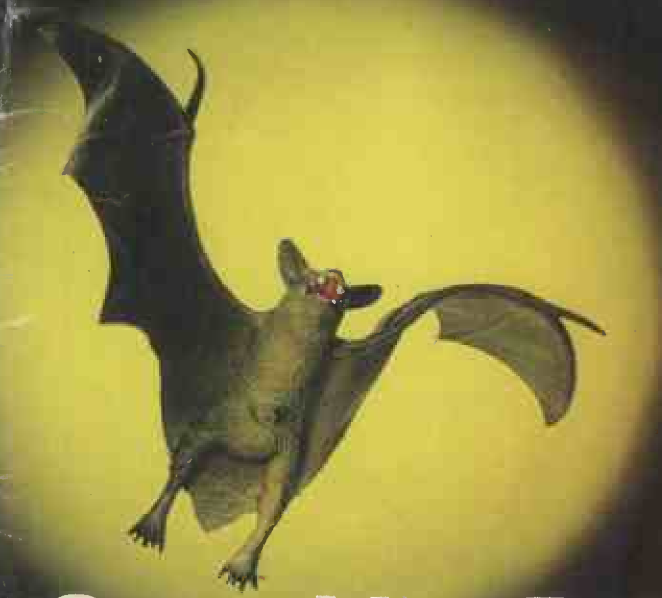
EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

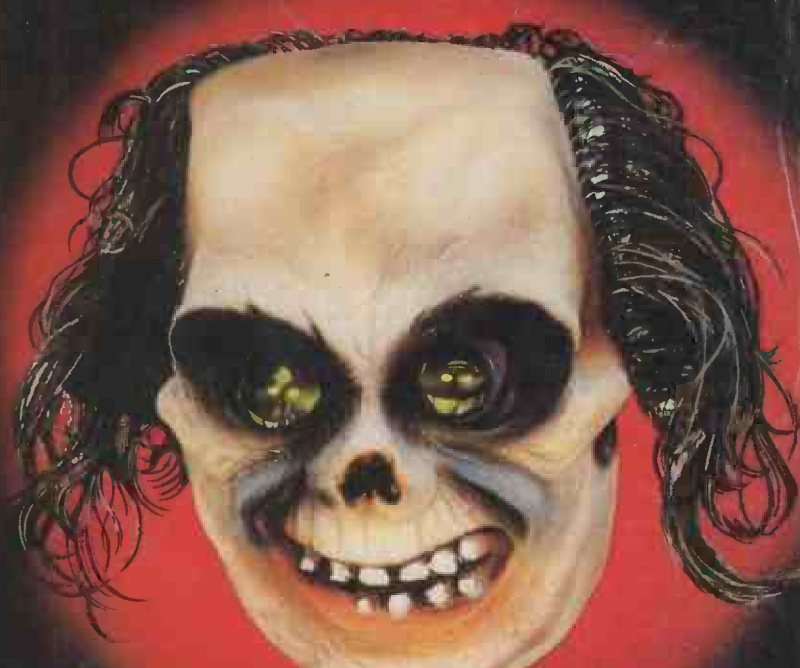
NOVEMBER 1985 £1·10

3 HALLOWEEN PROJECTS

Flashing Pumpkin



Squeaking Bat



Screaming Mask

PLUS...

SMALL TOOLS BUYERS GUIDE

TEACH IN '86 PROJECT – LCR BRIDGE

Newcomers Magazine for Electronic & Computer Projects

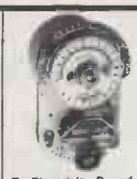
Australia $2 New Zealand $2.25 Malaysia $5.25

£1 BAKERS DOZEN PARCELS

(all £1 each 13 for £12)

All parcels are brand new components price £1 per parcel – if you order 12 then pick another free

BD115 – 1 Wall mounting thermostat with thermometer
BD116 – 3 pairs small and 2 pairs medium insulated croc clips
BD117 – 4 pairs large croc clips (car battery type)
BD118 – 1 Teak look 5" extension speaker cabinet with back
BD119 – 2 fibreglass fire fronts log effect & coal effect
BD120 – 2 component boards with 2 amp 400v bridge rectifier and 15 other recs
BD121 – 4 push push switches for table lambs etc
BD122 – 10 mtrs twin flex, screened and outer pvc covered
BD123 – 100 staples for thin flex white plastic and hardened nail
BD124 – 25 clear plastic lenses 1¾" diameter
BD125 – 4 items: rev per hour mains motor, counter, coin switch and srbp panel
BD126 – 4 pilot bulb lamp holders bakelite batten type
BD127 – 4 pilot bulb holders metal clip on type
BD128 – 10 very fine drills for pcbs etc
BD129 – 4 extra thin screw drivers for instruments
BD130 – 2 centre zero panel meters 100-0-100 uA
BD131 – 1 100 uA edge wise balance meter
BD132 – 2 plastic boxes with windows, ideal interrupted beam kits
BD133 – 1 Microsonic radio case in leather case
BD134 – 10 model aircraft motors – require no on/off switch, just spin
BD135 – 10 large and 20 small Screwit porcelain connector/insulators
BD136 – 2 car radio speakers 5" round 4 ohm made for Radiomobile
BD137 – 1 5" 4 ohm speaker 5 watts & 1 matching tweeter
BD138 – 1 9" × 4" 8 ohm 5 watt speaker
BD139 – 4 600 ohm microphone/speaker inserts
BD140 – 1 waterproof metal cased plug and socket 3 pin
BD141 – 10 miniature slide switches 2 pole c/o
BD142 – 10 4 ba spanners 1 end open, other end closed
BD143 – 5 100k multi turn pots with knob
BD144 – 10 chassis mounting fuse holders for 5 mm fuses
BD145 – 2 4 reed relay kits 3v coil can be normally open or c/o
BD146 – 20 pilot bulbs 6.5v ·3a Philips
BD147 – 1 Secret switch kit with data
BD148 – 1 Printed circuit kit with data and 100 circuits
BD149 – 4 socket covers (protect inquisitive little fingers) for twin 13A
BD150 – 5 socket covers (protect inquisitive little fingers) for single 13A
BD151 – 20 4 way terminal blocks 3A 250v
BD152 – 1 Air or gas shut off valve – clockwork
BD153 – 1 Air or gas shut off valve – thermostatic
BD154 – 1 12v drip proof relay – ideal for car jobs
BD155 – 3 Varicap push button tuners with knobs
BD156 – 2 pairs Ferrite cores Neosid 56 × 18 mm
BD157 – 6 2 circuit micro switches – Licon ideal for Joystick
BD158 – 5 12 way connector blocks 2A 250v
BD159 – 3 12 way connector blocks 25A 250v
BD160 – 6 pairs 3 way connectors plug in, terminal block type
BD161 – 1 13A panel socket MK ref 735 WH1
BD162 – 1 13A fused and switched spur for surface mounting or can be removed from box for flush mounting
BD163 – 3 13A sockets good British make but brown
BD164 – 2 13A switched sockets good British make but brown
BD165 – 1 13A switched socket on base for surface mounting
BD166 – 1 30A panel mounting toggle switch
BD167 – 1 8 pin flex terminating plug and chassis mounting socket (s.h.)
BD168 – 2 50 tag component mounting strips
BD169 – 4 Short wave air spaced trimmers 2 – 30pf
BD170 – 2 Hivac numicator tubes neon type
BD171 – 1 Shocking coil kit with data – have fun
BD172 – 10 12v 6w bulbs Philips m.e.s.
BD173 – 1 6v d.c. solenoid with plunger 1" travel
BD174 – 2 end of travel c/o switches – very robust mounted on heavy metal plate 10A 250v
BD175 – 1 200 rpm motor mains operated 2 watt
BD176 – 4 heavy duty push switches – ideal for foot operation 3A 250v
BD177 – 5 Lilliput bulbs 12v
BD178 – 3 Oblong amber indicators with lilliputs 12v
BD179 – 3 Oblong amber indicators with neons 240v
BD180 – 6 round amber indicators with neons 249v
BD181 – 100 p.v.c. grommets ⅜ hole size
BD182 – 1 short wave tuning condensor 50 pf with ¼" spindle
BD183 – 1 two gang short wave tuning condenser with ¼" spindle 2 × 50 pf
BD184 – 1 three gang tuning condenser each section 500 pf with trimmers and good length ¼" spindle
BD185 – 4 ferrite rod aerials 8" × ⅜" rods with long and medium wave coils
BD186 – 1 3 wafer switch: 18 pole 2 way, 12 pole 3 way, 9 pole 4 way, 6 pole 6 way, 3 pole 12 way, your choice
BD187 – 2 2 wafer switches 12 pole 2 way, 8 pole 3 way, 6 pole 4 way, 4 pole 6 way, 2 pole 12 way, any 2 your choice
BD188 – 1 plastic box sloping metal front, size 160 × 95mm average depth 45mm
BD189 – 2 double pole 20 amp 250v flush mounting switches – white

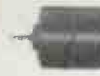


Ex-Electricity Board. Guaranteed 12 months.

VENNER TIME SWITCH

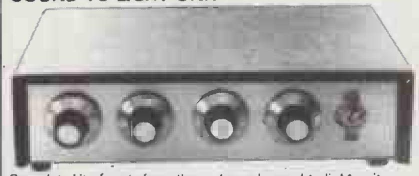
Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only **£2.95** without case, metal case – **£2.95**, adaptor kit to convert this into a normal 24hr. time switch but with the added advantage of up to 12 on/offs per 24hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £2.30.

12 volt MOTOR BY SMITHS



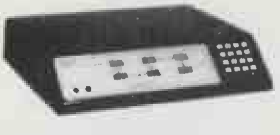
Made for use in cars, etc. these are very powerful and easily reversible. Size 3½" long by 3" dia. They have a good length of ¼" spindle –
1/10 hp £3.45
1/8 hp £5.75. 1/6 hp £7.50

SOUND TO LIGHT UNIT



Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is £14.95 in kit form.

PRESTEL UNITS



These are brand new and we understand tested, came with manufacturer's guarantee now void as the manufacturer no longer trades. These originally sold for over £150. We offer then complete, except for 7 plug in i.c.s and price is only **£14.95** (less than the value of the modem included).

TANGENTIAL BLOW HEATER

by British Solartron, as used in best blow heaters. 3Kw **£6.95** complete with 'cold' 'half' and 'full' heat switch, safety cut out and connection diagram.

Please add post £1.50 for 1 or 3 for £20 post paid
2.5 Kw KIT Still available: £4.95 + £1.50 post
or have 3 for £16 post paid.

FROZEN PIPES

Can be avoided by winding our heating cable around them – 15 mtrs connected to mains costs only about 10p per week to run. Hundreds of other uses as it is waterproof and very flexible. Resistance 60 ohms/metre. Price 28p/metre or 15m for £3.95.

CORDLESS TELEPHONES

"IT'S FOR YOU-OU" even if you are in the bath, its an infinite extension any room and even in the garden – have one on approval or come and try one here. BT approved £120 not yet approved **£69.** plus £2 post.

SOCKETS PLUGS ETC for BT phones

Master socket (has surge arrestor – ringing condenser etc) and takes B.T. plug	£3.95
Extension socket	£2.95
Dual adaptors (2 from one socket)	£3.95
Cord terminating with B.T. plug 3 metres	£2.95

Kit for converting old entry terminal box to new B.T. master socket, complete with 4 core cable, cable clips and 2 BT extension sockets £11.50

25A ELECTRICAL PROGRAMMER

Learn in your sleep. Have radio playing and kettle boiling as you wake – switch on lights to ward off intruders – have a warm house to come home to. You can do all these and more. By a famous maker with 25 amp on/off switch. Independent 60 minute memory jogger. A beautiful unit at **£2.50**

THE AMSTRAD STEREO TUNER

This ready assembled unit is the ideal tuner for a music centre or an amplifier, it can also be quickly made into a personal stereo radio – easy to carry about and which will give you superb reception.
Other uses are a "get you to sleep radio", you could even take it with you to use in the lounge when the rest of the family want to view programmes in which you are not interested. You can listen to some music instead.
Some of the features are: long wave band 115 – 170KHz, medium wave band 525 – 1650KHz, FM band 87 – 108 MHz, mono, stereo & AFC switchable, fully assembled and fully aligned. Full wiring up data showing you how to connect to amplifier or headphones and details of suitable FM aerial (note ferrite rod aerial is included for medium and long wave bands). All made up on very compact board.
Offered at a fraction of its cost — only £4.95

COMPUTER DESKS

Few still available
Computer desks – size approx 4' × 2' × 2'6" high formica covered, cost over £100 each. Our price only **£9.50** – you must collect – hundreds supplied to schools.

J. BULL (Electrical) Ltd.
(Dept. EE), 34 - 36 AMERICA LANE, HAYWARDS HEATH, SUSSEX RH16 3QU. Established 30 YEARS

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1 service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted day or night. Haywards Heath (0444) 454563. **Bulk orders:** phone for quote. Shop open 9.00 – 5.30, Mon to Fri, not Saturday.

TWO POUNDERS

Following the popularity of our BAKERS DOZEN £1 PARCELS, we are now introducing some BAKERS DOZEN £2 PARCELS. We feel that you will agree that most are exceptional bargains but you can still get a bit extra, as with the £1 parcel, if you buy 12 you get another free!

2P1 – 24 hour time switch with 2 on/offs. an ideal heating programmer
2P2 – Wall mounting thermostat, high precision with mercury switch and thermostat
2P3 – Variable and reversible 8-12v power supply, ideal for model control
2P4 – 24 volt psu with separate channels for stereo made for Mullard UNILEX Amplifiers.
2P5 – 12 volt psu 750 ma output – plastic cased
2P6 – 100 watt mains to 115 volts auto-transformer with voltage tappings
2P7 – Mini key, 16 button membrane keyboard, list price over £12, as used on PRESTEL
2P8 – Mains motor with gear box and variable speed selector. Series wound so suitable for further speed control
2P9 – Time and set switch. Boxed, glass fronted and with knobs. Controls up to 15 amps. Ideal to program electric heaters, battery chargers etc
2P10 – 12 volt 5 amp mains transformer – low volt winding on separate bobbin and easy to remove to convert to lower voltages for higher currents
2P11 – Power amp module Mullard Unilex EP9000 (note stereo pre-amp module Unilex 9001 is BD216
2P12 – Disk or Tape precision motor – has balanced rotor and is reversible 230v mains operated 1500 rpm
2P13 – Sun Lamp switch stays on for ½ hr or 1 hr depending on setting of grub screw
2P14 – Mug Stop kit – when thrown emit piercing squawk
2P15 – Interupted Beam kit for burglar alarms, counters, etc
2P16 – Lockable metal box with 2 keys, ideal for your tools
2P17 – 1 rev per minute mains driven motor with gear box, ideal to operate mirror ball
2P18 – Liquid/gas shut off valve mains solenoid operated
2P19 – Disco switch-motor drives 6 or more 10 amp change over micro switches supplied ready for mains operation
2P20 – 20 metres extension lead, 2 core – ideal most Black and Decker garden tools
2P21 – 10 watt amplifier, Mullard module reference 1173
2P22 – Motor driven switch 20 secs on or off after push
2P24 – Clockwork operated 12 hour switch 15A 250V with clutch
2P25 – 1000 watt flasher mains motor driven
2P26 – Counter resettable mains operated 4 digit
2P27 – Goodmans Speaker 6 inch round 8ohm 12 watt
2P28 – Drill Pump – always useful couples to any make portable drill
2P29 – 24 position Yaxley switch contacts rated 5A – ¼ spindle
2P30 – 15 metres 6 way telephone or interconnecting wire
2P31 – 4 metres 98 way interconnecting wire easy to strip to use the cores separately
2P32 – Hot Wire amp meter – 4½ round surface mounting – old but working and definitely a bit of history
2P33 – 0-30 amp meter 2" round panel mounting with shunt ex ministry equipment
2P34 – Solenoid Air Valve mains operated
2P35 – Battery charger kit comprising mains transformer, full wave rectifier and meter, suitable for charging 6v or 12v
2P36 – 20 Amp meter, with shunt unused but ex-equipment
2P37 – 0-100 micro amp meter, 2" square flush mounting good make
2P38 – 200 R.P.M. Geared Mains Motor 1" stack quite powerful, definitely large enough to drive a rotating aerial or a tumbler for polishing stones etc.
2P39 – Gear train size approx. 6½" × 3½", 2 brass pillars for motor mounting (1.9" fixing centres), first wheel made of fibre, 3 other steel and brass wheels. 80 turns of fibre wheel give one turn of final drive shaft which is ¼" dia. rod
2P40 – 12 volt motor – can be fitted to 2P39 gearbox

IONISER KIT

Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder – a complete mains operated kit, case included.
£11.95 plus **£2.00** post.

MORE BAKERS DOZEN £1 PARCELS

BD189 – 2 double pole 20 amp 250v flush mounting switches – white
BD190 – 2 double pole 20 amp 250v surface mounting switches with neon indicators – brown
BD191 – 6 B.C. lamp holder adaptors white
BD192 – 3 B.C. to 2 pin lamp holder adaptors
BD193 – 6 5 amp 3 pin flush sockets brown
BD194 – 3 5 amp 3 pin switched sockets surface mounting, brown
BD195 – 5 B.C. lampholder bakelite threaded entry
BD196 – 1 in flex simmerstat for electric blanket soldering iron etc
BD197 – 2 thermostats, spindle setting – adjustable range for heaters ovens etc
BD198 – 1 rod thermostat for water heater etc 11" rod
BD199 – 1 mains operated solenoid with plunger
BD200 – 1 10 digit switch pad for telephones etc
BD201 – 8 computer keyboard switches, with knobs, pcb or vero mounting
BD202 – 1 solenoid mains operated air valve 110v coil
BD203 – 2 8 push button switch banks 6 interlocking and two independent locking less knobs or one with knobs your choice
BD204 – 1 3 push mains voltage switch with knobs
BD205 – 1 ultra small 12v relay 3A gold-plated contacts normally open
BD206 – 20 metres 80 ohm coax, off white
BD207 – 20 metres high voltage flex 14.0075
BD208 – 1 Photo multiplier tube RCA 4555
BD209 – 1 Metal box approx. 7½ × 4½ × 1½
BD210 – 4 Transistors type 2N3055
BD211 – 1 Electric clock mains driven, always right time – not cased
BD212 – 1 Double 8v ½ amp mains transformer ideal for dimming or strobing fluorescent tubes
BD213 – 2 Curly 5 core leads for mobile telephones, transmitters etc
BD214 – 3 sub-miniature toggle switches spdt
BD215 – 5 miniature slide switches dpdt with chrome dolly
BD216 – 1 Stereo preamp Mullard EP9001
BD217 – 100 push on tag connector ¼ straight
BD218 – 100 push on tag connector ¼ right angled
BD219 – 100 soldercon terminals make IC sockets any length and width
BD220 – 3 Heat sinks for flat ICs predrilled size 40 × 40 × 25mm matt black, four sided

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EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

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

Projects

Series

Features

Buyers Guide

Our December 1985 issue will be published on Friday, November 15. See page 621 for details.

TEACH-IN '86

As usual, GREENWELD are supplying all TEACH-IN '86 items – as we have done over the past 10 years. Our experience with these projects ensures you receive top quality components as specified at the best possible price, so you can order with confidence. This years kits are available as follows:

BASIC ITEMS: M102B2 multimeter; Verobloc, bracket & design sheets, 10 leads with croc clips + FREE – The latest GREENWELD Catalogue and a resistor colour code calculator!! PRICE, inc VAT and post £21.95.
EXTRA COMPONENTS required for parts 1 and 2 .... £1.50
PSU – EE Special offer mains adaptor £4.95
REGULATOR UNIT: All parts including case, also in-line fuseholder, fuse and 2mm plugs for PSU £16.95
LCR BRIDGE: All parts including case £23.95

1985 CATALOGUE

More components than ever before! With each copy there's discount vouchers, Bargain List, Wholesale Discount List, Bulk Buyers List, Order Form and Reply Paid Envelope. All for just £1.00!!

NEW PACKS

K534 SLEEVE PACK – wide selections of types and sizes – PVC, rubber, silicone, heatshrink, etc. in bores from 1mm to 18mm, lengths 9mm to 100mm. Approx. 100 **£1.00**

K536 74 SERIES PACK – 'on board' chips for you to desolder – containing many LS and other types. Good mix.
40 **£1.85** 100 **£4.00**

K537 I.C. PACK – a mix of linear and logic chips, form 6 to 40 pin. All are new and marked, but some may not be full spec.
100 **£6.75** 250 **£14.00** *1000 **£45.00**
*mostly in tubes

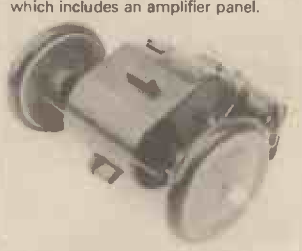
K538 DIODE PACK – untested small signal diodes like IN4148 etc. at a price never before seen!!
1000 **£2.50** 10,000 **£20.00**

K539 LED PACK – not only round but many shaped leds in this pack in red, yellow, green, orange and clear. Fantastic mix.
100 **£5.95** 250 **£13.50**

K540 RESISTOR PACK – mostly ⅛, ¼ and ½w, also some 1 & 2w in carbon, film, oxide etc. All have full length leads.
Tolerances from 5 to 20%. Excellent range of values
500 **£2.50** 2500 **£11.00**

K535 SPRING PACK – approx 100 assorted compression, extension and torsion springs up to 22mm dia and 30mm long **£1.70**

K541 – A selection of panels (PCB's) containing a wealth of components – logic and linear IC's, power and small signal transistors, trimpots, DIL switches, leds etc. A parcel of 2kg for **£7.00** which includes an amplifier panel.



MOTORIZED GEARBOX

The unit has 2 × 3V motors, linked by a magnetic clutch, thus enabling turning of the vehicle, and a gearbox contained within the black ABS housing, reducing the final drive speed to approx 50rpm. Data is supplied with the unit showing various options on driving the motors. Two new types of wheels can be supplied (the aluminium discs and smaller plastic wheels are now sold out). Type A has 7 spokes with a round black tyre and is 100mm dia. Type B is a solid heavy duty wheel 107mm dia with a flat rigid tyre 17mm wide.
PRICES: Gearbox with data sheets: **£5.95**
Wheel type A: **£0.70 ea**
Wheel type B: **£0.90 ea**

WHOLESALERS RETURNS

We have recently purchased a job lot of 'returns' and have reasonable quantities of the following items. They are all offered "as seen" and carry no guarantee other than they are complete. Many items are working perfectly – some have faults, others damaged cases etc. All are at a remarkably low price.

PM4401C CASSETTE £10.00
Top quality computer cassette unit deisgned specifically for use with Vic 20, CBM 64 home computers. Attractive, robust cream ABS body with brown 'piano' control keys. Record and playback levels are preset, giving perfect recordings every time and single reliable operation. Connections by glass edge socket.
Features include: Tape counter, auto stop, 'save' indicator, remote control facility. Input: 20mV, 2.5V p/p; 10k. Output: 2.5V p/p; 10k. Tape speed: +3%. Wow and flutter: Wr.m.s. 0.35%. Power: 240V a.c. 50 Hz.

TH55B SIREN £3.[illegible]
Gold coloured horn with fixing plate. Emits high-powered wailing note of 160 cycles per minute. Output: 115 dB (A) at 3m typ. Power: 12V d.c. 1.5 A. Dims: 130 (dia) × 160mm.

MW398 NI-CAD CHARGER £3.00
Universal NI-CAD battery charger. All plastic case with hinged lid. Charge/test switch with filament lamp showing degree of charge. Separate LED indicators at each of the five changing points. Charges: PP3 (9V) AA (1.5 penlite), C (1.5V HP11), D (1.5 HP2); Power: 240V a.c. 50Hz. Dims: 210 × 100 × 50 mm

NH56R MULTIMETER £5.00
Modern styled tester with carrying handle/stand. Rotary selector switch has 22 ranges. Leads (4mm plugs), battery and instruction manual supplied. Mirrored scale. 20KR/V. AC volts: 0-10-25-100-250-1000V + 5%. DC Volts: 0-0.25-1-2.5-10-25-100-250-1000V ± 4%. DC current: 0-50-500u-5m-50m-500mA ± 4%. Resistance: 0-6k-6-k-600k-6M ±4%. Decibels: −20 to + 22dB. Protection: Diodes. Dims: 130 × 88 × 37mm.

KUHG AERIAL AMPLIFIER £4.50
1 in 2 out HIGH GAIN antenna amplifier for colour and black/white T.V. White plastic case with On/Off switch. LED indicator and 1m lead. Band width: 300M Hz-890M Hz; Gain: 14 dB + 1 dB; Impedance: 75; Power: 240 Va.c. 50 Hz; Dims: 125 × 79 × 50mm.

MW88 POWER SUPPLY £2.50
Plug-in power supply fits directly into 13A socket. Fully encapsulated transformer and internal fuse for safety. Polarity reversing socket. Voltage selector switch. Output via lead with 4-way "spider" plug. Input voltage: 240 Va.c. 50 Hz; Output voltage: 3/4.5/6/7.5/9/12 Vd.c.; Output current: 100mA; Stability: 40%; Ripple: 1V; Dims: 74 × 52 × 46mm. (Transformer ok). Lots of 25 (unchecked) **£30.00.** Lots of 100 (unchecked) **£100.00.** Lots of 250 (unchecked) **£200.00.**

"SENSING & CONTROL PROJECTS FOR THE BBC MICRO"

Have you ever wondered what all those plugs and sockets on the back of the BBC micro are for? This book assumes no previous electronic knowledge and no soldering is required, but guides the reader (pupil or teacher) from basic connexions of the user sockets, to quite complex projects. The author, an experienced teacher in this field, has provided lots of practical experiments, with ideas on how to follow up the basic principles. A complete kit of parts for all the experiments is also available. Book, 245×185mm 120pp £5.95. Kit £29.95

GREENWELD
ELECTRONIC COMPONENTS

All prices include VAT; just add 60p P&P.
Min Access order £10. Official orders from schools etc. welcome – min invoice charge £10.
Our shop has enormous stock of components and is open 9-5.30 Mon-Sat. Come and see us!!
443D Millbrook Road Southampton SO1 0HX Tel (0703) 772501/783740

CMOS

4000	16p	4001	16p	4002	16p	4006	50p
4007	18p	4008	44p	4009	30p	4010	32p
4011	16p	4012	16p	4013	20p	4014	40p
4015	40p	4016	27p	4017	39p	4018	40p
4019	33p	4020	50p	4021	45p	4022	43p
4023	16p	4024	30p	4025	16p	4026	68p
4027	30p	4028	38p	4029	53p	4030	28p
4031	100p	4032	54p	4033	60p	4034	95p
4035	50p	4036	220p	4037	80p	4038	50p
4039	220p	4040	42p	4041	38p	4042	43p
4043	40p	4044	40p	4045	72p	4046	49p
4047	49p	4048	32p	4049	26p	4050	26p
4051	42p	4052	40p	4053	40p	4054	58p
4055	58p	4056	58p	4060	53p	4063	57p
4066	30p	4067	160p	4068	16p	4069	16p
4071	16p	4072	16p	4073	16p	4075	16p
4076	50p	4077	16p	4078	16p	4081	16p
4082	16p	4085	42p	4086	34p	4089	90p
4093	26p	4095	58p	4098	56p	4099	58p
4501	30p	4502	40p	4503	32p	4504	60p
4505	260p	4506	60p	4507	33p	4508	85p
4510	42p	4511	43p	4512	46p	4513	90p
4514	90p	4515	85p	4516	51p	4517	130p
4518	40p	4519	30p	4520	44p	4521	90p
4522	50p	4526	48p	4527	48p	4528	44p
4529	78p	4532	55p	4551	85p	4553	190p
4555	29p	4556	41p	4557	190p	4583	65p
4584	36p	4585	46p				

74LS SERIES

74LS00	17p	74LS01	17p	74L502	17p	74LS03	17p
74LS04	17p	74LS05	17p	74LS08	17p	74LS09	17p
74LS10	17p	74LS11	17p	74LS12	17p	74LS13	26p
74LS14	30p	74LS15	17p	74LS20	17p	74LS21	17p
74LS22	17p	74LS24	38p	74LS26	17p	74LS27	17p
74LS28	17p	74LS30	17p	74LS32	17p	74LS33	17p
74LS37	17p	74LS38	17p	74LS40	17p	74LS42	39p
74LS47	70p	74LS48	60p	74LS51	17p	74LS54	17p
74LS55	17p	74LS73	28p	74LS74	26p	74LS75	32p
74LS76	28p	74LS78	34p	74LS83	46p	74LS85	50p
74LS86	30p	74LS90	39p	74LS91	75p	74LS92	46p
74LS93	40p	74LS95	52p	74LS96	63p	74LS107	35p
74LS109	36p	74LS112	38p	74LS113	32p	74LS114	38p
74LS122	44p	74LS123	50p	74LS124	85p	74LS125	36p
74LS126	42p	74LS132	44p	74LS133	34p	74LS136	35p
74LS138	38p	74LS139	40p	74LS145	83p	74LS147	120p
74LS148	110p	74LS151	38p	74LS153	42p	74LS154	100p
74LS155	51p	74LS156	49p	74LS157	35p	74LS158	47p
74LS160	52p	74LS161	56p	74LS162	50p	74LS163	50p
74LS164	44p	74LS165	65p	74LS166	80p	74LS168	98p
74LS169	70p	74LS170	85p	74LS174	40p	74LS175	46p
74LS190	59p	74LS191	55p	74LS192	50p	74LS193	57p
74LS194	57p	74LS195	56p	74LS196	67p	74LS197	52p
74LS221	61p	74LS240	62p	74LS241	60p	74LS242	70p
74LS243	64p	74LS244	64p	74LS245	78p	74LS247	50p
74LS248	50p	74LS249	92p	74LS251	30p	74LS253	50p
74LS256	65p	74LS257	48p	74LS258	45p	74LS259	62p
74LS260	42p	74LS266	28p	74LS273	72p	74LS279	46p
74LS280	140p	74LS290	30p	74LS293	30p	74LS365	42p
74LS366	44p	74LS367	43p	74LS368	41p	74LS373	68p
74LS374	68p	74LS375	58p	74LS399	80p	74LS670	80p

VALVES

DAF96	60p	DF96	50p	DL92	47p	DY87	50p
DY802	45p	EABC80	50p	EB91	44p	EBF80	45p
EBF89	50p	ECC82	40p	ECC83	43p	ECC84	40p
ECC85	40p	ECH81	49p	ECH84	52p	ECL80	57p
ECL82	59p	ECL84	57p	ECL85	57p	ECL86	49p
EF80	31p	EF85	34p	EF89	43p	EF183	45p
EF184	53p	EL34	190p	EL36	60p	EL84	50p
EL95	50p	EL500	80p	EL504	100p	EY86	31p
EY87	31p	EY88	32p	EZ35	45p	EZ80	50p
EZ81	55p	GZ34	180p	PC97	100p	PCC85	42p
PCF80	58p	PCF200	135p	PCF801	110p	PCF802	57p
PCF806	115p	PCH200	100p	PCL81	54p	PCL82	63p
PCL84	50p	PCL85	55p	PCL86	55p	PCL805	55p
PFL200	85p	PL36	80p	PL82	45p	PL83	32p
PL84	50p	PL95	140p	PL500	110p	PL504	95p
PL508	170p	PL519	450p	PY81	70p	PY88	48p
PY500A	160p						

74 SERIES

7400	22p	7401	16p	7402	18p	7403	22p
7404	40p	7405	10p	7406	40p	7407	40p
7408	25p	7409	20p	7413	35p	7414	45p
7417	32p	7420	22p	7421	25p	7425	15p
7430	25p	7437	28p	7442	45p	7447	60p
7450	22p	7451	10p	7454	25p	7470	30p
7473	30p	7474	40p	7475	25p	7481	90p
7482	70p	7485	30p	7486	28p	7489	80p
7490	35p	7492	45p	7493	35p	7495	48p
7497	80p	74107	30p	74111	52p	74116	85p
74119	85p	74122	40p	74123	20p	74125	40p
74126	45p	74132	42p	74141	55p	74145	70p
74153	45p	74155	45p	74157	45p	74160	50p
74164	50p	74167	35p	74173	50p	74174	70p
74175	65p	74176	45p	74180	50p	74182	45p
74192	40p	74196	40p	74197	45p	74393	70p

VOLTAGE REGULATORS

7805	35p	7812	35p	7815	35p	7818	35p
7824	35p	7905	35p	7912	40p	7915	40p
7918	40p	7924	40p	78L05	28p	78L12	28p
78L15	28p	78L18	28p	78L24	28p	79L05	40p
79L12	45p	79L15	48p	LM309K	100p	LM317K	220p
LM317T	180p	LM323K	420p	LM723	32p	78HGKC	570p
78H05KC	520p	78GU1C	190p	79GU1C	215p	79HGKC	670p

LINEAR IC'S

AN-214P	200p	AN-240P	150p	AN-360	120p	AN-7110	140p
AN-7114	160p	AN-7115	160p	AN-7120	140p	AY3-1270	680p
AY3-1350	300p	AY3-8910	360p	AY3-8912	400p	AY5-3600	570p
CA270	40p	CA3046	60p	CA3048	190p	CA3060	280p
CA3080E	70p	CA3086	55p	CA3089E	150p	CA3090AQ	300p
CA3130E	80p	CA3130S	100p	CA3140E	38p	CA3189E	250p
HA-1156W	110p	HA-1197	150p	HA-1306W	170p	HA-1319	250p
HA-1339	170p	HA-1342	170p	HA-1366WR	160p	HA-1368	160p
HA-1377	220p	HA-1389	140p	HA-1392	230p	HA-1397	250p
HA-1398	240p	HA-1201	85p	LA-1352	120p	LA-1365	140p
LA-3301	120p	LA-3350	120p	LA-3361	115p	LA-4030	200p
LA-4031	140p	LA-4032	140p	LA-4050	130p	LA-4051	160p
LA-4100	120p	LA-4101	100p	LA-4102SK	140p	LA-4112	250p
LA-4125	210p	LA-4140	70p	LA-4201	120p	LA-4220	120p
LA-4400	190p	LA-4420	140p	LA-4422	130p	LA-4430	130p
LA-4460	170p	LA-4461	180p	LA-5112	120p	LM301.	26p
LM311	35p	LM324	35p	LM325	45p	LM339	40p
LM348	60p	LM380	100p	LM381	150p	LM382	130p
LM387	100p	LM709 DIL	30p	LM723	40p	LM741 DIL	18p
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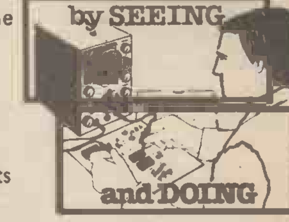

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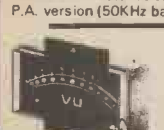
NOTE: Mos-Fets are supplied as standard (100KHz bandwidth & Input Sensitivity 500mV). If required, P.A. version (50KHz bandwidth & Input Sensitivity 775mV). Order — Standard or P.A.



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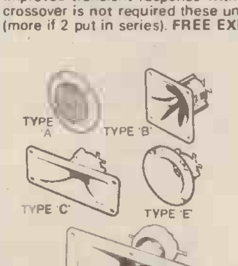

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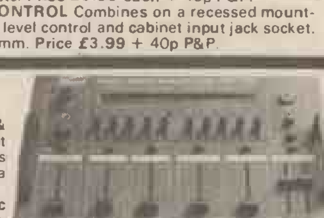

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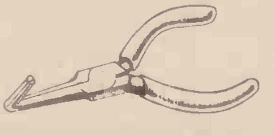

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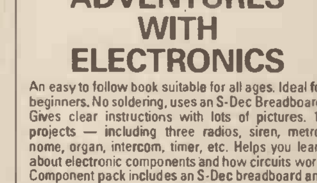

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EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

VOL 14 Nº11 NOVEMBER '85

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We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply must be accompanied by a **stamped self-addressed envelope** or a **self-addressed envelope and international reply coupons.**

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WELCOME

I would like to welcome all *Electronics Monthly* readers to our pages, I hope you like your new style magazine. I am sure you will like the lower cover price—15p lower than you have paid lately.

Unfortunately the purchase of *Electronics Monthly* took place over a very short period and we have not been able to fit everything we want to in this the first issue of EE & EM. New readers will also find a couple of series are now on part 2 or 3; to overcome this problem back numbers are available—see the note on this page.

Fortunately some of the series that *Electronics Monthly* were running were coming to an end but we will be continuing with *Reporting Amateur Radio* (which has just started) next month—space permitting.

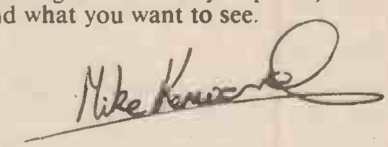
P.C.B.s

Many EM readers have been waiting for p.c.b.s for some time. Argus Specialist Press had got into a mess with their p.c.b. service but we have been able to sort it out quickly and everyone should now have their boards. All boards listed on our *PCB Service* page are now available from our service, this includes many from past issues of EM and some which have never been advertised before.

YOUR MAG

I hope all readers will like the new *Everyday Electronics and Electronics Monthly*—old EE readers may have read this before but EE & EM is your magazine, we want to make sure we publish what you want, that we give you enough information to help you along the way with this exciting hobby and possibly to help you move on to greater things in the future. Maybe some of you will find our sister publication *Practical Electronics* will become another regular purchase as your knowledge and experience grows. (PE is aimed at both experienced hobbyists and technicians/engineers in the electronics and allied industries.)

If there is some subject you would like to see us cover, an idea for different treatment or if you need more data at a particular interest level etc., please write in and let us know. Such feedback helps to shape future issues and with many new readers being introduced to the magazine your views would be appreciated. We hope you will find more to interest you in EE & EM. We are trying to make sure that the items we cover are better explained and better presented than previously. We will go on striving to continually improve, so let us know what you like, what you don't and what you want to see.



P.S. Just in case you have difficulty getting issues I would like to point out that a subscription costs less than the cover price—see the note on the left.

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3 HALLOWEEN PROJECTS

R.A.PENFOLD

FLASHING PUMPKIN

THIS is the first and most simple of three projects for halloween that are quite definitely in the "fun" category. All three projects are based on the same printed circuit board and are easy to construct from the electronic point of view. By their nature they provide something of a challenge as far as mechanical construction is concerned, calling for some unusual construction techniques, to say the least. This aspect need not be too difficult though, especially if a suitably skilled helper can be brought in to assist here, or ready made objects which form a satisfactory constructional basis can be found. Each project is fairly inexpensive, but can nevertheless provide a great deal of fun and entertainment (and not just at halloween).

This circuit merely flashes two l.e.d.s in anti-phase (as one switches on the other switches off), and the idea is for the unit to be installed in a hollowed-out halloween pumpkin. However, with little imagination it would probably be possible to think up a few other similarly festive ways of utilising this project (mask with flashing eyes, etc.).

555 TIMER

In common with the other two projects, the *Pumpkin Flasher* makes use of the ever popular 555 timer device. In fact some of the circuits use the 7555 timer integrated circuit, but this is essentially just a low current consumption version of the 555 and is no different in the way that it is used. Many readers will be familiar with the way in which the 555 operates, but for newcomers who are not, a brief description of the device will be provided here.

There are only two standard operating modes for the 555; the astable (oscillator) and monostable (timer) modes. In the astable mode the output of the device switches to-and-fro between virtually the positive and negative supply voltages. It is this switching action that we require in this application as it can be used to automatically switch two l.e.d.s on and off in the required manner. In the timer mode the output goes positive for a period which is determined by two discrete components. This mode is not needed in the present project, but is worthy of consideration here as it is utilised in both the other halloween projects.

Fig. 1 shows the internal arrangement of the 555 in block diagram form, and it also shows how the device operates in the astable mode. R1, R2 and C1 are discrete components, but R3 to R5 are internal resistors. It is these three equal value resistors plus the two voltage comparators that are at the heart of the 555. The resistor network provides a reference voltage equal to 1/3 of V+ to one input of comparator 2, and 2/3 of V+ to one input of comparator 1.

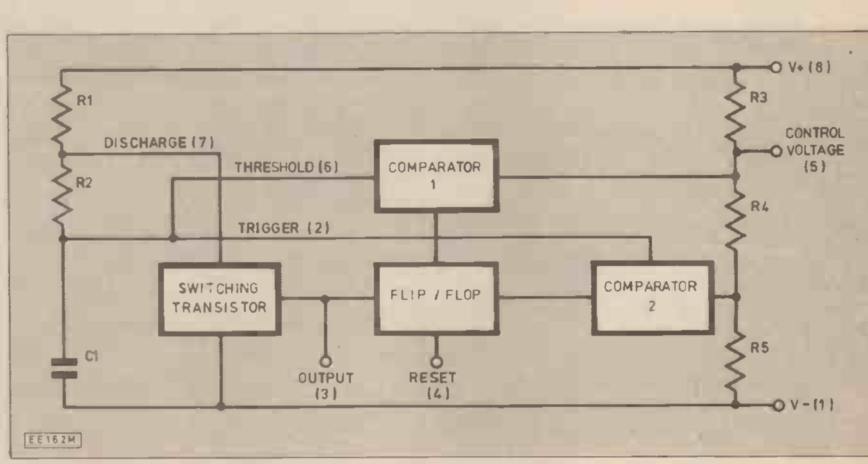
When power is first applied to the circuit the switching transistor is switched off and C1 is able to charge from the supply lines via the series resistance of R1 and R2. The charge potential on C1 is monitored by an input of each voltage comparator, and charging continues until the charge on C1 exceeds 2/3 of V+. The output of comparator 1 then changes state, resetting the flip/flop and turning on the switching transistor. C1 then discharges through R2 and the switching transistor, and the fall in voltage results in the output of comparator 1 returning to its original state. However, this does not affect the flip/flop which remains in the reset state.

C1 continues to discharge until the charge voltage falls below 1/3 of V+. This triggers the output of comparator 2 to the opposite state, causing the flip/flop to be set back to its original state. C1 is then able to charge by way of R1 and R2 again, and the rise in charge voltage sets the output of comparator 2 back to its original state, but this does not have any effect on the flip/flop.

The circuit is now back in its original state, and C1 continues to charge until the charge potential exceeds 2/3 of V+. Then, as before, the output of comparator 1 changes state, the flip/flop is reset, and the switching transistor is turned on. This process continues indefinitely, with C1 being repeatedly charged and discharged. This gives a very roughly triangular waveform across C1, but in most applications it is not this signal that is required. The primary output of the circuit is from the flip/flop at pin 3, and this is a rectangular waveform. Pin 3 goes high while C1 is charging and low when it is being discharged. In this basic configuration the period during which the output is high must be longer than the low output period, since C1 charges through both R1 and R2, but only discharges through R2. The output will be close to a squarewave though, if R1 is made low in value when compared to R2. Having R1, R2 and C1 as discrete components enables a very wide range of operating frequencies and mark-space ratios to be achieved.

An external reset input for the flip/flop is available, and this is useful as a gate input when the 555 operates as an astable. Taking the reset input high enables oscillation, while taking it low blocks oscillation. Pin 5 gives access to the potential divider circuit and enables the reference voltages to be modified to some degree, but this is a facility which is not required in the present applications.

Fig. 1. 555 astable configuration.



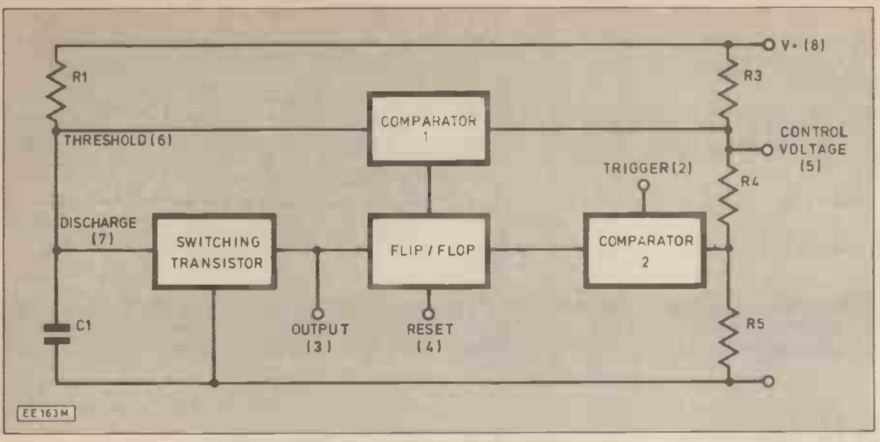


Fig. 2. 555 monostable configuration.

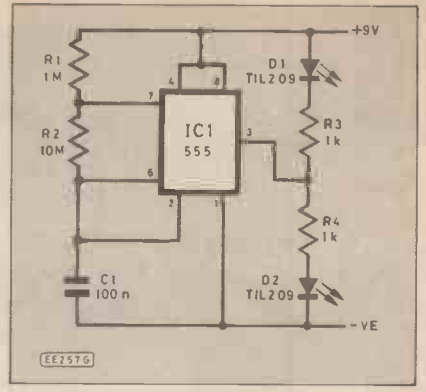


Fig. 3. Circuit diagram of the *Pumpkin Flasher*.

Fig. 2 shows the arrangement used in the monostable mode. Only two discrete components are required in this operating mode, with just one timing resistor being used. Initially the trigger input is held above 2/3 of V+; then the switching transistor is turned on, and C1 is prevented from charging via R1. Taking the trigger input below 1/3 V+ sets the output at pin 3 high and switches off the switching transistor so that C1 can charge by way of R1. C1 is allowed to charge until a potential of more than 2/3 of V+ is reached. This is detected by comparator 1 which then resets the flip/flop, resetting the output at pin 3 to the low state. This also turns on the switching transistor which almost instantly discharges C1 and takes the circuit back to its original state, ready to be triggered again. However, an important point to note when using the 555 in the monostable mode is that the output pulse will only end after the appropriate charge on C1 has been reached if the trigger input has been returned to more than 1/3 of V+. Otherwise the circuit is held with the output high until the trigger input is taken back above the trigger threshold.

Conversely, when IC1's output goes low power is supplied to D1 but D2 is cut off. The required alternate flashing action is thus obtained.

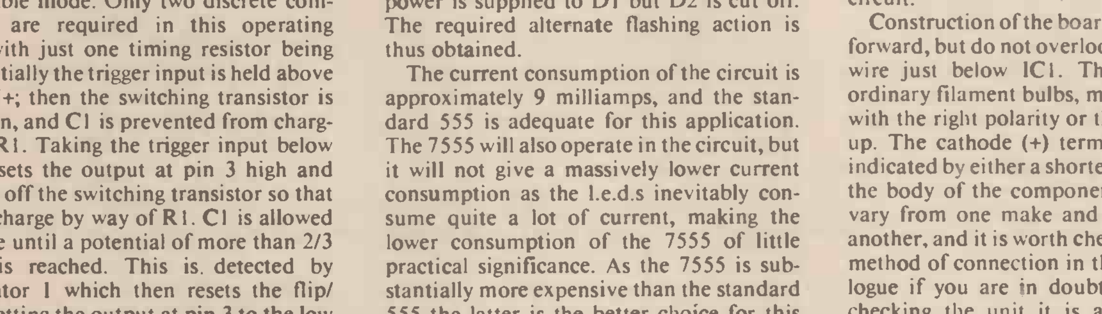
The current consumption of the circuit is approximately 9 milliamps, and the standard 555 is adequate for this application. The 7555 will also operate in the circuit, but it will not give a massively lower current consumption as the l.e.d.s inevitably consume quite a lot of current, making the lower consumption of the 7555 of little practical significance. As the 7555 is substantially more expensive than the standard 555 the latter is the better choice for this circuit.

CONSTRUCTION

Details of the printed circuit component layout for the unit are provided in Fig. 4. As explained earlier, all three halloween projects are built using the same printed circuit design. As the *Pumpkin Flasher* unit is by far the most simple of the three circuits, much of the board is left unoccupied. Rather than leave vast expanses of board unused you may prefer to trim off the unused ends using a hacksaw. Of course, if you make your own board it is only necessary to copy and produce the section of the board that is actually required for this circuit.

Construction of the board is very straightforward, but do not overlook the single link-wire just below IC1. The l.e.d.s, unlike ordinary filament bulbs, must be connected with the right polarity or they will not light up. The cathode (+) terminal is normally indicated by either a shorter lead or a flat on the body of the component, but this does vary from one make and type of l.e.d. to another, and it is worth checking the correct method of connection in the retailer's catalogue if you are in doubt. When initially checking the unit it is alright to simply mount D1 and D2 on the printed circuit board together with the other components, but in use it will probably be necessary to mount them off-board, and to connect them to the board using twin insulated leads. It is not essential to use ordinary red l.e.d.s, and the circuit will work perfectly well with green or yellow types (or mixed colours). Some green or yellow l.e.d.s are not very bright, and with these it would be advisable to reduce R3 and R4 to 470R in order to give increased l.e.d. current and brightness.

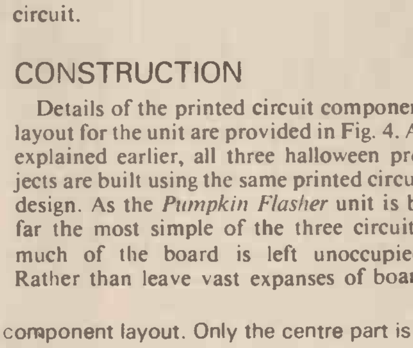
Fig. 4. P.c.b. and the component layout. Only the centre part is used for this project.



FLASHER CIRCUIT

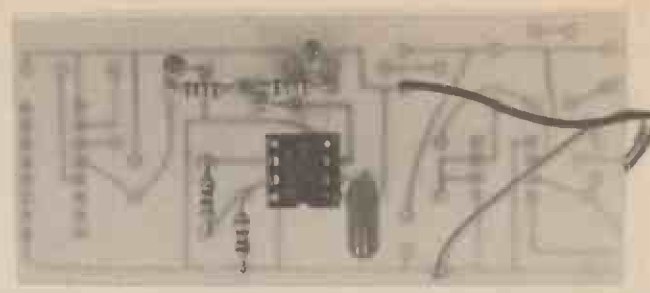
The circuit diagram of the *Pumpkin Flasher* appears in Fig. 3.

IC1 is the 555 and it is connected in the standard astable configuration. The values of R1, R2 and C1 give an operating frequency of just under 1Hz (just under one flash per second), and as the value of R2 is high compared to that of R1 the "on" times of the two l.e.d.s are approximately the same. The l.e.d.s are D1 and D2, with R3 and R4 acting as current limiting resistors to prevent excessive l.e.d. currents. D2 is switched on when the output of IC1 goes high, but the voltage across D1 is reduced to practically zero and it is switched off.



An on/off switch could be included in series with the battery, but with this project, and the other two halloween projects, the addition of an on/off switch would probably be a little awkward in practice, and it is probably best to omit one. However, be careful not to accidentally try to connect the battery to the battery connector the wrong way round, as this could just possibly damage some of the components. A small (PP3 size) 9 volt battery will run the unit continuously for many hours, but if the unit is likely to receive a great deal of use it would be better to use a higher capacity type such as a PP9, or rechargeable cells.

COMPONENTS approximate cost £5.00



With power connected to the unit D2 should switch on for about a second, and then the l.e.d.s should switch on alternately at the appropriate rate. If the appropriate action is not obtained, switch off at once and recheck all the wiring.

The flash rate can be altered if desired by changing the value of C1. Changes in the value of C1 produce an inversely proportional change in the operating frequency (e.g. a reduction to 47nF increases the flash rate to about 2Hz). □

COMPONENTS

Resistors

R	1M	
R2	10M	
R3,4	1k (2 off)	

All ¼W carbon 5%

Capacitor

C1	100n polyester

Semiconductors

IC1	555 timer
D1,2	TIL209 (2 off) or any coloured l.e.d.s

See Shop Talk page 602

Miscellaneous

Printed circuit board (available from *EE* P.c.b. Service, No. EE506), 9 volt battery and connector, wire, solder, etc.

SQUEAKING BAT

THIS second halloween project is a "squeaking bat", which has eyes that light up in addition to the "squeaking" sound effect. As is really the case for all three projects, it is not essential to use the device in the suggested manner, and there is plenty of scope for someone who is prepared to let their imagination run riot to come up with something equally scarey. The recommended way of using the circuit is to fit it inside a home-made bat which is hung from a wall on a length of string. If someone's curiosity gets the better of them and they disturb the bat, it objects by flashing its eyes and emitting a rapid sequence of squeaking sounds. The bat can provide much amusement for bystanders who are aware of its talents, and short term cardiac arrest for those who are not.

The unit is triggered by means of a tilt switch, which can be either a proper mercury type or a simple component improvised by the constructor. The circuit has an extremely low stand-by current consumption so that it can be run economically from an ordinary 9 volt battery even if the unit is to be left running for prolonged periods (which will presumably be the case).

SYSTEM OPERATION

The block diagram of Fig. 1 helps to explain the way in which the unit functions.

Although it might seem that the "squeaker" circuit and the l.e.d.s to make the eyes flash could be powered via the tilt switch, and would be activated in the required manner when the unit was disturbed, this could well fail to operate properly in practice. The problem is simply that the tilt switch is likely to give only intermittent contact, for perhaps only a very short overall time. This could make the unit rather erratic and unspectacular.

A monostable multivibrator is used to solve this problem. It is triggered by the tilt switch, and once triggered it gives an output pulse of about 1·5 seconds or so which is used to activate the display circuits. One drawback of this arrangement is that it results in power being permanently supplied to the circuit, and there is a continuous drain on the battery rather than only when the unit is activated. In fact it is only the monostable which draws current continuously, and it is only this section of the unit that needs to have a low current consumption in order to make ordinary battery power a practical proposition. In this circuit the device used in the monostable is a 7555 which gives a typical current consumption of a mere 80 microamps from a 9 volt supply.

The monostable controls the l.e.d.s and sound effects circuit via an electronic switch. The two l.e.d.s merely light up continuously while the switch is activated, and they do not flash on and off as in the *Pumpkin Flasher* unit.

One way of generating the squeaking sound would be to just gate a high pitched audio oscillator on and off, but in practice this tends to sound rather mechanical and unconvincing. There are several possible ways of giving a rather less mechanical sound, but the one finally adopted is to frequency modulate the pitch of the squeaking sounds. The audio oscillator is a VCO (voltage controlled oscillator), which is an oscillator that has its frequency controlled by means of a voltage applied to an input terminal. In this case a simple C–R network is used to provide the control voltage, and this is a voltage which starts at a high level and gradually decays over a period of a second or two. This gives a falling pitch from the VCO.

As far as the bat sound effect is concerned this gives quite authentic results, with the bat squeaking at a high pitch when it is initially disturbed, then squeaking at a lower pitch as it calms down, and finally going silent again. Although you might think that bats do not actually produce audible squeaks at all, and that they only produce inaudible (to humans) ultrasonic sounds as part of their *radar* location system, many bats do in fact produce audible squeaks.

Here we require a rapid sequence of short squeaking sounds rather than a continuous falling pitch sound. An LFO (low frequency oscillator) is therefore used to drive the gate input of the VCO so that the VCO is switched on and off at a frequency of a few Hertz. The output of the VCO is fed to a loudspeaker which converts the electrical signals into corresponding audio ones. The loudspeaker used here is not the usual moving coil type, but is a Piezo ceramic sounder. This has the advantage of small size and relatively good efficiency at the high audio frequencies involved here.

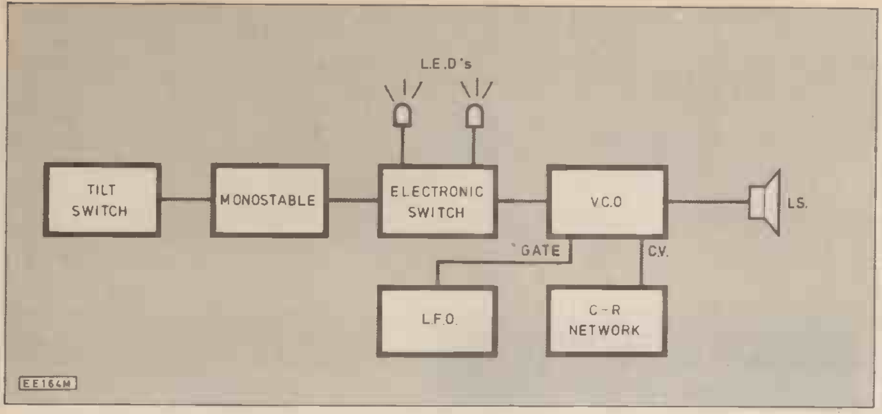


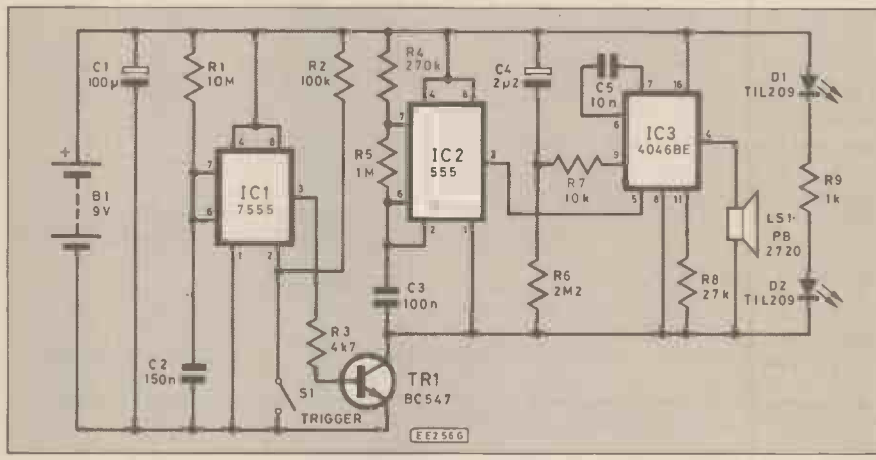
Fig. 1. Block diagram.

Fig. 2. Circuit diagram of Squeaking Bat.

CIRCUIT OPERATION

The full circuit diagram of the *Squeaking Bat* appears in Fig. 2.

IC1 is the 7555 used as the monostable, and it is connected in the standard configuration described earlier. The output pulse duration is 1·1 CR seconds, which is nominally 1·65 seconds with the specified values for R1 and C2. R2 holds the trigger input of IC1 at the positive supply potential, and S1 is the tilt switch which pulls this input to the 0 volt supply potential when it is activated. The positive output pulse from IC1 is used to switch on common emitter switching transistor TR1, which controls the negative supply to the rest of the circuit. TR1 is a silicon device, and when in the off state this has a leakage current of under 1 microamp so that it does not significantly boost the quiescent current consumption of the circuit.



IC2 is a 555 astable circuit, and it acts as the low frequency oscillator rather than the VCO. An ordinary 555 is satisfactory here, since this part of the circuit will only consume current during the brief periods when the circuit is activated, and the lower current consumption of the 7555 would probably not significantly increase battery life. The LFO operates at a frequency of a few Hertz, giving a fairly rapid and excited series of squeaking sounds from the unit.

The VCO could be based on another 555 astable, but a different device, the CMOS 4046BE is more convenient in this case, and has therefore been chosen instead. The 4046BE is actually a phase locked loop device rather than just a VCO, but it is quite possible to utilize the VCO section of the device while ignoring the other stages, and this is the way in which the 4046BE is used here. Consequently there are a number of pins which are left unconnected.

There is an "inhibit" input at pin 5 of the 4046BE (IC3), and this can be used as a gate input for the VCO. As its name implies, taking this input high inhibits the VCO while taking it low enables normal operation. Simply connecting the output from pin 3 of IC2 direct to the inhibit input of IC3 consequently gives the required pulsing of the VCO.

C5 and R8 are the timing components which determine the centre frequency of the

Fig. 3. The standard p.c.b. (actual size).

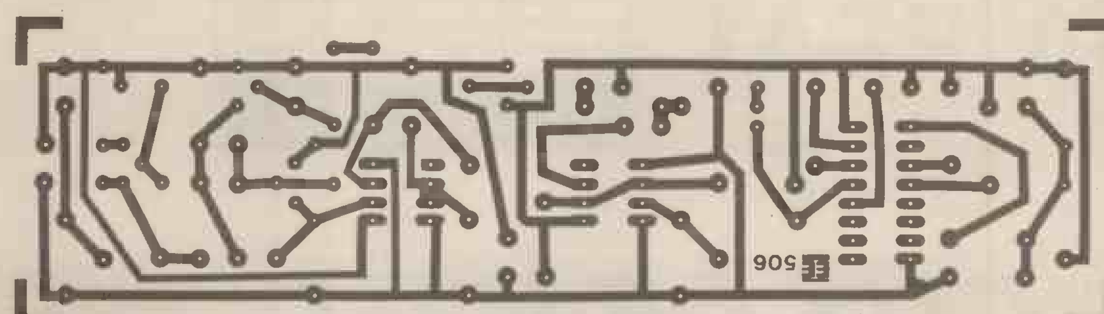
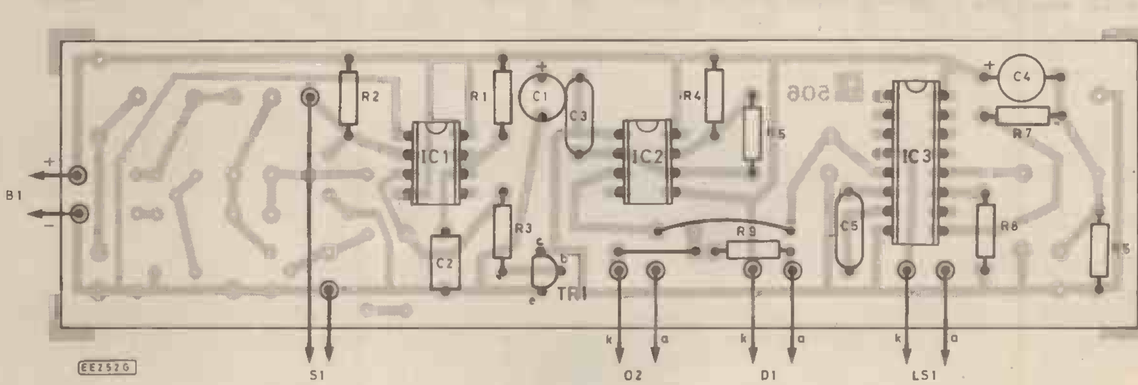


Fig. 4. Component layout.



VCO. The output frequency can be varied over wide limits by means of a control voltage applied to pin 9. This voltage is generated by the C–R network formed by C4 and R6, and it is coupled to pin 9 of IC3 by protection resistor R7. When power is first connected through to the sound effects circuit C4 will be in an uncharged state and the control voltage will be equal to the positive supply potential. As C4 gradually charges by way of R6 the control voltage decreases. The output frequency of IC3 changes in proportion to the control voltage, and this falling control potential produces the required falling pitch effect.

Although IC3 can provide only a very limited output current it can drive a ceramic resonator at reasonable volume. An ordinary moving coil loudspeaker should not be connected in the LS1 position as it would give a virtually inaudible output, and could possibly overload and damage the output stage of IC3.

D1 and D2 are the "eye" l.e.d.s, and these are simply wired in series across the switched supply rails via current limiting resistor R8, so that they light up continuously for the duration that the circuit is active.

CONSTRUCTION

Details of the printed circuit component layout are shown in Figure 3.

This circuit is somewhat more complex than the previous project, but electronically it is still fairly simple and straightforward to construct. In this case there are two link wires on the board, both just below IC2. These run quite close together and to avoid accidental short circuits they must either have a minimal amount of slack, or one of them should be insulated with a short piece of PVC sleeving.

IC1 is a CMOS device, but it has built-in protection circuits that render the antistatic handling precautions normally associated with this type of device totally unnecessary. On the other hand, IC3 is a standard CMOS type which does require the normal handling precautions. Boiling these down to the bare essentials, a (16 pin d.i.l.) integrated circuit holder should be used for IC3, but the device should not be plugged into the holder until the board is in all other respects complete. It should be left in the antistatic packaging (conductive foam, plastic tube, or whatever) until then, and when it is time to plug IC3 into the holder, handle the pins of the device as little as possible.

This circuit occupies more of the board than the previous one, but there are still a number of holes in the board which are left vacant. When fitting the components be careful to avoid the potential confusion that the unused holes could cause, and to fit each of the components in the right place. Thoroughly check the finished board for mistakes.

COMPONENTS

Resistors

R1	10M
R2	100k
R3	4k7
R4	270k
R5	1M
R6	2M2
R7	10k
R8	27k
R9	1k

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

Capacitors

C1	100µ 10V radial elect.
C2	150n carbonate
C3	100n polyester
C4	2µ2 63V radial elect.

Semiconductors

IC1	ICM7555 low power timer
IC2	555 timer i.c.
IC3	4046BE
TR1	BC547
D1,2	TIL209 (2 off) or any coloured l.e.d.s

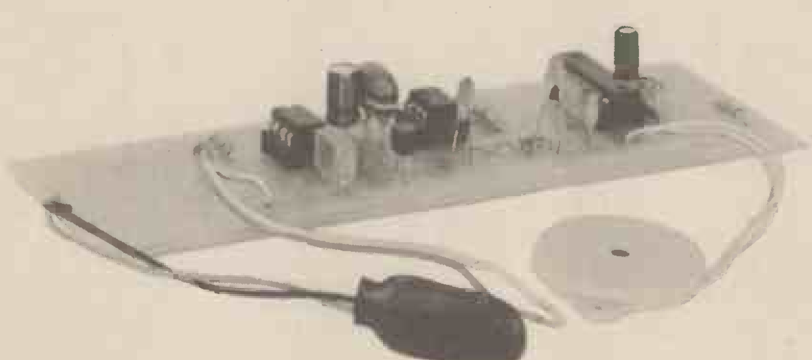
Miscellaneous

S1	Tilt switch
LS1	PB2720 ceramic resonator
B1	9 volt (PP3 size)

Battery connector; printed circuit board; wire, solder, etc.

Approx. cost Guidance only **£9.00**

A REAL BAT *OUT OF HELL*



TILT SWITCH

By far the easiest solution to the tilt switch is to buy a ready-made component. The standard form of tilt switch consists basically of a tube of insulating material which contains a small amount of mercury. Two electrodes are fitted inside the tube, and lead-out wires or some other form of external connections to these are made available. With the switch in some positions the mercury does not cover both electrodes, and there is a high resistance across the two terminals. In other positions the mercury does bridge the electrodes, providing an electrical connection between the two electrodes and effectively closing the switch.

Unfortunately, tilt switches can be rather difficult to obtain and can also be quite expensive. This makes some form of improvised tilt switch an attractive proposition, and perhaps a more practical solution in a simple application of this type. In its most simple form a tilt switch can just consist of two short lengths of single strand, non-insulated wire hanging very close together, but not quite touching. Any movement of the object on which they are mounted tends to cause them to touch together, completing the circuit. Simple switches of this type are not very efficient, but in this application only a very brief contact is needed in order to activate the circuit, and a low contact resistance is not needed either.

When initially testing the circuit the two leads to S1 can simply be shorted together in order to trigger the unit, and this should produce the squeaking sounds and switch on the l.e.d.s for a second or two. It is possible to modify the sound effect to suit individual tastes, and the squeaking frequency can be increased by making C3 lower in value, or decreased by making it higher in value. The general pitch of the sound can be adjusted by means of R8, and is again increased by using a lower value or decreased by using a higher value. Do not try to reduce the pitch by a large amount as LS1 is a ceramic resonator which will not work efficiently at low frequencies. □

SCREAMING MASK

HOW TO SCARE GRANDAD WITH . . . A 555 TIMER

FOR the record, halloween (or hallowe'en, depending on which dictionary you consult) is on the eve of All Saints Day, or on October 31st in other words. Halloween is apparently derived from All Hallows Even (even meaning evening rather than the opposite of odd in this case). In times past it was believed that practically anything could happen on this day, including witches riding on broomsticks and elves playing pranks on mere mortals. These days it tends to be mere mortals playing pranks on other mere mortals, using gadgets such as our third halloween project. This one is intended for use with a halloween mask which it endows with a screaming sound effect and flashing eyes. The unit is triggered whenever a sound is made in its vicinity.

SYSTEM OPERATION

This project is by far the most complex of the three, although the component count and cost have still been kept down. Fig. 1 shows the block diagram for the screaming mask.

An inexpensive crystal microphone insert is used to pick up sounds and convert them into electrical signals. The output from the microphone is at a very low level, and considerable amplification is required in order to make the unit reasonably sensitive. Two stages of amplification are therefore provided, and both stages are low current types so that the quiescent current consumption of the unit is kept down to a level which permits economic battery operation of the unit. The second amplifier drives a monostable multivibrator which controls the sound effects and display circuits via an electronic switch. This part of the unit is essentially the same as the equivalent circuit in the *Squeaking Bat* unit described previously. As in this previous project, the monostable is based on a 7555 which gives a suitably low stand-by current consumption.

In this application the tone generator must operate continuously rather than be pulsed, but the LFO is still included and is used to flash the "eye" l.e.d.s. A VCO is used to generate the audio signal, as in the previous project, and a ceramic resonator is again used as the loudspeaker. A C–R network provides frequency modulation of the VCO, but in this case a rising pitch seems to be preferable to a falling pitch, and the network generates a falling control voltage.

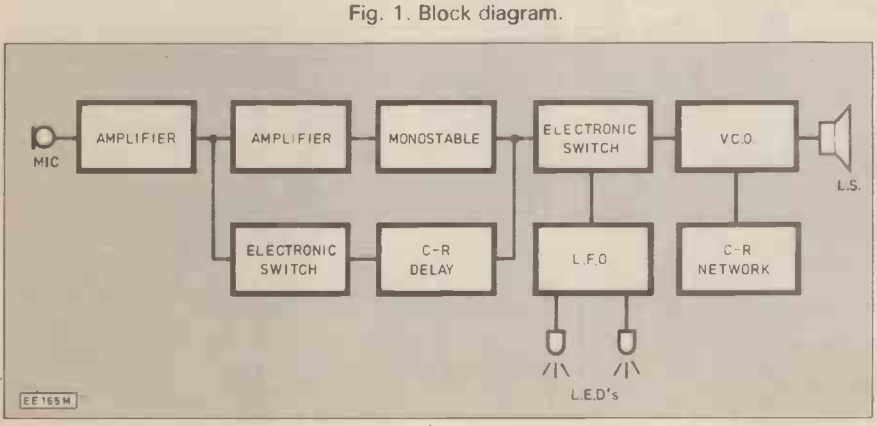
There is a flaw in the basic arrangement described so far, and this is due to acoustic feedback from the loudspeaker to the microphone. The practical result of this feedback is that once triggered the unit will retrigger itself indefinitely, and it will not give the required single-shot operation. This problem is circumvented by driving a second electronic switch from the output of the monostable. When turned on this switch short circuits to earth the output signal from the first amplifier stage, and it therefore cuts off the input signal. A simple C–R delay circuit at the input of the switch holds it momentarily in the on state after the output pulse from the monostable has ended. This ensures that the input circuitry is kept muted until the audio output from the unit has completely ceased, and that there is no risk whatever of the unit retriggering itself. On the face of it the delay circuit is not needed, but in practice the output from the loudspeaker will not end instantly, and it takes a short time for the sound waves to travel from the loudspeaker to the microphone.

CIRCUIT OPERATION

The full circuit diagram of the *Screaming Mask* project appears in Fig. 2.

TR1 acts as the input amplifier, and this is a low gain stage having negative feedback provided by unbypassed emitter resistor R4. R2 and C2 decouple the positive supply to the input amplifier and prevent low frequency instability due to feedback through the supply lines. There is a very high resistance through a crystal microphone and this avoids the need for a d.c. blocking capacitor at the input of the circuit. The collector load resistor (R3) and base bias resistor (R1) have been made high in value so as to keep the current consumption of the amplifier down to an acceptable level. The collector current for TR1 is actually only about 40 microamps. For good results a crystal microphone requires a fairly high load impedance, and the combination of low collector current and negative feedback provided by R4 provide a suitably high input impedance.

Fig. 1. Block diagram.



The second amplifier is built around TR3, and this is a straightforward common emitter amplifier. It is operated at a low collector current of only around 40 microamps, and this gives the circuit a total quiescent current consumption (including the monostable) of about 150 microamps or so. Even a small 9 volt battery can provide this for very many hours without becoming exhausted. TR2 is the gating transistor, and C3, C4, and R5 are included to prevent the gating action from generating a pulse which would cause unwanted retriggering.

IC1 is the 7555 which acts as the basis of the monostable. This has timing components R9 and C6 which give an output pulse duration of approximately five seconds. The trigger input of IC1 is fed direct from the collector of TR3, and this point in the circuit is biased to about half the supply voltage. Under quiescent conditions IC1 is not triggered, but in the presence of an input signal of adequate strength the trigger input of IC1 is taken below the 1/3 of V+ threshold level on negative excursions, and triggering is produced.

TR4 is the common emitter switch that controls the display and sound generator circuit. R10, D1, and C5 provide the switch off delay for gating transistor TR2. The delay is quite short at well under one second, but it is more than long enough to provide reliable operation of the unit.

The low frequency oscillator uses 555 timer device IC2 in the astable mode, and this part of the circuit is in fact identical to the *Pumpkin Flasher* circuit described previously. The VCO is based on a 4046BE, and this section of the circuit is similar to the tone generator section of the *Squeaking Bat* project which was also described earlier. However, there are one or two important differences. In the C–R circuit that generates the control voltage the resistor (R16) and capacitor (C8) have been swopped over to give the required rising control voltage and pitch. C8 is initially uncharged, giving zero control voltage, but as C8 charges up the control voltage increases. R17 is included to limit the maximum control voltage and to modify its characteristic. D4 ensures that C8 is quickly discharged at the end of the monostable's output pulse, so that the unit is almost immediately ready to operate properly again if the unit is quickly reactivated. The output impedance of the control voltage generator is very high, but no buffer amplifier is required as the input impedance at pin 9 of IC3 is extremely high indeed.

With zero control voltage the output frequency of IC3 is zero. As the control voltage increases, the output frequency increases from a very low audio frequency and soon rises into the desired range. This does not give quite the required effect, and

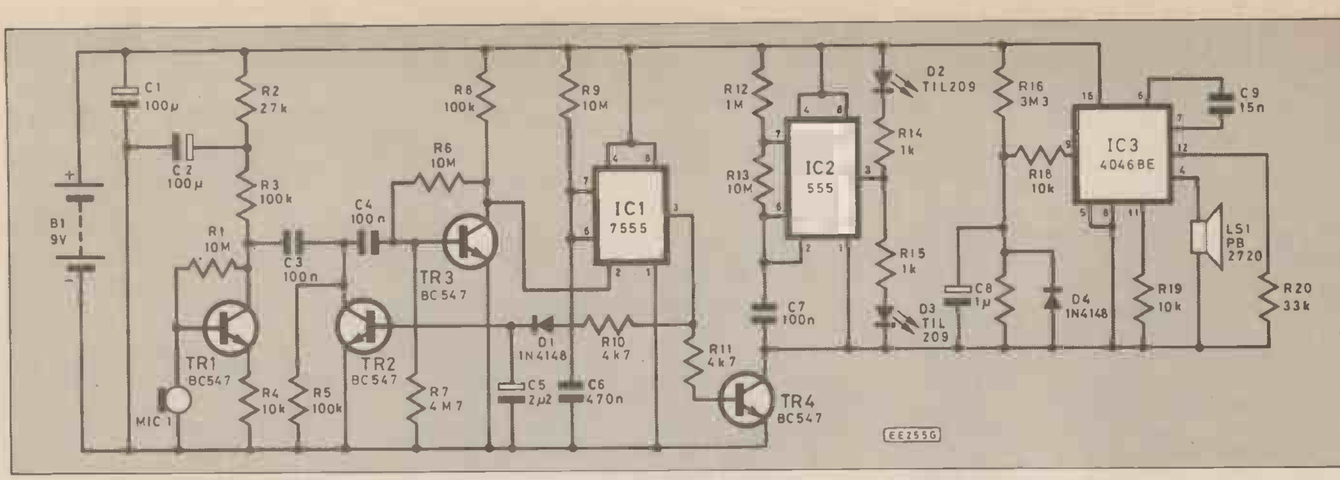


Fig. 2. Circuit diagram of the *Screaming Mask*.

it would be much better to have the VCO commence at a fairly high frequency. The 4046BE has a facility that permits this, and all that is required is the inclusion of offset resistor R20.

CONSTRUCTION

Fig. 3 shows the printed circuit track pattern and the component layout. With this project the printed circuit board is almost fully utilized, with just one hole being left unused. There are two linkwires, one below IC2 and the other one is just above C9. IC3 is a CMOS device and therefore requires the normal antistatic handling precautions to be taken. In this application it is not necessary to have a long microphone lead, and a screened input lead is consequently unnecessary. Many crystal microphone inserts seem to have flying leads these days, and these should be all that is needed to carry the connections to the board. However, make sure that they do not short circuit together or to any other exposed leads, and insulate them with short lengths of PVC sleeving if necessary. Incidentally, a ceramic resonator seems to be a perfectly good substitute for the crystal microphone insert, and if anything it actually seems to give slightly better sensitivity. The two l.e.d.s will almost certainly

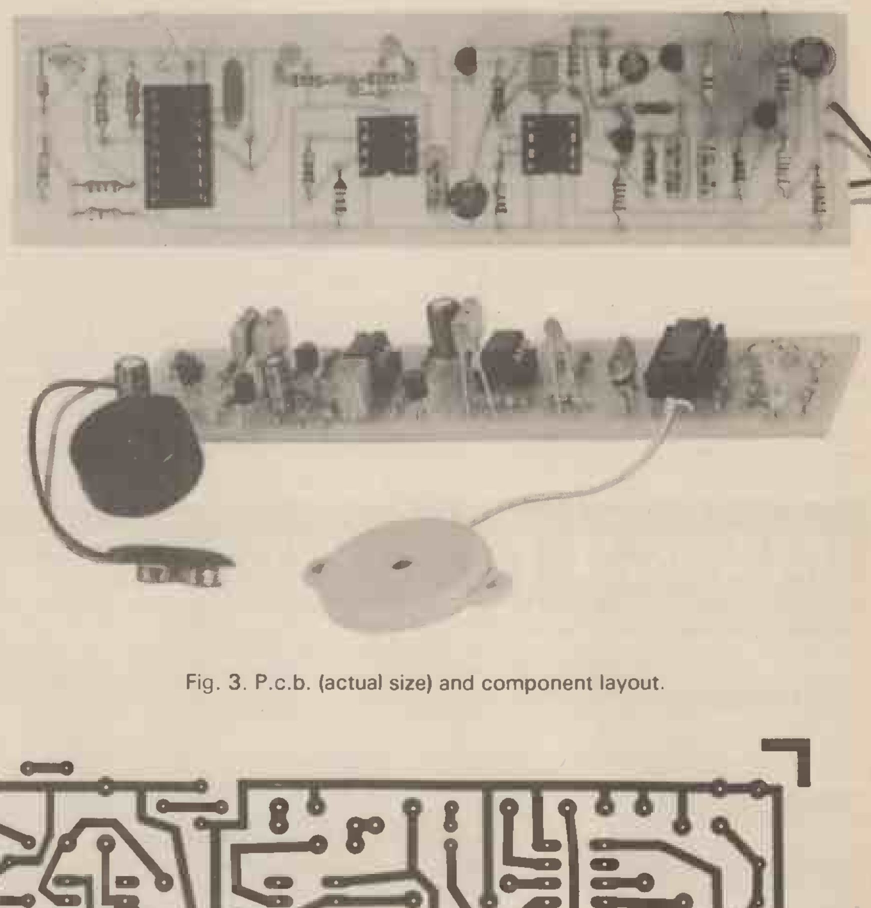
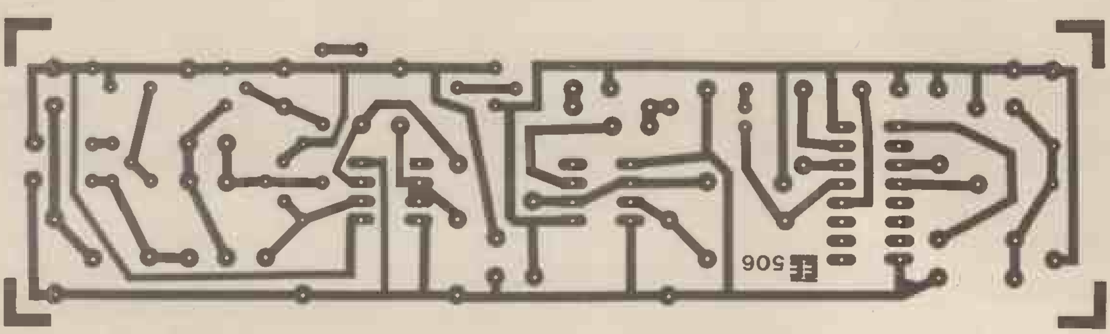
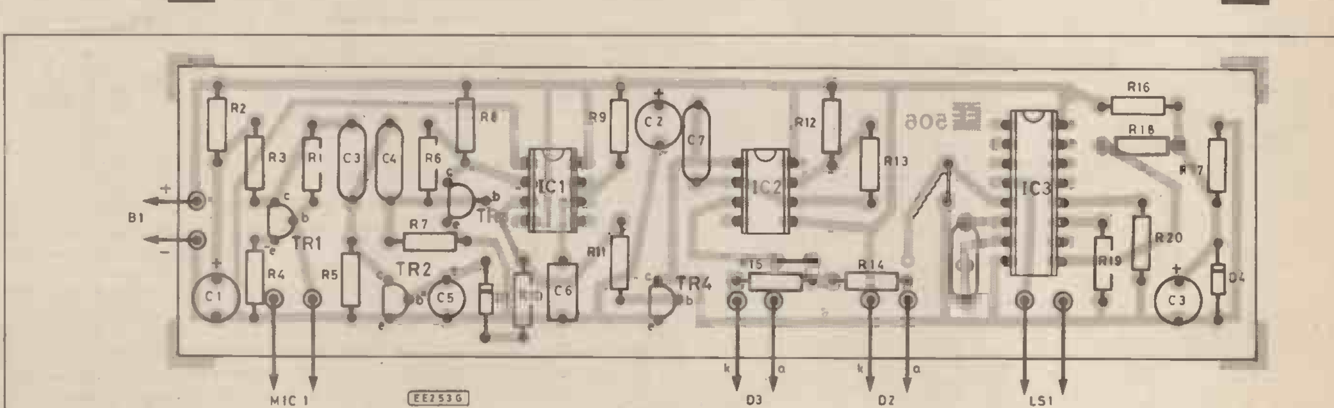


Fig. 3. P.c.b. (actual size) and component layout.





COMPONENTS

Approx. cost Guidance only **£11**

Resistors

R1,6,13	10M (3 off)
R2	27k
R3,5,8	100k (3 off)
R4,18,19	10k (3 off)
R7	4M7
R10,11	4k7 (2 off)
R12	1M
R14,15	1k (2 off)
R16,17	3M3
R20	33k

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

Capacitors

C1,2	100µF 10V radial elect (2 off)
C3,4,7	100nF polyester (3 off)
C5	2µ2 63V radial elect
C6	470nF carbonate
C8	1µF 63V radial elect
C9	15nF polyester

Semiconductors

IC1	ICM7555 low power timer
IC2	555 timer
IC3	404BE CMOS PLL
TR1,2,3,4	BC547 (4 off) silicon npn
D1,4	1N4148 (2 off) silicon signal diode
D2,3	TIL209 (2 off) or any coloured l.e.d.s

Miscellaneous

Mic1	Crystal microphone insert
LS1	PB2720 ceramic resonator
B1	9 volt (PP3 size)

Battery connector, printed circuit board, wire, solder, etc.

See Shop Talk page 602

have to be mounted off-board and connected to the component panel via twin insulated leads.

It is not essential for either the microphone or the loudspeaker to be fitted on the outside of the mask, especially if it is made from a fairly thin material and is open-backed, but in order to achieve optimum sensitivity and volume they would need to be mounted externally (and preferably disguised in some way).

TESTING

The unit might be triggered when it is connected to the battery, but if not try tapping the microphone. This should certainly trigger the unit and produce both the flashing l.e.d. display and the rising pitch sound. If not, disconnect the battery immediately and recheck all the wiring very carefully.

There is some scope to vary the sensitivity of the unit. As the circuit stands the unit should respond to a voice at a distance of a metre or two. Reducing the value R4 will boost the sensitivity, but it is probably best to avoid making the unit so sensitive that even the slightest background sound sets it off. If the particular microphone insert you are using has above average sensitivity you might find that a reduction in sensitivity would be helpful, and this can be achieved by increasing the value of R4. The sound effect can be altered to suit individual requirements, and the starting pitch of the sound generator can be raised or lowered by respectively decreasing or increasing the value of R20. The general pitch range can be changed by altering the value of C9, and it is inversely proportional to this value. The amount of pitch modulation can be increased by reducing the value of R16, or decreased by raising the value of this component. Finally, the duration of the sound effect and display is proportional to the value of C7.

Fig. 4 shows a typical "death mask" layout. □

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Accountability

I must admit I went along to British Telecom's first Annual General Meeting expecting a shambles; they have 1·7 million shareholders. All are entitled to go to the AGM and ask questions. BT admitted that it had no idea how many people would turn up, how many would ask questions and how well they would behave.

Amongst the 1·7 million there are bound to be a few people looking for trouble and self-publicity. Also, spare a thought for the Chairman, Sir George Jefferson, who was up for public interrogation on every aspect of BT's giant empire. No-one can know everything about a company. In some cases (although I think not in Sir George's) the Chairman seems to know least of all.

Well, I have to report that there wasn't any trouble. The whole thing ran like clockwork. This is doubtless why the press didn't give it much coverage. And it was all thanks to some very clever behind the scenes electronics.

BT employed British firm Crown International of Esher, to organise the audio/visual show and communications. The meeting went so smoothly that Crown has already been promised the £300,000 contract for next year. The National Exhibition Centre in Birmingham was the venue, Britain's biggest meeting hall.

The AGM was treated as a military operation and Crown created the most elaborate two-way communications network ever provided for a conference meeting. They estimated a maximum attendance of 20,000, booked two of the largest halls at the NEC, and erected an overflow marquee.

Crown brought in nine professional TV cameras to record the event on video for regional meetings and provide constant live coverage. Cameras in Arena Hall could have sent TV pictures of Chairman Sir George Jefferson and his directors to the overflow halls.

In the event they were not needed, as only 4,500 people turned up. But the TV signals were still used, live. Because Hall 7 is so large, and Sir George appeared to most of the audience like a diminutive pop star in the distance, TV pictures were projected onto two 6 × 4·5 metre screens mounted high above the directors' table.

Crown used General Electric light valve projectors. Conventional projectors work by forming an image of a TV tube by a lens system, so picture brightness is limited by tube brilliance. The GE light valve projector creates an image on screen by beaming light through a film of oil which is modulated with the video signal to create a transparent video image, like a film frame. So a very bright screen image can be created.

But the engineers hit snags when they tried to mount the projectors on a gantry at the rear of the hall. The throw, of nearly 100 metres, was so long that the pictures on screen were far too large and dim. They could not get a projector lens of focal length long enough to produce a small picture on such a long throw.

So Crown brought in a Quantel video special effects unit, of the type used by broadcast TV stations to create squeeze effects on commercials and pop videos. With this they artificially reduced the size of the picture by 30 per cent before feeding it to the projector, so the final picture was of reasonable size and brilliance.

Because the arena is so large, with bare walls, it has an echoing acoustic which makes speech unintelligible. Paul Ellis of Crown describes the Arena as "a giant bathroom". He used 34 separate 750W BGW pop-group amplifiers making a total of over 25 kilowatts of sound power.

Instead of feeding all the amplified sound signal to a stack of loudspeakers at the front, as at a pop concert, they split the signal between sixty smaller loudspeakers dotted around the arena. A digital delay line created an artifical lag in the sound sent to speakers towards the rear of the hall, so that sound heard at any position in the hall arrived from all directions at the same time.

Hot Line

The biggest concern was how to deal with hecklers, but still make questions from the floor audible. Crown built eight soundproof booths out of transparent plastics, and dotted them around the arena.

Each booth had its own telephone inside. Although apparently normal BT Slimtels, each had its normal mouthpiece microphone replaced by a high quality Sony electret microphone. Sound signals from all the booths were fed to a 24-track recording studio mixing desk.

As Sir George took questions from one of the numbered booths, the engineers faded up a spotlight on the booth, lifted the level of sound from its microphone and fed it through to the main amplification system. When a questioner failed gracefully to stop talking, the sound engineers simply faded out the signal, plunged the booth into darkness and switched to another questioner in another booth across the hall.

Expecting a barrage of questions on service problems, BT played the master stroke of printing in advance a form which shareholders could fill in after the meeting. This asked them to detail their complaint. Anyone who tried to harangue the chairman about wrong numbers or crossed lines during the meeting, was simply told by Sir George to fill in the form and then switched off by the engineers as the Chairman called for "next question".

Mission Control

But how did Sir George answer so many questions so easily, with facts apparently at his fingertips? The facts were, quite literally, at his fingertips—on a TV monitor screen hidden on his lectern.

Every questioner had to fill in a form before going into the booth. This was not bureaucracy; the forms were continually collated in a hidden mission control centre. Here BT "experts" had prepared in advance 200 prompt sheets with vital facts on every question likely to be asked. These could be placed in front of a closed circuit TV camera, and the image routed to the lectern monitor. So by the time a questioner had reached the booth and started talking, Sir George already knew the answer.

Where questions touched on issues not covered by the prompt cards, another team of "experts" typed essential data into a video text generator which relayed help to Sir George's private screen.

Red Dust-up

Late last summer the popular press was full of reports on how the KGB in Russia had endangered the health of foreigners by sprinkling spy dust on them. The dust is invisible to the human eye but shows up under ultraviolet light.

Inevitably this prompted some questions because the KGB were using a technical trick already well known to laundries, theatres and night clubs. How safe is it?

The key phenomenon is fluorescence. Near-ultraviolet or "black" light, in the wavelength range 320 to 400 nanometres, causes a wide range of chemicals to fluoresce. They absorb the invisible short wavelength UV energy and radiate visible light of longer wavelength. Ultraviolet light of shorter wavelengths, in the middle and far bands, causes skin tanning and kills bacteria. In excess it burns skin, especially the eyes.

Black light is generated by a modified domestic fluorescent lamp. An electric discharge in mercury vapour produces far-UV radiation which causes phosphors deposited on the inside of the tube to radiate visible light and near UV at around 350nm.

A filter of dark glass, called Woods glass, blocks escape of visible light but lets through the invisible near-UV. This filtering increases the contrast when the UV falls on a fluorescent substance.

In an almost dark environment it glows very brightly; in normal ambient lighting it stands out like a sign written in fluorescent paint. So the KGB can watch for fluorescence without the subject knowing, for instance by putting a black light source over a doorway.

In California visitors to the Disneyland amusement park can get a "pass-out" to go on a monorail into the nearby Disneyland hotel. They go there for a drink, because Disneyland is "dry". The pass out is a stamp on the back of the hand. It's an ink which is barely visible in daylight but glows brightly in UV light. Many British clubs and discos do the same.

Crime prevention officers in the UK recommend that British householders mark their property with a pen sold by Berol of King's Lynn. This contains an ink which is sensitive to ultraviolet light. Every UK police force now has black light equipment to check for hidden markings when stolen property is recovered.

So is it safe? Disneyland confirmed to a colleague of mine after the KGB scare that its dye was nothing like the Russian chemical. Believe it or not they call it "Blak-Ray blacklight fluorescent invisible readmission swimming pool ink".

Berol buys its dye for its markers from chemical giant Ciba Geigy. It is an optical brightener, similar to that used to make paper look clean and white. They also provided health and safety clearance data.

Berol's chemists have already checked that they are not dealing with nitro phenyl pentadiene (NPP) the KGB's pet chemical.

CT1000K CLOCK/TIMER KIT
24hr Digital clock with presetable ON and OFF time for output. Ideal for use with tape recorders, lighting etc. **£14.90**

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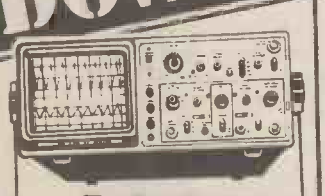

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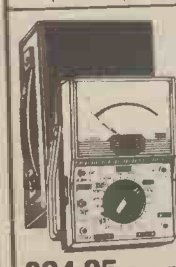

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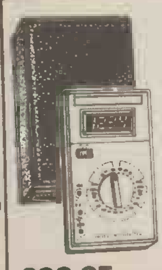

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8	4	9.43	1.86
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12	6	11.43	2.15
16	8	13.62	2.33
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15×2	.2A×2	2.53	.96
12-0-12	.05	3.21	.96
20×2	.3×2	3.55	1.30
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TEACH-IN '86

PART 2 · Michael Tooley BA David Whitfield MA M Sc C Eng MIEE

IN electronics an important distinction exists between components used as prime movers in the generation and amplification of signals (i.e. transistors and integrated circuits) and those which have more mundane applications such as filters, attenuators, and bias networks.

Transistors and integrated circuits rely on a source of direct current for their operation and are said to be **active**. Resistors, capacitors, and inductors, on the other hand, do not require a supply and are said to be **passive**.

Most practical circuits comprise a mixture of both active and passive components. A simple single-stage transistor amplifier, for example, contains a single active device (the transistors) aided and abetted by several passive devices (including resistors which provide the prescribed bias current for the transistor and capacitors which allow signals to be coupled into, and out of, the stage). In this second part of Teach-In we shall be taking a detailed look at the principles and construction of passive components.

RESISTORS

In last month's instalment we mentioned that a circuit diagram is nothing more than a form of electronic street map. Furthermore, we assumed that the direct links between components shown in a circuit diagram have negligible resistance and thus offer no opposition to the passage of current.

Within a circuit, paths for current are also provided by resistors; the greater the resistance the smaller the current that will be flowing (assuming, of course, that the same voltage is applied).

Developing the previous analogy further, we could equate a direct connection (having a resistance of a mere fraction of an ohm) with a motorway and a resistance of several thousand ohms with a footpath; the volume of traffic that can flow being representative of the amount of current that can pass.

As briefly mentioned in Part One, we need to consider a number of factors when selecting a resistor quite apart from its resistance value. These factors include its power rating, tolerance, stability, and sometimes also its construction. We shall now take a brief look at the construction of some common types of resistor which have their characteristics summarised in Table 2.1.

Resistor type	Wirewound	Carbon composition	Carbon film	Metal oxide
Resistance range [Ω]	0·1 to 22k	2·2 to 1M	10 to 10M	10 to 1M
Typical tolerance [%]	±5	±10	±5	±1
Ambient temperature range [°C]	−55 to +200	−40 to +105	−40 to +125	−55 to +125
Typical noise level [μV/V]	(see note)	>2	1·0	0·1
Typical stability [% over 1 year]	±1	±5	±2	±0·1
Power rating [W]	2·5 to 17	0·125 to 1	0·25 to 2	0·25 to 0·5
Note: Noise level is unlikely to be an important consideration in applications involving wirewound resistors				

Table 2.1. Typical characteristics of some common types of resistor.

WIREWOUND

The resistance of a metallic wire is directly proportional to its length and inversely proportional to its area. Thus, for a given material, longer and thinner wires exhibit a higher resistance than their shorter and fatter counterparts.

Wirewound resistors are made by winding "resistance wire" (made from alloys like constantan, nichrome and manganin) on a ceramic or fibreglass insulating former. The resulting assembly is then coated with silicone or vitreous enamel which is capable of withstanding surface temperatures of several hundred degrees celsius.

Typical values for wirewound resistors range from a fraction of an ohm to around 22kΩ. Commonly available power ratings range from around 2·5W to 17W. They are also rather large and inappropriate for rating requirements of around 2W or less. Hence we have to turn to different materials, the most obvious choice for which is carbon.

CARBON COMPOSITION

Carbon composition resistors use a mixture of carbon and clay moulded into a rod and fitted with leads. Carbon composition resistors tend to be inexpensive but both their tolerance and stability tend to be poorer than that associated with other types. Values range from around 2·2Ω to 1MΩ at a tolerance of ±10 per cent. Commonly available power ratings range from 0·125W to 1W.

CARBON FILM RESISTORS

Carbon film resistors rely upon a film of carbon which is deposited on a ceramic rod. This is then coated with

an insulating surface layer, the resulting resistor exhibiting a closer tolerance and higher stability than its carbon composition counterpart. Values range from 10Ω to 10MΩ at tolerances of ±5 per cent and power ratings of between 0·25W and 2W.

The tolerance of carbon resistors tends to be limited to about ±5 per cent and, whilst this is adequate for most applications, a closer tolerance is sometimes required. Furthermore, the random fluctuations of resistance within carbon resistor result in a small unwanted "noise" voltage. For most applications this is of little consequence however, where the resistors are to be used in high gain amplifiers, the "noise" produced may become significant and hence a better form of resistor is required.

METAL OXIDE

Metal oxide resistors are similar in construction to their carbon film counterparts but instead employ a film of tin oxide deposited on a ceramic rod. This results in tolerances of around ±1 per cent coupled with very high stability (i.e. the resistance does not change appreciably as time goes on).

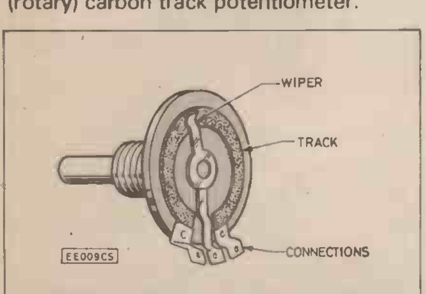
POTENTIOMETERS

In a variety of applications it is necessary to be able to continuously vary the resistance in a circuit rather than rely on a range of fixed values. Some "close to home" examples include the volume and tone controls in radio and audio equipment and the brightness and contrast controls of a television receiver.

Variable resistors come in a variety of different forms but invariably they are fitted with three, rather than two, terminals. In this form, variable resistors are more correctly referred to as "potentiometers" since they constitute a potential divider (an arrangement which we met briefly in Assignment 1.2).

Potentiometers are available as either rotary or slider types, the former enjoying greater popularity amongst equipment manufacturers. A rotary potentiometer (see Fig. 2.1) consists essentially of a carbon (or wirewound) track which occupies an arc of approximately 270°. Each end of the resistive track is fitted with a connecting tag to facilitate soldering. The third connection is linked to a wiper, the position of which is controlled by the shaft on which the knob is mounted. The resistance between the wiper and end terminals thus varies according to the position of the shaft.

Fig. 2.1. Internal construction of a typical (rotary) carbon track potentiometer.



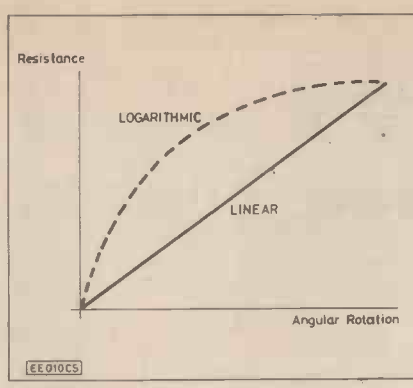


Fig. 2.2. Resistance characteristics of linear and logarithmic potentiometers.

Pre-set potentiometers are smaller and usually used for p.c.b. work, they are somewhat similar in their construction and require adjustment with a small screwdriver or trimming tool.

Whilst some potentiometers have a "linear" track (i.e. the change in resistance is constant) others (particularly those used in volume controls) exhibit a logarithmic characteristic (see Fig. 2.2).

THE WHEATSTONE BRIDGE

At this point we shall briefly digress from our main theme in order to introduce a circuit which is both useful and elegant in its simplicity. This circuit forms the basis of this month's Practical Project, the LCR Bridge, page 604.

If four resistors are connected as shown in Fig. 2.3, the arrangement is said to constitute a "bridge".

To understand how the bridge circuit works first consider the action of each half of the circuit, as shown in Fig. 2.4. Each pair of resistors constitutes a "potential divider"; the voltage at the junction of the two resistors being, in the case of equal value resistors, exactly half the supply voltage.

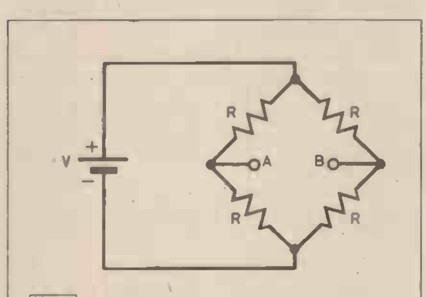
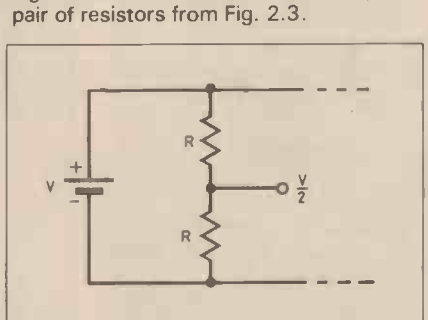


Fig. 2.3. Basic Wheatstone bridge configuration.

Fig. 2.4. Potential divider, formed by each pair of resistors from Fig. 2.3.



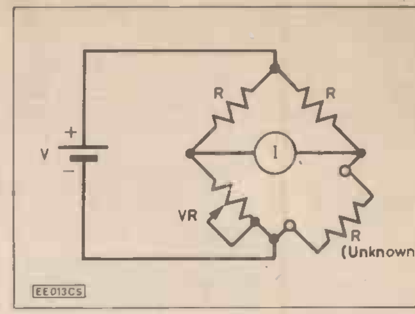


Fig. 2.5. Practical form of Wheatstone bridge.

If all four resistors have the same value, identical potentials (relative to either of the supply rails) will appear at A and B (Fig. 2.3). Hence the potential difference existing between A and B will be zero. In this condition the bridge is said to be "balanced" and no current would flow in a meter connected between A and B.

If we now replace one of the resistors (arms) of the bridge with a calibrated variable resistor (or potentiometer with one end terminal left disconnected) and an adjacent resistor (arm) with an "unknown" resistor, a balanced condition would be obtained whenever the variable arm has a resistance which is exactly equal to the unknown resistance. The balanced condition can be detected by simply connecting a milliammeter (ideally with a "centre zero" movement) between terminals A and B, as shown in Fig. 2.5.

The range of indications of the basic Wheatstone bridge can be extended by including switched decade values of resistance in the two fixed arms. These are then referred to as "ratio arms". The bridge circuit can also be modified so that capacitance and inductance can be measured (for this we require an a.c. rather than d.c. source). Once again this can be seen in the LCR Bridge, page 604.

ENERGY AND POWER

Energy exists in many forms; heat and light being perhaps the most obvious examples. In electrical circuits, the electrical energy supplied to a resistor is dissipated as heat. A resistor can therefore be thought of as a device which changes electrical energy to heat energy. A lamp, on the other hand, converts the electrical energy applied to it to both heat and light.

Energy is measured in joules (J). One joule of electrical energy is changed into other forms of energy when one coulomb of charge passes through a circuit across which a potential difference of one volt exists. Thus:

joules = coulombs × volts

or

$$W = QV$$

where W is the energy in joules (J), Q is the charge in coulombs (C), and V is the potential difference in volts (V).

Power is the rate at which energy is changed from one form to another. Power is measured in Watts (W). One watt of power exists when energy is converted at the rate of one joule per second.

watts = joules/seconds

or

$$P = W/t$$

where P is the power in watts, W is the energy in joules and t is the time in seconds.

Now, to put all this into context let's take a simple example. Suppose we have a torch which contains a light bulb rated at 6V, 250mA. If we leave the torch switched "on" for 1 minute, the charge consumed will be 0·25A × 60s = 15C. The energy converted by the torch will be 15C × 6V = 90J. Finally, the power will be 90J/60s = 1·5W.

We could, of course, have calculated the power rating using the formula which we met last month;

$$P = IV$$

where I is the current in Amps and V is the potential difference in Volts.

The power in our light bulb will thus be 6V × 0·25A = 1·5W which, of course, gives the same result as with the other formula.

Electrical energy may be temporarily stored in the form of either an electric field or a magnetic field. In either case the energy expended in creating the field is returned when the field collapses. This vital concept forms the basis of two important components; the capacitor and the inductor.

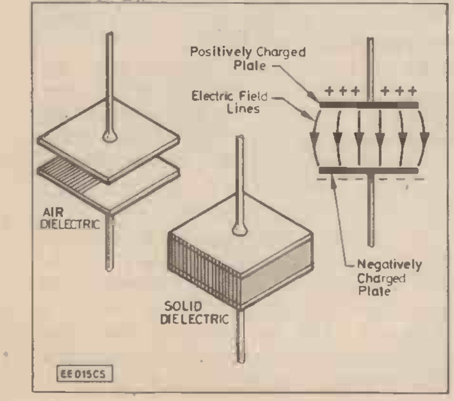
CAPACITORS

In Part One of Teach-In we identified the need for a device capable of storing electric charge. Unlike a battery, such a device need only provide short term storage of charge since we can arrange for regular replenishment of any lost charge from the supply.

A capacitor is a storehouse for electric charge. Fig. 2.6 shows the simplest form of capacitor which consists of a pair of parallel metal plates separated by an insulating material known as a dielectric.

When a potential difference appears between the plates, a difference of charge appears across the dielectric and an electric field is established within the dielectric. The material chosen for the dielectric is designed to support an electric field without allowing the charge to leak away (Fig. 2.6).

Fig. 2.6. Basic parallel plate capacitor construction showing charge and electric field lines.



The capacitance (C) of a capacitor is a measure of its ability to store a charge. The larger the capacitance the greater the charge that can be stored for a given applied potential difference. Capacitance is measured in farads (F). A capacitor is said to possess a capacitance of one farad (F) if it stores a charge of one coulomb when a potential difference of one volt is applied. Thus:

capacitance = charge/voltage

or

$$C = Q/V$$

where C is the capacitance in farads (F), Q is the charge in coulombs (C), and V is the p.d. in volts (V).

In practice a capacitance of 1F is somewhat large and we frequently have to resort to very much smaller sub-multiples, the most common of which are:

microfarads × 10^{-6}F abbreviated μF
nanofarads × 10^{-9}F abbreviated nF
picofarads × 10^{-12}F abbreviated pF

An important characteristic of a capacitor is its "working voltage". This is the maximum d.c. (or peak a.c.) voltage which can safely be applied to the capacitor. Voltages in excess of this value are likely to cause permanent damage to the dielectric and this, in turn, can lead to the failure of other components.

Capacitors are distinguished by the material used for the dielectric. Commonly used dielectrics are mica, polyester, polystyrene, and aluminium oxide (electrolytics) and their characteristics are summarised in Table 2.2.

POLYSTYRENE

The plates of polystyrene capacitors are formed by thin strips of aluminium foil, separated by a plastic film and rolled into the form of a tube. The completed assembly is then fitted with its axial connecting leads and coated with plastic.

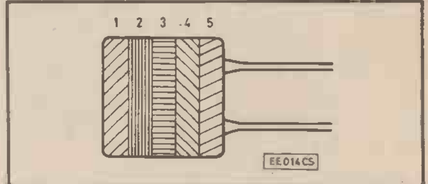
MICA

Mica capacitors offer close tolerance (±1 per cent typical) coupled with very high stability. The plates of the capacitor are formed by two layers of silver deposited on the opposite faces of a thin slice of mica. The capacitor is then treated with a protective coating of cement.

POLYESTER

A system of colour coding is applied to polyester capacitors along much the same lines as that applied to resistors. The capacitor body is coded with coloured bands, as shown in Fig. 2.7. Note, however, that unlike the system used for resistors, no gaps are left between adjacent coloured bands. This sometimes causes confusion when digits are repeated (as would be the case with 22nF, for example).

Fig. 2.7. Colour coding for polyester capacitors.



COLOUR	BAND 1 1st FIGURE	BAND 2 2nd FIGURE	BAND 3 MULTIPLIER	BAND 4 TOLERANCE	BAND 5 WORKING VOLTAGE
BLACK	0	0		± 20%	
BROWN	1	1			
RED	2	2			250V
ORANGE	3	3	×1,000		
YELLOW	4	4	×10,000		400V
GREEN	5	5	×100,000	± 5%	
BLUE	6	6			
VIOLET	7	7			
GREY	8	8			
WHITE	9	9		± 10%	

Note: Values are quoted in pF

Note that the values are quoted in pF (rather than F) and that it is usual to convert to nF or μF by shifting the decimal point three and six places to the left respectively.

Here are just two examples of the use of the capacitor colour code:—

Band 1	Band 2	Band 3	Band 4	Band 5
Brown	Black	Orange	Black	Red = 10,000pF (10nF), 20%, 250V
Yellow	Violet	Red	White	Yellow = 4,700pF (4.7nF), 10%, 400V

Table 2.2. Typical characteristics of some common types of capacitor.

Capacitor type (dielectric)	Mica	Polyester	Polystyrene	Electrolytic
Capacitance range [F]	2·2p to 10n	10n to 2·2μ	10p to 10n	1μ to 10000μ
Typical tolerance [%]	±1	±10	±2·5	±20
Ambient temperature range [°C]	−40 to +85	−40 to +100	−40 to +70	−25 to +80
Typical d.c. voltage [V]	350	250	160	25
Typical insulation resistance [Ω]	$>5 \times 10^{10}$	$>10^{10}$	$>10^{12}$	(see note)

Note: Leakage current depends on capacitance value and working voltage

ELECTROLYTICS

The principal disadvantage of all of the previous capacitor types is that they become impractically large when high values of capacitance are required. Polyester capacitors, for example, tend to become disproportionately large for capacitance values of only a few microfarads. Fortunately, electro-chemistry comes to our aid with chemical dielectrics which permit large value capacitors of very small physical size.

Electrolytic capacitors use a polarised chemical dielectric which comprises a thin layer of aluminium oxide. In order to polarise the dielectric, a direct voltage (of usually between about 1V and 15V) has to be applied to the capacitor. Furthermore, this polarising voltage *must* be applied with the correct polarity and, since a variety of different marking conventions are employed, it is always wise to check the connections of an electrolytic capacitor very carefully before wiring it into a circuit. Readers should be aware that the effect of connecting an electrolytic capacitor with incorrect polarity can, in some cases, be disastrous. In exceptional cases there may even be some risk of explosion!

CAPACITORS IN SERIES AND PARALLEL

Just like resistors, capacitors, may be connected in series or parallel arrangements in order to provide any desired value. When two capacitors are connected in series (as shown in Fig. 2.8) they each have the same charge whilst the applied voltage is shared between them. Thus,

$$Q = C1\ V1 = C2\ V2$$

$$\text{or } V1 = Q/C1 \text{ and } V2 = Q/C2$$

Now, the sum of the individual voltage drops, V1 and V2, must be equal to the applied voltage, V. Hence,

$$V = V1 + V2$$

If we combine the three previous formulae we arrive at,

$$V = Q/C1 + Q/C2$$

and since V = Q/C we deduce that,

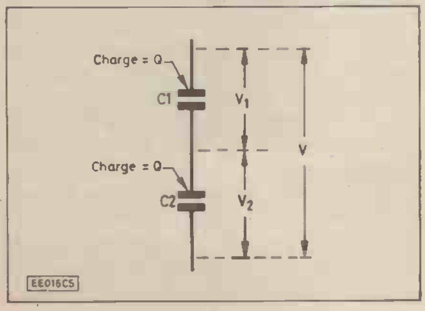
$$Q/C = Q/C1 + Q/C2$$

Dividing this last expression throughout by Q gives,

$$1/C = 1/C1 + 1/C2$$

When two capacitors are connected in parallel as shown in Fig. 2.9 they each have the same applied voltage and the charge is then shared between

Fig. 2.8. Capacitors connected in series.



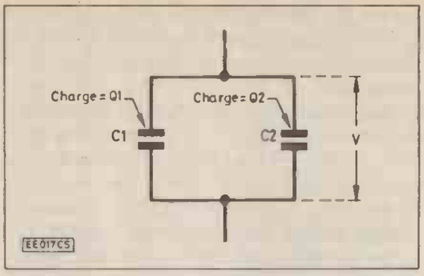


Fig. 2.9. Capacitors connected in parallel.

them. Hence,

$$V = Q1/C1 = Q2/C2$$

$$\text{or } Q1 = C1\ V \text{ and } Q2 = C2\ V$$

The total charge, Q, must be the sum of the individual charges, Q1 and Q2. Thus,

$$Q = Q1 + Q2$$

Combining the last three expressions gives,

$$Q = C1\ V + C2\ V$$

and, since Q = C V (where C is the total capacitance),

$$C\ V = C1\ V + C2\ V$$

Finally, dividing throughout by V, we arrive at,

$$C = C1 + C2$$

Readers should recall that the formulae for series and parallel arrangements of capacitors take the opposite form from those which relate to resistors, as summarised below:

	Resistors
Series	R1 + R2 + . . .
Parallel	1/R1 + 1/R2 + . . .

	Capacitors
Series	1/C1 + 1/C2 + . . .
Parallel	1/C1 + C2 + . . .

CHARGE AND DISCHARGE

If an initially uncharged capacitor is connected to a battery, we generally assume that charge is transferred from the battery to the capacitor instantaneously. In practice this is never the case as the rate of charging is always limited by the internal resistance of the battery and the resistance of the connecting wires.

A large number of electronic circuits do, in fact, rely on the charging and discharging of a capacitor over a period of time. To delay the transfer of charge we only need introduce some resistance into the circuit. To understand how this works consider the circuit of Fig. 2.10. With S1 in position A, the capacitor, C, charges from the supply with current supplied through the series resistor, R1. The rate of charging is determined by the product of the capacitance and resistance, C × R1, which is known as the "time constant" of the charging circuit.

As the capacitor charges, the voltage on its plates rises in an exponential fashion, as shown in Fig. 2.11.

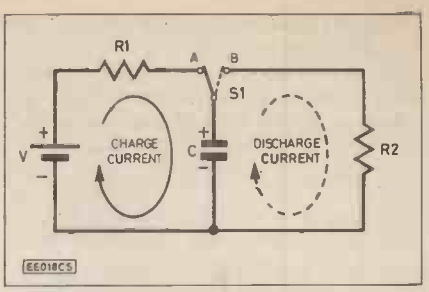


Fig. 2.10. Capacitor charge/discharge arrangement.

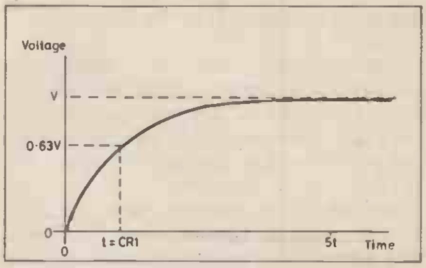


Fig. 2.11. Exponential rise of voltage across a capacitor undergoing charge.

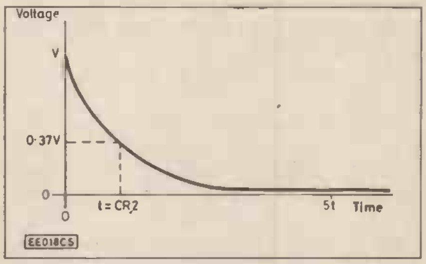


Fig. 2.12. Exponential fall of voltage across a capacitor undergoing discharge.

After a period equal to one complete time constant, the capacitor voltage will have risen to approximately 63 per cent of its final value. During the next time constant period it will achieve 63 per cent of the remainder, and so on.

Eventually the capacitor voltage becomes very nearly equal to the supply voltage. It should, however, be noted that the capacitor never quite becomes fully charged and there will always be some small difference between the capacitor voltage and the supply voltage. In practice we can safely assume that the capacitor is fully charged after a period equal to about five times the charge time constant (i.e. approximately 5 × C R1).

Now let us assume that our "fully charged" capacitor is discharged by switching S1 to position B (Fig. 2.10). Current flows through R2 as the capacitor's charge gradually leaks away. The rate of discharge depends upon the time constant, C × R2.

As the capacitor discharges, its voltage falls in an exponential manner (see Fig. 2.12) to 37 per cent of its initial value at the end of one time constant period. During the next time constant period it will fall to 37 per cent of the remainder, and so on.

Eventually, the capacitor voltage becomes very nearly equal to zero (i.e. 0V). Again, the capacitor never quite becomes fully discharged, however it is again safe to assume that the capacitor will have lost all of its charge after a period of time equal to about five times the discharge time constant (i.e. approximately 5 × C R2).

If all of this is beginning to sound a little too theoretical don't panic! The essential point is that we can control the rate of charge and discharge of a C-R circuit by means of an appropriate choice of component values. By increasing the values (of either C or R) we can slow-up the response or by decreasing the values we can speed-up the response. This leads to numerous applications in the fields of wave-shaping and timing.

INDUCTORS

An invisible magnetic field surrounds any wire which carries an electric current. When a wire is straight, the field lines surrounding it are circular. By coiling the wire, we effectively concentrate the strength of the field in the centre of the coil (Fig. 2.13). A further increase in flux density (for a given applied current) can be achieved by introducing a flux-supporting medium (such as iron or steel) in the centre of the coil.

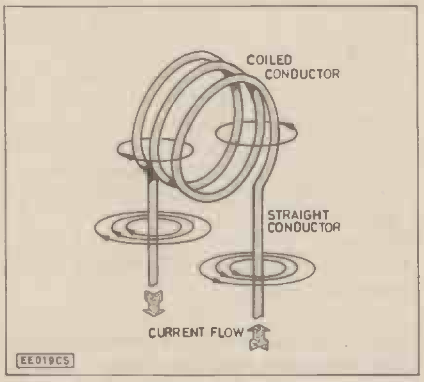


Fig. 2.13. Magnetic field lines in straight and coiled conductors.

If a steady direct voltage is suddenly applied to an inductor, the changing magnetic flux induces an e.m.f. within it which effectively opposes the applied voltage. Hence the current flowing in the inductor gradually builds up to a steady value (determined ultimately by the resistance of the circuit).

If the applied voltage is alternating (rather than direct) the continual change in current will produce a changing magnetic flux which, in turn, opposes the applied e.m.f. The result is an opposition to current which increases with increasing rate of change of current. Since inductors offer negligible opposition to the passage of direct current but offer an appreciable opposition to alternating current flow, inductors are often called "chokes".

Inductors are usually distinguished by the core material (i.e. the material in which the flux exists). High value inductors require a core which easily supports flux and this is achieved using high quality steels which are laminated to reduce losses and hence improve efficiency.

Other inductors use ferrite (a non-conducting ferric oxide) formed into a suitably shaped core. Ferrite "pot cores" are used to completely enclose a coil wound on a small bobbin. Other inductors use coils wound on ferrite rods and these are often found in radio equipment. The characteristics of a variety of common inductors are summarised in Table 2.3.

INDUCTORS IN SERIES AND PARALLEL

Series and parallel arrangements of inductors are somewhat less usual than series and parallel arrangements of resistors or capacitors. For the sake of completeness, however, we should perhaps mention that series and parallel arrangements of inductors behave in a similar manner to those of resistors. Thus, for a series arrangement of two inductors:

$$L = L1 + L2$$

and for a parallel arrangement of inductors:

$$1/L1 = 1/L1 + 1/L2$$

IMPROVED POWER SUPPLY

Finally, having briefly outlined the principles of capacitors and inductors, we shall put them to good use by making a few improvements to the rudimentary power supply described in Part One.

The first and most obvious improvement is to incorporate a capacitor which will act as a charge reservoir, as shown in Fig. 2.14. This capacitor alternately charges as the peak of each positive half-cycle approaches and then discharges through the load (i.e. the circuit connected to the power supply).

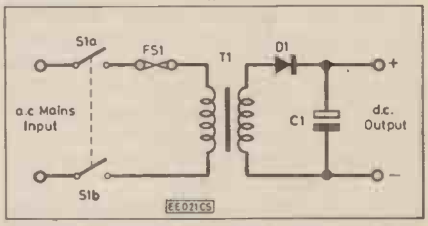


Fig. 2.14. Improved power supply incorporating a reservoir capacitor.

The value chosen for the "reservoir capacitor" is made as large as possible in order to maintain a reasonably steady current through the load. (Doubtless readers will have remembered that the charge stored in a capacitor is directly proportional to its capacitance!)

Typical values for reservoir capacitance range from around 470µF to around 10,000µF in applications where load currents range from between 100mA to around 5A. Electrolytic types are thus essential!

Fig. 2.15. Output voltage waveforms showing effects of reservoir capacitor and smoothing filter.

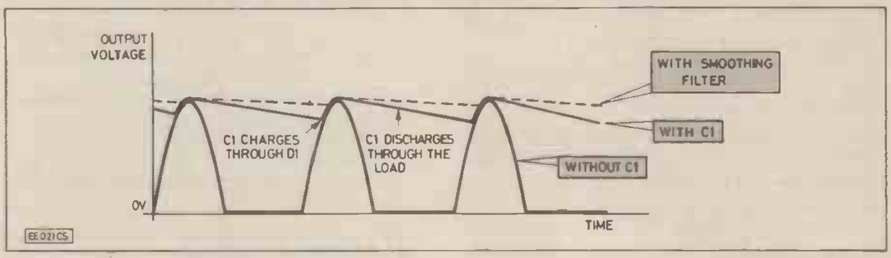


Fig. 2.16. Improved power supply incorporating reservoir capacitor and smoothing filter.

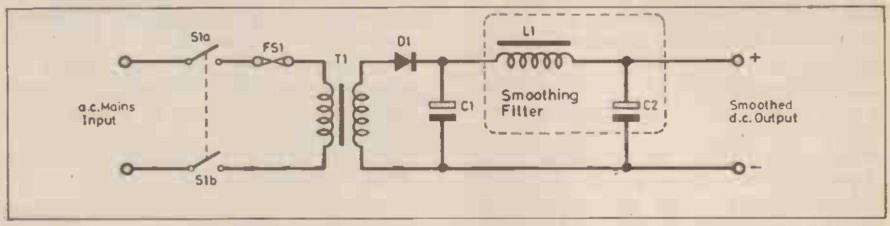


Table 2.3. Typical characteristics of some common types of inductor.

Inductor type (cove)	Laminated steel	Ferrite pot or ring	Ferrite slug	Air
Inductance range [H]	20m to 20H	10µ to 100m	100n to 1m	1n to 100µ
Typical tolerance [%]	±20 (see note)	±10	±10	±5
Typical frequency range [Hz]	10 to 10k	1k to 100k	100k to 100M	100k to 500M
Note: Inductance liable to vary according to any d.c. component present				

Unfortunately, the output of our improved power supply is still far from perfect. The regular charging and discharging of the capacitor produces a small "ripple" which is effectively superimposed on the direct output voltage, see Fig. 2.15.

Our power supply may be further improved by taking some positive steps to remove the residual ripple. This may be achieved by adding a simple inductance/capacitance filter, as shown in Fig. 2.16. This filter needs to comprise of nothing more than a series inductor, L, and a shunt capacitor, C2, and it allows direct current to pass unhindered whilst, at the same time, considerably reducing the level of the alternating ripple component at the output (Fig. 2.15). We shall be looking at filters in greater detail in Part Six of the "Teach-In" series.

Next month we shall deal with the principles and operation of some common semiconductor devices.

PROBLEMS

Difficulty rating: (e) easy; (d) difficult; (m) moderate.

2.1 How much energy is consumed by a domestic 60W light bulb in 1 hour? (e)

2.2 What type of resistor would be best suited to each of the following applications?
(a) A multiplier resistor used in a multimeter.
(b) A resistor used as a high current load for testing power supplies.
(c) A bias resistor for use in the first stage of a low-noise amplifier. (e)

2.3 A polyester capacitor is coded with the following coloured bands; orange, orange, yellow, red, white. What is the value, tolerance, and working voltage of the capacitor? (e)

2.4 What type of capacitor is best suited to each of the following applications?
(a) A reservoir capacitor for use in a power supply.
(b) A low value capacitor for use in the oscillator stage of a high frequency transmitter.
(c) A medium value capacitor for general use. (e)

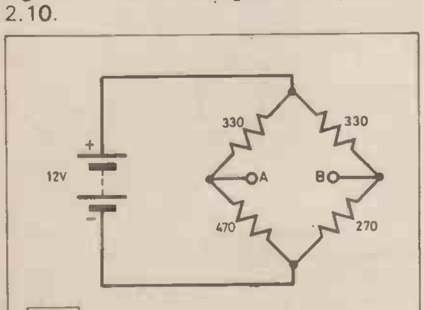
2.5 A capacitor of 16μF is charged to a potential difference of 50V. What charge is contained in the capacitor? (e)

2.6 A capacitor of unknown value is connected in series with a known 2μF capacitor. The series arrangement is then charged by connecting it to a 100V d.c. supply. If 20V appears across the 2μF capacitor determine the value of the unknown capacitor. (m)

2.7 A capacitor of 470μF is connected in series with a resistor of 220kΩ. What is the time constant of the arrangement? (e)

2.8 An oscillator requires a C-R circuit having a time constant which is adjustable from approximately 1ms to 11ms. Assuming that a capacitor of 100nF is available devise a suitable circuit and specify the component values required. (d)

Fig. 2.17. Circuit diagram for problem 2.10.



2.9 A 1μF capacitor is charged from a 10V supply via a 1MΩ resistor. What voltage will appear across the capacitor
(a) 1 second
and
(b) 2 seconds after connection? (m)

2.10 The circuit shown in Figure 2.17 shows an unbalanced Wheatstone bridge. Determine the voltage appearing between terminals A and B. (m)

THE ANSWERS TO THESE PROBLEMS WILL APPEAR IN TEACH-IN PART 3

ANSWERS TO LAST MONTH'S PROBLEMS

1.1 six
1.2 11Ω, 36kΩ, 2MΩ
1.3 2.22A
1.4 (a) 43·6mA
(b) 2·053V
1.5 150Ω x 2
1.6 Unfortunately this question was wrongly printed and should, therefore, be ignored
1.7 4V (min) to 8V (max)
1.8 3V (min) to 6V (max)
1.9 27kΩ 5% tolerance
1.10 No
1.11 47kΩ, yellow/violet/orange/silver
1.12 339V peak, 678V pk-pk
1.13 4V pk-pk, 500Hz

Practical Assignments

COMPONENTS

Besides the items used for Part One, you will need the following components in order to complete the practical assignments described in this part of Teach-In:—
Resistors 0·25W, 5 per cent, 100Ω (1), 470Ω (4), 1kΩ (1), 10kΩ (3)
Capacitors 16V electrolytic, 1000μF (1), 2200μF (1).

In addition, readers will require a digital wristwatch preferably incorporating an elasped time display.

ASSIGNMENT 2.1

Charge and discharge of a capacitor

This assignment is designed to demonstrate the charge/discharge characteristics of a C-R arrangement. Before we begin, a few words of explanation are necessary concerning our choice of component values used in this experiment.

Firstly, since we shall be using nothing more sophisticated than a watch and a multimeter (for recording time and voltage or current respectively) we shall need to use some relatively long values of time constant.

Since we are aiming for a large C x R value readers might be forgiven for thinking that we should make both C and R as large as possible. To some extent this is true but consider, for a moment, the effect of the voltmeter's own internal resistance. This will appear in parallel with the circuit at the point of connection.

The voltmeter has a finite resistance (200kΩ on the 10V d.c. range) and, to ensure that any current drawn by the voltmeter will be insignificant by comparison with that flowing in R, we must choose a value for R which is very much smaller.

A sensible value for R would thus be about one tenth of that of the voltmeter (i.e. between 10kΩ and 30kΩ). Unfortunately this poses something of a problem since, in order to produce a time constant of several tens of seconds, we are now constrained to using some fairly large values of capacitor.

Secondly, large capacitance values can only be achieved with the use of electrolytic devices. Such devices tend not only to be of rather poor tolerance (i.e. we cannot assume that their marked value is precise) but they are also prone to some leakage (i.e. small direct current flows in the dielectric). These problems tend to become more severe as the value of capacitance increases.

The choice of C-R values has, therefore, to be something of a compromise; C must be large but not so large that leakage becomes significant, whilst R must be low but not so low that we are forced into using excessively large values for C. All this serves to illustrate the sort of dilema that often faces the electronic equipment designer!

Now to turn to the assignment itself. For convenience we have split the assignment into three separate parts, as follows:

(a) Investigation of capacitor voltage during charge
(b) Investigation of capacitor current during charge
(c) Investigation of capacitor voltage during discharge

In each part of the experiment we will examine the effect of various C-R combinations in order to assess the performance of the circuit with different time constant values. Readers should tabulate all values (using the tables provided) so that graphs can be plotted and compared with those found earlier in the text.

PROCEDURE AND RESULTS

Connect the circuit shown in Fig. 2.18 on your breadboard, using the wiring diagram shown in Fig. 2.19. The value initially used for R should be 10kΩ whilst C should be 1000μF. Set the voltmeter to the 10V d.c. range (*do not* subsequently change the range).

Start the wristwatch time display (or choose a convenient value displayed on the normal seconds indication) and *at the same time* remove the shorting link. Now observe and record the capacitor voltage at each 5 sec. interval to a maximum of 60 sec. (You may find it best to enlist the help of another person who can call out the times

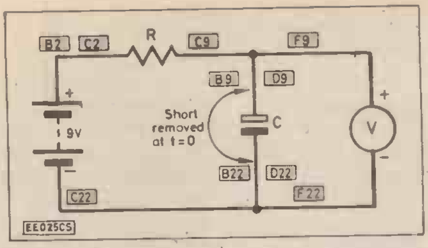


Fig. 2.18. Investigation of charging voltage.

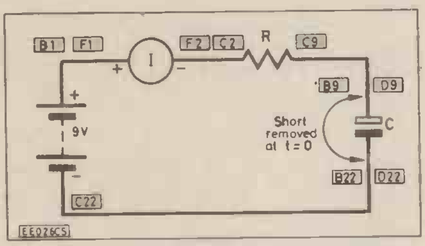


Fig. 2.20. Investigation of charging current.

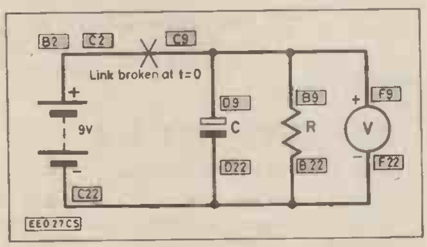


Fig. 2.22. Investigation of discharging current.

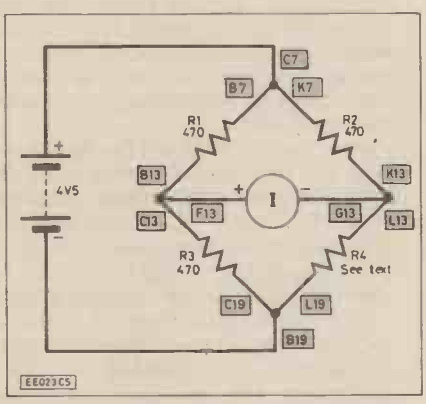


Fig. 2.24. Wheatstone bridge circuit for assignment 2.2.

whilst you read the meter and note down the results!) Your results should agree with those in Table 2.4.

Now repeat the measurements with R = 20kΩ and R = 30kΩ (wiring modifications are shown inset in Fig. 2.19) and C = 2200μF. You should obtain a total of six sets of results for the six different C-R combinations. Plot these results in the remainder of Table 2.4.

Results should now be plotted on graph paper and the graphs compared with Fig. 2.11. Readers should also calculate the time constant for each circuit and relate this to the graphs obtained.

Now connect the circuit shown in Fig. 2.20 using the wiring diagram shown in Fig. 2.21. The value initially chosen for R should be 10kΩ whilst C should be 1000μF. Set the multimeter to the 5mA d.c. current range (*do not* subsequently change the range).

Again remove the link at t = 0 but this time record values of current at 5

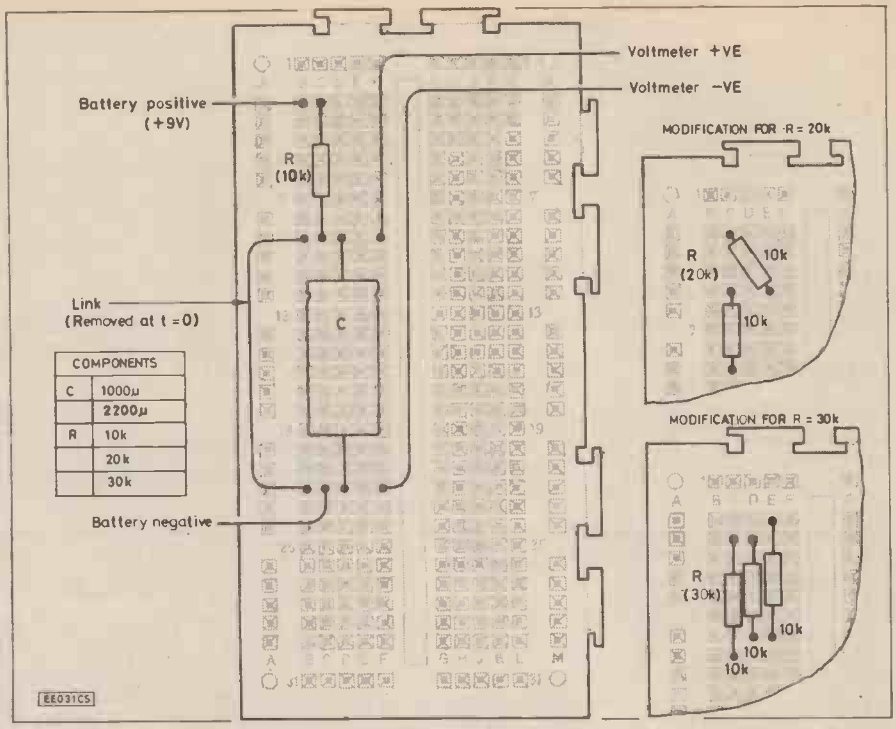


Fig. 2.19. Wiring diagram (Fig. 2.18).

Fig. 2.21. Wiring diagram (Fig. 2.20).

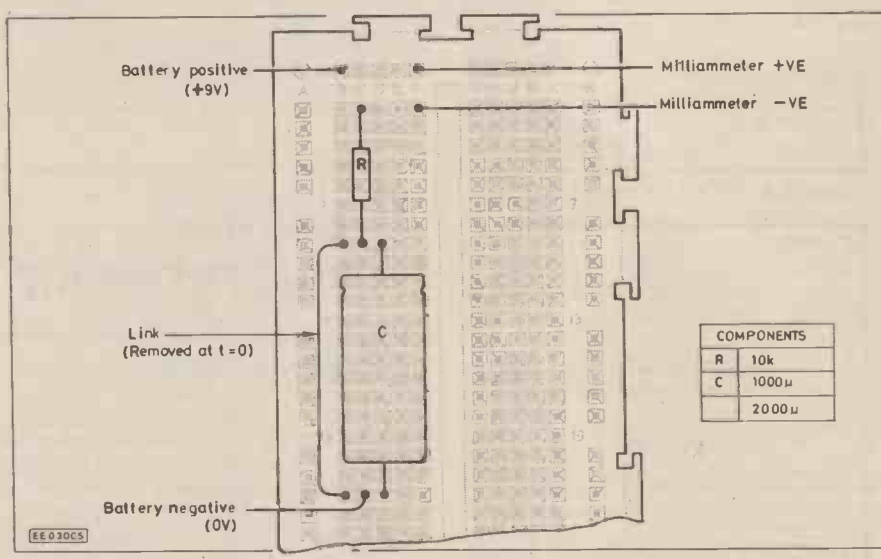
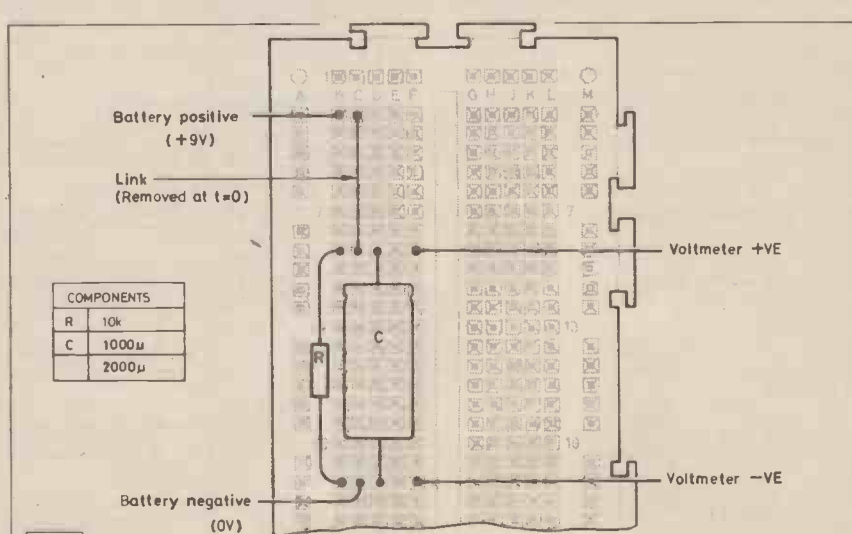


Fig. 2.23. Wiring diagram (Fig. 2.22).



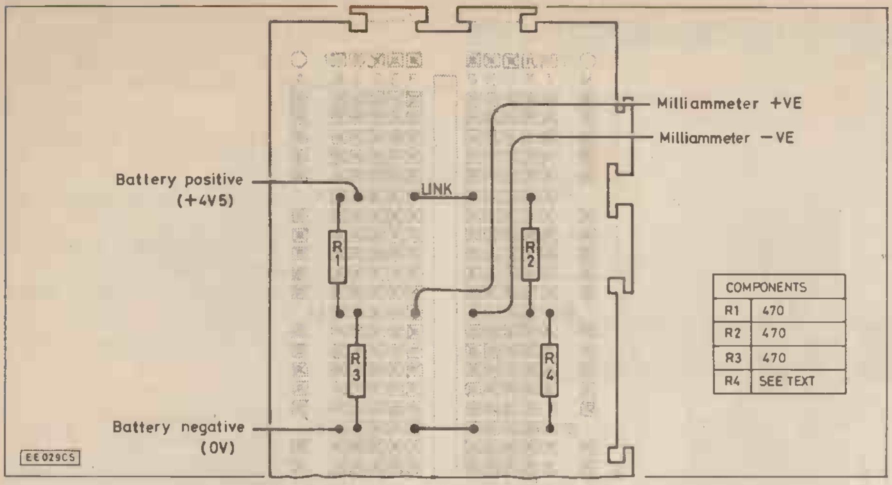


Fig. 2.25. Wiring diagram (Fig. 2.24).

C = 1000µF	Time, t (s)	0	5	10	15	20	25	30	35	40	45	50	55	60
R = 10kΩ	Voltage, v (v)	0	3	5·5	6·7	7·5	8·1	8·4	8·6	8·7	8·75	8·8	8·85	8·9
C = 1000µF	Time, t (s)	0	5	10	15	20	25	30	35	40	45	50	55	60
R = 20kΩ	Voltage, v (v)													
C = 1000µF	Time, t (s)	0	5	10	15	20	25	30	35	40	45	50	55	60
R = 30kΩ	Voltage, v (v)													
C = 2200µF	Time, t (s)	0	5	10	15	20	25	30	35	40	45	50	55	60
R = 10kΩ	Voltage, v (v)													
C = 2200µF	Time, t (s)	0	5	10	15	20	25	30	35	40	45	50	55	60
R = 20kΩ	Voltage, v (v)													
C = 2200µF	Time, t (s)	0	5	10	15	20	25	30	35	40	45	50	55	60
R = 30kΩ	Voltage, v (v)													

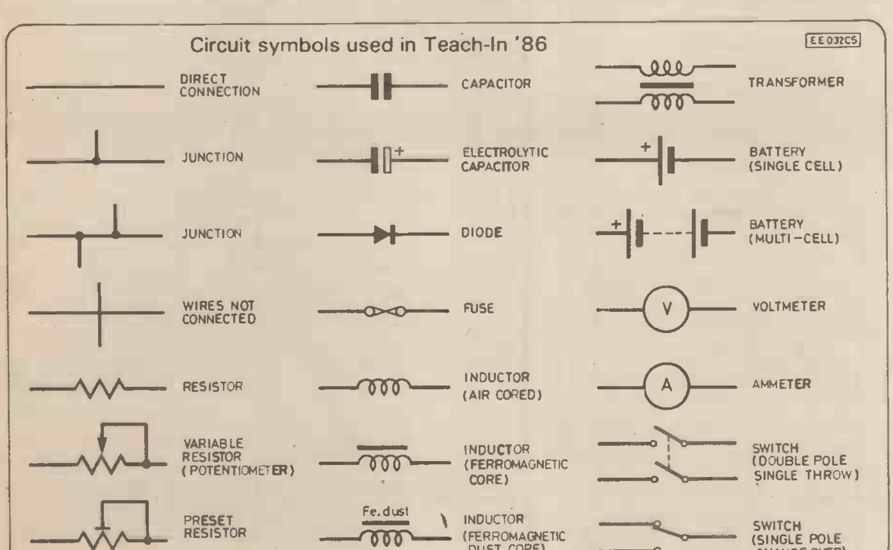
Table 2.4. Results for assignment 2.1 to be entered in this table (voltage during charge).

C = 1000µF	Time, t (s)	0	5	10	15	20	25	30	40	50	60
R = 10kΩ	Current, I (mA)	0·9	0·55	0·35	0·2	0·12	0·08	0·05	0·02	0·015	0·01
C = 2200µF	Time, t (s)	0	5	10	15	20	25	30	40	50	60
R = 10kΩ	Current, I (mA)										

Table 2.5. Results for assignment 2.1 to be entered in this table (current during charge).

C = 1000µF	Time, t (s)	0	5	10	15	20	25	30	35	40	45	50	55	60
R = 10kΩ	Voltage, v (v)	9	5·5	3·6	2·2	1·8	1·2	0·8	0·6	0·5	0·45	0·4	0·35	0·3
C = 2200µF	Time, t (s)	0	5	10	15	20	25	30	35	40	45	50	55	60
R = 10kΩ	Voltage, v (v)													

Table 2.6. Results for assignment 2.1 to be entered in this table (voltage during discharge).



sec. intervals to a maximum of 60 sec. Repeat the measurements with C = 2200µF. Your results can be entered in Table 2.5. Then plot graphs for both values of time constant. Attempt to reconcile the shape of these current/time graphs with the voltage/time graphs for the same C-R values (i.e. does the circuit obey Ohms law?).

Finally set up the discharge circuit shown in Fig. 2.22 using the wiring diagram of Fig. 2.23. The value initially chosen for R should be 10kΩ whilst C should be 1000µF. The multimeter should be set to the 10V d.c. range (and again this must *not* be subsequently changed during measurement).

Remove the link at t = 0 and then record values of voltage at 5 sec. intervals to a maximum of 60 sec. Repeat the measurements with C = 2200µF. Your results can be entered in Table 2.6. Then plot graphs for both values of time constant comparing the results with the graph shown in Fig. 2.12. Calculate the value of time constant for each circuit and again relate this to each graph.

ASSIGNMENT 2.2

The Wheatstone bridge

This assignment is dedsigned to illustrate the operation of a simple Wheatstone bridge.

Connect the circuit shown in Fig. 2.24 using the wiring diagram depicted in Fig. 2.25. All four resistors should initially be 470Ω and the multimeter should be set to the 5mA d.c. range. Readers should note that, in this initially balanced state, no current flows in the meter.

Now replace R4 first by 100Ω and then by 1kΩ. In each case note the indication produced on the meter (reverse the meter connections if the meter indicates a negative current).

Finally, replace R4 by a 1kΩ variable resistor (i.e. the same variable resistor used in Part One). Note the effect of varying R4 over its complete range of adjustment. Then carefully set R4 to produce a balanced condition. Now disconnect the variable resistor and the multimeter from the circuit and, using the multimeter "Ohms" range, measure the resistance presented by the variable resistor.

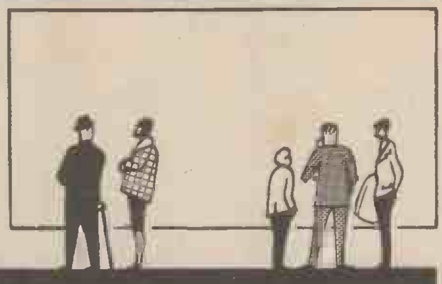
RESULTS

Relate the values of current flowing in the meter to the conditions within the bridge circuit. (Readers may like to calculate the currents and voltages appearing in each arm of the bridge for all three conditions). Finally, readers should confirm that the resistance presented by the variable resistor is the same as that present in the adjacent arm (R3).

Next Month you will need the following additional components in order to complete the practical assignments.

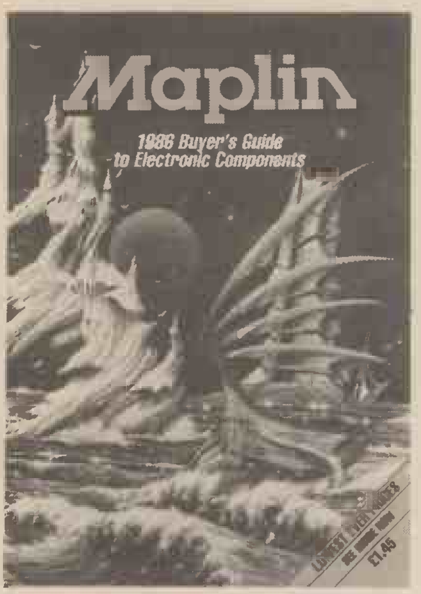
Resistors ($\frac{1}{4}$ Watt, 5% carbon). 100Ω (1 off); 220Ω (1 off); 2·7kΩ (1 off);
Potentiometer 100k (linear)
Semiconductors OA-91 (1 off); IN4148 (1 off); BZY-88-C3V9 (1 off), BZY-88-C4V7 (1 off); BFY-50 (1 off); 2N3053 (1 off).

SHOP TALK



BY RICHARD BARRON

OVER the years, for numerous and various reasons, many suppliers of electronic components have become household names to the hobbyist. Some have gained a reputation for speed or value, others for reliability and quality. Many have grown from small part-time businesses to thriving multi-million pound industries, one such company being **Maplin Electronics.**



Humble beginnings

Maplin Electronic Supplies Ltd. are now one of the largest and probably the best known supplier to the hobbyist. The company was founded by, and is still run by Roger Allen, his wife Sandra and Doug Simmons. Back in 1972, during the peak of the amateur constructor boom, Roger and Doug saw the need for a reliable and speedy mail order service. Hobbyists themselves, they had experienced long delays when ordering components and so decided that they could provide a better service.

Convinced that they had the right strategy, low prices and a promise of delivery by return of post, they placed an advert in *Practical Electronics* (our sister publication). Both Roger and Doug were working so Sandra was to stay at home to answer the phone and process mail orders; at this time they were wondering whether to have extra phone lines installed to cope with expected demand.

Unfortunately they were to be disappointed. Orders came in slowly and their investment was not paying off yet, despite this, their enthusiasm never diminished. Continuing with their policy of providing a reliable, first-class service, they struggled on.

After further investment, more debts and advice from the accountant to give up, the business slowly pulled through. Both Roger and Doug gave up their jobs and they acquired some small business premises above a launderette. Several problems and set-backs later, the first Maplin shop was opened in 1974, in Southend-on-Sea.

There are now five Maplin shops situated in: Birmingham, London, Manchester, Southampton and Southend-on-Sea. At all times, every effort is made to ensure that the shops are fully stocked with the complete Maplin range so, if you're in the area, a visit should be well worth while. If you know exactly what you want, a quick phone call is all that is required to confirm availability but should an item be out of stock, it will be ordered immediately.

Catalogue

A comprehensive catalogue is produced every year by Maplin and is available from branches of W.H. Smith or by mail order. It is crammed with useful information, pinouts, specifications, application notes, projects, kits and circuit ideas, as well as the usual stock lists and prices. The new 1986 catalogue will be available soon and, as usual, will depict a futuristic scene with an electronics theme; an idea which has become something of a hallmark for Maplin. Also, a calendar with all the 'Maplin Scenes' may be available in the future.

To avoid confusion and standardize prices, components bought mail order will be exactly the same price as those in the shops. There will be a standard charge of 50p for mail order and a small handling charge for orders under £5. To keep customers up to date Maplin's produce a quarterly magazine which includes price changes, new projects and products.

Around 150,000 Maplin catalogues are sold each year, so as you may imagine their distribution centre must be well organised. It is. They have just extended their 'factory' premises in Southend and now employ around 100 staff.

As orders arrive or are phoned in, they are entered into a computer together with a unique customer reference number. At all times the main computer knows the exact stock level of all components and can therefore give an immediate indication of availability. A printer prints out a customer address label and the order is put together and packed by efficient staff. The Post Office collect the packages for delivery each day so same-day dispatch is usually achieved.

Policy

As far as the hobbyist is concerned, Maplin's policies have changed little over the years. Reliability and low prices have always been a major objective. However, in the 1986 catalogue, low prices will be stressed even more. Roger Allen says that for some reason,

"many people believe Maplin's prices are a little high,"

so he would challenge anyone to compare prices. In the new catalogue there will be the "lowest ever" prices on a range of products as well as many new items.

To highlight the slight changes in policy, there will be some subtle changes to the Maplin image such as a new design for the Maplin logo.

'Tap into the Maplin Computer'

Maplin's services can be used in a variety of ways. You can place orders by phone or by post and payments may be made by cash, cheque, postal order, credit card or the special Maplin credit facility. Also available to computer users, with an RS232 compatible port and modem, is the CASHTEL service (Computer Aided SHopping by TELephone). With this service, you can get access to the Maplin computer to place orders, make comments about the service or check stock levels and prices. For further information contact:
Maplin Electronic Supplies Ltd., PO Box 3, Rayleigh, Essex SS6 8LR. ☎ (0702) 554155. ☎ (Sales only) (0702) 552911.

Five Six Seven Eight Nine Ten

Apart from their wide variety of components, telephone accessories, project kits and ancillary equipment, **TK Electronics** are perhaps best remembered by their telephone number, (01) 5-6-7-8-9-10.

TK Electronics provide a wide range of project kits designed to cater for the absolute beginner through to the experienced hobbyist. Their beginner's kit includes a solderless breadboard and sufficient components to build ten simple projects. At the other end of the range are microprocessor timers and mains wiring remote control units.

For full details of all TK Electronics projects and products, a comprehensive catalogue is available free of charge. The catalogue is designed for easy reading, each section being clearly marked and all components shown together with the current price. To ensure up to date information and prices, the catalogue is updated every few months.

Security

TK Electronics, as well as the general components range, also supply a number of telephone accessories and security products. These include: master and extension sockets for phones, line chords with four-way plugs and spade terminals, door and window security contacts, pressure mats and ultrasonic burglar alarms.

For a free catalogue, send a stamped addressed envelope to: **TK Electronics, 11 Boston Road, London W7 3SJ. ☎01-567 8910.**

For technical enquiries, these are dealt with on Tuesdays and Thursdays after 3pm. For general enquiries ☎01-579 9794 and for technical enquiries ☎01-579 2842.

Catalogue Received

The 1985/86 catalogue from **MS Components** is now available free of charge to both trade and retail customers. It contains almost 300 pages compiled in 20 sections for ease of reference and lists around 10,000 products. All the products are held in stock and the company offers 24 hour dispatch time for any size of order.

The catalogue itself is quite an impressive publication, full of well reproduced photographs, application notes, data and specifications. All products are fully described and appear together with the catalogue order number and the price. Items range from sophisticated electronic instruments to less interesting but essential items like sleeving.

For non account customers there is a minimum order charge of £10 including VAT and orders can be made in writing or by phone. More details are available from: **MS Components Ltd., Waring Street, West Norwood, London, SE27 9LH.** ☎**01-670 4466**.

CONSTRUCTIONAL PROJECTS

Flux Density Transducer (Transducers-3)

The main component for the Flux Density Transducer is a linear hall effect i.c. This i.c. produces a differential output voltage which is directly proportional to the magnetic flux density. The one used in the prototype is available from **RS**, part no. 304-267. If an alternative is used it should have a linear output over a 40mT range and a sensitivity around 8·5 mV/mT.

Hallowe'en Projects

This month we feature three topical 'fun' projects including: Flashing Pumpkin, Squeaking Bat and Screaming Mask. As far as the electronics go, for these projects, there should be no problems as they are all common components available from a number of suppliers.

However, if you decide to build them at any time other than Hallowe'en, you may experience difficulty in obtaining a pumpkin. In actual fact, the prototype was built a couple of months ago, and was fitted in a melon—it collapsed! The mask and the 'toy' bat are available at most joke shops.

Simple Audio Amplifier (Building Blocks)

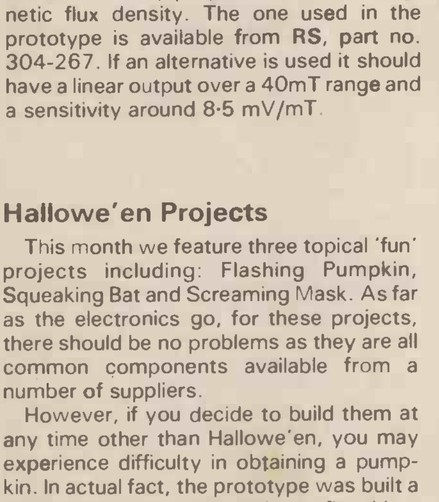
Once again, no difficulty with the components in Building Blocks and the p.c.b. is available from the EE PCB Service. If an alternative case is used, as suggested, a metal type is preferred such as one similar to the Verospeed 86-20101F. Orders to: **Verospeed, Stanstead Road, Boyatt Wood, Eastleigh, Hants, SO5 4ZY.** ☎ 0703 644555.

Universal LCR Meter (Teach In '86)

A number of advertisers are offering complete kits for the Teach In '86 projects or alternatively, the components may be ordered separately. If so, there should be no problems, except for the case.

With each project, the front panel of the case is printed allowing a more professional result to be achieved. However, this restricts the type of case to one of the correct size, and the one used in the prototype is in short supply at the moment. This may mean some delays but most of our regular advertisers have a few in stock or have them on order.

Hobbyist Kits and Printed Circuit Boards



Croydon Discount Electronics have just announced the availability of a range of components, including relays and motors, which may be useful to hobbyists experimenting with robotics. Croydon also supply a number of low cost projects in kit form such as a mini drill and controller at £11.95 and a NiCad charger at £3.50.

For the beginner to p.c.b. work, a useful kit comprising everything required to produce small printed circuit boards is available, including instructions, for £5.95. Full details from: Croydon Discount Electronics, 38 Lower Addiscombe Rd, Croydon, Surrey, CR0 6AA ☎ 01-688 2950.

TEACH-IN '86 PROJECT 2

UNIVERSAL LCR BRIDGE

Michael Tooley BA **David Whitfield** MA MSc CEng MIEE

A LARGE proportion of any electronic circuit is usually made up of resistors, capacitors, and (to a lesser extent) inductors. It is often useful to be able to measure the values of these passive components, since their markings can easily become obscured or the colour codes may fade. With resistors, this can be accomplished fairly easily with the aid of a general purpose multimeter. For measuring the values of inductors and capacitors, however, the problem is more difficult since their characteristics vary with frequency. In particular, the technique used in a multimeter for making resistance measurements (using a d.c. supply/battery) are particularly unsuitable, since at d.c. capacitors behave like very high impedances (theoretically infinite), and inductors usually have very low impedances (theoretically zero).

This month's project is a Universal LCR Bridge which is capable of measuring a wide range of values of resistance, capacitance and inductance, and performs all of its measurements at a frequency of approximately 1 kHz.

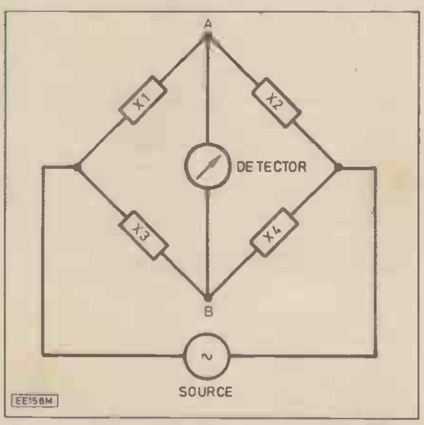


Fig. 2.1. General bridge circuit.

UNIVERSAL BRIDGE

Bridge circuits are used a great deal in measuring components of unknown value. Broadly, they work by comparing the unknown component against a number of other 'standard' components of known value. The general form of such a bridge circuit is shown in Fig. 2.1. The four arms of the bridge are arranged as two potential dividers, with an impedance in each arm. A voltage source is applied across two opposite corners of the bridge, and a detector is connected across the remaining two corners (i.e. A to B).

To measure the value of an unknown impedance, it is used to replace one of the arms of the bridge. The value(s) of one or more of the other arms of the bridge are then adjusted so that there is no reading on the detector. At this point the bridge is said to be balanced, and the potential at point A is the same as that at point B. The impedance of the detector does not feature when the bridge is balanced since no current flows through it. Similarly, the output level of the voltage source is not important since in effect only ratios are being compared. Thus, when the bridge is balanced, the following relationship holds true:—

$$\frac{X1}{X2} = \frac{X3}{X4}$$

If one of the impedances is the unknown (X1, say), this relationship can then be rearranged to allow its value to be determined, e.g.

$$X1 = X2\left(\frac{X3}{X4}\right)$$

Knowing the frequency of the source, it is then a simple matter to convert from impedance to capacitance or inductance, as appropriate.

Depending on the component to be measured, various different configurations of bridge may be used. The objective here is to use standard resistors wherever possible, since these are most readily available in high accuracy at relatively low cost. Similarly, they are also most readily and conveniently available in variable form.

The universal bridge to be described uses three different bridge configurations to measure capacitance, inductance, and resistance. These basic configurations are based on the classic Hay, Maxwell and Wheatstone bridges, respectively, and their general forms are illustrated in Fig. 2.2. The advantage of these arrangements is that they use standard resistors wherever possible, and when a reactance is required, a standard capacitance is employed.

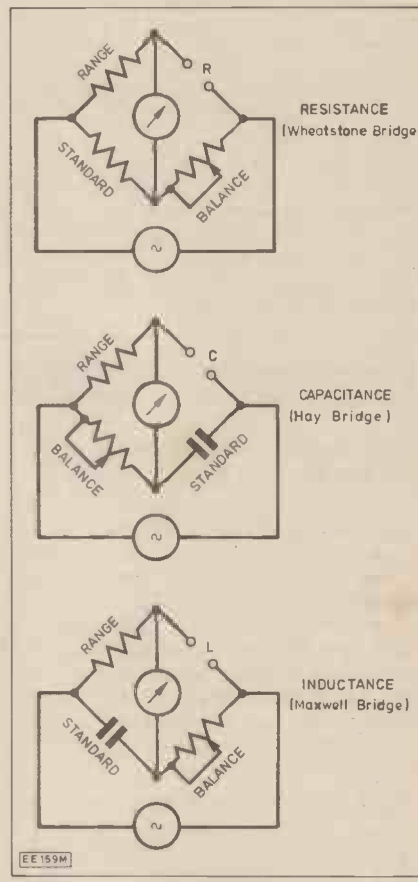


Fig. 2.2. LCR bridges.

CIRCUIT DESCRIPTION

The circuit for the universal bridge is shown in Fig. 2.3. The main circuit falls into three main sections: the 1kHz signal source, the bridges, and the balance detector.

The oscillator stage is based on a phase shift ladder network with a bipolar transistor as the active element. The frequency of oscillation is set by R1, R2, R3 and C2, C3, C4, which form a rather lossy phase shift network. The actual frequency is also slightly affected by the collector load, R5. A high gain transistor is used for TR1 to overcome the loss in the ladder network. The stage is required to have a gain of 29 for oscillation to be sustained. The output level is approximately 0·5V RMS, and the signal is a.c. coupled via C5 to the next stage.

After the oscillator, an FET buffer is used to isolate the oscillator stage from the variable load impedance of the bridge circuits. TR2 is arranged as a source follower, which presents a very high input impedance to the oscillator, but a low output impedance to the bridges. The output signal is a.c. coupled to the bridge circuits via C7.

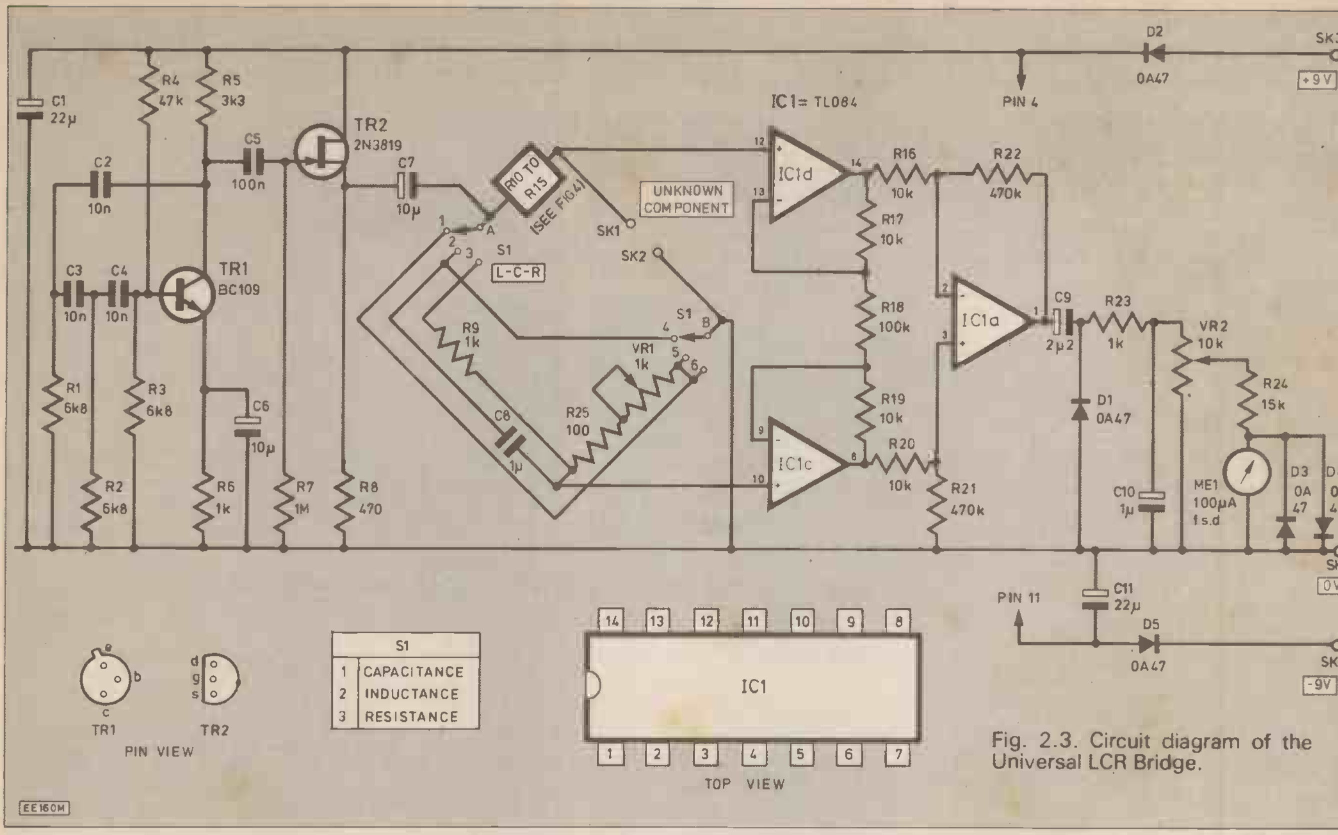


Fig. 2.3. Circuit diagram of the Universal LCR Bridge.

The individual bridge configurations are shown in Fig. 2.2, and the bridge required is selected by means of S1. The standard capacitor for the Hay and Maxwell bridges is provided by C8. The switched resistors used to set the range are shown in Fig. 2.4, and the ranges which result are shown in Table 2.1. The balance arm of the bridges is formed by R25 and VR1, while the unknown component is connected between SK1 and SK2.

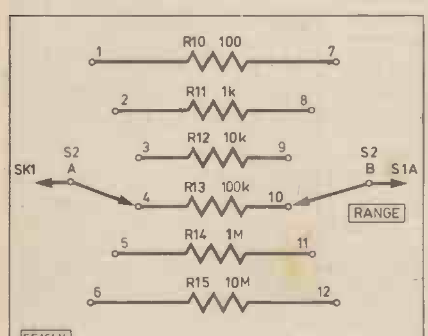


Fig. 2.4. Range switch.

Table 2:1. Switched range settings.

S2	L (Henrys, H)	C (Farads, F)	R (ohms, Ω)
1	10µ–110µ	1µ–11µ	10–110
2	100µ–1m1	100n–1µ1	100–1k1
3	1m-11m	10n–110n	1k–11k
4	10m–110m	1n–11n	10k–110k
5	100m–1·1	100p–1n1	100k–1M1
6	1–11	10p–110p	1M–11M

The detector circuit is formed by three of the BIFET operational amplifiers in IC1. The difference signal across the bridge is sensed by two amplifiers, IC1c and IC1d, which are both configured as voltage followers. This configuration minimises the loading on the bridge (particularly since the input impedance of the amplifiers is of the order of $10^{12}\Omega$), while providing a differential input to the final stage. The two buffers then drive the third amplifier which is arranged as a subtractor stage with gain.

The output from the subtractor is proportional to the amount by which the bridge is currently unbalanced. After rectification by D1, this signal is used to drive the balance detector, M1. The sensitivity of the meter is adjusted by VR2, which allows the meter sensitivity to be increased as the balance point is approached. A zero reading is obtained on the meter at the balance point; D3 and D4 serve to protect the meter against serious abuse.

The bridge is powered from a ±9V supply whose inputs are on SK3, SK4 and SK5, with protection against incorrect polarity provided by D2 and D5.

COMPONENTS

Resistors

R1,R2,R3	6k8 * (3 off)
R4	47k
R5	3k3 *
R6,R23	1k (2 off)
R7	1M
R8	470
R9,R11, R25	1k * (3 off)
R10	100 *
R12	10k *
R13	100k *
R14	1M *
R15	10M *
R16,R17, R19,R20	10k (4 off)
R18	100k
R21,R22	470k (2 off)
R24	15k

All 0·25W 10% except where marked * which should be 2%

See Shop Talk page 602

Potentiometers

VR1	1k linear pot. (wire-wound type preferred)
VR2	10k linear pot

Capacitors

C1,C11	22µ 16V electrolytic (2 off)
C2–C4	10n polyester 5% (3 off)
C5	100n polyester
C6,C7	10µ 16V electrolytic (2 off)
C8	1µ polyester 5%
C9	2µ2 16V electrolytic
C10	1µ 16V electrolytic

Semiconductors

IC1	TL084 quad bifet op amp
TR1	BC109
TR2	2N3819E
D1–D5	OA47

Miscellaneous

SK1,SK2	4mm terminals
SK3	red 4mm socket
SK4	green 4mm socket
SK5	black 4mm socket
M1	100 µA edgewise meter
S1	4P-3W rotary switch
S2	2P-6W rotary switch

Veroboard 0·1" pitch 34 strips × 50 holes; terminal pins; knobs with pointers (4 off); mounting pillars (4) and hardware; stick on plastic feet (4 off); case.

Approx. cost Guidance only **£24**

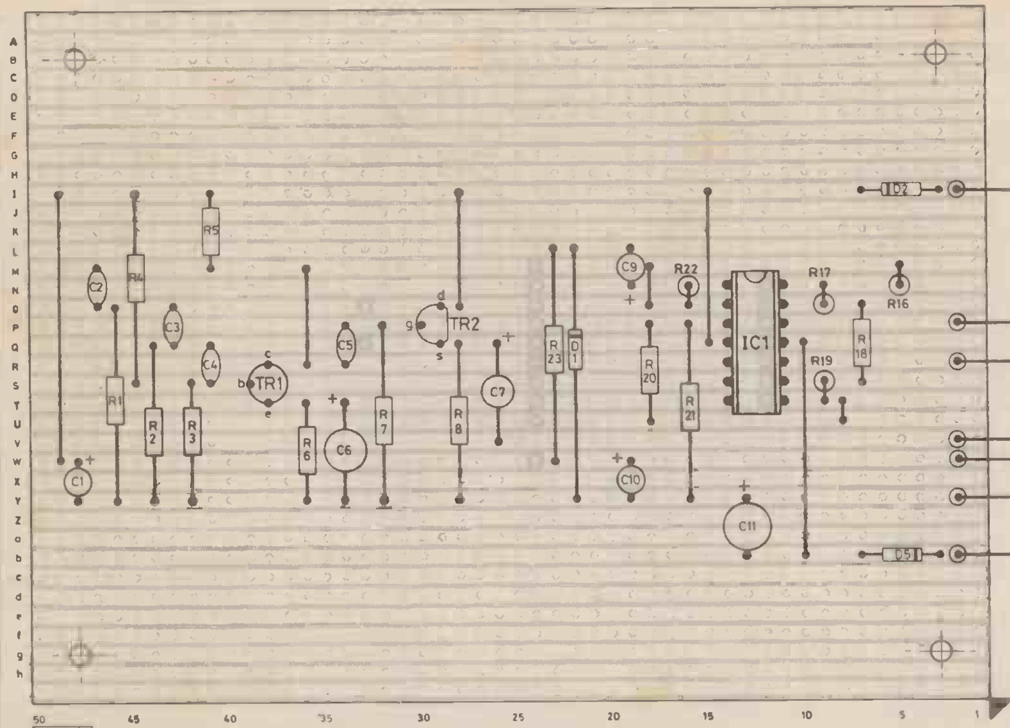


Fig. 2.5. Veroboard component layout.

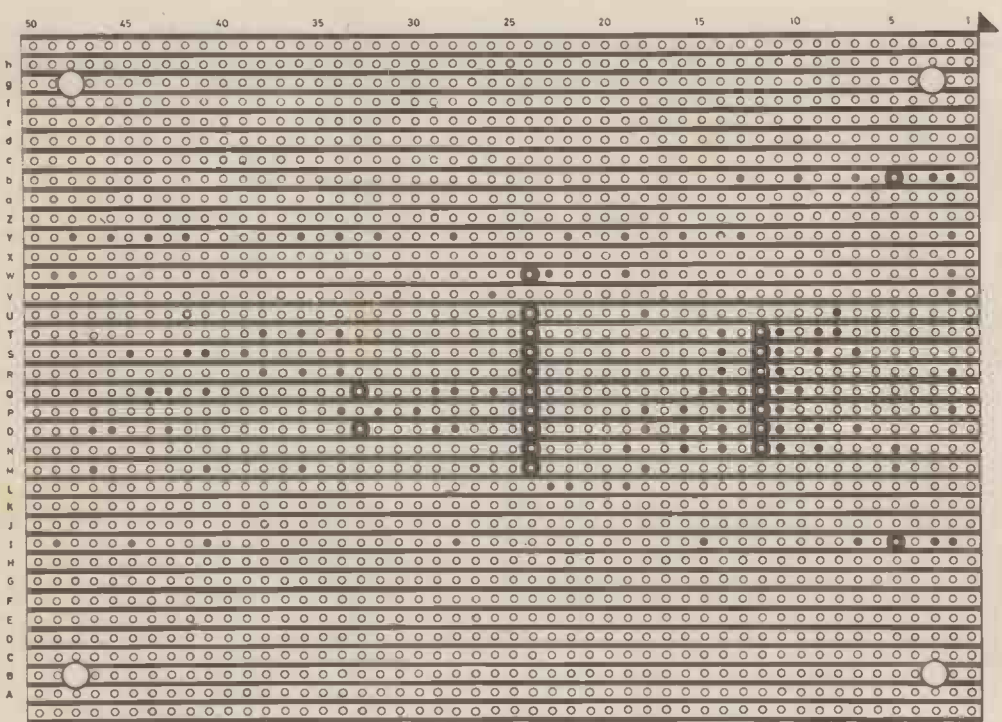


Fig. 2.6. Veroboard track cutting details.

After assembly of the board is complete, a careful check should be made of the underside of the board to ensure that there are no accidental splashes of solder, or other unwanted solder bridges. Another visual check of the component arrangement is then worthwhile, since it may well save many hours of troubleshooting later on!

The circuit board should then be mounted in the case, leaving plenty of space for the front panel mounted components. The front and rear panels should then be drilled to accommodate the various controls and connectors. The panel overlay shown in Fig. 2.7 (photocopy) may then be fixed to the front panel. It is worth protecting the overlay with self adhesive transparent film.

The final stage in the construction is to wire the main circuit board to the front panel and rear panel components. The mounting for the meter will depend on the type used. In the prototype, a centre-zero type (RS 259-549) was used and fixed with

CONSTRUCTIONAL DETAILS

The main Veroboard for the bridge is shown in Fig. 2.5 and construction starts by drilling the four mounting holes for holding the board in the case. Once this has been done, there are 21 track cuts to be made, as shown in Fig. 2.6. These should be made using either a track cutter or a large diameter sharp drill rotated slowly by hand.

The components are then mounted on the board. There are no special mounting considerations to be observed, although constructors may wish to fit IC1 into a 14-pin d.i.l. socket. Terminal pins are recommended to simplify all off-board wiring. It is suggested that the terminal pins and the wire links (7 off) should be fitted first, followed by the remaining components. Particular care should be taken to ensure that all polarised components (semiconductors and electrolytic capacitors) are mounted correctly aligned.

TEACH-IN '86 SOFTWARE NEWS

To complement each published part of the Teach-In series, we have produced an accompanying computer program. The Teach-In Software is available for both the BBC Microcomputer (Model B) and the Sinclair Spectrum (48k) or Spectrum-Plus. The programs are designed to reinforce and consolidate important concepts and principles introduced in the series. The software also allows readers to monitor their progress by means of a series of multi-choice tests, with scores at the end.

There will be three cassettes in all, each with three full parts, i.e. parts 1, 2 & 3 will be on Tape 1, parts 4, 5 & 6 will be on Tape 2, and parts 7, 8 & 9 will be on Tape 3.

Tape 1 is now available for £4.95 (inclusive of VAT and postage) from Everyday Electronics and Electronics Monthly, Westover House, West Quay Road, Poole, Dorset, BH15 1JG.

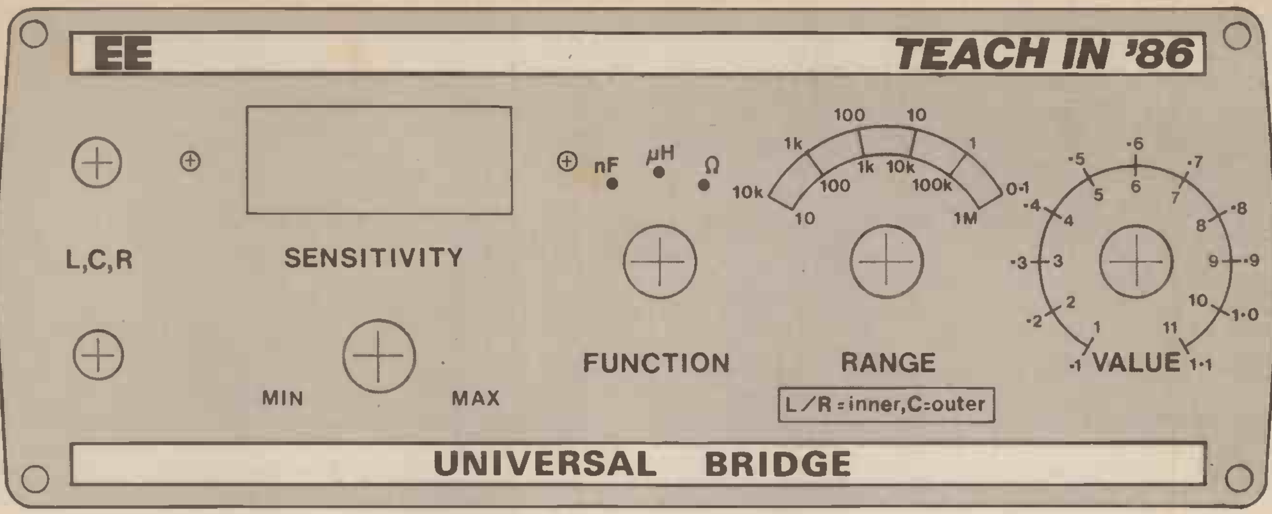


Fig. 2.7. Front panel artwork for the Universal LCR Bridge.

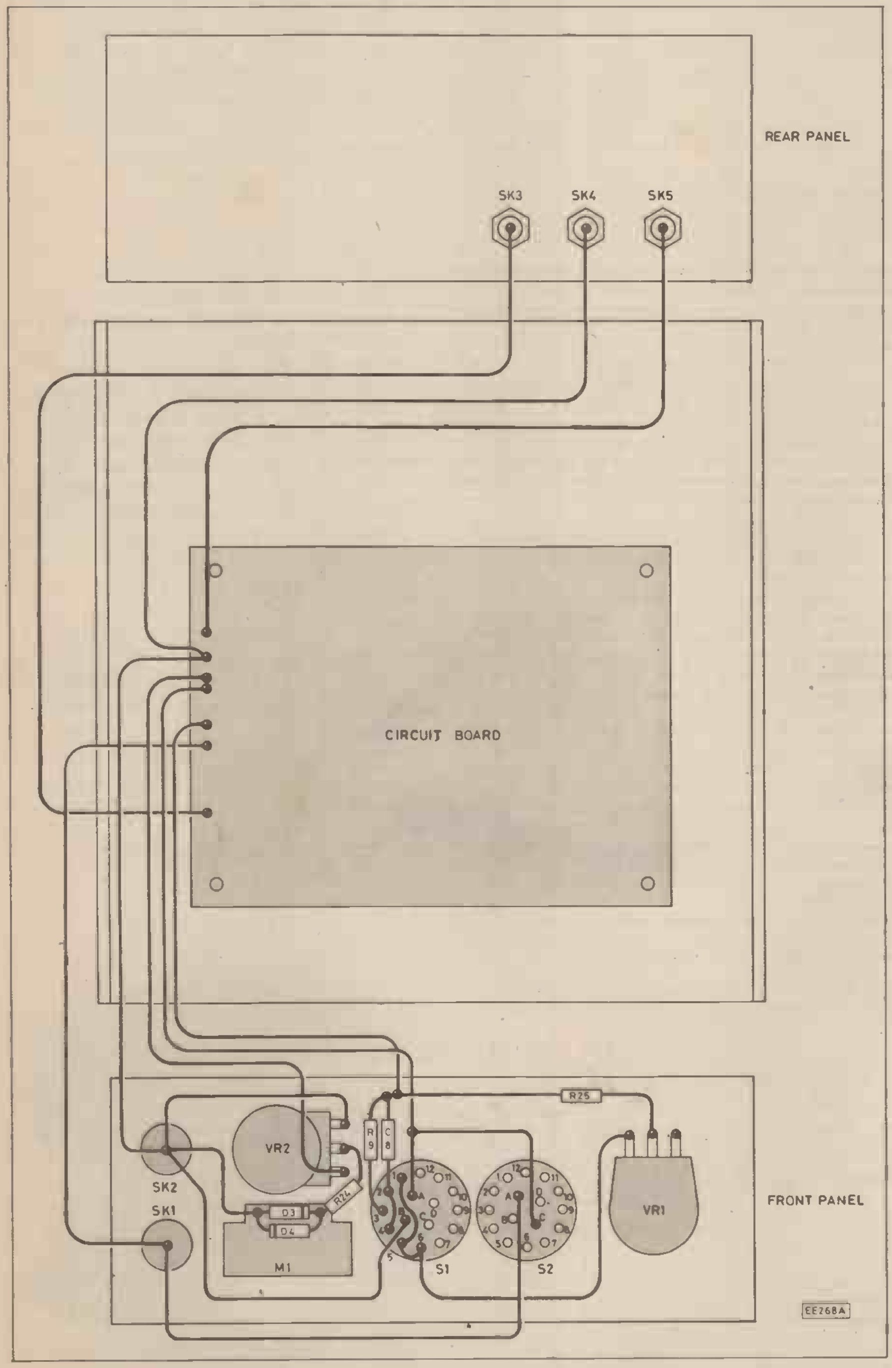


Fig. 2.8. Overall wiring diagram.

the brackets provided, but a 0–100μA type is to be preferred (e.g. RS 259-561). Due to the lack of panel space, and in the interests of a neater finished result, the meter may instead be glued to the panel from the rear.

The overall wiring diagram is shown in Fig. 2.8, and it should be noted that this includes all the remaining components specified in the components list. The wiring arrangement for S2 has been omitted for clarity, but it follows the scheme shown in Fig. 2.4, with resistors R10 to R15 mounted on the tags of the switch, using sleeving on the leads as necessary. After a final check, the lid may be put back on the case.

SETTING-UP

Initial testing of the unit involves measuring the supply current drawn to make sure that it does not exceed approximately 20 mA. The bridge will operate from a supply of between ±9V and ±15V. Any significant deviation in the current drawn should lead to a check on the wiring. If no current is drawn, particular attention should be paid to the polarity of D2 and D5.

When all is satisfactory, set S1 to the resistance range, and connect a 4k7 resistor across the bridge terminals. The setting of the sensitivity control should then be increased until a full-scale meter reading is obtained. Next the setting of R2 and VR1 should be adjusted to produce a minimum meter indication. As this balance point is approached, the sensitivity may be increased. When the minimum reading is achieved, the value of resistance may be read by multiplying the figure on the inner ring of the VALUE scale (e.g. it should be 4·7) by the figure on the RANGE switch (e.g. it should be 1k), to give the value in ohms. Similar checks should be performed with other values of resistance, capacitance and inductance. The outer scales are used for capacitance, and the inner scales for resistance and inductance.

Any significant scale errors should be investigated. If the resistance scale only is correct, the likely source of error is the frequency of the oscillator. Errors on all ranges suggest that one of the bridge arms is in error. Errors in extremely high resistances and inductances, and with very small values of capacitance may be due to stray wiring effects, and rearranging the wiring may help reduce these effects.

Next Month: Project 3 will be a Diode/Transistor Tester.

small tools Buyer's Guide

Mike Abbott

AMONG the many reasons for going d.i.y., be it in electronics, motor maintenance or the home, is to save cash. But even when the activity doubles as a hobby, and economy is only a partial consideration, there remains the risk of attempting to swell savings by improvising, or abusing inappropriate tools. Almost always this leads to frustration, and ultimately the deprivation of job satisfaction. Taking hold of the right tool for the job feels good and puts the hobbyist in a positive frame of mind. Just *one* initial outlay can be the downpayment on a lifetime of satisfied grins.

Browse through a tools catalogue or scan the shelves of a d.i.y. supercentre and one thing becomes clear. These days there are implements to do every conceivable job. Often there are several tools capable of doing the same job, each with a nuance that brings on galloping indecision in the purchaser.

This guide is intended to help clear the jungle a little for the electronics hobbyist, at the very least by providing the addresses of the major suppliers (and many manufacturers) of appropriate hand tools to be contacted for further information.

TYPICAL TOOLKIT

Some readers may ask why pin chucks are not included (we had to draw the line somewhere), or likewise stripboard spot face cutters (only one type exists so there is no choice. Also, the hobbyist may use a twist drill). Other readers might wonder why the directory differentiates between screwdriver types, yet not pliers and wire cutters which have a greater number of varients. The answer is that suppliers tend to be less predictable in the range of screwdrivers they stock than they do in cutters, strippers and instrument pliers. That is to say, vendors stocking this class of tool invariably offer a range with something to represent every possibility (see facing page). As far as the hobbyist is concerned the difference between one supplier's snipe-nose pliers, for example, and another's often amounts to little more than the price and the colour of the handle insulation. Before any tool suppliers write to *EE* to argue that there are differences in the quality of steel used, and robustness etc., these are differences that are of concern more to the intensive user in R&D and production than the weekend activist. The best advice to the hobbyist, who after all has his own ideas about quality, is to get hold of the toolmakers' catalogues. They are mostly of excellent quality and provide a more than adequate graphic representation of the tools on offer.

Further omissions from this guide include all soldering related equipments because these can only be done justice in a separate guide, and other tools requiring power. Ready-made toolkits are rather pricey and mostly inappropriate in content, being mainly aimed at service technicians. Toolboxes are not in themselves tools, of course, and are perhaps one area in which improvisation *can* be worthwhile anyway.

TIPS TIP

Screwdriver tips are so varied that they often cause confusion, and so to clarify the situation the illustrations in Fig. 1 are included. Basically the difference between Pozidriv and Supadriv is negligible so that they are effectively interchangeable. The situation is much the same with Phillips and crosspoint screws and drivers in which the difference lies mainly in the name.

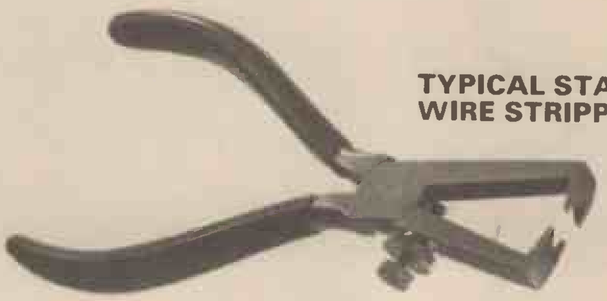
Almost all suppliers of screwdrivers market wallet sets and interchangeable bit sets.

Hex screwdrivers and keys are included in the directory, and these tools are sometimes specialised, such as the "ball end" type giving a 30° freedom of angle. An asterisk denotes the availability of specialised versions of hex tools, and specialised tools such as 'Torx' drivers.

DIRECTORY

The directory chart is divided into columns representing the components of a typical comprehensive hobbyist toolkit, although with so many plastic and metal boxes available off the shelf these days, many of the metalworking tools could be overlooked. The rows comprise the major suppliers of tools rather than the manufacturers (with exceptions), since many of the latter are based overseas. Many suppliers also incorporate their own brand tools in their range.

Fig. 1. Screw types



TYPICAL STANDARD WIRE STRIPPERS

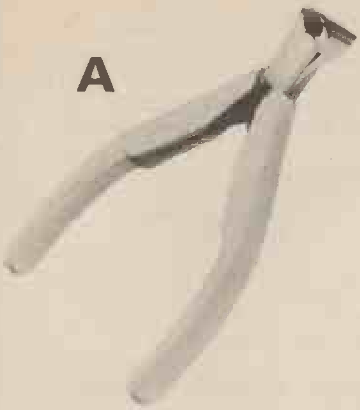
TYPICAL AUTOMATIC WIRE STRIPPERS

(Available from Welwyn)

(Available from Cliff)

Plastic mini-vice (£1.60 from Greenweld)

A



B

C

Numerous types of wire cutters and pliers exist, each designed for a specific purpose, and many so specialised that they are of little interest to the hobbyist requiring a set of general purpose tools.

The photographs illustrate many of the basic types available (showing Lindstrom units and kindly supplied by Bahco Tools Ltd.) Of the family of wire cutters the type shown in Photo A is called the 'oblique' cutter. Photo B shows a typical 'end' cutter and Photo C the most commonplace 'diagonal' type—this being the *de facto* general purpose wire cutter.

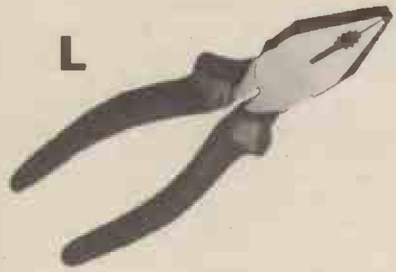
Beyond these, manifold types exist such as the 'angulated flush' version of Photo D. Many models either incorporate, or may be fitted with a lead catcher, the latter being illustrated by Photo E. Because the snipping action of wire cutters is fierce the snipped off end often flies away to land somewhere mischievous. The lead catcher prevents this. Wire cutters, unlike pliers, almost always incorporate a return spring to force the cutter open when the user's grip on the handle is released.

Pliers are equally varied in their design. Photo F shows the most commonplace type called the 'snipe nose' plier. These are available in various lengths and with, or without serrated gripping surfaces (non serrated is recommended for component lead forming.) Photo G shows 'round nose' pliers, and deciding which type to use is largely a matter of imagination and experience. The 'bent tip' type of Photo H is surprisingly handy, and so too are the 'flat nose' pliers of Photo J. Another common pair of pliers is the serrated pair of Photo K, commonly referred to as 'radio pliers' and which incorporate a wire cutting nipper.

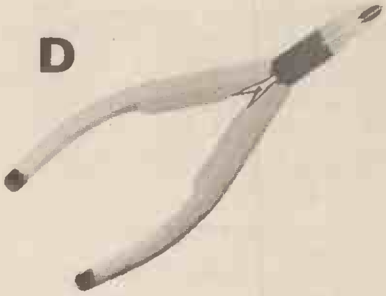
The engineer's or 'combination' grips incorporate a wire cutting nipper. As can be seen in Photo L, these are for heavier work. The cutter is capable of severing thick gauge wire, and even steel wire up to about paperclip thickness (something ordinary instrument wire cutters should never be used for.)

Most tool suppliers stock the panoply of both cutters and pliers with finely illustrated colour catalogues to fully explicate their uses.

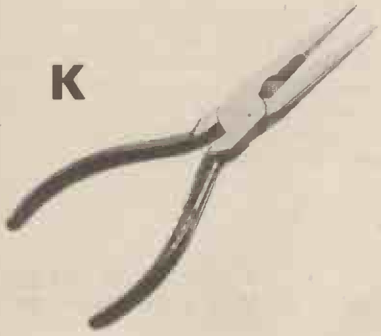
L



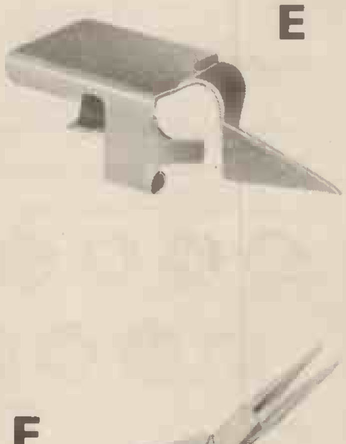
D



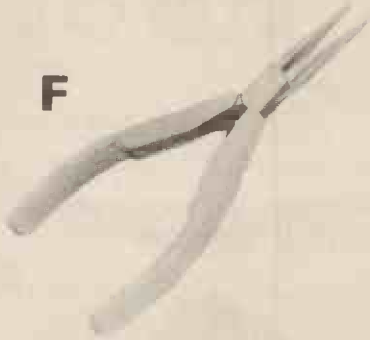
K



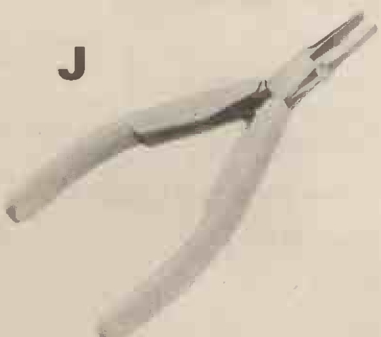
E



F

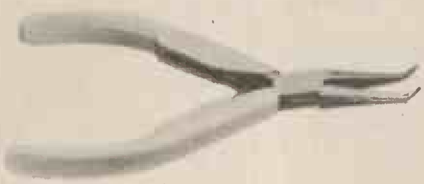


J



G

H



The tool manufacturers and suppliers included in this guide are listed below in alphabetical order.

AB—See TOOLRANGE.

Abingdon King Dick Ltd.,
Kings Rd.,
Tyseley,
Birmingham B11 2AE.

Adcola Products Ltd.,
Adcola House,
Gauden Rd.,
London SW4 6LH.

Bahco Tools Ltd.,
Bahco House,
Beaumont Rd.,
Banbury,
Oxfordshire OX16 7TB.
(See STC.)
(See TOOLRANGE.)
(See TOOLMAIL.)

Belzer—See STC.
Bernstein—See TOOLRANGE.
Bondhus — See TOOLRANGE.

Bostik Ltd.,
Ulverscroft Rd.,
Leicester LE4 6BW.

Britool—See NEILL TOOLS, TOOLMAIL.

CeKa Tools (CK),
CeKa Works,
Caernarvon Rd.,
Pwllheli,
Gwnedd,
Wales.
(See TOOLRANGE.)

Cirkit,
Park Lane,
Broxbourne,
Hertfordshire.

Clauss—See TOOLRANGE.

Cliff Electronic Components Ltd.,
76 Holmethorpe Avenue,
Holmethorpe Industrial Estate,
Redhill,
Surrey RH1 2PF.

Commercial Tools Ltd.,
72–77 Lower Tower St.,
Birmingham B19 3HL.

Cooper Tools Ltd.,
Sedling Rd.,
Wear District 6,
Washington,
Tyne & Wear.

Crescent—See TOOLRANGE.

Cricklewood Electronics Ltd.,
40 Cricklewood Broadway,
London NW2 3ET.

Dormer—See COMMERCIAL TOOLS.
Dowidat—See TOOLRANGE.

Draper Tools,
Hursley Rd.,
Chandlers Ford,
Hampshire.
(See STC.)

Eclipse—See NEILL TOOLS, TOOLRANGE, TOOLMAIL.

Electrovalue Ltd.,
28 St. Judes Rd.,
Englefield Green, Egham,
Surrey TW20 0HB.

Elliott Lucas—See NEILL TOOLS, TOOLRANGE.
Elora—See STC, DRAPER.
Erdi—See WELWYN, TOOLRANGE.
Ergo—See BAHCO.
Facom—See TOOLRANGE.
Fisco—See TOOLMAIL.
Footprint—See TOOLMAIL.
Gilbow—See BAHCO, TOOLMAIL.
Granit—See WELWYN.

Greenweld Electronics Ltd.,
443 Millbrook Rd.,
Southampton, SO1 0HX.

Hanso—See TOOLRANGE.

Hellermann Electric,
Pennycross Close,
Plymouth PL2 3NX.

Idealtek—See TOOLRANGE.
JoKari—See TOOLRANGE.
Kiesel—See TOOLRANGE.

Klippon Electricals Ltd.,
Power Station Rd.,
Sheerness,
Kent ME12 3AB.
(See WELWYN.)

Knipex—See TOOLRANGE, DRAPER.

Leytool—See TOOLMAIL.

Lindstrom—See BAHCO, TOOLRANGE.

Magenta Electronics Ltd.,
135 Hunter St.,
Burton-on-Trent,
Staffordshire DE14 2ST.

Maplin Electronic Supplies Ltd.,
PO Box 3,
Rayleigh,
Essex SS6 8LR.

Marco Trading,
The Maltings,
High St., Wem,
Shropshire SY4 5EN.

Marples—See BAHCO, TOOLMAIL.
Micro—See TOOLMAIL.
Moore & Wright—See NEILL TOOLS.

MS Components Ltd.,
Zephyr House,
Waring St.,
West Norwood,
London SE27 9LH.

Neill Tools Ltd.,
Napier St.,
Sheffield S11 8HB.

Nicholson—See STC, TOOLRANGE.

OK Industries (UK) Ltd.,
Dutton Lane,
Eastleigh, SO5 4SL.

Olfa—See TOOLRANGE.
Oryx—See VEROSPEED
Osborne—See TOOLRANGE.
Panavise—See STC, TOOLRANGE.
Powerlock—See STANLEY.
Presto—See STC, TOOLMAIL.
Q-Max—See TOOLRANGE.

Rapid Electronics Ltd.,
Hill Farm Industrial Estate,
Boxted, Colchester,
Essex CO4 5RD.

Record Tools—See BAHCO.
Ridgway—See BAHCO.
Safico—See TOOLRANGE.
Sandvik—See TOOLMAIL.
Sibille—See TOOLRANGE.
SKF—See COMMERCIAL TOOLS.

Spear & Jackson (Tools) Ltd.,
St. Pauls Rd.,
Wednesbury WS10 9RA.
(See TOOLRANGE.)

Spiralux Handtools Ltd.,
Gillingham,
Kent.
(See TOOLMAIL.)

Stanley Tools (The Stanley Works Ltd.),
Woodside,
Sheffield S3 9PD.
(See COMMERCIAL TOOLS.)
(See TOOLRANGE.)
(See TOOLMAIL.)

STC Electronic Services,
Edinburgh Way,
Harlow,
Essex CM20 2DF.

Steadfast—See STC.
Stirex—See TOOLRANGE.
Stripax—See TOOLRANGE.
Stubs—See NEILL TOOLS.
Superior—See TOOLRANGE.
Supreme—See TOOLMAIL.
Surform—See STANLEY.

Tandy Corporation (UK),
Tameway Tower,
Bridge St., Walsall,
West Midlands WS1 1LA.

Thor—See TOOLRANGE.

TK Electronics,
13 Boston Rd.,
London W7 3SJ.

Toolmail Ltd.,
7 London Rd.,
Sevenoaks,
Kent TN13 1AH.

Toolrange Ltd.,
Upton Rd.,
Reading,
Berkshire RG3 4JA.

Toptool—See TOOLRANGE.
Vaco—See TOOLRANGE.

Verospeed,
Stansted Rd.,
Boyatt Wood,
Eastleigh,
Hampshire SO5 4ZY.

Vigor—See WELWYN.

Vitrex Tools Division,
Florin Ltd.,
457–463 Caledonian Rd.,
London N7 9BB.

Bold type – see adverts for more information

Weidmuller—See TOOLRANGE.

Welwyn Tool Co. Ltd.,
4 South Mundells,
Welwyn Garden City,
Hertfordshire AL7 1EH.

Weralit—See TOOLRANGE.
William Whitehouse—See TOOLRANGE.
Wiss—See STC.
Xcelite—See STC, TOOLRANGE, TOOLMAIL.
Xuron—See WELWYN.
Yankee—See STANLEY.
Yankee Handyman—See STANLEY.

DIRECTORY

○ – P.c.b. sizes only

★ – Other specialist types available

		Welwyn	Vitrex	Verospeed	Toolrange	Toolmail	TK	Tandy	STC	Stanley	Spiralux	Rapid	OK	Neill	MS	Marco	Maplin	Magenta	Hellerman	Greenweld	Electrovalue	Draper	Cricklewood	Cooper	Commercial	Cliff	Cirkit	CK	Britool	Bostik	Bahco	Adcola	Abingdon
	Abrafile			★	●	●												●															
	Allen keys			●	●	●		●	●	●		●	●		●	●	●	●		●	●	●		●			●	●					●
centre punch	standard			●	●	●			●	●		●		●	●							●						●					
centre punch	automatic				●	●			●					●	●																		
	craft knife			●	●	●		●	●	●	●	●			●	●	●					●		●			●	●					
	eyeglass				●					●						●		●															
hacksaw	standard			●	●	●			●					●	●							●						●					
hacksaw	junior			●	●	●			●	●	●	●		●	●	●	●	●		●		●					●	●					
hammer	soft face				●	●																●						●					
hammer	hard face			●	●	●			●	●		●			●							●		●				●			●		●
	hand-drill		●	●	●	●	●	●	●	●		●			●	●						●						●			●		
	Hole cutter (Q Max type)			●	●	●									●	●	●	●			●						●						
	i.c. inserter/remover	●			●		●		●				●		●	●		●			●			●									
	inspection mirror	●			●	●			●						●	●		●				●											
	mini-vice			●	●	●		●	●	●		●	●		●	●	●	●		●	●	●									●		
	needle files			●	●	●		●	●			●		●	●	●	●					●		●			●	●					
	nibbler				●	●									●	●	●					●											
	pliers	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●		●	●	●			●	●	●
	pliers combined with cutter	●		●	●	●		●	●	●	●	●	●	●		●	●	●	●	●	●	●		●			●	●			●		●
	pop rivet gun			●	●	●					●				●		●				●	●					●			●			
	ruler (steel)			●	●	●			●				●	●	●							●						●					
screwdrivers	standard	●		●	●	●	●	●	●	●	●	●	●		●	●	●	●		●	●	●	●	●			●	●	●		●		●
screwdrivers	Pozidrive	●		●	●	●			●	●	●	●	●		●	●	●				●	●	●	●			●	●	●				●
screwdrivers	Phillips type	●			●	●		●	●	●	●	●	●		●	●	●	●		●	●	●	●	●			●	●	●				●
screwdrivers	hex slot			●	★			●	●	●					★	●						★		★					●				
screwdrivers	flexible shank	●			●				●		●					●	●											●					
screwdrivers	right-angled				●	●			●	●							●					●						●					
screwdrivers	extended shank				●	●				●					●							●						●					
screwdrivers	ratchet action				●	●			●	●	●	●	●		●	●	●					●		●				●					
screwdrivers	with screw clasp			●	●				●						●	●	●					●						●					
screwdrivers	jeweller's			●	●			●	●			●	●	●	●	●	●	●		●	★	●						●					
	scriber				●				●					●	●							●											
spanners BA & Metric	nut spinner	●		●	●			●	●		●		●		●	●	●				●	●		●			●	●					●
spanners BA & Metric	open ended			●	●	●			●	●			●		●	●	●			●	●	●						●	●				●
spanners BA & Metric	ring			●	●	●			●	●					●	●	●				●	●						●	●				●
	tinsnips			●	●	●			●			●	●		●			●				●		●				●			●		
	trimmer tool (non-ferrous)				●			●				●	●			●	●	●		●							●						
tweezers	standard	●		●	●	●		●	●			●	●		●	●	●	●	●					●			●	●			●		
tweezers	miniature			●	●											●								●									
	twist drills			●	●	●	○		●	●		●			●	●	●	●			●	●			●		○	●					
wire cutters	standard	●		●	●	●	●	●	●			●	●	●	●	●	●	●	●	●		●		●		●	●	●			●	●	●
wire cutters	miniature				●							●				●		●		●						●							
wire strippers	standard	●		●	●	●	●	●	●			●	●	●	●	●	●	●	●		●	●		●		●		●			●		
wire strippers	miniature	●			●							●														●							
wire strippers	automatic	●		★	★		●	●	●	●		●			●	●	●		●			●				●					●		

The directory is as complete and as accurate as possible under practical conditions, but *EE* cannot accept responsibility for the consequences of any errors there may be.

small tools Buyer's Guide

Mike Abbott

NEWS ...from the world of electronics

Future training

Just as the Department of Trade and Industry's Information Technology Skills Shortages Committee has laid the blame firmly on Industry's doorstep for aggravating the shortage in skilled IT staff, BPICS (The British Production and Inventory Control Society) has announced the formation of a National Training Committee to develop a UK programme of fomal training courses on production control aimed at all levels of users.

Arthur Evans, Chairman of the Training Committee, said *"There are currently only some seventy seven people taking First or higher degrees in Production Control. We estimate that over the course of the next few years, some two thousand companies will install manufacturing systems. Consequently there will be a need for approximately fifty thousand people to be trained in this field"*

The Training Committee is approaching industrial consultants nationwide in order to establish a series of modular courses, varying in length and complexity to be announced over the next eighteen months to two years. These are aimed at providing practical first-hand training for industry by industry.

TOUCHDOWN

Touchdown, British Telecom's unique touch-screen computer and phone system, has been chosen to help run British Rail's Southern Region.

The installation at Waterloo is part of a £350,000 contract to speed up communications and ensure information to passengers is fully up-to-date.

The first stage, is a suite of terminals enabling train operations controllers to direct train movements literally at the touch of their fingertips. Touch sensitive screens give immediate access to telephone lines and computer data.

The complete installation comprises 28 terminals which combine telephone, data and telex facilities. They have been installed at Waterloo regional headquarters to help keep track of some 6,000 train movements a day on the Southern Region.

From a single desk-top terminal each of the controllers has direct telephone links to signalling centres, stations and depots, as well as the railway police. Calls are connected automatically by touching the appropriate names on the screen. Action to be taken, in special circumstances, can also be displayed on the screens and controllers are able to log incidents direct from the keyboard.

The Government of Western Australia, in association with the Commonwealth Bank of Australia, will be holding a seminar at the Australian High Commission in London on 7 November 1985.

The aim of the seminar is to encourage participation in the development and expansion of the State's electronics and technology based industries.

FELLOWSHIP AWARD

A year's work in Japan lies ahead of Bradford University student Ranjit Singh Mand. Ranjit is currently finishing his PhD research in the University's School of Electrical and Electronic Engineering, and has been awarded one of the coveted Toshiba Fellowships. He will spend a year possibly longer, working at Toshiba's Research and Development Laboratories in Kanagawa, Japan.

The Toshiba Fellowship has been established by the Japanese electronics manufacturing giant to encourage research and innovation from young scientists in the UK.

Micro Change

Over 25 per cent of the products and services currently being sold on the UK micro marketplace have been launched or revamped within the past few months. In contrast, the rate at which new suppliers are entering the market, particularly in software, appears to have dropped sharply.

These are some of the conclusions to be gleaned from the recently published Computing Survey *from the NCC. The survey covers more than 10,000 products, packages and courses known to be available on the UK market and reveals that just under 2,800 (27·5 per cent) have been launched or revised with new features within the last few months.*

Celebrity Match

Visitors to the Amstrad stand at this year's *PCW Show* were able to meet top entertainers such as Alex "Hurricane" Higgins, from the world of snooker, and Tottenham Hotspur and England footballer Glen Hoddle, as well as their own star performer the PCW8256 Home computer/Wordprocessor (see last month's News page).

Both celebrities were helping to promote software which has been launched under the Amsoft range. The games are simulations of their respective sports and they were on hand to challenge visitors to a match.

Glen Hoddle shows football and computer enthusiast Phil Mordecai how relaxing it can be to play football in the comfort of your own home, or in this case, at the Amstrad stand.

Computer Dig

British Olivetti is to provide an archaeological project from the Archaeology Department of Cambridge University with computer hardware and software for use in excavations currently under way at the famous medieval town of Gubbio in Central Italy.

The Cambridge team, led by Caroline Malone and Simon Stoddart, is excavating those archaeological remains which precede the medieval period. The research is being carried out at relatively low cost thanks to sponsorship from companies such as Olivetti, the National Geographic, the British Academy, the Regione of Umbria and the Commune of Gubbio, and the unsalaried work of students working on the project.

The sponsorship takes the form of the provision of M24 and M10 micros, printers and software, worth nearly £10,000. Maintenance for the systems will be provided by Olivetti's service staff.

One set of PC's is to be installed in Cambridge and another set in Gubbio. Three principal databases will be used: one for each of the two sites being excavated this year and one for the field survey which is recovering archaeological material from all over the valley, surrounding the town.

TRANSDUCERS

PART 3 MEASURING MAGNETIC FIELD STRENGTH...

MIKE FEATHER BSc

THE MEASUREMENT of magnetic field strength or flux density is of considerable importance, particularly to the designer of electromagnetic devices such as motors, transformers etc.

Traditional methods of measuring magnetic flux density tended to rely upon the electromagnetic induction effect in which a small coil—often called a search coil—was moved through the field. Fig. 3.1 shows the arrangement.

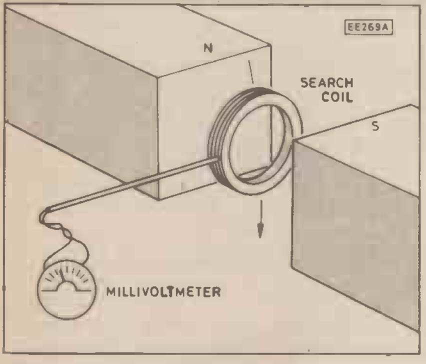


Fig. 3.1. Search coil action.

The voltage induced across the coil was measured and taken as an indication of the strength of the field. If the charge induced in the coil can be measured, then this can be shown to depend only on the field strength and the resistance of the coil, so that the flux density can be determined.

Search coil methods suffer from two drawbacks however:

(a) There must be some relative movement between the coil and the magnetic field in order to induce a charge.

(b) With a weak magnetic field, the induced charge is likely to be small and the direct measurement of small quantities of charge can present problems.

THE HALL EFFECT

Modern techniques for magnetic flux density determination are usually based on the Hall effect. This was observed as long ago as 1879 and is illustrated in Figs. 3.2 and 3.3.

The metal slab carries a steady current of electrons from "A" to "B", provided by the battery.

With no applied magnetic field, the distribution of the moving electrons will be more or less uniform throughout the slab, as shown in Fig. 3.2.

Fig. 3.3 shows the slab placed in a magnetic field which is perpendicular to its face PQRS. The moving electrons will now experience a force acting on them which will cause them to drift towards the back edge of the slab. This will make edge PQ more negative than SR and a small voltage—the Hall voltage—will appear between the two edges. The size of this voltage will depend, amongst other things, upon the flux density of the magnetic field and a millivoltmeter can be used to read this.

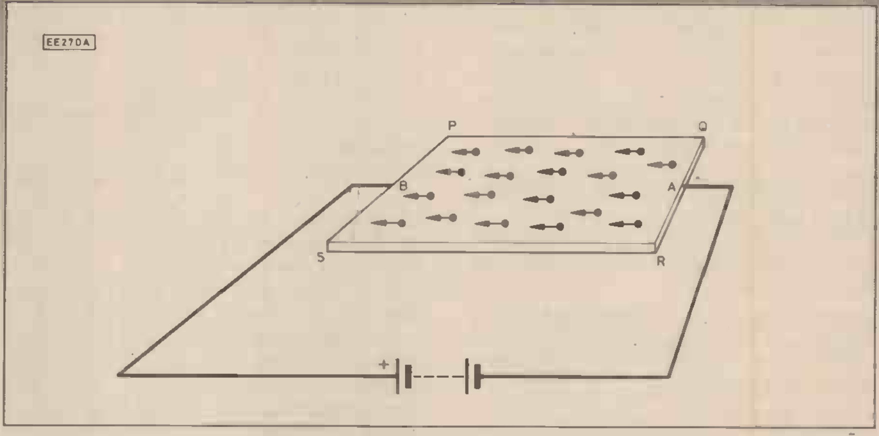


Fig. 3.2. Electron flow through an unmagnetised metal plate.

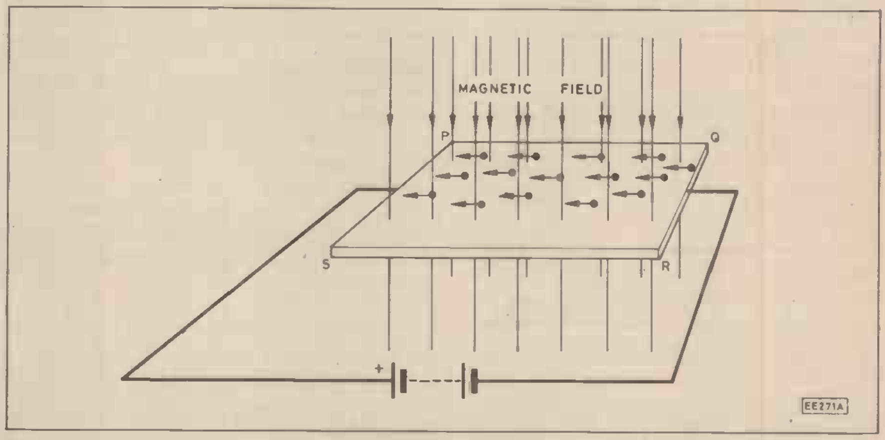


Fig. 3.3. The Hall effect—the applied transverse magnetic field causes electron drift.

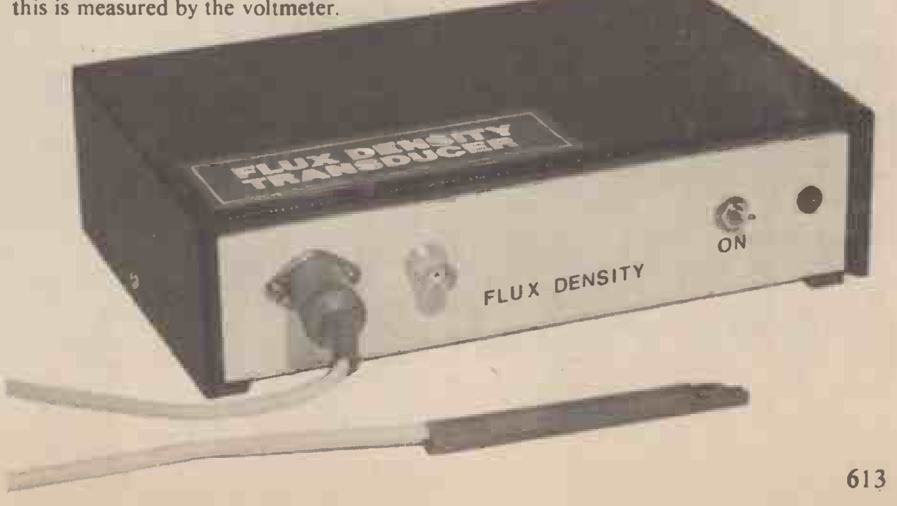
For pure metals, the Hall voltage is very small and the arrangement would not be suitable for measuring the strengths of weak magnetic fields. If, however, a slice of semiconductor material is used for the slab, the Hall voltage becomes much greater and such materials are employed in Hall effect sensors. The arrangement of a typical sensor is shown in Fig. 3.4.

A small current (usually of the order of a few milliamps) is passed through the semiconductor. If a magnetic field is applied perpendicular to the face of the slice, a Hall voltage is developed between its sides and this is measured by the voltmeter.

THE UNIT OF MAGNETIC FLUX DENSITY—THE TESLA

In order to define the unit of magnetic flux density, we use the fact that a current-carrying wire placed in a magnetic field will experience a force acting upon it—the so-called motor effect.

The unit is called the **TESLA (T)** and 1T may be defined as the flux density of a field in which a wire one metre long situated at right angles to the field and carrying a current of 1A experiences a force of



1 Newton acting upon it. A flux density of 1T is a strong magnetic field and smaller unit, the milliTesla (mT) is often used.

The remainder of this article describes the theory and construction of a flux density transducer system for measuring fields within a range of 0–40 mT.

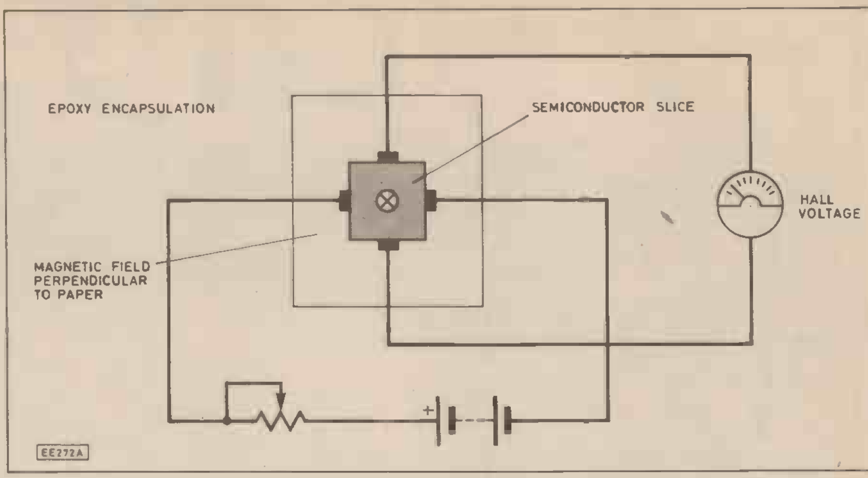


Fig. 3.4. Hall-effect sensor in basic circuit.

A FLUX DENSITY TRANSDUCER USING A HALL-EFFECT SENSOR

The 634SS2 device is a 4-pin d.i.l. i.c. which includes a semiconductor Hall-effect slab and associated circuitry designed to produce an output voltage which varies linearly with magnetic flux densities within the range ± 40 mT. The principal characteristics are given in Table 1.

Table 1: Characteristics of 634SS2 device

Supply voltage	+4V to +10V
Supply current	3·5mA (typical)
Output voltage at zero flux density	1·75V to 2·25V at +5V supply
Sensitivity	7·5 to 10·6mV/mT
Frequency range	d.c. to 100kHz

The chip has two outputs, one of which increases linearly in voltage whilst the other decreases as the magnetic flux density increases. The circuit diagram of the complete transducer unit is shown in Fig. 3.5, and the physical construction of the 634SS2 is also illustrated.

The negative going output (pin 2) of the 634SS2 is used and this is applied to the inverting input of the LM301 operational amplifier. Increasing flux densities will thus cause the output pin of the operational amplifier to go more positive. As with other projects in this series, the output of the transducer unit can be measured with a voltmeter (analogue or digital) or it may be used as the input to an analogue-to-digital converter so that the data can be processed by a microcomputer.

At zero flux density, the outputs of the 634SS2 are somewhere between 1·75V and 2·25V. The potential divider network consisting of R3/VR1/R4 provides a variable offset voltage so that the input to the operational amplifier can be adjusted to zero when the sensor is not in a magnetic field. The non-inverting input of the operational amplifier is taken to ground via R7.

VR2 enables the feedback and hence the gain of the circuit to be varied so providing a sensitivity control for the unit. The LM301 operational amplifier requires an offset zero facility and this is achieved by the R9/VR3 combination. VR1 and VR3 are used as coarse and fine set-zero controls for the circuit; for ease of adjustment, multi-turn potentiometers are used for these components.

R8 and C1 set the overall gain/frequency response of the operational amplifier and, with values chosen, this tails off rapidly above about 500Hz

The ± 5V power supply lines are derived from the 9V batteries via +5V and −5V 100mA regulators IC2 and IC3. The l.e.d provides a visual on/off indicator for the unit.

CONSTRUCTION OF THE UNIT

The circuit can be built using Veroboard, but it is recommended that the p.c.b design shown in Fig. 3.6 is used. Components should be inserted in accordance with the overlay diagram, taking special care to observe the orientation of polarised components such as the voltage regulator i.c.s and the two electrolytic capacitors C2 and C4.

An 8 pin d.i.l. socket should be used for IC1: the LM301 should not be placed in the socket until all the wiring has been completed. Veropins should be inserted and soldered in at all external connection points.

Check the circuit board carefully for dry joints, solder bridges etc. and then complete the external wiring—see the photograph.

CONSTRUCTION OF THE PROBE UNIT

The 634SS2 is a very small device and it is convenient to mount it in a probe arrangement such as that shown in Fig. 3.7, and the photograph.

The sensor is soldered into a small piece of Veroboard which is mounted at one end of a short length of rigid plastic tubing (the case of an old felt-tip pen can often be used for this purpose). A length of 4-core cable is used to connect the probe to the transducer unit via a 5 pin DIN plug and socket.

TESTING AND CALIBRATING

Connect up the probe to the unit, install the batteries and switch on. Measure the

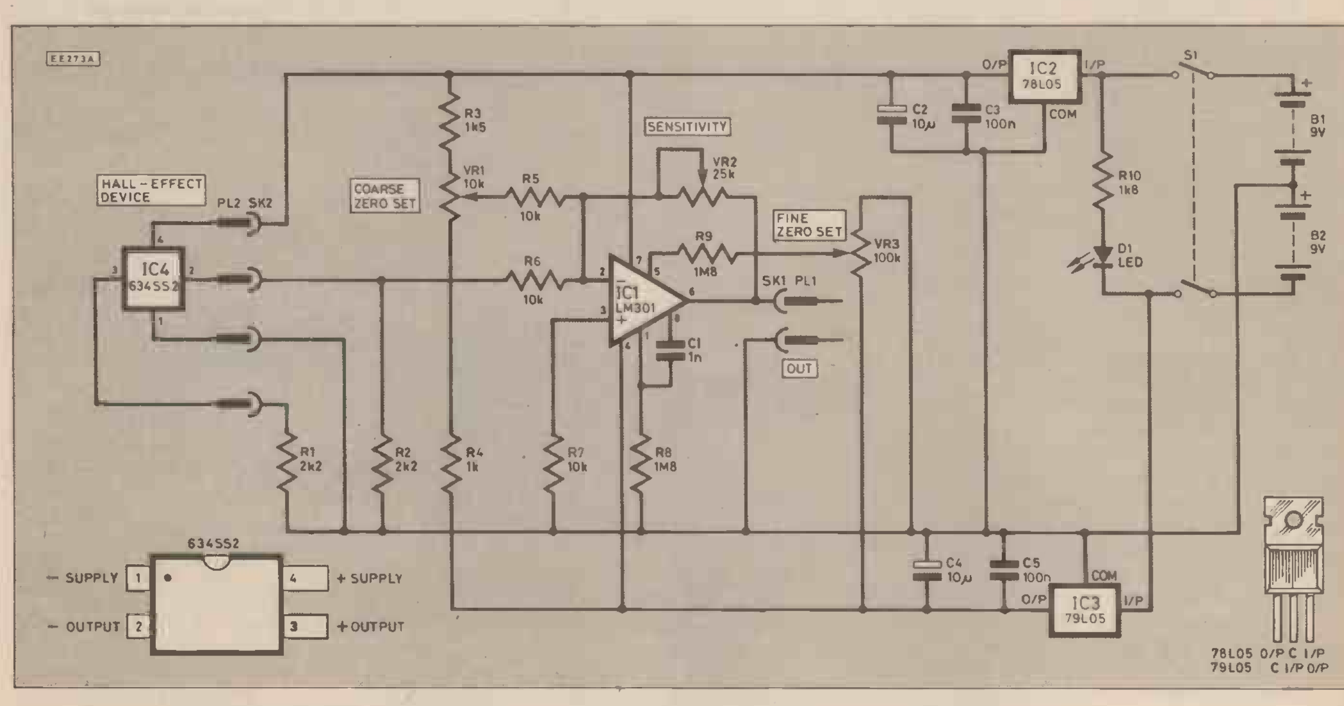
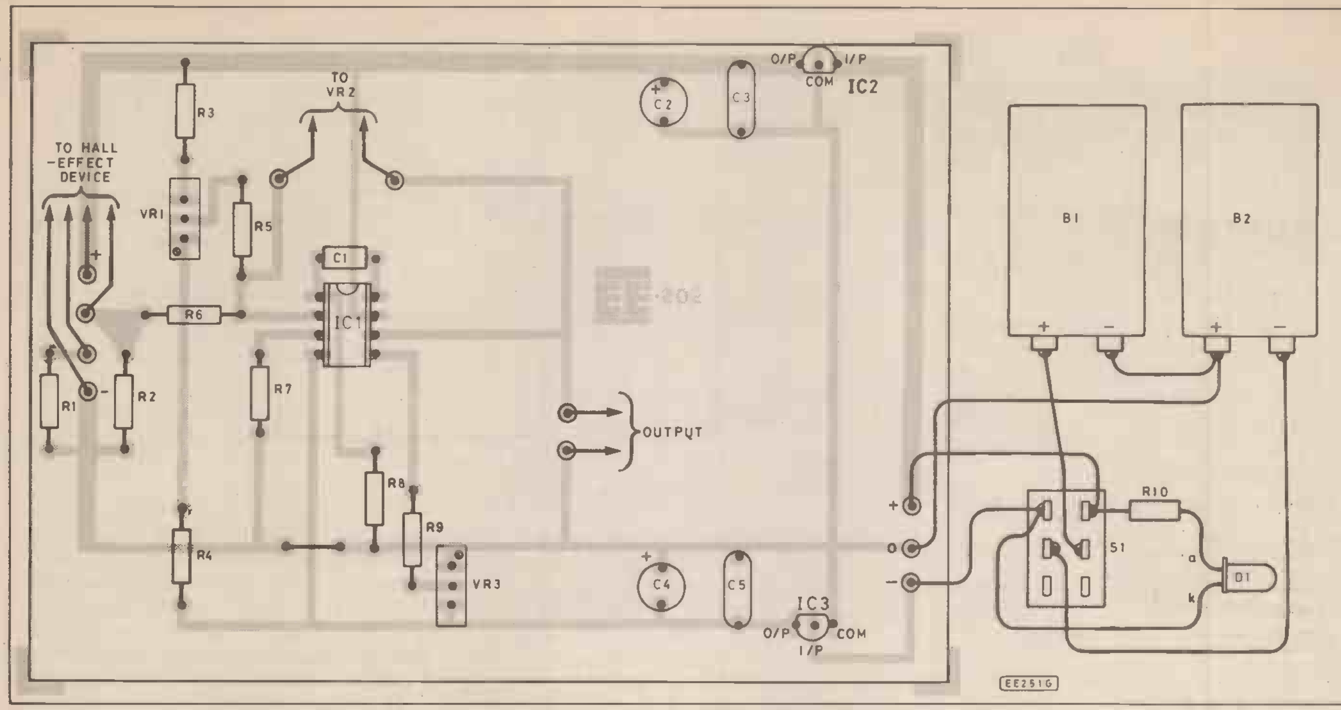


Fig. 3.5. Circuit diagram for the magnetic flux density transducer amplifier.



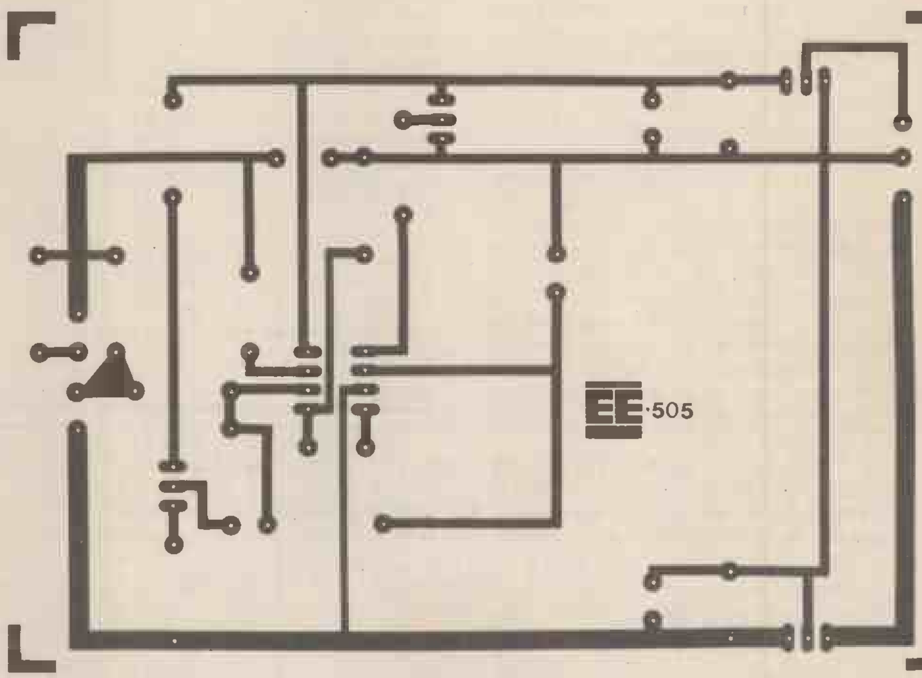


Fig. 3.6. Top, layout of components on the p.c.b., and interwiring details for the transducer amplifier. Above, the actual-size p.c.b.

COMPONENTS

See Shop Talk page 602

Resistors

R1,R2	2k2 (2 off)
R3	1k5
R4	1k
R5,R6,R7	10k (3 off)
R8,R9	1M8 (2 off)
R10	1k8

All $\frac{1}{4}$W ±5% carbon film

Potentiometers

VR1	10k 25 turn cermet
VR2	25k linear carbon
VR3	100k 25 turn cermet

Capacitors

C1	1n polyester
C2,C4	10µ 16V radial elect. (2 off)
C3,C5	100n polyester (2off)

Semiconductors

D1	0·2 in l.e.d.
IC1	LM301 8 pin d.i.l. op-amp
IC2	78L05 +5V 100mA voltage regulator
IC3	79L05 –5V 100mA voltage regulator
IC4	634SS2 Hall-effect sensor

Miscellaneous

B1,B2	9V PP3 batteries (2 off)
PL1	BNC plug
PL2	5 pin DIN plug
S1	min. double-pole toggle switch
SK1	BNC socket
SK2	5 pin DIN socket

Case—approx. 203 × 127 × 51mm; printed circuit board, available from the *EE PCB Service*, order code EE-505; terminal clips for batteries; l.e.d. mounting clip; adhesive feet for case.

COMPONENTS approximate cost £25

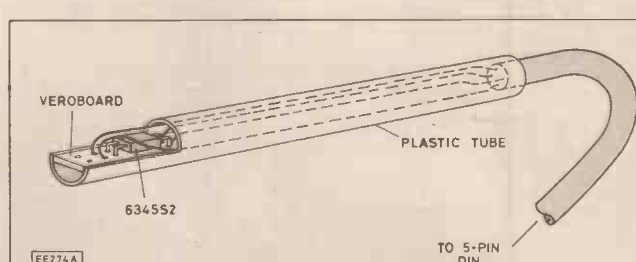
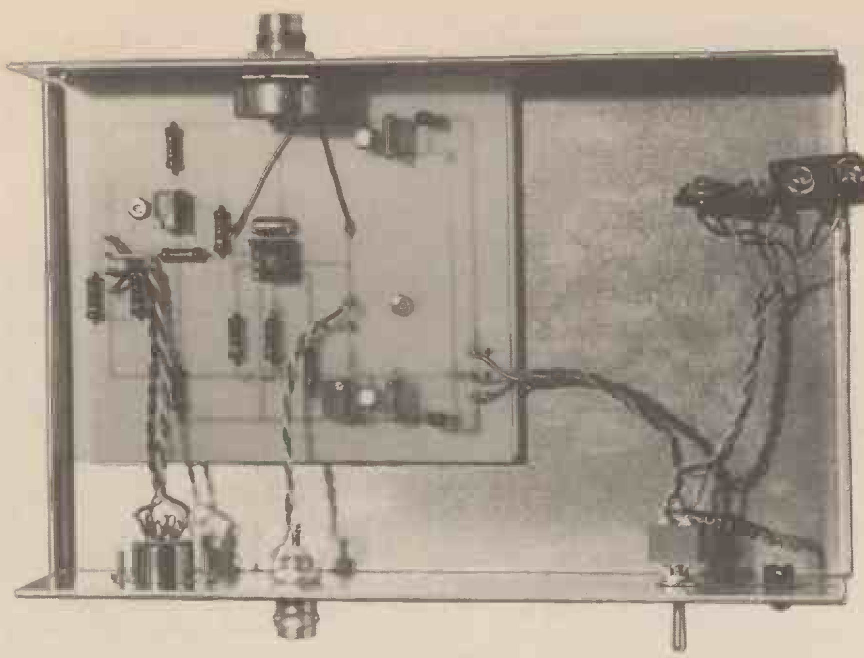


Fig. 3.7. The transducer mounted in a plastic tube.

Above, the photograph shows the 634SS2 transducer soldered onto a small piece of Veroboard, and fixed into a tube to form the probe.



The prototype unit: the large potentiometer fixed to the rear of the case is VR2.

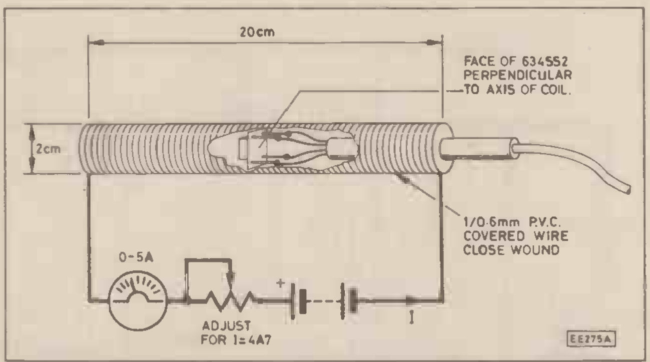


Fig. 3.8. Calibration of the transducer. Although not essential for many purposes, it is not difficult to calibrate the unit by this means. See the text for full details.

voltages at the regulated positive and negative supply lines. They should not differ appreciably from ±5V.

Connect a voltmeter (preferably a digital type) to the output of the unit and set VR2 to its maximum value. Adjust the coarse zero set control VR1 until the voltmeter reads zero. Switch the voltmeter to its most sensitive range and adjust the fine zero set control VR3 so as to bring the output voltage back to zero.

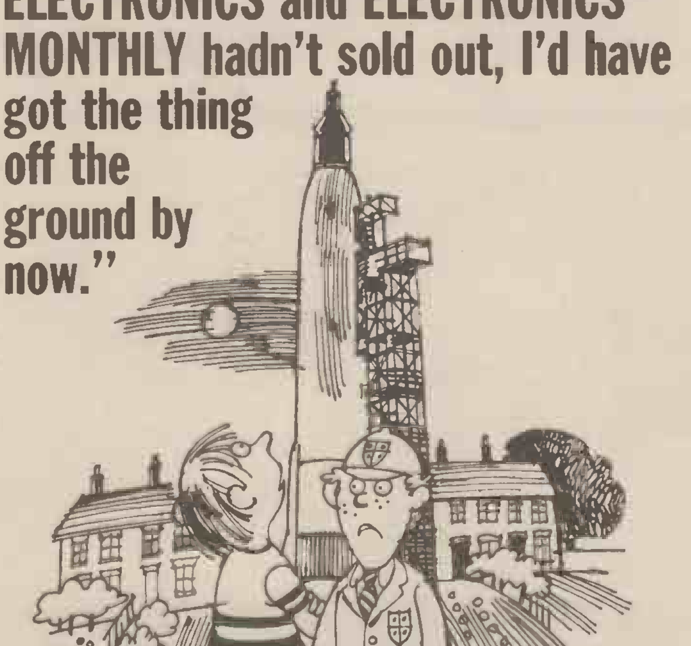
The sensor can now be placed in the field of a small permanent magnet: this will produce an output voltage which is proportional to the flux density of the field. Although the unit is not yet calibrated, it can now be used to compare the strengths of magnetic fields produced by other magnets, coils etc. and, for many purposes, this is quite adequate.

Calibration of the transducer requires a magnetic field of known flux density and the only convenient method of realising this is to construct a solenoid coil. Knowing the number of turns per metre length and the current flowing in it, the flux density within the coil may be calculated using a simple formula.

Such a solenoid can be made up using 1/0·6mm single cored PVC covered wire. This gives a coil of approximately 850 turns per metre and a current of 4·7A flowing in this will produce a flux of 5mT at the centre of the coil acting along its axis.

The sensor can be placed in this coil and the sensitivity control VR2 may then be adjusted so as to produce an appropriate output voltage from the transducer unit —see Fig. 3.8. The orientation of field and sensor is important and, during calibration, the position of the sensor relative to the axis of the coil should be adjusted so as to obtain maximum output.

NEXT MONTH: An optical intensity transducer.



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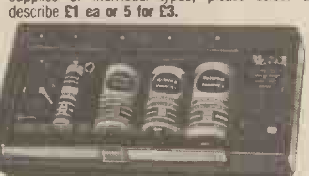

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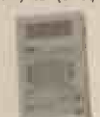

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a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS MONTH, as promised, we shall be taking a look at a number of add-on modules which can vastly improve the Spectrum's audio and video capabilities.

Whilst each module is useful in its own right, readers may wish to combine several of them together on a single external plug-in board. It would then be possible to drive colour and monochrome monitors simultaneously, as well as produce sound from an external loudspeaker.

More Audio

Most Spectrum users will be only too well aware of the machine's shortcomings as a generator of sounds. Regrettably, the "BEEP" command is a frank description of the sound that it produces. This, however, is perhaps not all that surprising when one remembers that the transducer in the Spectrum is only 25mm in diameter.

A considerable improvement can be achieved by amplifying the sound output from the Spectrum and delivering it to a loudspeaker of reasonable size. The resulting increase in output and extension of low frequency response renders the machine much more acceptable for games—you really can zap the aliens now!

For the technically minded, we shall now digress a little and explain how the Spectrum goes about generating sound. Fig. 1 and Fig. 2 show the internal circuitry associated with the Spectrum's cassette tape interface for Issues 1 and 2 (and later) models. The two cassette connectors (labelled "EAR" and "MIC") are effectively linked together at pin 28 of the ULA (the Uncommitted Logic Array). This arrangement is, of course, permissible as the "SAVE" and "LOAD" operations are mutually exclusive. The internal logic of the ULA ensures that pin 28 is linked to the appropriate CPU data bus line whenever an I/O port address of 254 (FE hex) is enabled.

Sound is produced in the loudspeaker whenever a sequence of OUT (FE), A instructions is performed in which bit 4 of the accumulator is alternately set and reset. This is achieved by XORing the contents of the accumulator with an immediate value of 16 (10 hex) and different frequencies are produced by incorporating a timing loop of appropriate length.

Since the BEEP output signal appears at the "MIC" connector, an increased level of sound output may be achieved by connecting an external amplifier to this point. The simple circuit shown in Fig. 3 is perfectly adequate for this application and furthermore can readily derive its supply from the nominal 9V unregulated d.c. available at B4 of the Spectrum's edge connector.

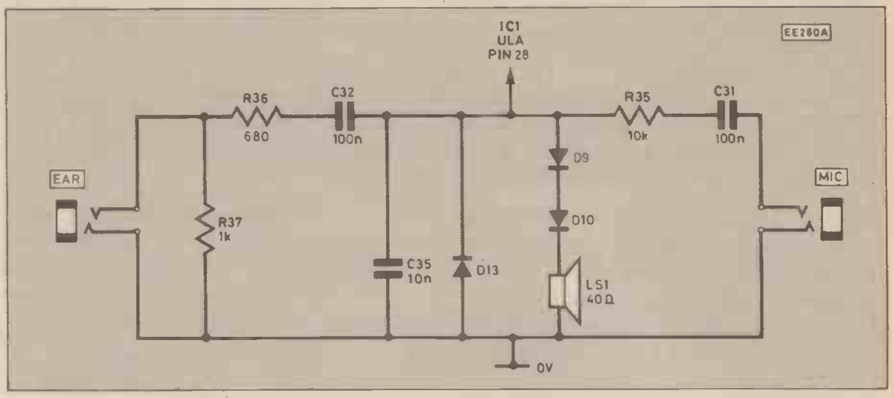

Fig. 1. Circuit for the Spectrum's cassette tape interface—Issues 1 and 2.

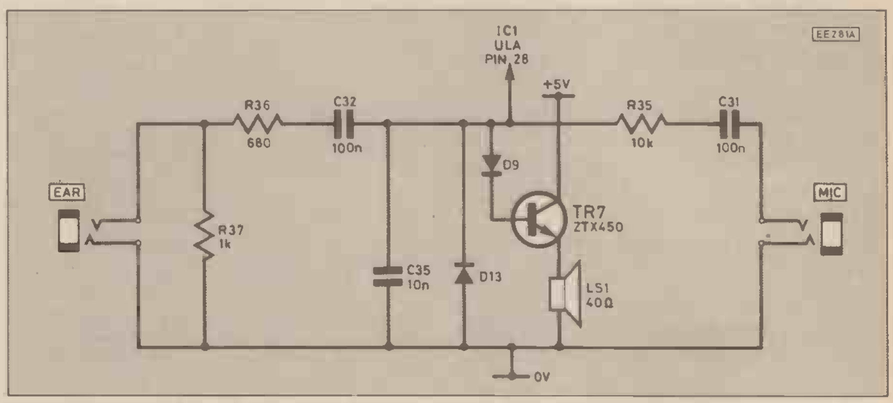

Fig. 2. The cassette tape interface circuit—Issue 3 and later.

The LM380N is an integrated circuit audio amplifier capable of delivering powers of around 1W to an 8Ω load. The device is housed in a 14 pin d.i.l. plastic encapsulation and does not normally require a heatsink.

Driving a Monochrome Monitor

Serious users of the Spectrum will undoubtedly be using software which reconfigures the TV display for 40 or 64 column text rather than the normal 32 characters. Unfortunately, most domestic colour televisions have difficulty displaying 64 characters per line. Whereas this problem is easily resolved with the use of an external monochrome monitor, the Spectrum has no facility for interfacing with such a device.

A simple interface for linking a Spectrum to a standard monochrome monitor is shown in Fig. 4. The video signal is derived from the $\overline{Y}$ (inverted luminance) output from the ULA. This gives a rather better picture than that which can be obtained using the VID (composite video) line as, in this application, the colour information is not required. TR1, which can be almost any low-power medium frequency silicon transistor, operates as an inverter. VR1 is adjusted for correct black level and VR2 for contrast. C1 provides some additional high frequency emphasis and improves bandwidth. The effect of C1 is particularly noticeable when characters such as "m" are displayed; without C1 these tend to be rather blurred.

In order to remove noise from the supply rail (which may otherwise result in degradation of the picture with spurious dots and

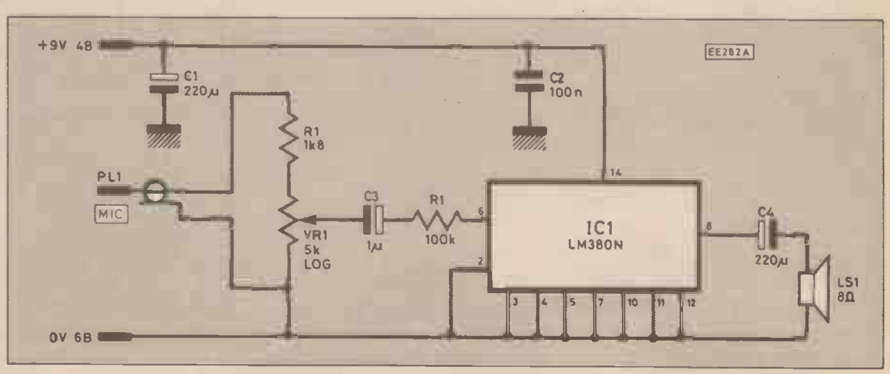

Fig. 3. Circuit diagram for the audio amplifier module.

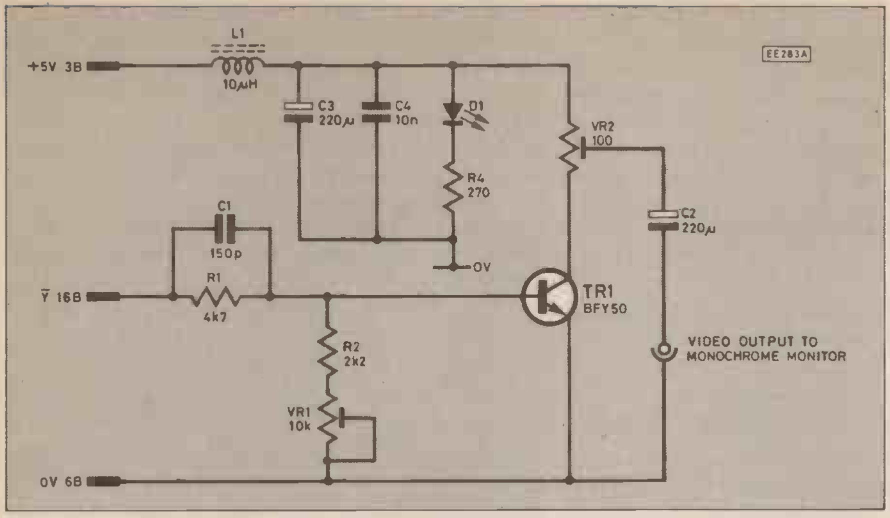

Fig. 4. Interface circuit for linking a Spectrum to a standard monochrome monitor—giving a much higher-resolution display than is possible with a domestic TV.

lines), a choke/capacitor filter comprising L1 and C3/C4 has been incorporated. The inductor should be a miniature ferrite cored component: but its value is not critical.

It is also essential to ensure that the circuit has an adequate 0V (earth) connection between the video output connector, the negative ends of C3 and C4, and 6B (0V) on the Spectrum's edge connector. Failure to observe such a precaution may also result in objectionable video noise.

Connection to the monitor should be made via a short length of 75Ω coaxial cable and, while many people may prefer the use of standard "cheap and cheerful" Belling-Lee type TV plugs and sockets, readers may choose to use BNC or DIN types in order to match the style of connector provided at the monitor.

Driving a Colour Monitor with Composite Video Input

A circuit for driving a colour monitor having a composite video input is shown in Fig. 5. Unlike its monochrome counterpart, this circuit makes use of the video (VID) signal available at 15B of the Spectrum's edge connector. It is important to note that this signal was only made available on Issue 3 (and later) versions of the Spectrum. On earlier versions an internal link (marked "VID" and situated adjacent to TC1) will have to be fitted in order to provide external composite video.

Readers having access to the "official" Spectrum circuit diagram covering Issue 3 may also like to note that, in addition to several other errors, the connections to 15A and 15B have been transposed; 15B is the VID signal and 15A is the HALT line. Doubtless this will have already been the cause of a few sleepless nights.

As the VID signal is of the correct sense, there is no need for an inverter as was the case with the monochrome interface. It is, however, good practice to include a transistor buffer in order to prevent the monitor and its associated cable from loading the VID line. An emitter follower, TR1, is therefore incorporated together with preset resistors, VR1 and VR2, which respectively provide black level and contrast adjustment.

The earlier comments concerning supply line filtering and common rail connections are again valid and constructors should take care to observe the same precautions suggested for the monochrome interface.

Sound From Your Television

As an alternative to an external audio amplifier, readers may wish to consider making use of the audio stages within their own TV receivers. In such cases it will be necessary to add an external modulator. This will functionally replace the internal modulator and also accommodate an additional sound channel input. Modulators of this type have only recently become generally available and, due to their relative complexity, are unfortunately somewhat more expensive than their older "video only" counterparts.

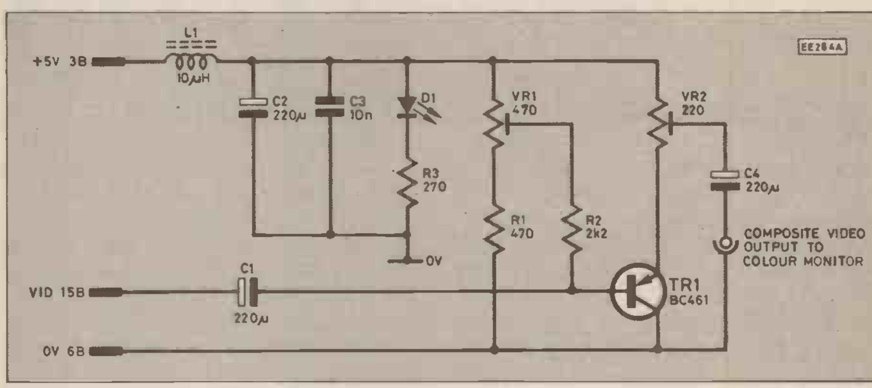

Fig. 5. Circuit for driving a colour monitor with a composite video input—Issue 3 and later.

The circuit for a combined external video and sound modulator is shown in Fig. 6. Again, this arrangement benefits from additional supply line filtering; furthermore, since the modulator requires a slightly different d.c. level on its composite video input waveform, bias adjustment is provided by VR1. Fig. 7 shows the pin connections for the UM1286. It should be noted that a means of fine tuning is provided by the application of an adjustable bias voltage to pin 4. This, however, will not normally be necessary as the user can simply make this adjustment at the TV receiver rather than at the modulator.

At this point, a word of caution is perhaps necessary. Readers are warned against making adjustments to the ferrite and brass cores which are rather temptingly made available through the four access holes provided in the external screening of the UM1286. Not only is their adjustment critical for optimum picture quality but the ferrite cores are extremely brittle. To avoid damage, a purpose-designed trimming tool is an essential pre-requisite to making any adjustment. Furthermore, adjustment is not likely to improve the picture—indeed it is more likely to worsen it.

A typical video waveform compatible with the UM1286 is also shown in Fig. 7. As previously stated, the d.c. level of this waveform is adjusted by means of VR1 and readers should experiment to achieve the correct setting (some interesting effects can be produced by means of this control).

Construction

Apart from the recommendations concerning supply line filtering and earthing, construction of the modules is generally

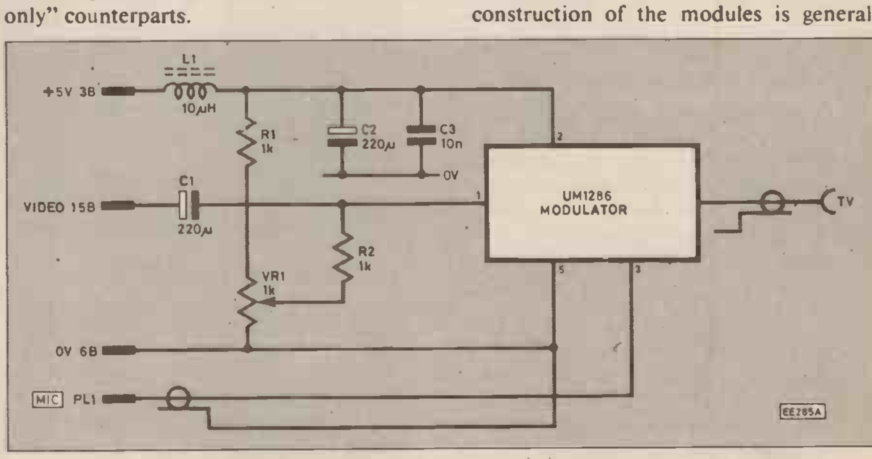

Fig. 6. The UM1286 combined video and sound modulator interface circuit.

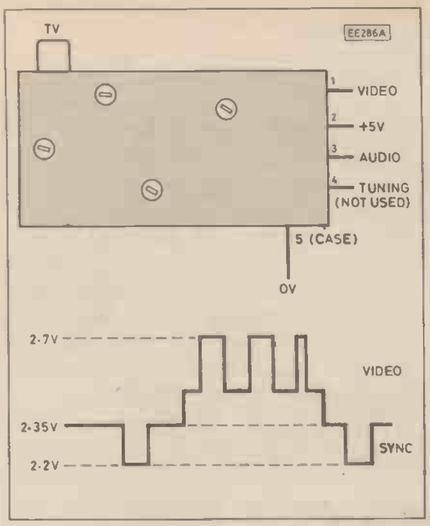

Fig. 7. Top, the connections for the UM1286. Above, the video waveform needed.

uncritical and the circuits can be conveniently mounted on a small piece of Veroboard in the same manner as the modules previously described in these pages.

It should be noted that, whereas the monochrome and colour monitor interfaces only require access to the edge connector, the amplifier and modulator modules also require inputs from the "MIC" and "MIC"/"TV" connectors respectively. Short lengths of screened cable fitted with miniature 3·5mm jack and phono plugs should suffice for this purpose.

Testing your TV/Monitor

This month, a program which can be used for testing and adjusting your TV/monitor is available from the address opposite, included in the "Spectrum Update" package. Whilst not intended to completely replace the functions of a full-blooded TV pattern generator, the program should prove to be extremely useful to anyone involved with setting-up or servicing TVs or monitors and should more than repay the effort required to key it in.

If you have any comments or suggestions please drop me a line at:

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P.S. Don't forget to include a stamped addressed envelope if you would like to receive a copy of our latest "Update".

NEXT MONTH: A simple three-chip analogue-to-digital interface.

The Man Behind the Symbol

Nº4 Charles Augustin de Coulomb

by Morgan Bradshaw

THIS month we meet the man who gave his name to the SI practical unit of electric charge (Table 1). Charles Augustin De Coulomb, later to be described by a contemporary as a "Mathematician and Engineer with the love of definition and the habit of measurement".

Born on June 14, 1736, in the town of Angouleme in south western France, Charles was the only son of Henry De Coulomb, who held important legal and administrative posts in Montpelier, and Catherine De Senac from one of France's most wealthy and important families. Always a bright boy, the young Charles was sent to the engineering school in Paris in the autumn of 1758 where he revealed an outstanding aptitude for mathematics.

> **Table 1: THE COULOMB (C)**
>
> *The International Congress of Electricians meeting in Paris in 1884 recognising the importance of Coulomb's discoveries and how they had paved the way for other scientists to follow new lines of research, selected his name to designate the practical unit of electric quantity.*
>
> *Since 1950 the absolute Coulomb (C) has been defined as the amount of electric charge that crosses a surface in one second when the current flowing is one ampere (A).*

In November 1761 he joined the army as a Lieutenant of Engineers serving in various parts of the then large French Empire, including a spell in Martinique where in between bouts of illness he masterminded the building of a chain of military forts.

In 1722 he was posted to Bouchain where he wrote an article on mechanics which brought him to the notice of the Paris Academy of Science. His next posting was to Cherbourg where he began work on his magnetic compasses which gained first prize in the Academy's competition for 1777.

In 1779 Charles was posted to Rochefort to assist the Marquis de Montalembert in the construction of a wooden fort on the Ile d'dix. Whilst working in the shipyards there he carried out experiments in friction which in later years led to the invention of his well known torsion balance. This torsion balance found many uses and Cavendish was later to use it to determine the density of the earth by comparison with that of a ball of lead. Coulomb however made the most successful application of his invention when he used it to measure the feeble force of frictional electricity and magnetism and the discovery of the inverse square law.

COULOMB'S LAW

Coulomb found that "The attractive or repulsive force" between two charged bodies (whose charges behave as though they were concentrated at a point), is proportional to the magnitude of the charges and inversely proportional to the square of the distance between them. In other words if the distance between the bodies was doubled or trebled the force they exerted in each other was respectively a fourth and a ninth of what it had been.

These discoveries lead to Coulomb being elected to the Académie des Sciences and a post which carried with it a residence in Paris. Charles "had arrived". He was famous and happily married with a young family.

PRISON

Then in 1783 much against his will Coulomb was sent to Brittany to sit on the national coal and harbour improvement commission, and he was made the scapegoat for the critical report which resulted in him serving a short prison sentence in November of that year.

In 1789 to escape the revolution, Coulomb and Jacques Tenon the French Surgeon General came to England to lecture and to examine the hospital service. On his return he was "retired" from the Corps of Engineers as a Lt. Colonel and forced to leave Paris by the law expelling all nobles.

His army pension helped him to purchase a small estate in Blois where he continued his scientific research and experiments and published many internationally acclaimed papers.

In 1801 he achieved a life long ambition when he was elected President of the new Institute of France where he met and worked with many of the great men of the day, including Napoleon.

Coulomb died in Paris at the age of 70 on August 23, 1806, the first pioneer to apply mathematics to the phenomenon of electricity.

DECEMBER FEATURES...

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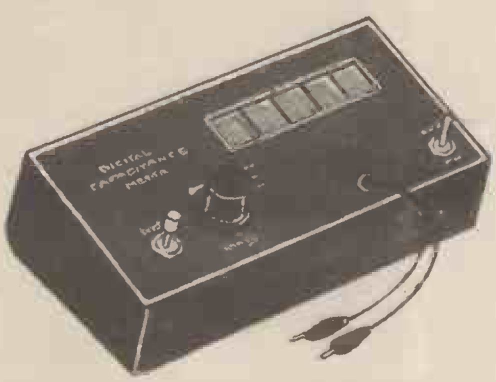

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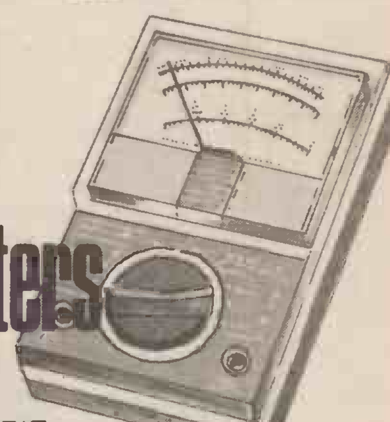


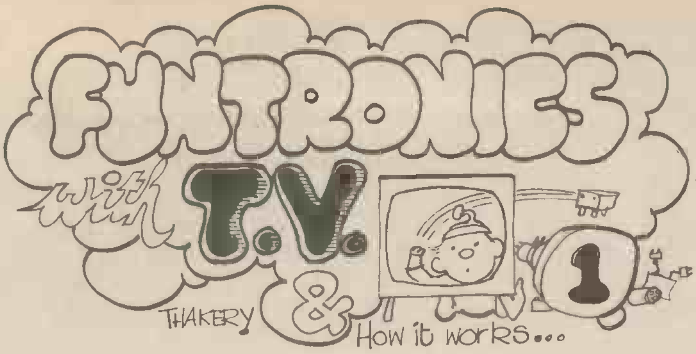
CHRISTMAS GIFT BUYERS GUIDE

Having problems selecting a suitable gift for Xmas? We offer our grand selection of ideas for all the family—from tools, meters and robots to the very latest in "home entertainment".

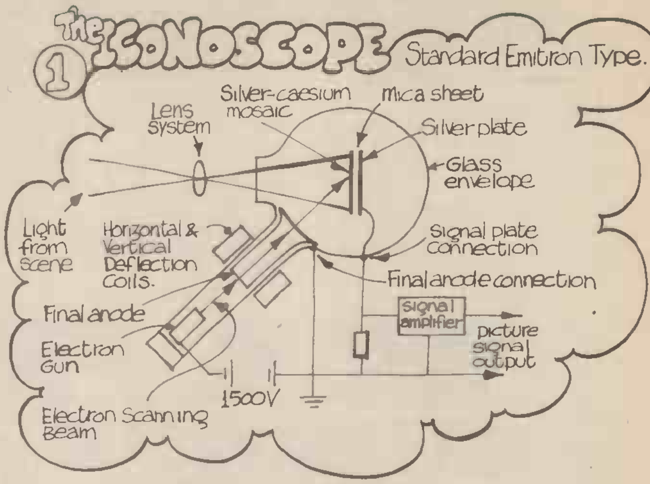
EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

DECEMBER 1985 ISSUE ON SALE FRIDAY, NOVEMBER 15

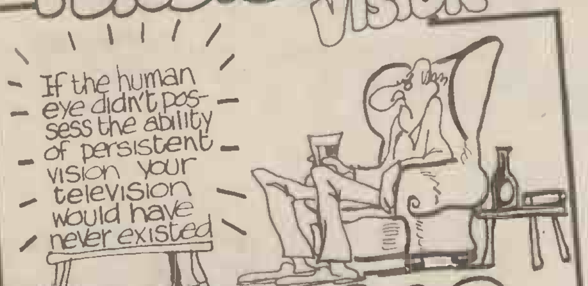
FUNTRONICS with T.V. & How it works... 1



The ICONOSCOPE 1 — Standard Emitron Type.



PERSISTENT VISION

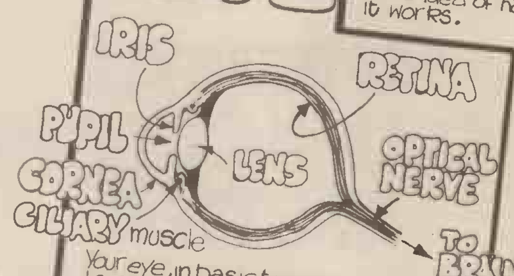


The Human Eye possesses the ability to retain an impression of the shape, the colour and the brightness of an image for a fraction of a second after light from the image has ceased to be received.

...this means that the illusion of a continuous picture can be obtained from a series of individual images, each differing slightly from its predecessor, presented to the eye in very rapid succession.

The HUMAN EYE

The human eye is a marvellously efficient optical instrument. It's worth having some idea of how it works.



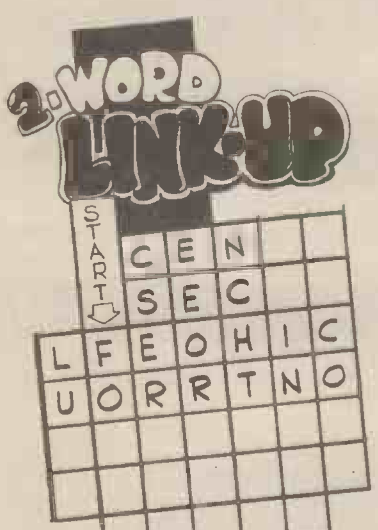
Your eye, in basic terms, is a crystalline lens system which collects light of ALL frequencies in the *VISIBLE SPECTRUM*, and focuses it onto a light-sensitive screen (RETINA) situated in a concave arc round the back of the eye.

The Retina is made up of MILLIONS of nerve fibres, each sensitive to light of a different frequency, which are connected in groups to the OPTIC nerve. This nerve in turn is connected to the brain.

The focusing of the image is done by the lens system of the eye. The CILIARY muscle controls the degree of curvature of the crystalline lens, and so its focal length.

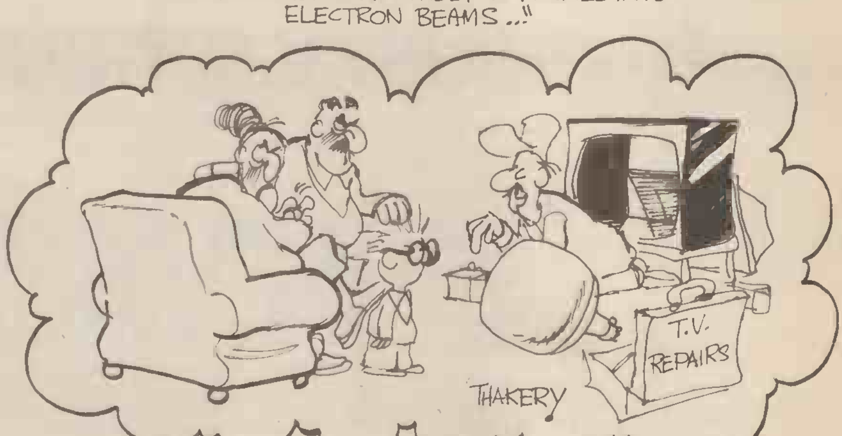
The **Cornea** collects the light and the **Iris** protects the delicate **Retina** by contracting during bright light conditions and expanding during dark conditions.

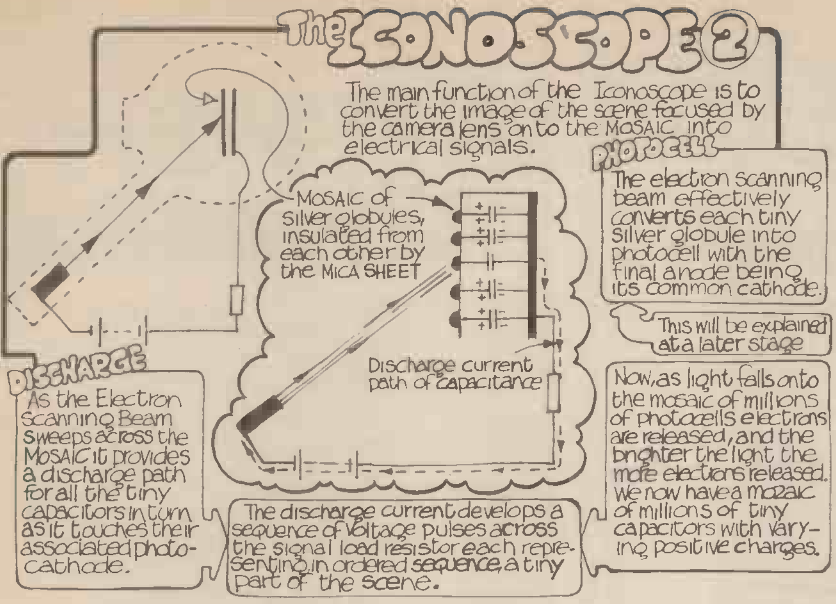
2-WORD LINK-UP

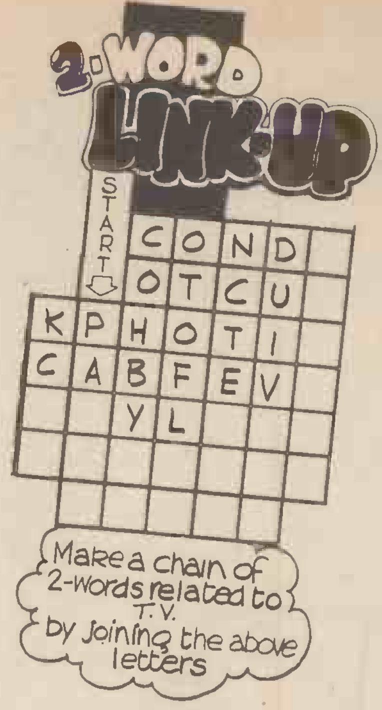


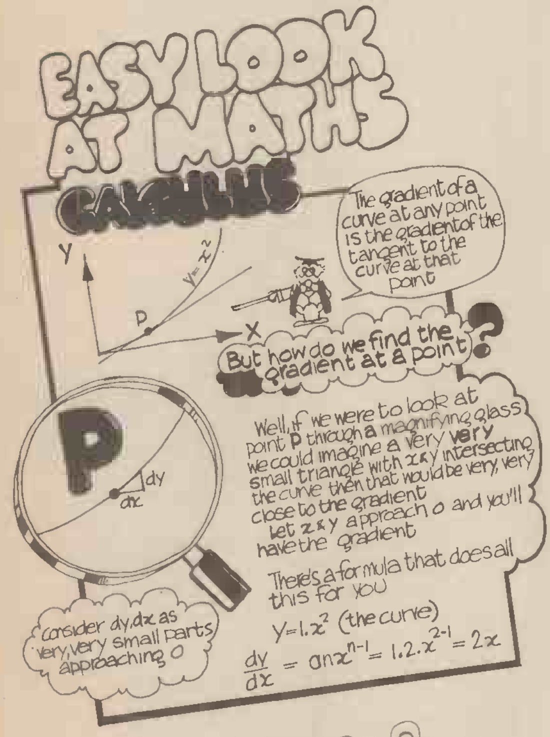
Make a chain of 2-words related to *Television* by joining the above letters

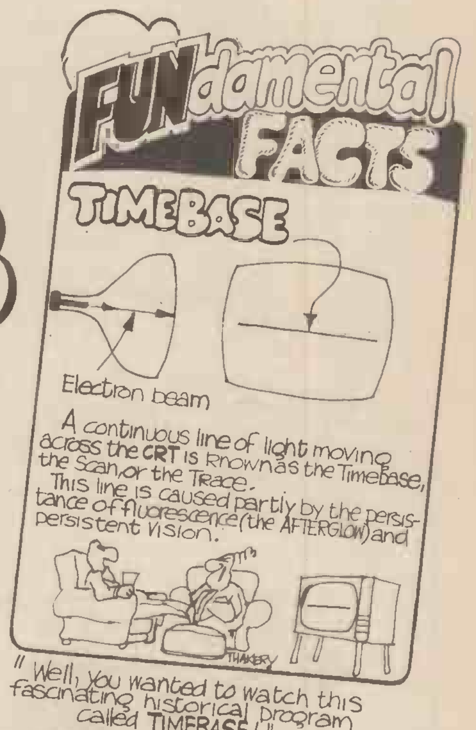
"...THEN **CORONATION STREET** IS FORMED INTO ELECTRON BEAMS..."



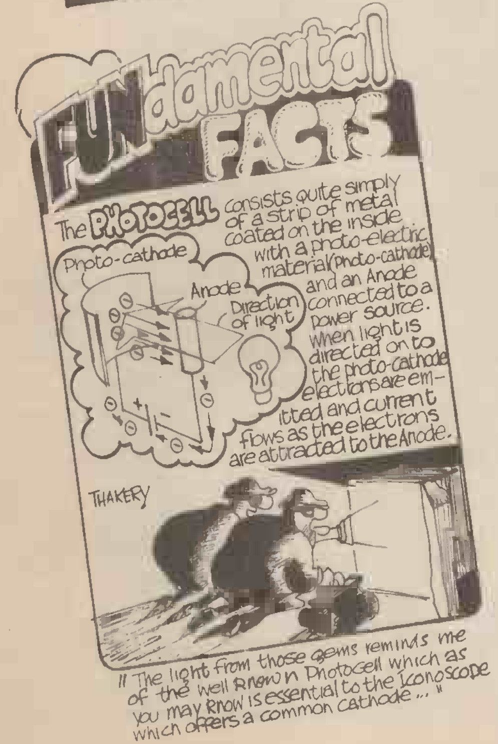


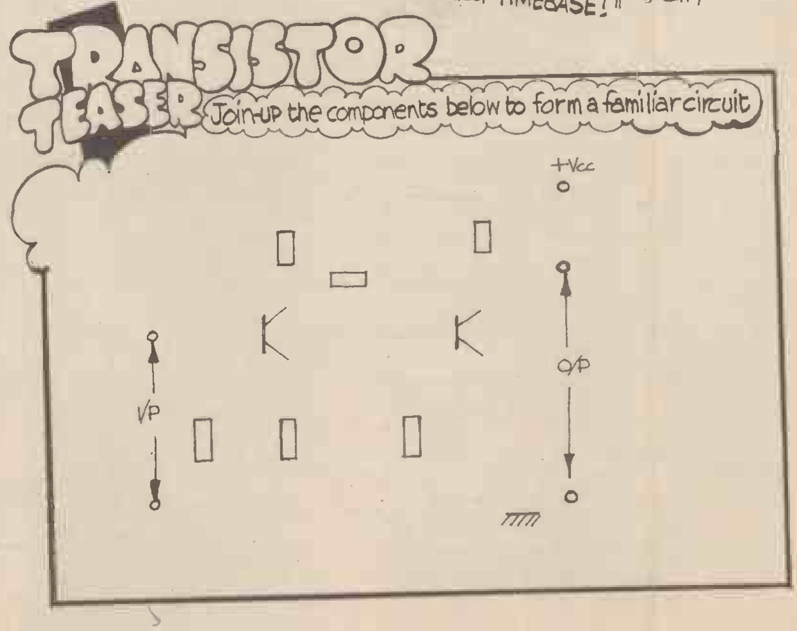






Solutions on page 626





ELECTRONIC BUILDING BLOCKS

PART FOUR

RICHARD BARRON

AMPLIFIERS are, probably, the most common device used in electronic circuits. As their name suggests, amplifiers are used to amplify electronic signals by causing an increase in voltage or current, which generally means causing an increase in power. In some form or another, they are used in almost every electronic circuit, so this month, we will take a look at the basic *building blocks* of electronic amplifiers, including transistor and i.c. designs.

PARAMETERS

The general parameters of an amplifier are shown in Fig. 1, and for ease of reference and understanding, are listed below, together with a short explanation.

INPUT IMPEDANCE: In the simplest of terms, the input impedance of an amplifier is the resistance presented to the input signal and is given by Rin=Vin/Iin. Similarly, the OUTPUT IMPEDANCE is given by Rout=Vout/Iout. In practice, these parameters are much more complicated as impedance is dependant on such things as resistance, capacitance and inductance, and is different for d.c. and varying signals.

EFFICIENCY: As with any system, the efficiency is given by the ratio of the total power in, including the power supplied from the power supply and the signal, to the signal power out.

GAIN: The gain of an amplifier is the ratio of the output signal to the input signal. Thus the voltage gain, Av=Vout/Vin. The current gain Ai=Iout/Iin and since power is the product of voltage and current, Ap=AvxAi.

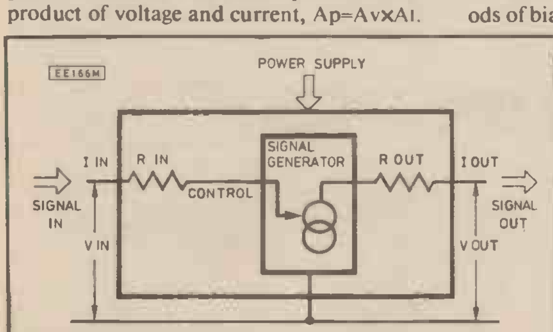


Fig. 1. Basic amplifier characteristics.

As shown in Fig. 1, an amplifier can be considered as a signal generator whose output is controlled by the level of the input. In general, the output signal should only differ from the input with regard to level. Any difference in shape, to the output signal, is referred to as DISTORTION. Also any unwanted signal produced at the output is called NOISE. This noise may be caused by the amplifier itself or it may be as a result of input noise being amplified together with the signal.

In most cases, the input impedance of an amplifier should be very high to prevent undue loading of the input source. The output impedance should be low, allowing most of the signal power to be dissipated by the load, and avoiding undue dissipation within the amplifier itself.

TRANSISTOR AMPLIFIERS

In its basic form, the transistor is a current amplifier, as a small base current will cause a large collector current. This is shown in Fig. 2a. It is easy to convert a current gain, by adding a resistor as shown in Fig. 2b, to a voltage gain. As the current in the collector circuit increases, the voltage across Rc will decrease proportionally. Under these conditions, only a small change to the input voltage will cause a large change to the output voltage. This is an inverting amplifier.

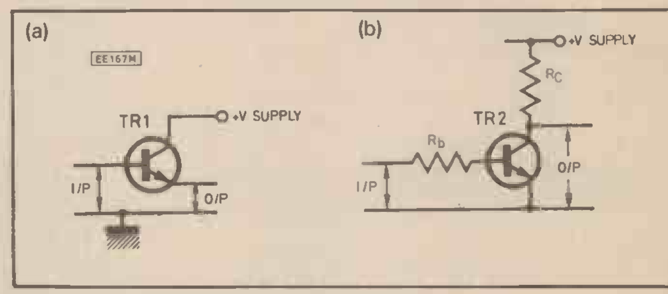


Fig. 2. Simple current and voltage amplifiers using a single transistor.

In the circuits of Fig. 2, the amplifier will only work when the base emitter voltage is sufficient to cause the transistor to conduct (around 0·6V). This means that unless the signal input is at the correct level, distortion would be a major problem caused whenever the base voltage fell below a certain level. This type of distortion can be overcome by biassing the input so as to keep the transistor in a state of permanent conduction.

The circuits of Fig. 3 illustrate two methods of biassing. In Fig. 3a, a single resistor is connected between the base and the positive supply, causing a standing (quiescent) current to flow all the time. Rb should be set to cause a quiescent voltage (Vq) to be around half the supply voltage, thus a small change in the input signal will allow the output to swing up to the positive rail or down to ground.

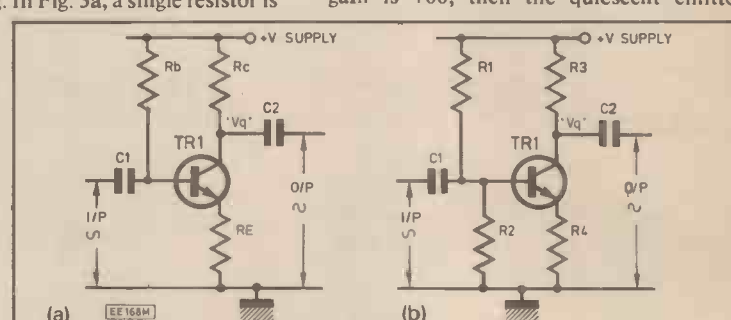


Fig. 3. Amplifier biassing techniques.

BETTER BIAS

This method of biassing is a little more difficult than that of Fig. 3b. Using the latter method, a simple voltage divider connected to the base ensures that the quiescent voltage is set at the correct level as the emitter voltage will be the divider voltage minus 0·6V. In both these cases, a capacitor has been used to isolate the input signal from the d.c. bias.

STABILITY

Unfortunately, transistors are not particularly stable devices. Their current gain can vary dramatically with temperature variations, and unless precautions are taken transistor amplifiers will at best not function correctly and, at worst, the transistor could be destroyed by excess current. If, for example, an amplifier is designed to have a quiescent base current of 0·5mA and its gain is 100, then the quiescent emitter collector current will be 50mA. However, if the temperature rises, then the current gain may rise causing the collector current to rise. This will cause the quiescent voltage to change resulting in distortion of the output.

Also transistors of similar types may have

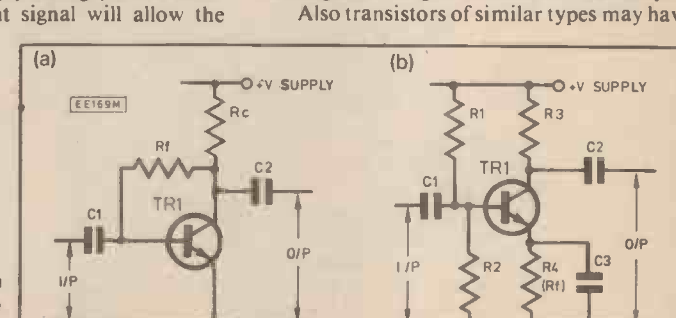


Fig. 4. Stabilisation using negative feedback.

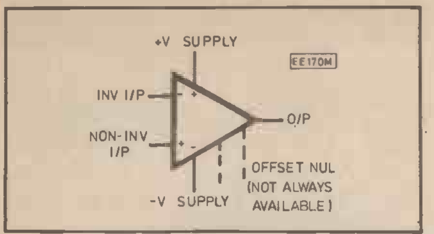


Fig. 5. Op-amp circuit symbol.

widely different gains. This means that although they should be interchangeable, in practice they are not. That is, of course, unless some type of stabilisation is employed. Stabilisation is achieved by including negative feedback in the circuit as shown in Fig. 4.

In Fig. 4a, a simple feedback resistor, Rf, is connected between the collector and the base. In this set-up the feedback resistor provides both stabilisation and bias. If the gain is too high, the voltage across Rc increases and thus the bias current decreases. In Fig. 4b an improved method of negative feedback is used.

When the emitter current increases, a voltage increase across R4 causes the base-emitter voltage to decrease, thus reducing the current in the collector circuit. C3 ensures that only the d.c. bias causes feedback by allowing the signal to bypass R4. (Remember the impedance of a capacitor is low for a.c. or varying signals.)

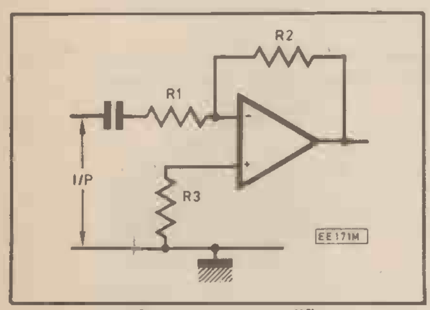


Fig. 6. Inverting amplifier.

OPERATIONAL AMPLIFIERS

Transistor amplifier design is, of course, very much more complicated than has been shown so far. However, since the introduction of operational amplifier i.c.s, the use of discrete transistor amplifiers has become much less common op-amps are basically high gain direct-coupled amplifiers which rely on a few external components to control their stability and gain.

The circuit symbol and ideal specifications for op-amps are shown in Fig. 5 and Table 1 respectively. Although these are ideal specifications, modern technology brings actual devices close to these, and for the purpose of design, these characteristics can be accepted as true. Because, they are such versatile devices next month's article will continue with more op-amp details, but this month, we shall look at their basic operation.

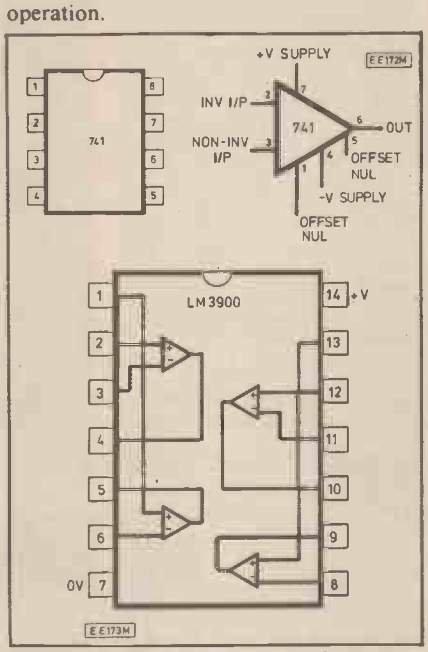


Fig. 8. Typical op-amp packages.

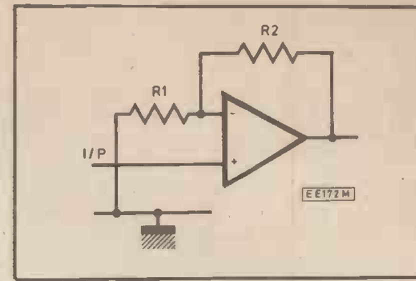


Fig. 7. Non-inverting amplifier.

As shown in Table 1, the open-loop gain of an op-amp is typically 10^7, so obviously in its basic form it would be very unstable as a few µV variation to the input would cause a variation of several volts to the output. To overcome this, negative feedback is applied via the inverting input.

Table 1. Ideal op-amp specifications.

Specifications
I/P impedance......................infinite
O/P impedance..........................zero
Open loop gain.......................infinite
Freq. response..............................flat
Common mode rejection.............high
d.c. coupled

Using negative feedback, the gain can be reduced using just two resistors. This is shown in Fig. 6. In this configuration, the op-amp is connected as an inverting amplifier and the gain is given by Av=R1/R1. The input impedance is equal to R1 which should be kept high. Alternatively, a non-inverting amplifier can be formed which has a very high input impedance and a gain, AV=1+R2/R1. This is shown in Fig. 7. Some typical op-amp packages are shown in Fig. 8.

NEXT MONTH: A closer look at op-amps and lots of circuit ideas.

SIMPLE AUDIO AMPLIFIER

This month's constructional project is a simple amplifier, designed primarily to be used in conjunction with last month's audio generator. It is a very basic single rail amplifier with a variable voltage gain up to 100×. Its performance is very poor, as far as noise and reproduction is concerned, but is acceptable for our purposes.

The circuit is built around a dual op-amp, IC1, the first stage providing amplification and a buffer for the input and the second buffers the output. Both the input and output are a.c. coupled via C1 and C2 respectively. VR1 is included to provide input level control and VR2 sets the gain.

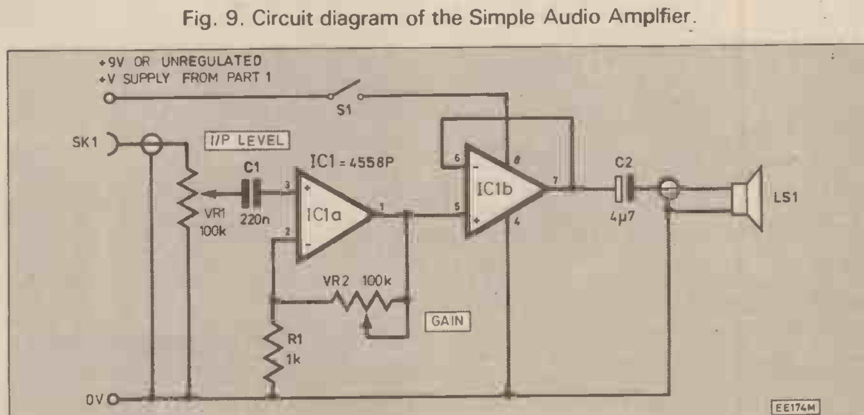
USE

As was stated earlier, the main use of this project, is as a signal tracer to be used in conjunction with the signal injector of Part 3. The idea being, that an audio signal should be injected into a circuit, such as a hi-fi device and faults may be located by tracing the signal through various parts of the circuit. Obviously, the level of the test signal will vary in different parts of the circuit, so VR1 allows a proportion of this signal to be presented to the input stage and to keep loading of the circuit to a minimum, VR1 is 100k.

If a strong signal is being tested, say 5V peak, then a fraction of this is presented to the amplifier stage and the gain is kept fairly low. However, if the signal is weak, then the full signal is presented, and the amplifier gain should be set high. In this manner, using VR1 and VR2 together, a wide variety of signals may be detected from a few mV to several volts.

Unfortunately, partly due to bad design, there are several short-comings in this circuit. It can only deal with signals which are

Fig. 9. Circuit diagram of the Simple Audio Amplfier.



more positive, with respect to 0V and it is very susceptible to noise. In practice, it works satisfactorily under most conditions and to improve its specifications dramatically, it would have to be much more complicated and a split-rail supply would have to be used.

The original idea was to use this project with the Building Blocks power supply, but since it is common to the audio generator, noise becomes a major problem. It was found in practice to work much better from a battery supply. Similarly it was found that the problem could be reduced by using screened cable and housing the project in a metal box keeping it away from the oscillator.

CONSTRUCTION

Construction of this project should present no major problems as all the components are mounted on a small p.c.b. and there is very little interwiring involved. The smaller components, such as the capacitors and resistor should be mounted first together with the i.c. socket. Terminal pins should be used for connection to the power supply wiring input and speaker wires.

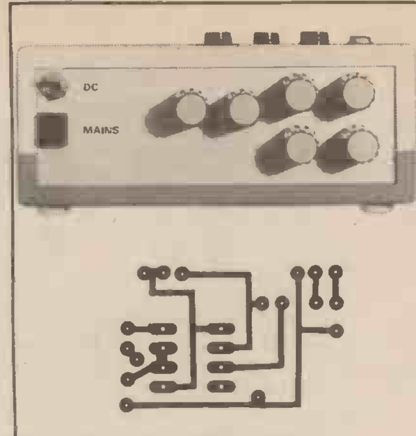


Fig. 10. P.c.b. design.

COMPONENTS

See Shop Talk page 602

Resistor
R1 1k ¼W 5%

Potentiometers
VR1, VR2 100k p.c.b. mounted

Capacitors
C1 220n silvered mica
C2 4U7 tant. elect.

Miscellaneous
SK1, miniature phone socket; S1, s.p.s.t.; LS1 miniature 8 speaker; wire; cable; solderpins, etc.

Approx. cost Guidance only £3.90

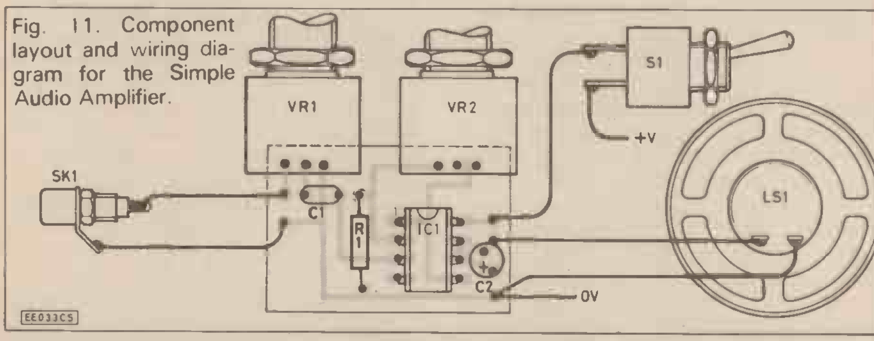
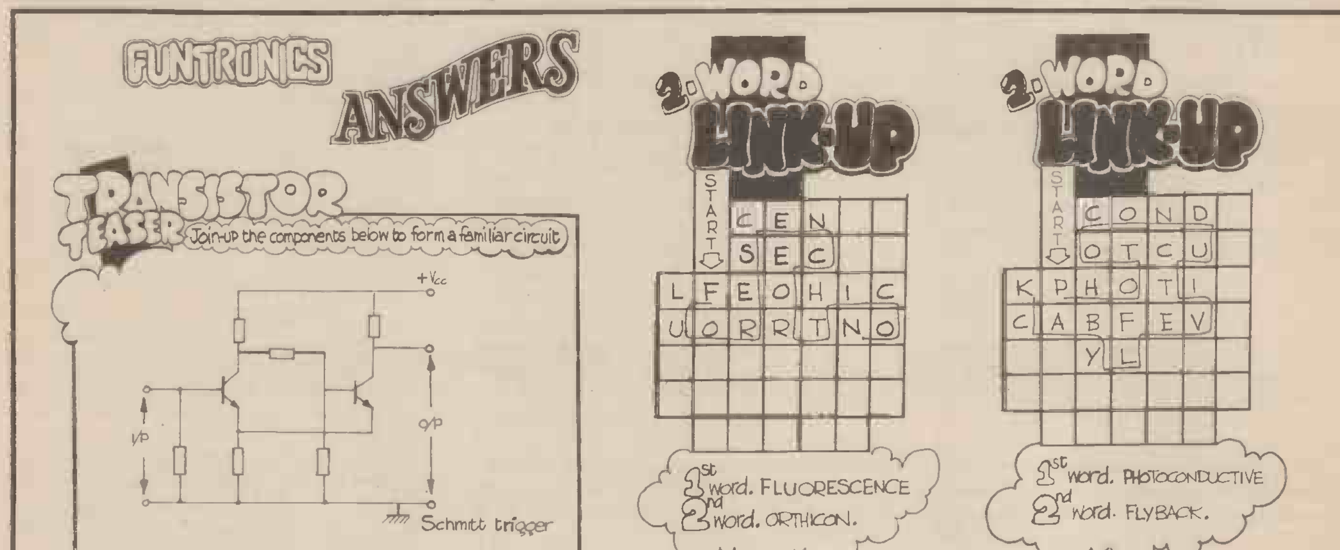


Fig. 11. Component layout and wiring diagram for the Simple Audio Amplifier.

On the prototype, the speaker, p.c.b. input socket, SK1, was mounted inside the case used in Building Blocks, Part 1–Part 3, but as was suggested earlier, it is probably better to use an alternative case. The p.c.b., speaker and socket should be mounted in a suitable size metal case for screening purposes and any input wires should be screened cable.

NEXT MONTH: The constructional project will be a useful logic probe for testing TTL circuits.



Actually Doing it!!

Robert Penfold

ALTHOUGH the humble transistor has been ousted to some extent by the ever increasing use of integrated circuits, if you look through some back issues of this magazine you will still find plenty of projects that use one or more of these devices. In most cases transistors do not provide any real difficulties to the constructor, even so, it is worthwhile checking that the apparently obvious method of connection is the correct one before fitting the transistors into place.

MOUNTING

When using stripboard you will often find that the leadout wires of transistors need to be carefully preformed before they will fit onto the board. Here more care needs to be exercised if connection errors are to be avoided. The three leadout wires should be marked "e" (emitter), "b" (base), and "c" (collector) on the component layout diagram. It is not necessary to understand anything about transistor operation or any other electronics theory in order to construct an electronic project, and in this case it is really just a matter of referring to the leadout diagram to determine which lead is which, and then fitting the device in place. If the article does not provide a leadout diagram for the transistors in the design you can find these diagrams in the larger component mail order catalogues.

When using leadout diagrams avoid the pitfall of thinking that they show the devices as they are seen in component layout diagrams. The convention has transistor leadout diagrams showing base views (i.e. looking onto the leadouts of the devices).

You may sometimes see references to something like a "TO-92" device, and this is the type of encapsulation. TO-92 is a plastic type and is probably the most common, although the TO-18 metal type is also frequently encountered. A possible cause of confusion for beginners is the use of several leadout configurations with most case styles. Fig. 1 shows leadout diagrams for a few common TO-92 devices, and the leadout configuration is different in each case. Therefore, you *must* find a leadout diagram that refers *specifically* to the device in question.

FET'S

Not all transistors have the usual base, emitter, and collector terminals, you may encounter field effect types (f.e.t.s) which have gate, source, and drain terminals instead. There are also dual gate types which have four leadout wires, and unijunction devices which lack a collector terminal but have an extra base leadout wire. Fortunately, for the constructor it does not really matter what the leadout wires are called or how many there are, it is still just a matter of referring to the diagrams to determine which leadout is which, and where on the board each leadout must be fitted.

The original germanium devices have now been superseded by silicon types which are generally much tougher, especially with regard to damage by overheating when they are being soldered into place. At one time special heat-shunts were available, and these were fitted over each leadout wire as it was soldered into place to tap off much of the heat travelling up the lead and prevent it from reaching the interior of the component. Much the same effect can be obtained using a pair of pliers, but provided each joint is completed quickly and the leadouts are not cropped short a heat-shunt should not really be necessary.

You may occasionally be faced with a transistor for which you can find no leadout diagram. Using a multimeter set to an ohms range it is quite easy to find the base lead by trial and error. With the negative test prod connected to the base leadout there will be a low resistance indicated with the positive test prod connected to either of the other two leadouts (reverse the test leads for *pnp* devices). Trying this check with the emitter and collector leadouts will always produce a high resistance reading.

Once the base has been identified, the test circuit of Fig. 2 can be used to sort out the emitter and collector terminals. This test can easily be rigged up with the aid of a breadboard or crocodile clip leads. A resistance range having a midscale value in the region of a few hundred ohms is suitable. For an *npn* device the positive test lead is the one connected to the emitter if a low resistance is indicated, or to the collector if there is little deflection of the meter. The test will work with *pnp* types, but the positive test lead is then connected to the collector if a low resistance reading is obtained, or to the emitter if a high resistance is indicated.

Fig. 1. Leadout diagrams for three TO-92 devices.

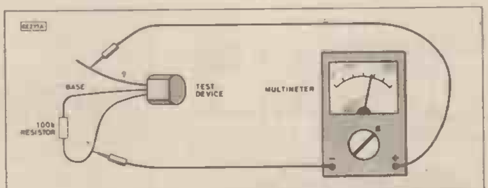


Fig. 2. Identifying the collector and emitter terminals. A low resistance reading indicates that the "+" is connected to the emitter and the "−" is connected to the collector. A high reading indicates the opposite.

POWER DEVICES

Power devices, be they transistors, triacs, thyristors, or even integrated circuits, differ physically from ordinary types not only in that they are bigger, but also in that they have a heat-tab of some kind which must be bolted to a heatsink. The latter is just a piece of metal which acts as a cooling fin and prevents the power device from being destroyed by overheating. The heatsink might just be a small type fitted on the circuit board, or it might be a large type mounted (say) on the rear panel of the case. Sometimes the cost of a special heatsink is avoided by utilising the metal case or chassis of the project as a heatsink.

The heat-tab of the component often has to be insulated from the heatsink as the two do not always have the same operating potential. This insulation is not invariably needed, and it certainly makes things much easier if it is not. Special insulation kits are available, but you must be careful to order the right type for the case style of the particular component you are using. Fig. 3 shows how an insulation kit is used. The mica washer (which is usually made of plastic these days) fits between the heatsink and the metal heat-tab of the component. The washer is very thin so that it does not greatly hinder the transfer of heat from the power device to the heatsink, but the heat transfer can be made more efficient by smearing silicon grease between the device and the washer. Use a large drill bit to remove jagged edges around the mounting hole which could pierce the mica washer.

The washer alone is not sufficient to insulate the device from the heatsink since the mounting nut and bolt will provide an electrical connection between the two. This is avoided by using a plastic bush which fits over the bolt and insulates it from the heatsink. The mounting hole in the heatsink must therefore be somewhat larger than the mounting bolt would normally require, as the larger diameter of the insulating bush has to be accommodated. Always use a continuity tester or a multimeter set to a high resistance range to check that the insulation is effective.

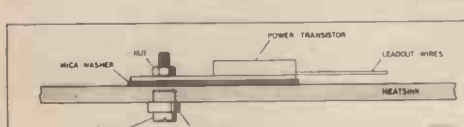


Fig. 3. Insulating a plastic power device from its heatsink.

PLASTIC POWER

Most modern power devices are of the so called "plastic power" type and have a single mounting hole. Some older types and very high power types have the all metal, diamond-shaped, TO-3 and (smaller) TO-66 encapsulations. These require a total of four mounting holes. Two of these take mounting bolts, and the other two take the emitter and base leadout wires, which are actually pins about 10 millimetres or so long on the underside of the device. The collector terminal is the metal case. Fig. 4 shows how these components are mounted, and this is basically the same as for plastic types. However, two insulating bushes and mounting bolts are required, and a soldertag is fitted on one of the bolts to provide a connection to the collector. □

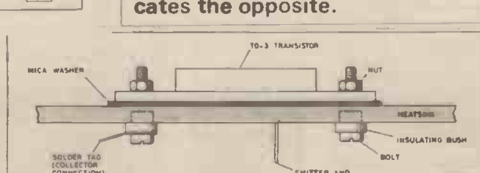


Fig. 4 (right). The mounting arrangement for TO-3 and TO-66 devices.

PCB SERVICE

Printed circuit boards for certain constructional projects are now available from the PCB Service, see list. These are fabricated in glass-fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to: The PCB Service, Everyday Electronics and Electronics Monthly Editorial Offices, Westover House, West Quay Road, Poole, Dorset BH15 1JG. Cheques should be crossed and made payable to IPC Magazines Ltd.

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COUNTER INTELLIGENCE

BY PAUL YOUNG

One for the Road

Never having reached the top echelons, or even the middle ones for that matter, and having to raise three expensive children, I have invariably been in the state they call impecunious.

As a result, I don't manage to swop my Deux Chevaux every time the ash trays are full, but usually after the mileometer has been right round the clock three times. Even then, it will be probably for a car about four years old.

All the same, there are advantages in not being able to afford the latest. I have avoided cars with lights flashing all over the dashboard and even worse, with built-in computers. Only recently I read of a man being driven mad by one. His Microchip mistress with an acid voice, tells him of non-existent faults, and forgets to report the real ones.

The visual display is as bad, within minutes of collecting his new vehicle it flashed up, "This car needs a service". Since then it has reported faulty brakes, failing lights and low oil pressure all of which turned out to be incorrect, but not a word about not releasing the handbrake, or doors not being closed. Now after ten trips to the dealer, he has had enough.

To be fair, I will admit, there are one or two inovations I welcome, such as non-reflecting glass over the dials, indicators (if they work properly) showing doors not completely shut, the delay on windscreen wipers and electronic ignition, both pioneered by magazines including Everyday Electronics.

Criminal Hackers

Some time ago, an American computer expert, using a home computer, managed to tap into the computer system of one of the big banks and transferred a million pounds into his own account in Switzerland. He then moved to Switzerland and commenced living in luxury.

The bank hadn't noticed it (I suppose the odd million is just tea money to them) and he was apparently completely in the clear. Unfortunately, he went back to America for a holiday and one day having run out of small change, found that all he had in his pockets were one or two large uncut diamonds that he had purchased quite legitimately. He went into a jewellers to try to sell them which aroused the jeweller's suspicions, he alerted the F.B.I. and now the poor man faces a long jail sentence.

This reminded me that during the war, aircrew were given various items to help them escape if they were shot down over enemy territory. Included in the escape kit was local currency but such was the brilliance of the planners, that the unfortunate airman concerned, when faced with this situation, found he had been given the equivalent in Deutch Marks of a five hundred pound note. What chance had he got of changing it and remaining inconspicous?

Arising out of this, I heard a story, apocryphal, but probably true of a Wing Commander in this position, who made good use of the money. He had a business in Berlin until the outbreak of hostilities, so when he suddenly appeared, it caused no comment. He decided to spend the money on new suits, watches, cameras, anything portable and when he was ready, buy a train ticket to neutral Switzerland, where he would have no difficulty in returning to the UK. On arrival here he would have been entitled to the Military Cross (given automatically to escapees). I think he deserved it for enterprise!

To return to the incorrect use of computers, I was alarmed to read that a group of American schoolboys had tapped into the Pentagon computer system and were able to alter the trajectory of American satellites. Surely if American schoolboys can do it so can unfriendly foreign powers?

I can imagine the super powers both re-routing each others infernal machines, each one trying to make the other score an "Own Goal". I do hope they get their co-ordinates right.

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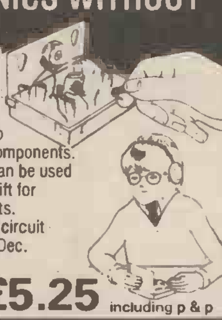

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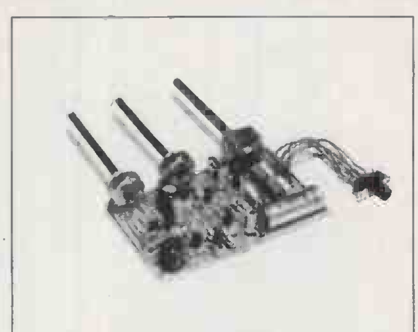

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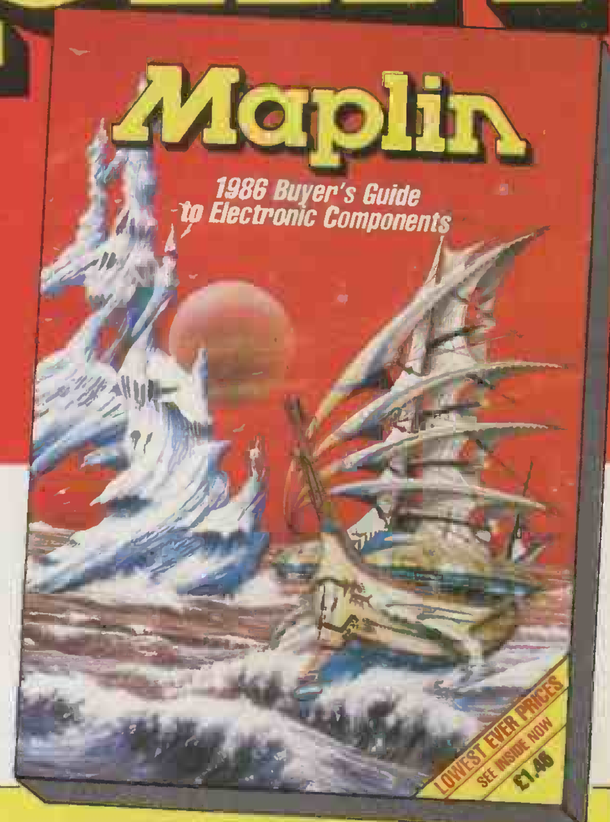

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IV