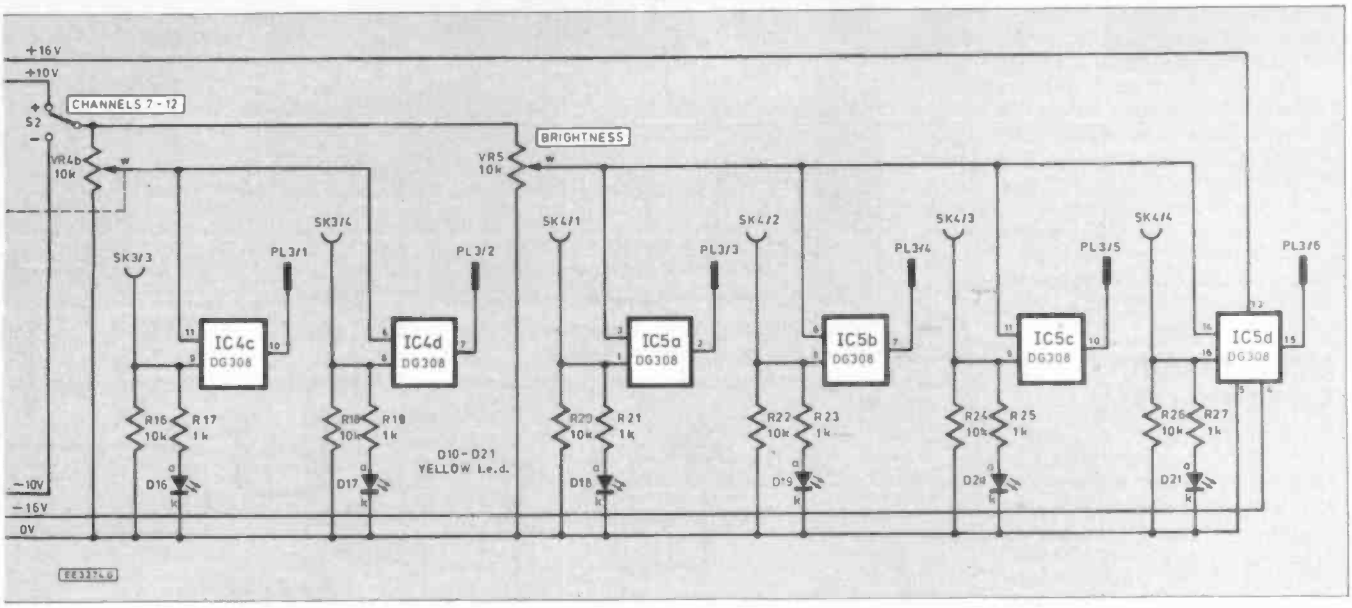
The power supply circuit (Fig.1) for this module is more complex than for other modules because of two factors, which only apply to this module. The first of these two reasons is the fact that commercial dimmer equipment is manufactured with two standard input control voltages as discussed earlier.

The second complication which affects the design of the power supply is the need for these output voltages to be limited to a maximum of 10 volts. Although some commercial dimmer racks are tolerant of voltages in excess of 10 volts, others are not and switch off when a control voltage in excess of 10 volts is applied to their inputs.

In order to accommodate this factor, the positive and negative power supply lines governing the output voltage of the system are stabilized with voltage regulators, IC1 and IC2, which can be adjusted to ensure that an output voltage in excess of 10 volts cannot be supplied by the module. In addition to these two stabilised voltages it is necessary also to provide the standard +16V d.c. supply required to drive the effects and other input modules.

The 240 a.c. mains supply for the unit is fed, via PL1 and fuse FS1 to the primary winding of the transformer T1. The fuse is a 63mA anti-surge type, which is mounted on the printed circuit board, and wired in series with the mains input, so as to provide protection in the event of excess current being drawn through the transformer primary windings.

Current from each of the two separate secondary windings of the transformer is



passed via fuses FS2 and FS3 respectively to two independent bridge rectifiers (D1-D4 and D5-D8). These convert the a.c. supply from the transformer secondary to a d.c. supply which is then smoothed by the two smoothing capacitors (C1 and C2) to produce a d.c. supply of approximately +/− 16V.

The +16V supply is fed, via fuse FS4, to pin 7 of each of the input sockets (SK1 to SK4) and provides the power required to drive the input modules. This supply is also used to provide the positive power required to drive the switching integrated circuits (IC3, IC4 and IC5).

The +10V and −10V stabilised supplies are derived from the appropriate voltage rail of the unsmoothed power supply circuit being stabilized by means of the regulators IC1 and IC2. The +10V supply is obtained via IC1, which is a LM317T *positive* voltage regulator. Preset VR1 and resistor R1 are used to set the output voltage of the integrated circuit with capacitor C3 acting to further smooth the output voltage derived from IC1.

The −10V supply is derived in a similar manner via IC2 (which is a LM337T *negative* voltage regulator integrated circuit). This time preset VR2 and resistor R2 providing the adjustment for the output voltage and capacitor C2 providing smoothing in the same way as for the positive power regulator circuit.

Diode D9 is a standard red l.e.d. which is used to indicate that the power supplies in the module are functioning correctly. It is wired, in series with the dropping resistor R3, across the +10V and −10V stabilised power supply rails. By connecting it in this manner it is possible to monitor all four of the d.c. voltages in the module with one l.e.d.

OUTPUT CIRCUIT

The circuit diagram for the input/output sections of the dimmer interface is shown in Fig.2. These circuits are identical and have only been split so that they will fit on the pages. The action of the output circuits are best understood by reference to the input associated with IC5a, which is driven by channel one of the third input to the Dimmer Interface Module.

The output signal from channel one of the effects module connected to input three is fed, via pin 1 of socket SK4, to the control input (pin 1) of IC5a, a quad analogue switch. The input is also connected to the pull down resistor R20, which ensures that it is held at a Logic 0 level whenever no signal is present at the input. The state of the input is indicated on the front panel by the yellow l.e.d., D18, which is wired in series with the current limiting resistor R21.

The logic state of the input governs the presence or otherwise of a conductive path between the signal input (pin 3) and output (pin 2) of the integrated circuit. If a logic 1 ("high") signal is present at pin 1, then whatever voltage is present at pin 3 will also be present at the output pin 2.

When a logic 0 ("low") state is present at pin 1 the i.c. acts as a high resistance path and no voltage is allowed to pass between pin 1 and pin 2. The output at pin 2 is therefore effectively at 0V.

Pin 3 of IC5a is connected to the wiper (w) or moving contact of potentiometer VR5. This acts as a "dimmer" control to adjust the voltage applied to Pin 3. This is used to allow fine control of the brightness of the stage lanterns connected to the output of the dimmer channel, since the output brightness of a theatrical dimmer-rack is governed by the input voltage. Pin 5 of IC5 is the "ground" input and is connected to the "earthed" 0V rail.

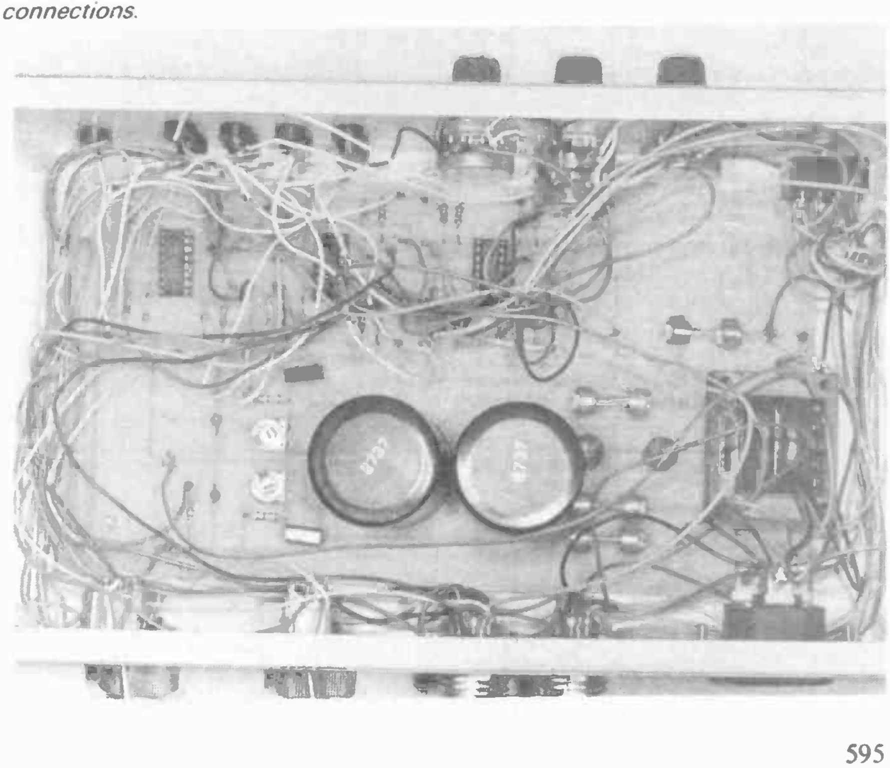
The power supply requirements of IC3, IC4 and IC5 are obtained by connecting Pin 13 to the +16V and Pin 4 to −16V unregulated power supply rails. This configuration is necessary to ensure that the power supply to the i.c.'s covers the entire range of the voltages which may be inputed to them.

BRIGHTNESS

The function of the Dimmer Interface Module is to supply a signal voltage to the inputs of the dimmer control racks which is controlled in two ways. Whether the voltage is supplied or not it is dependent upon the logic input which is determined by the output from the Effect Module(s).

The second control is provided by the facility built into the Dimmer Interface to adjust the magnitude of the voltage supplied to the dimmer rack. This may be

Birdseye view of the completed unit showing the large number of wiring connections.



within the range from 0 volts to 10 volts and governs how bright the output of the controlled channel is required to be.

This is set by adjusting the position of the channel Brightness controls, VR3, VR4 or VR5 – depending upon which block of input circuits is concerned. This circuit is straight forward in so far that it is a standard potentiometer arrangement with the switched input of the integrated circuit connected to the wiper of the variable resistor and the ends of the potentiometer connected across a stabilised 10 volt supply.

VOLTAGE MATCHING

It is also necessary to control the sense of the output voltages to match them to that required by the dimmer-rack. The output voltage sense is selected by means of the output sense selector switches. Switch S1 sets the output voltage sense for dimmer channels 1 to 6 and switch S2 sets the output voltage sense for dimmer channels 7 to 12.

These switches simply connect the "hot" end of the associated potentiometers concerned to either the +10V or the −10V stabilised power supply rail. It is thus possible to allow connection of the Dimmer Interface Module to commercial dimmer-racks of different manufacture and input voltage sense requirements.

Because each of the Effects Modules of the *Modular Disco Lighting System* has four output channels per module and commercial dimmer-racks have six outputs per rack, as standard configurations, a slightly interesting complexity arises with channels 5, 6, 7 and 8, which are controlled via IC4a, IC4b, IC4c and IC4d respectively. In order to accommodate for the fact that these outputs are split between two different dimmer-rack outputs, the dimmer control potentiometer for these channels (VR4) has to be a stereo linear potentiometer. The "hot" end of one of the twin potentiometers, which controls the brightness of channels 5 and 6, is connected to switch S1 and the other, which controls the brightness of channels 7 and 8, to switch S2.

SWITCHED/PROPORTIONAL OUTPUT SWITCH

In order to accommodate switching between a proportional output module and an ordinary switched output module, switch S3 is connected between the outputs of IC3a, IC3b, IC3c and IC3d and the proportional socket input (SK1/1, SK1/2, SK1/3 and SK1/4).

When S3 is in the switched module position the outputs to dimmer channels 1, 2, 3 and 4 are connected to the outputs of IC3, which are controlled by the out-

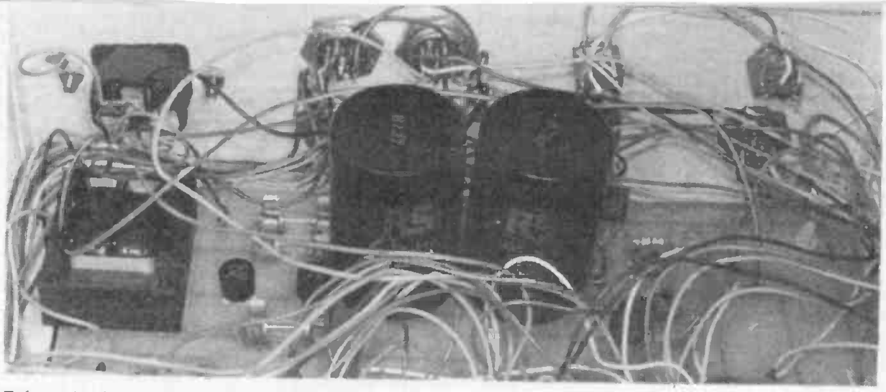
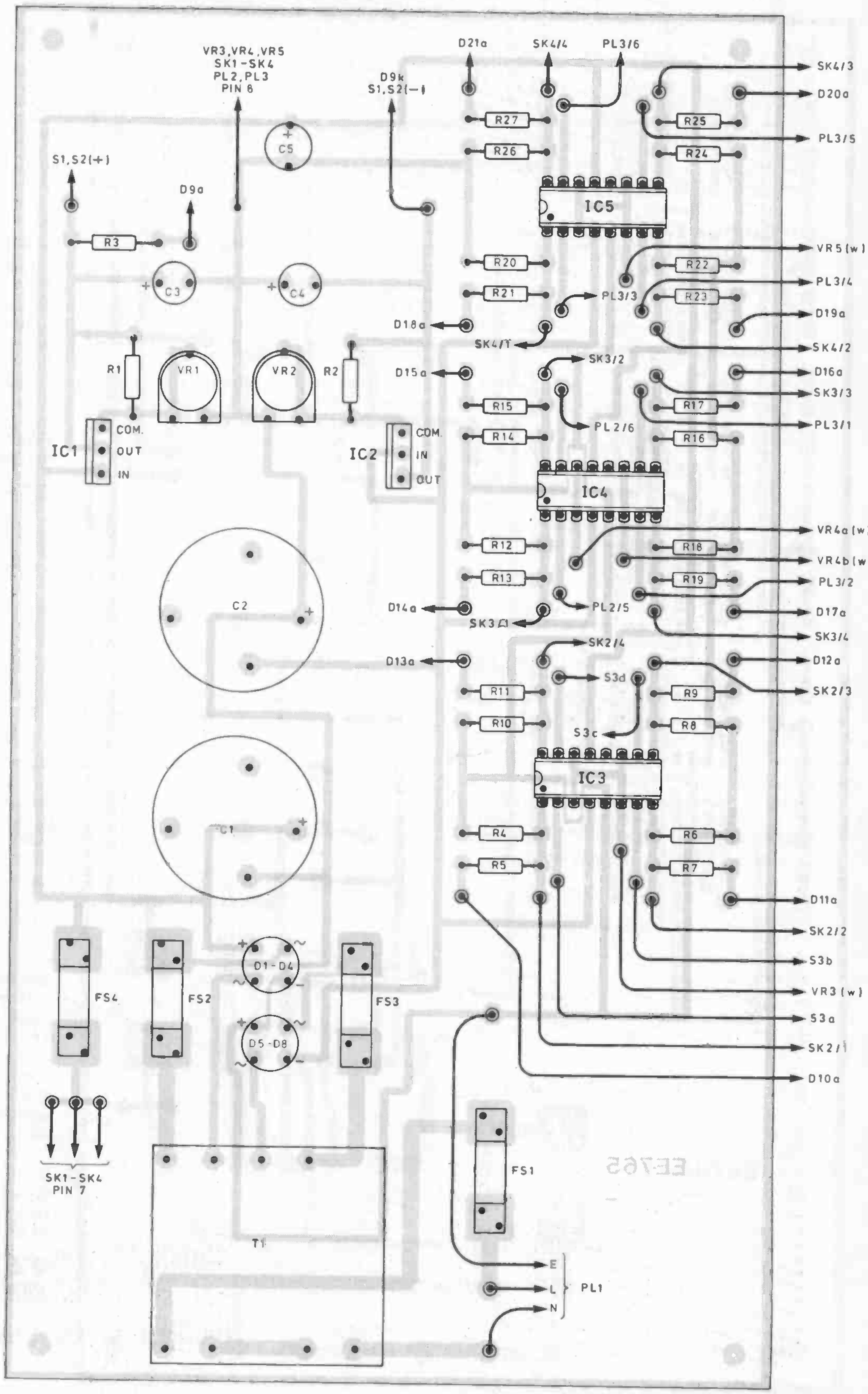
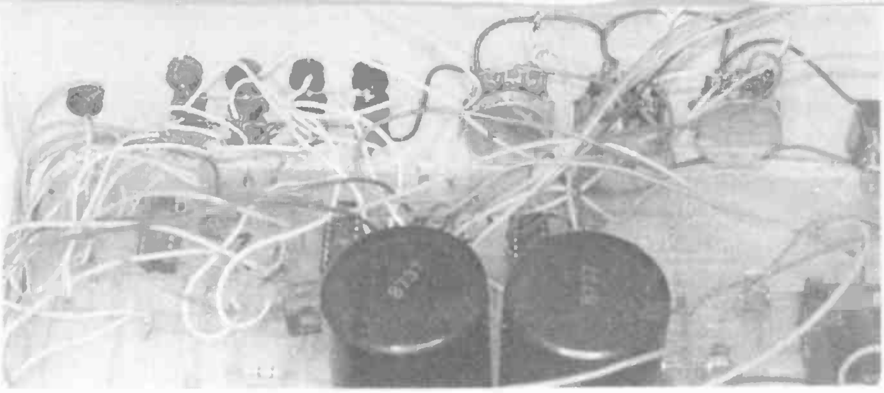
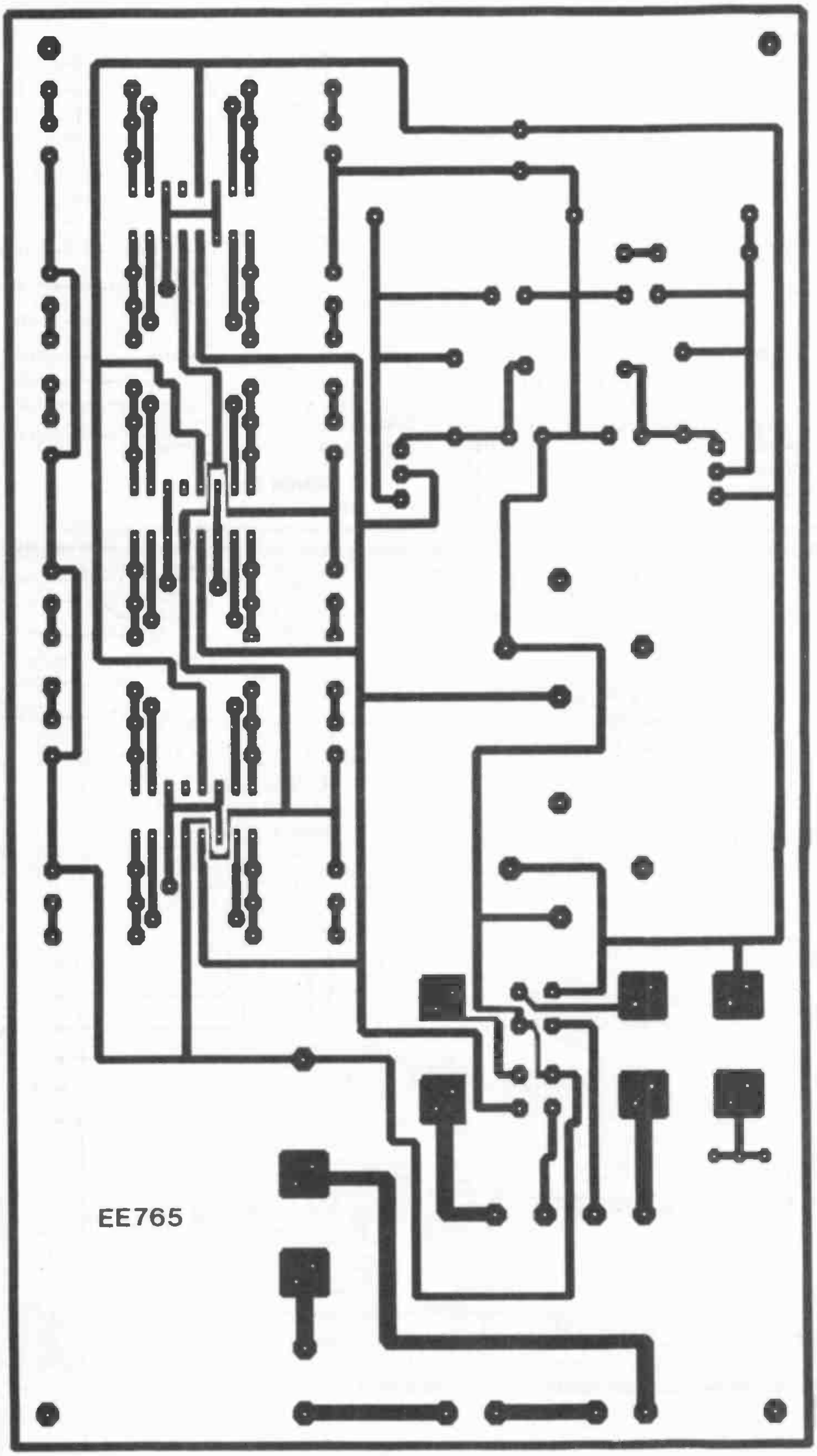


Fig. 3. Printed circuit board component layout and full size (right) copper foil master pattern for the Dimmer Interface Module.





Wiring to the rear (left) and front (above) panel components.



puts from whichever module is connected into input socket SK2 of the Dimmer Interface Module. With S3 in the Proportional position, the output of the proportional module (which must be connected into input socket SK1) is fed direct to the inputs dimmer channels 1, 2, 3 and 4.

It must be realised that this requires that the proportional output module connected to the proportional input to the interface *must* be of the same sense as that required to drive the dimmer rack connected to channels 1 to 6.

CONSTRUCTION

Construction of this project is relatively simple with most of the circuitry being accommodated on the single-sided printed board (p.c.b.) shown in Fig.3. This board may be purchased from the *EE PCB Service*, code 765.

When making up the p.c.b. you will probably find that it is easiest to install the components onto the board, in the positions shown in Fig.2, in ascending order of size. Care should be taken to ensure that all polarised components are installed on the p.c.b. the correct way round.

It is best if IC3, IC4 and IC5 are accommodated in holders, which should be soldered to the board at the construction stage. The i.c.s are installed as the last task before testing the circuit. The wiring up of the module will be made much easier if the wired connections to the printed circuit board are fitted with solder pins.

ASSEMBLY AND WIRING-UP

Prior to installing the board in the case it will be necessary to cut the appropriate sized holes into the metalwork and letter the case as appropriate. The case mounted components should then be mounted, with their connecting wires fitted, in the appropriate locations. There are an extremely large number of wire connections to be made for this module and it is therefore advisable to use as large a number of coloured wires for the connections as possible.

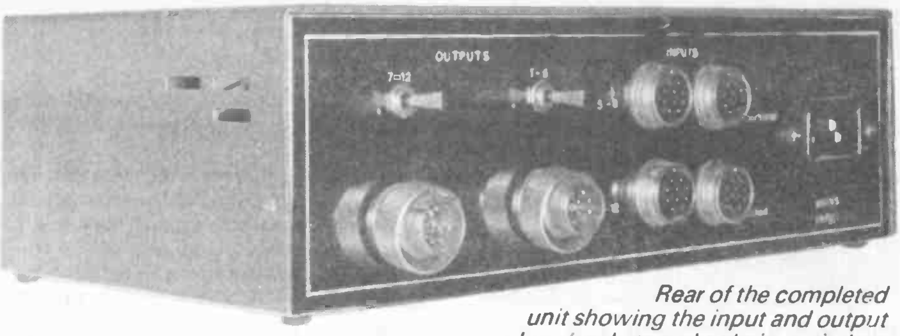
The 13 l.e.d.s in this project may all be installed on the front panel and their cathodes (k) connected together by a suitable piece of bared wire before connecting them to the appropriate point on the p.c.b. In order to facilitate this it will be found best to install all of the l.e.d.s so that the flat (indicating cathode) markings on the l.e.d. cases are all aligned in the same direction.

Once the p.c.b. has been completed four adhesive stand-off mountings should be inserted into appropriate holes on the board. The board should then be positioned in an appropriate place in the base of the case and the stand-offs pressed into position.

Once the p.c.b. is secured then the connections from the various case mounted components should be made to the correct places on the printed circuit board. When interwiring from the board to the case mounted components, you should remember that it may be necessary to remove it from the case, for servicing and fault finding, so it is advisable to ensure that there is an adequate length of wire left to make this possible.

TESTING AND SETTING UP

Before IC3, IC4 and IC5 are inserted into their holders it is advisable to test and



Rear of the completed unit showing the input and output plugs/sockets and polarity switches.

set up the power supply. In order to do this the input mains connector should be inserted into the panel mounted plug PL1 and connected to a suitable supply.

Please remember that mains voltage is present on the board in the area of the transformer and great care must be exercised when working in this area.

A voltmeter should now be connected between a suitable 0V connection and the +10V output point on the circuit board. Preset VR1 should then be adjusted to set the voltage measured to +10 volts.

The process should then be repeated, connecting a voltmeter between 0V and the *negative* output to switches S1 and S2. Preset VR2 should then be adjusted until a reading of −10 volts is obtained.

Once the supply voltages have been set, IC3, IC4 and IC5 can be inserted into their sockets and the entire unit tested to see if it performs as described in the circuit description. It is not necessary to connect modules to all the inputs to test that the circuit works properly since it is possible to operate the internal switches by simply applying a voltage of +9V or more between 0 volts and the module inputs. If necessary this may be done by making a temporary connection to a standard 9 volt battery between 0 volts and each input.

If all is well then each of the outputs should, in turn, give an output which is the right sense, is controlled by the appropriate rotary potentiometer and operated only when the input connection is supplied with a control voltage. If any of the outputs is found not to be working properly then it will be necessary to check thoroughly through that part of the circuit associated with it to find where the fault lies.

IN USE

Before connecting up the Dimmer Interface Module to any commercial dimmer-racks it will be necessary to make the appropriate link cable to connect between the outputs from the dimmer interface and the inputs of the commercial dimmer racks. In order to do this it will be necessary that you fully understand not only the input characteristic of the dimmer rack but the pining of input connections.

The manufacturers of the equipment will be able to supply this information to you as will any reputable supplier of theatre equipment. The theatre industry is always extremely helpful with regard to technical queries so you should have no qualms about approaching them.

The most complicated part of using this interface is the setting up of the system. **Before connecting the interface module to the dimmer racks it is necessary to set the output sense selector switches (S1 and S2) to the appropriate setting for the dimmer rack which you are using.**

The switch should be set to the plus (+) position when connected to dimmer racks manufactured by Pulsar, Eltec and Zero 88, whilst it should be set to the minus (−) or negative position when connected to dimmer racks manufactured by Rank Strand. The dimmer-racks should then be connected to the outputs of the interface module and the modules which you require to control and the dimmer channels should be connected to the input sockets.

It is necessary also to connect the unit to the mains. At this point l.e.d. D9 should illuminate and the 12 other l.e.d.s should operate at the same time as the output l.e.d.s of the modules which are connected to the inputs. When the l.e.d. is illuminated the output circuit connected to appropriate channel of the dimmer-rack should be operated at a brightness which is set by the position fo the appropriate brightness controls (VR3, VR4 and VR5).

Next Month: Sound Unit.

ROBOT ROUNDUP

Nigel Clark

EXPANSION

UMI is continuing its expansion with the addition of Systems Control of Middlesborough. The company has been renamed UMI Labman reflecting the range of robots on which the company is concentrating.

In the past Systems has been associated with the SmartArm, which it created and sold until 1984, and the Open University robot which it designed and which is now sold by TecQuipment.

Systems joined forces with UMI in February giving it access to UMI's larger sales network and greater availability of resources for development.

There are four robots in the range, the Labman 350, 450, 900 and 1200. The degrees of complexity and cost increase with the numbers. The 350 starts at about £3,000, the 450 at £11,000 and the 1200 at £16,000. The 900 is the odd one out being priced at £7,000.

The prices are approximate, being specially designed for use in laboratories there are a number of extras which are usually included in the system.

SPECIFICATIONS

All four Labmans are SCARA robots and all, apart from 350, are based on the same software and electronics. Only the mechanics differ to suit the users' requirements. Another of the products the company offers is to custom-build robots based around the common software and electronics.

Each robot has a basic three axes with the capability of being expanded to eight, although the maximum the company has so far achieved is seven. The expansion is achieved by creating a variety of end effecters, for example a decapper and a vibrofeeder. There is also the usual array of electrical, pneumatic and suction grippers.

The 350 can lift 200gm with a repeatability of 1mm and can operate within a working envelope measuring 350mm by 600mm, governed by the size of the base on which it is supplied. The other three have greater accuracy with a repeatability of 0.1mm, and a load capacity for the 450 of 1kg and 2kg for the 900 and 1200.

The 450 has a reach of 450mm and its waist can move through 270 degrees. The gripper has vertical movement of 150mm. Both the 900 and 1200 operate on horizontal tracks giving them rectangular operating areas measuring 900mm by 400mm and 1200mm by 600mm.

Each robot has its own controller and it is possible to enter instructions by way of a keypad. However an IBM PC is required for downloading instructions and in many cases for control as well, particularly when the robot is working in hazardous conditions.

NEW NAMES

Two names new to me at the recent *Automan* exhibition were CRSPlus and Rob3. CRSPlus is a Canadian company which makes a range of three robots, imported by Orme Systems Automation. Being quite expensive they are aimed at the light industrial market.

The A150 is the smallest and slowest for about £11,000. The A250 costs £13,000 with £20,000 being needed for the A460. Both the A150 and A250 share the same mechanics but the A250 is faster and more accurate because of its better control system.

The A150 has a repeatability of 0.13mm. The A250, because of something called proportional integral derivative (PID) has a claimed repeatability of 0.05mm. PID enables the system to make quite small adjustments to its position, which, apart from the accuracy, allows the A250 to start decelerating later than the A150 thus increasing its speed.

With five axes plus a gripper both machines can lift up to 2kg and have a reach of 26 inches including the gripper. Drive is provided by d.c. servos with optical encoders for feedback.

They come with their own controllers which have 8K of battery-backed RAM. Instructions can be entered by a keypad or by making use of the Limp mode which allows the robots to be positioned by hand.

The controller's memory can be expanded to 56K with an optional 32K of EEPROM memory.

There is also an interface available for IBMs enabling routines to be written off-line and then downloaded or programs to be saved from the controller.

A number of further options are available including a braking system which holds the robot in its latest position if anything should happen to disrupt its procedure such as a power failure. Four kinds of grippers can be attached, electrical, pneumatic, magnetic and suction.

Each machine has three spare lines allowing an extra peripheral to be customised. And the controller has the capacity for up to 16 inputs and 16 outputs.

A development soon to be made available is an expandable track on which the robots can be placed, giving them the ability to cover a larger area.

The larger cousin of the A150 and A250, the A460, which has only recently been launched in this country, has all the abilities of the other two apart from the braking facility. However is has six axes plus the gripper, a reach of 840mm and can lift 3kg with a repeatability of 0.05mm.

GERMAN ROBOT

Rob3 is a German educational machine, which with its larger industrial version Rob3i, is imported by JMA. Both have five axes plus gripper with an accuracy of 0.5mm. Rob3 can lift 250gm while Rob3i has a capacity double that.

All five axes on both machines can move through 200 degrees and there is a choice of three grippers, electrical, pneumatic and suction.

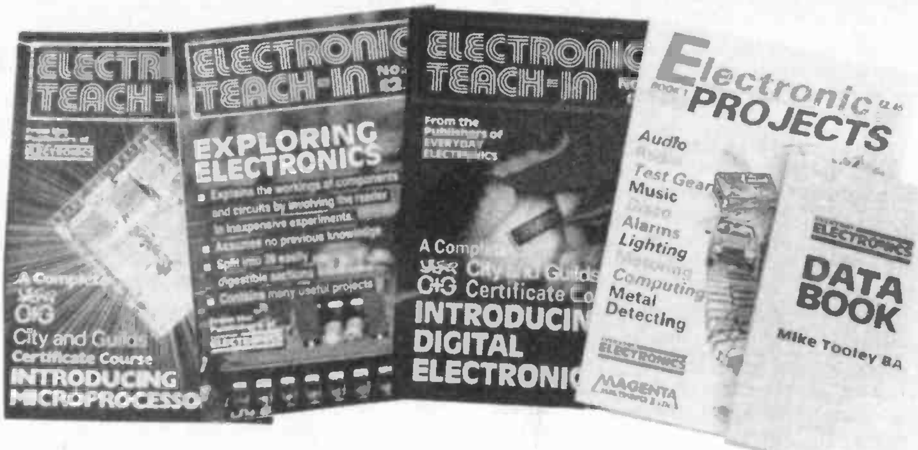
Instructions can be entered into the robots' own controllers by way of a keypad. There is also software available for linking to an IBM PC or compatible.

The robots can be linked together to form a work cell and JMA supplies a variety of components including a turntable, conveyor belt, and a vision system. A complete cell costs between £20,000 and £25,000 depending on the components.

The vision system, Inspector 16, is also sold separately by JMA for about £5,000. For that the user gets the camera, lens, lighting and software. It uses a high definition CCD camera.

A Labman 900 set up with a Bar Code reader as a slide preparation system

SPECIAL EVERYDAY ELECTRONICS BOOKS



ELECTRONICS TEACH-IN 88/89– INTRODUCING MICROPROCESSORS
Mike Tooley BA (published by *Everyday Electronics*)
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc.
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ELECTRONICS TEACH-IN No. 3 – EXPLORING ELECTRONICS (published by Everyday Electronics)
Owen Bishop
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Exploring Electronics contains more than 25 useful projects, assumes no previous knowledge of electronics and is split into 28 easily digestible sections.
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ELECTRONICS TEACH-IN No. 4
INTRODUCING DIGITAL ELECTRONICS (published by *Everyday Electronics*)
Michael J. Cockcroft
Although this book is primarily a City & Guilds Introductory level course (726/301), approximately 80% of the information forms a very basic introduction to electronics in general, it therefore provides an excellent introductory text for beginners and a course and reference book for GCSE students.
Full details on registering for C&G assessment, details of assessment centres, components required and information on the course in general are given.
The City & Guilds Introduction to module 726/301 reads: "A candidate who satisfactorily completes this module will have a competence to identify basic components and digital integrated circuits and connect them together to form simple working circuits and logic units." This provides an excellent introduction to the book.
112 pages (A4 size) Order code T14 £2.95

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Mike Tooley BA
(published by EE in association with PC Publishing)
This book is an invaluable source of information of everyday relevance in the world of electronics. It contains not only sections which deal with the essential theory of electronic circuits, but it also deals with a wide range of practical electronic applications.
It is ideal for the hobbyist, student, technician and engineer. The information is presented in the form of a basic electronic recipe book with numerous examples showing how theory can be put into practice using a range of commonly available "industry standard" components and devices.
A must for everyone involved in electronics!
256 pages Order code DATA £8.95

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The books listed have been selected by Everyday Electronics editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page. For another selection of books see next month's issue

TESTING, THEORY AND REFERENCE

ELECTRONIC TEST EQUIPMENT HANDBOOK
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The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of the instruments are also examined.
Everything from Audio oscillators, through R, C & L measurements (and a whole lot more) to Waveform Generators and testing Zeners. A truly comprehensive book for the hobbyist, student, technician and engineer.
206 pages Order code PC109 £8.95

HOW TO TEST ALMOST EVERYTHING ELECTRONIC – 2nd EDITION
Jack Darr and Delton T. Horn
Describes electronic tests and measurements – how to make them with all kinds of test equipment, and how to interpret the results. New sections in this edition include logic probes, frequency counters, capacitance meters, and more. (An American book.)
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GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold
This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.
In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.
96 pages Temporarily out of print

MORE ADVANCED USES OF THE MULTIMETER
R. A. Penfold
This book is primarily intended as a follow-up to BP239, (see above), and should also be of value to anyone who already understands the basics of voltage testing and simple component testing. By using the techniques described in chapter 1 you can test and analyse the performance of a range of components with just a multimeter (plus a very few inexpensive components in some cases). Some useful quick check methods are also covered.
While a multimeter is supremely versatile, it does have its limitations. The simple add-ons described in chapter 2 extended the capabilities of a multimeter to make it even more useful. The add-ons described include an active r.f. probe, a high resistance probe, an a.c. sensitivity booster, and a current tracer unit.
84 pages Order code BP265 £2.95

THE ILLUSTRATED DICTIONARY OF ELECTRONICS – 4th EDITION
Rufus P. Turner and Stan Gibilisco
With more than 27,000 terms used in electronics today, this collection is THE most comprehensive dictionary available. Including all practical electronics and computer terms, it is as up-to-date as the latest advances in the field itself! Tables and data on subjects most often consulted for projects and experiments are included. Other conversion tables include English/metric and metric/English conversions for units of energy, power and volume, and Fahrenheit/Celsius temperature conversion charts.
Setting this edition apart from other electronic dictionaries is its emphasis on illustration. Featuring more than complete definitions, this fourth edition includes over 450 detailed drawings and diagrams.
All entries are listed in alphabetical order. Abbreviations and initials are listed in sequence with whole words. All terms of more than one word are treated as one word. (An American book).
648 pages Order code T2900 £23.65

ELECTRONICS – A "MADE SIMPLE" BOOK
G. H. Olsen
This book provides excellent background reading for our *Introducing Digital Electronics* series and will be of interest to everyone studying electronics. The subject is simply explained and well illustrated and the book assumes only a very basic knowledge of electricity.
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F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.
Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.
The book is divided into six basic sections: Units and Constants, Direct-current Circuits, Passive Components, Alternating-current Circuits, Networks and Theorems, Measurements.
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MICROELECTRONIC SYSTEMS N2 CHECKBOOK
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The aim of this book is to provide a foundation in microcomputer hardware, software and interfacing techniques. Each topic is presented in a way that assumes only an elementary knowledge of microelectronics systems and logic functions. The book concentrates on 6502, Z80 and 6800 microprocessors and contains 60 tested programs, 160 worked problems and 250 further problems.
256 pages Order code NE04N £8.95

PRACTICAL DIGITAL ELECTRONICS HANDBOOK
Mike Tooley (Published in association with *Everyday Electronics*)
The vast majority of modern electronic systems rely heavily on the application of digital electronics, and the *Practical Digital Electronics Handbook* aims to provide readers with a practically based introduction to this subject. The book will prove invaluable to anyone involved with the design, manufacture or servicing of digital circuitry, as well as to those wishing to update their knowledge of modern digital devices and techniques. Contents: Introduction to integrated circuits; basic logic gates; monostable and bistable devices; timers; microprocessors; memories; input and output devices; interfaces; microprocessor buses. Appendix 1: Data. Appendix 2: Digital test gear projects; tools and test equipment; regulated bench power supply, logic probe; logic pulser; versatile pulse generator; digital IC tester; current tracer; audio logic tracer; RS-232C breakout box; versatile digital counter/frequency meter. Appendix 3: The oscilloscope. Appendix 4: Suggested reading. Appendix 5: Further study.
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ELECTRONICS-BUILD AND LEARN
R. A. Penfold
The first chapter gives full constructional details of a circuit demonstrator unit that is used in subsequent chapters to introduce common electronic components – resistors, capacitors, transformers, diodes, transistors, thyristors, fets and op amps. Later chapters go on to describe how these components are built up into useful circuits, oscillators, multivibrators, bistables and logic circuits.
At every stage in the book there are practical tests and experiments that you can carry out on the demonstrator unit to investigate the points described and to help you understand the principles involved. You will soon be able to go on to more complex circuits and tackle fault finding logically in other circuits you build.
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AUDIO AND MUSIC

MAKE MONEY FROM HOME RECORDING
Clive Brooks

Now that you've spent a fortune on all that recording gear, MIDI and all, wouldn't it be nice to get some of it back? Well here's the book to show you how.

It's packed with money making ideas, any one of which will recoup the price of the book many times over. Whether you have a fully fledged recording studio at home, or just a couple of stereo cassette recorders and a microphone, you'll be able to put the ideas in this book into practice and make money.

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INTRODUCTION TO DIGITAL AUDIO
Ian Sinclair

Digital recording methods have existed for many years and have become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring digital audio methods into the home. The next step is the appearance of digital audio tape (DAT) equipment.

All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.

This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.

128 pages **Order code PC102** £5.95

SYNTHESIZERS FOR MUSICIANS
R. A. Penfold

Modern synthesizers are extremely complex, but they mostly work on principles that are not too difficult to understand. If you want to go beyond using the factory presets or the random poking of buttons, this is the book for you.

It covers the principles of modern synthesis – linear arithmetic as used by Roland, phase distortion (Casio), Yamaha's frequency modulation, and sampling – and then describes how the instruments are adjusted to produce various types of sound – strings, brass, percussion, etc. The theoretical side of synthesis is treated in an easy to understand way – the technical information being restricted to what you need to know to use your instrument effectively.

168 pages **Order code PC105** £6.95

AUDIO
F. A. Wilson, C. G. I. A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Analysis of the sound wave and an explanation of acoustical quantities prepare the way. These are followed by a study of the mechanism of hearing and examination of the various sounds we hear. A look at room acoustics with a subsequent chapter on microphones and loudspeakers then sets the scene for the main chapter on audio systems – amplifiers, oscillators, disc and magnetic recording and electronic music.

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CIRCUITS AND DESIGN

ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF MODEL RAILWAYS
R. A. Penfold

Home computers may easily be applied to the control of model railways and really quite sophisticated control, which needs only simple programming, is not too difficult to achieve. The main problem lies in interfacing the computer to the layout, but fortunately it is not too difficult or expensive to build suitable interfaces, and this book shows you how.

The project consists of various types of controller, including a high quality pulse type, as well as circuits for train position sensing, signal and electric points control etc. The use of computers does not have to be restricted to massive layouts. Something as simple as an oval of track with a single siding can be given a new dimension by adding computer control and much fun can be had from these relatively simple set-ups.

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REMOTE CONTROL HANDBOOK
Owen Bishop

Remote control systems lend themselves to a modular approach. This makes it possible for a wide range of systems, from the simplest to the most complex, to be built up from a number of relatively simple modules. The author has tried to ensure that, as far as possible, the circuit modules in this book are compatible with one another. They can be linked together in many different configurations to produce remote control systems tailored to switch a table lamp on and off, or to operate an industrial robot, this book should provide the circuit you require.

226 pages **Order code BP240** £3.95

COIL DESIGN AND CONSTRUCTION MANUAL
B. B. Babani

A complete book for the home constructor on "how to make" RF, IF, audio and power coils, chokes and transformers. Practically every possible type is discussed and calculations necessary are given and explained in detail. Although this book is now rather old, with the exception of torroids and pulse transformers little has changed in coil design since it was written.

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30 SOLDERLESS BREADBOARD PROJECTS – BOOK 1
R. A. Penfold

Each project, which is designed to be built on a "Verobloc" breadboard, is presented in a similar fashion with a brief circuit description, circuit diagram, component layout diagram, components list and notes on construction and use where necessary. Whenever possible, the components used are common to several projects, hence with only a modest number of reasonably inexpensive components, it is possible to build in turn, every project shown. Recommended by BICC-Vero.

160 pages **Order code BP107** £2.95

BOOK 2 –
All projects use CMOS I.c.s. but the items on component identification etc., are not repeated from Book 1.

160 pages **Order code BP113** £2.25

ELECTRONIC CIRCUITS HANDBOOK
Michael Tooley BA

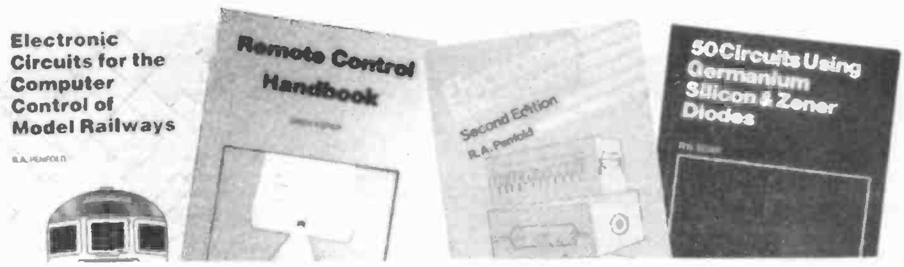
This book aims to explode two popular misconceptions concerning the design of electronic circuits: that only those with many years of experience should undertake circuit design and that the process relies on an understanding of advanced mathematics. Provided one is not too ambitious, neither of these popularly held beliefs is true.

Specifically, this book aims to provide the reader with a unique collection of practical working circuits together with supporting information so that circuits can be produced in the shortest possible time and without recourse to theoretical texts.

Furthermore, information has been included so that the circuits can readily be modified and extended by readers to meet their own individual needs. Related circuits have been grouped together and cross-referenced within the text (and also in the index) so that readers are aware of which circuits can be readily connected together to form more complex systems. As far as possible, a common range of supply voltages, signal levels and impedances has been adopted.

As a bonus, ten test gear projects have been included. These not only serve to illustrate the techniques described but also provide a range of test equipment which is useful in its own right.

277 pages **Order code NE05** £16.95



AUDIO IC CIRCUITS MANUAL
R. M. Marston

A vast range of audio and audio-associated i.c.s. are readily available for use by amateur and professional design engineers and technicians. This manual is a guide to the most popular and useful of these devices, with over 240 diagrams. It deals with i.c.s. such as low frequency linear amplifiers, dual pre-amplifiers, audio power amplifiers, charge coupled device delay lines, bar-graph display drivers, and power supply regulators, and shows how to use these devices in circuits ranging from simple signal conditioners and filters to complex graphic equalizers, stereo amplifier systems, and echo/reverb delay line systems etc.

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HOW TO DESIGN ELECTRONIC PROJECTS
R. A. Penfold

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TIMER/GENERATOR CIRCUITS MANUAL
R. M. Marston

This manual is concerned mainly with waveform generator techniques and circuits. Waveform generators are used somewhere or other in most types of electronic equipment, and thus form one of the most widely used classes of circuit. They may be designed to produce outputs with sine, square, triangle, ramp, pulse, staircase, or a variety of other forms. The generators may produce modulated or unmodulated outputs, and the outputs may be of single or multiple form.

Waveform generator circuits may be built using transistors, op-amps, standard digital ICs, or dedicated waveform or "function" generator ICs.

The manual is divided into eleven chapters, and presents over 300 practical circuits, diagrams and tables. The subjects covered include: Basic principles; Sine wave generators; Square wave generators; Pulse generator circuits; "Timer IC" generator circuits; Triangle and sawtooth generators; Multi-waveform generation; Waveform synthesizer ICs; Special waveform generators; Phaselocked loop circuits; Miscellaneous "555" circuits.

267 pages **Order code NE18** £12.95

OPTOELECTRONICS CIRCUITS MANUAL
R. M. Marston

A useful single-volume guide to the optoelectronics device user, specifically aimed at the practical design engineer, technician, and the experimenter, as well as the electronics student and amateur. It deals with the subject in an easy-to-read, down-to-earth, and non-mathematical yet comprehensive manner, explaining the basic principles and characteristics of the best known devices, and presenting the reader with many practical applications and over 200 circuits. Most of the i.c.s. and other devices used are inexpensive and readily available types, with universally recognised type numbers.

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POPULAR ELECTRONIC CIRCUITS – BOOK 1
POPULAR ELECTRONIC CIRCUITS – BOOK 2
R. A. Penfold

Each book provides a wide range of designs for electronic enthusiasts who are capable of producing working projects from just a circuit diagram without the aid of detailed construction information. Any special setting-up procedures are described.

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R. M. Marston

Written for the professional engineer, student or enthusiast. It describes the basic principles and characteristics of these devices and includes over 200 circuits.

All the circuits have been designed, built and fully evaluated by the author; all use inexpensive and internationally available devices.

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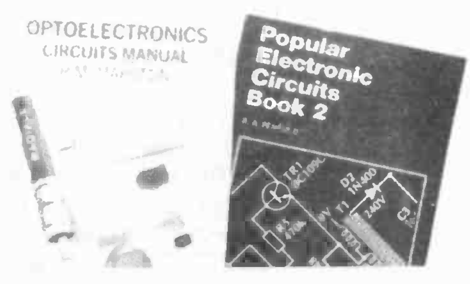

PROJECT CONSTRUCTION

HOW TO DESIGN AND MAKE YOUR OWN P.C.B.s
R. A. Penfold
Deals with the simple methods of copying printed circuit board designs from magazines and books and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.
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HOW TO GET YOUR ELECTRONIC PROJECTS WORKING
R. A. Penfold
We have all built projects only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.
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O. Bishop
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R. A. Penfold
Shows the complete beginner how to tackle the practical side of electronics, so that he or she can confidently build the electronic projects that are regularly featured in magazines and books. Also includes examples in the form of simple projects.
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TEST EQUIPMENT CONSTRUCTION
R. A. Penfold
This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.
The following designs are included:- AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Millivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe. The designs are suitable for both newcomers and more experienced hobbyists.
104 pages Order code BP248 £2.95

DATA AND COMPONENT IDENTIFICATION

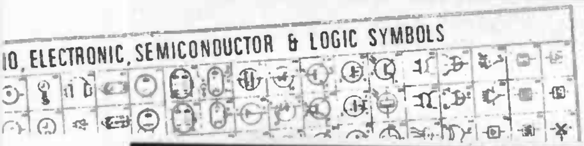

CHART OF RADIO, ELECTRONIC, SEMICONDUCTOR AND LOGIC SYMBOLS
M. H. Banani B.Sc.(Eng.)
Illustrates the common, and many of the not-so-common, radio, electronic, semiconductor and logic symbols that are used in books, magazines and instruction manuals, etc., in most countries throughout the world.
Chart Order code BP27 £0.95

INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE
A. Michaels
Helps the reader to find possible substitutes for a popular selection of European, American and Japanese transistors. Also shows material type, polarity, manufacturer and use.
320 pages Order code BP85 £3.50

RADIO, TV, SATELLITE

BEGINNER'S GUIDE TO RADIO – 9th EDITION
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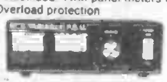

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