Easy to build projects for everyone

Everyday ELECTRONICS

OCT. 77

35p

A VALUABLE COMPANION

FREE!

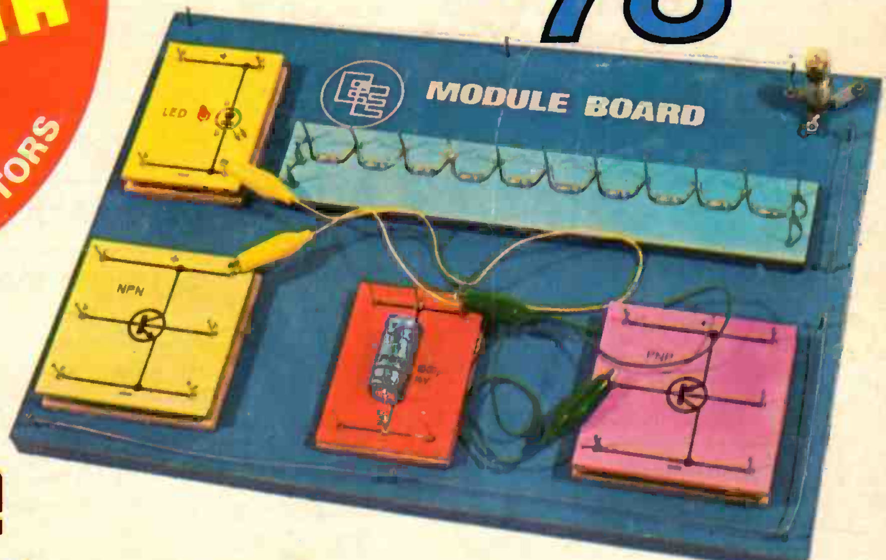
IN THIS ISSUE

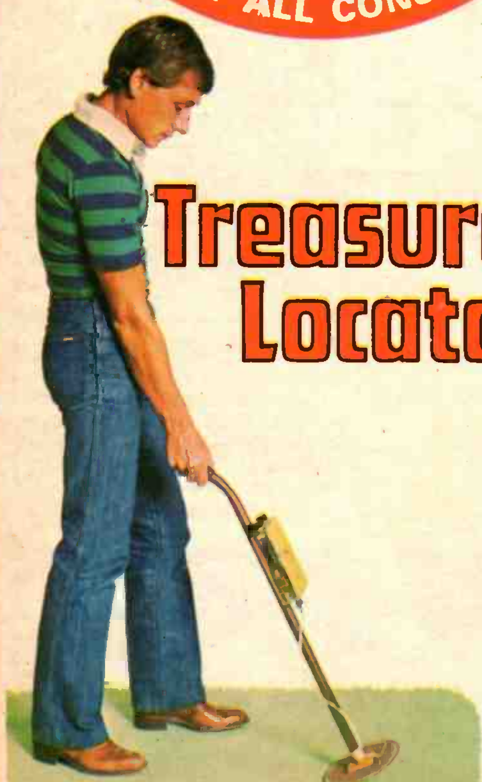
POCKET DATA CHART

FOR ALL CONSTRUCTORS

...Just starting!

Teach-in '78





Treasure Locator

Also...

ENLARGER TIMER

MODEL TRAIN CONTROLLER

TRANSISTOR TESTER

LEARN ELECTRONICS THIS SIMPLE WAY!

FOLLOW OUR 12 PART SERIES

SEMICONDUCTORS—COMPONENTS

BABANI BOOK OFFER

Purchase books to the value of £5·00 from the list below and choose any 60p pak from this page FREE.

BP2	Handbook of Radio, TV & Industrial & Transmitting Tube & Valve Equivalents	60p
BP3	Handbook of Tested Transistor Circuits	40p
BP6	Engineers and Machinists Reference Tables	40p
BP7	Radio & Electronic Colour Codes and Date Chart	15p
BP10	Modern Crystal and Transistor Set Circuits for Beginners	35p
BP14	Second Book of Transistor Equivalents	95p
BP15	Constructors Manual of Electronic Circuits for the Home	50p
BP16	Handbook of Electronic Circuits for the Amateur Photographer	60p
BP18	Boys and Beginners Book of Practical Radio & Electronics	60p
BP22	79 Electronic Novelty Circuits	75p
BP23	First Book of Practical Electronic Projects	75p
BP24	52 Projects Using IC741 (or equivalents)	75p
BP26	Radio Antenna Handbook for Long Distance Reception and Transmission	85p
BP27	Giant Chart of Radio Electronic Semiconductor and Logic Symbols	60p
BP29	Major Solid State Audio Hi-Fi Construction Projects	85p
BP32	How to Build Your Own Metal & Treasure Locators	85p
BP34	Practical Repair & Renovation of Colour TVs	95p
BP35	Handbook of IC Audio Preamplifier & Power Amplifier Construction	95p
BP36	50 Circuits Using Germanium, Silicon and Zener Diodes	75p
BP37	50 Projects Using Relays, SCR's and TRIACS	1·10p
BP39	50 (FET) Field Effect Transistor Projects	1·25p
129	Universal Gram-motor Speed Indicator	08p
160	Coil Design and Construction Manual	50p
161	Radio, TV and Electronics Data Book	60p
196	AF-RF Reactance—Frequency Chart for Constructors	15p
202	Handbook of Integrated Circuits (ICs) Equivalents and Substitutes	75p
205	First Book of Hi-Fi Loudspeaker Enclosures	60p
213	Electronic Circuits for Model Railways	85p
214	Audio Enthusiasts Handbook	85p
216	Electronic Gadgets and Games	85p
217	Solid State Power Supply Handbook	85p
219	Solid State Novelty Projects	85p
220	Build Your Own Solid State Hi-Fi And Audio Accessories	85p
222	Solid State Short Wave Receivers for Beginners	95p
223	50 Projects Usins IC CA3130	95p
224	50 CMOS IC Projects	95p
225	A Practical Introduction to Digital IC's	95p
226	How to Build Advanced Short Wave Receivers	1·20p
RCC	Resistor Colour Code Disc Calculator	10p

THYRISTORS

600mA TO18 CASE

Volts	No	Price
10	THY600/10	£0·15
20	THY600/20	£0·16
30	THY600/30	£0·20
50	THY600/50	£0·22
100	THY600/100	£0·25
200	THY600/200	£0·38
400	THY600/400	£0·44

1 AMP TO5 CASE

Volts	No.	Price
50	THY1A/50	£0·26
100	THY1A/100	£0·28
200	THY1A/200	£0·32
400	THY1A/400	£0·36
600	THY1A/600	£0·45
800	THY1A/800	£0·58

3 AMP TO66 CASE

Volts	No.	Price
50	THY3A/50	£0·28
100	THY3A/100	£0·30
200	THY3A/200	£0·33
400	THY3A/400	£0·42
600	THY3A/600	£0·50
800	THY3A/800	£0·65

5 AMP TO66 CASE

Volts	No.	Price
50	THY5A/50	£0·36
100	THY5A/100	£0·46
200	THY5A/200	£0·50
400	THY5A/400	£0·57
600	THY5A/500	£0·69
800	THY5A/800	£0·81

5 AMP TO220 CASE

Volts	No.	Price
400	THY5A/400P	£0·57
600	THY5A/600P	£0·69
800	THY5A/800P	£0·81

7 AMP TO48 CASE

Volts	No.	Price
50	THY7A/50	£0·48
100	THY7A/100	£0·51
200	THY7A/200	£0·57
400	THY7A/400	£0·62
600	THY7A/600	£0·78
800	THY7A/800	£0·92

10 AMP TO48 CASE

Volta	Nol	Price
50	THY10A/50	£0·51
100	THY10A/100	£0·57
200	THY10A/200	£0·62
400	THY10A/400	£0·71
600	THY10A/500	£0·99
800	THY10A/800	£2·22

16 AMP TO48 CASE

Volts	No.	Price
50	THY16A/50	£0·54
100	THY16A/100	£0·58
200	THY16A/200	£0·62
400	THY16A/400	£0·77
600	THY16A/600	£0·90
800	THY16A/800	£1·30

30 AMP TO94 CASE

Volts	No.	Price
50	THY30A/50	£1·18
100	THY30A/100	£1·43
200	THY30A/200	£1·63
400	THY30A/400	£1·79
600	THY30A/600	£3·50

No.	Price
BT101/500R	£0·80
BT102/500R	£0·80
BT106	£1·25
BT107	£0·93
BT108	£0·98
2N3228	£0·70
2N3525	£0·77
BTX30/50L	£0·33
BTX30/400L	£0·46
C106/4	£0·60

ORDERING

PLEASE WORD YOUR ORDERS EXACTLY AS PRINTED. NOT FORGETTING TO INCLUDE OUR PART NUMBER

VAT

ADD 12½% TO PRICES MARKED* ADD 8% OT OTHERS EXCEPTING THOSE MARKED † THESE ARE ZERO RATED.

POSTAGE AND PACKING

Add 25p for postage and packing unless otherwise shown. Add extra for airmail. Min. order £1.

SUPER UNTESTED PAKS

Pak No.	Qty.		Order No.	Price
U50	100	Germ gold bonded OA47 diode	16130	£0·60
U51	150	Germ OA70/81 diode	16131	£0·60
U52	100	Silicon diodes 200mA OA200	16132	£0·60
U53	150	Diodes 75mA 1N4148	15133	£0·80
U54	50	Sil rect top hat 750mA	16134	£0·60
U55	20	Sil rect stud type 3 amp	16135	£0·60
U56	50	400mW zeners D O7 case	16136	£0·60
U57	30	NPN trans BC107/8 plastic	16137	*£0·60
U58	30	PNP trans BC177/178 plastic	16138	*£0·60
U59	25	NPN TO39 2N697/2N1711 silicon	16139	£0·60
U60	25	PNP TO59 2N2905 silicon	16140	£0·60
U61	30	NPN TO18 2N706 silicon	16141	£0·60
U62	25	NPN BFY50/51	16142	£0·60
U63	30	NPN plastic 2N3906 silicon	16143	*£0·60
U64	30	PNP plastic 2N3905 silicon	16144	*£0·60
U65	30	Germ 0071 PNP	16145	£0·60
U66	15	Plastic power 2N3055 NPN	16146	£1·20
U67	10	TO3 metal 2N3055 NPN	16147	£1·20
U68	20	Unijunction trans TIS43	16148	£0·60
U69	10	1 amp SCR TO39	14149	£1·20
U70	8	3 amp SCR TO66 case	16150	£1·20

Code Nos. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

COMPONENT PAKS

Pak No.	Qty.		Order No.	
C1	200	Resistor mixed value approx. (count by weight)	16164	*£0·60
C2	150	Capacitors mixed value approx. (count by weight)	16165	*£0·60
C3	50	Precision resistors. Mixed values	16166	£·060
C4	80	⅛W resistors mixed preferred values	16167	*£0·60
C5	5	Pieces assorted ferrite rods	16168	*£0·60
C6	2	Tuning gangs. MW/1W VHF	16169	*£0·60
C7	1	Pack wire 50 metres assorted colours single strand	16170	£0·60
C8	10	Reed switches	16171	*£0·60
C9	3	Micro switches	16172	*£0·60
C10	15	Assorted pots	16173	*£0·60
C11	5	Metal jack sockets 3 × 3·5mm 2 × standard switch types	16174	*£0·60
C12	30	Paper condensers preferred types mixed values	16175	*£0·60
C13	20	Electrolytics trans. types	16176	*£0·60
C14	1	Pak assorted hardware—nuts/bolts, gromets, etc.	16177	£0·60
C15	5	Mains slide switches ass.	16178	*£0·60
C16	20	Assorted tag strips and panels	16179	£0·60
C17	15	Assorted control knobs	16180	*£0·60
C18	4	Rotary wave change switches	16181	*£0·60
C19	2	Relays 6-24V operating	16182	*£0·60
C20	1	Pak. copper laminate approx 200 sq. in	16183	£0·60
C21	15	Assorted fuses 100mA-5 amp	16184	£0·60
C22	50	Metres PVC sleeving assorted size and colour	16185	£0·60
C23	60	½ watt resistors mixed preferred values	16168	*£0·60
C24	25	Presets assorted type and value	16186	*£0·60
C25	30	Metres stranded wire assorted colours	16187	£0·60

SLIDER PAKS

Pak No.	Qty.		Order No.	Price
S1	6	Slider potentiometers, mixed values	16190	*£0·60
S2	6	Slider potentiometers. all 470 ohms	16191	*£0·60
S3	6	Slider potentiometers. all 10k Ω lin	16192	*£0·60
S4	6	Slider potentiometers. all 22k Ω lin	16193	*£0·60
S5	6	Slider potentiometers. all 47k Ω lin	16194	*£0·60
S6	6	Slider potentiometers. all 47k Ω log	16195	*£0·80

CERAMIC PAK

Containing a range of first quality miniature ceramic capacitors. Unrepeatable value.

Pak No.	Qty.		Order No.	Price
MC1	24	miniature ceramic capacitors 3 of each value—22pF. 27pF 33pF, 39pF, 47pF, 68pF and 82pF	16160	*£0·60
MC2	24	miniature ceramic capacitors 3 of each value—100pF, 120pF 150pF, 180pF, 120pF, 270pF. 330pF, and 390pF	16161	*£0·60
MC3	24	miniature ceramic capacitors. 3 of each value—470pF, 560pF. 680pF, 820pF 1,000pF, 1,500pF. 2,200pF and 3,300pF	16162	*£0·60
MC4	21	miniature ceramic capacitors. 3 of each value—4,700pF, 6,800pF. 0·01µF, 0.015µF, 0·022µF 0·033µF and 0·045µF.	16163	*£0·60

Just a selection from our huge stocks

SEE OUR 1977 CATALOGUE

126 pages packed with valuable information

ORDER NOW ONLY 50p
plus 15p p. & p.

LINEAR PAKS

Manufacturer's "Fall Outs" which include Functional and part-Functional Units. These are classed as "out-of-spec" from the maker's very rigid specifications, but are ideal for learning about ICs and experimental work.

U721—30 Assorted Linear Types 709, 741, 747, 748, 710, 588, etc.
ORDER No. 16227 — *£1·50

U76SD FM STEREO DECODER
5 ICs 76110 equivalent to MC1310P-MA767. Data supplied with pak.
ORDER No. 16229 — *£1·50

U76A AUDIO POWER OUTPUT AMPLIFIERS
8 assorted types. SL403. 76013, 76003, etc. Data supplied with pak.
ORDER No. 16228 — *£1·00

74 SERIES PAKS

Manufacturer's "Fall Outs" which include Functional and part-Functional Units. These are classed as "out-of-spec" from the maker's very rigid specifications, but are ideal for learning about ICs and experimental work.

74G—100 Gates assorted 7400-01-04-10-50-60, etc.
ORDER No. 16224 — £1·20

74F—50 Flip-Floops assorted 7470-72-73-74-76-104-109, etc.
ORDER No. 16225 — £1·20

74M—30 MSI. Assorted Types. 7441-47-90-154. etc.
ORDER No. 16226 — £1·20

VEROBOARDS PAKS

VB1—Approx. 30sq. in various sizes. All 0·1in matrix.
ORDER No. 16199 — 60p

VB2—Approx. 30sq.in various sizes. 0·15in matrix.
ORDER No. 16200 — 60p

ELECTROLYTIC PAKS

A range of paks each containing 18 first quality. mixed value miniature electrolytics.

EC1—Values from 0·47mF to 10mF
ORDER No. 16201 — *60p

EC2—Values from 10mF to 100mF
ORDER No. 16202 — *60p

EC3—Values from 100mF to 680mF
ORDER No. 16203 — *60p

C280 CAPACITOR PAK

75 Mullard C280 capacitors mixed values ranging from 0·01µF to 2·2µF complete with identification sheet
ORDER No. 16204 — *£1·20

CARBON RESISTOR PAKS

These paks contain a range of Carbon Resistors, assorted into the following groups

R1—60 mixed ¼ W 100–820 ohms
ORDER No. 16213 — *60p

R2—60 mixed ¼ W 1–8 2kΩ
ORDER No. 16214 — *60p

R3—60 mixed ¼ W 10–82kΩ
ORDER No. 16215 — *60p

R4—60 mixed ¼ W 100–820kΩ
ORDER No. 16216 — *60p

R5—40 mixed ½ W 100–820Ω
ORDER No. 16217 — *60p

R6—40 mixed ½W 1–8·2kΩ
ORDER No. 16218 — *60p

R7–40 mixed ½ W 10–82kΩ
ORDER No. 16219 — *60p

R8—40 mixed ½ W 100–820kΩ
ORDER No. 16220 — *60p

R9—60 mixed ¼ W 1–10MΩ
ORDER No. 16230 — *60p

R10—40 mixed ½ W 1–10MΩ
ORDER No. 16231 — *60p

E.E. TEACH-IN-KIT

BI-PAK OFFER YOU A FULL KIT OF PARTS (LESS BATTERIES) WHICH WILL ENABLE YOU, SUCCESSFULLY, TO COMPLETE ALL THE PROJECTS IN THIS COURSE.
ONLY £11·50 incl. V.A.T. & P.P.

BI-PAK

Dept. EE10, P.O. Box 6, Ware, Herts

SHOP AT 18 BALDOCK ST., WARE, HERTS.
OPEN 9 to 5.30 Mon/Sat.

NEW

BEGINNER'S GUIDE TO RADIO

GORDON J. KING – 8th Edition

- Introduces the reader in easy step-by-step stages to all aspects of radio technology, from simple electromagnetic theory to the full range of radio components and circuits.
- Completely rewritten and updated, the 8th edition contains all the latest developments in radio technology.
- Written in a non-technical style with a minimum of mathematics, this new edition will develop the reader's knowledge and interest, and enable him to use radio equipment with confidence and skill.

CONTENTS: Electricity and magnetism. Radio signals. Signal propagation and reception. Transmitter principles. Receiver principles. Radio components. Valves, solid-state devices and transistors. Integrated circuits. Microphone, pickup and loudspeaker. Modern radio receivers. Index.

Sept. 1977 240 pages £2.75

ANOTHER RECENT TITLE

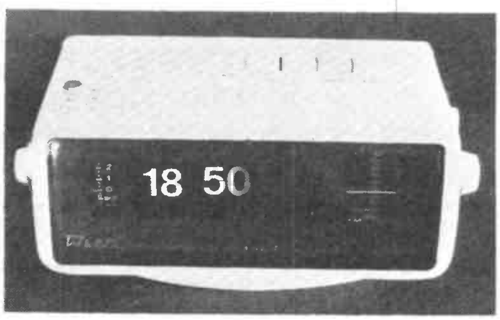
Beginner's Guide to Integrated Circuits
I. R. Sinclair

CONTENTS: What is an Integrated Circuit? Production of i.c.s., Simple Voltage Amplifier i.c.s. Simple Digital i.c.s., MOS i.c.s., Domestic Uses of i.c.s. Other Specialised i.c.s., Practical Construction, Index.

1977 192 pages £2.75

Order NOW from
NEWNES TECHNICAL BOOKS
Borough Green, Sevenoaks, Kent TN15 8PH

SPECIAL OFFER FOR READERS



£18·50 inc VAT + £1·45 p. & p. & i.

- AM/FM Radio Alarm Clock (AC 220-240V only)
- 24-Hour Clock
- High quality white abs case
- Push-button mode selection
- Sleep delay control
- Illuminated clock and radio scale
- Alarm with buzzer and/or music
- All chrome control knobs
- Complies with BS415, (1972) safety requirements
- Each unit fully inspected before despatch
- Guaranteed for one year

Please send cheque or postal order to:

D. & D. POWER SUPPLY CO. LTD.
79 LOWFIELD STREET, DARTFORD, KENT
Please allow 10–14 days for delivery
Callers welcome Monday–Friday 9–5, Saturday 9–1.

CRESCENT RADIO LTD.

164-166 HIGH ROAD LONDON N22 6EJ 888-3206
(also) 13 SOUTH MALL, Edmonton, N.9 803-1685
MAIL ORDER DEPT. 1 St Michaels Terrace Wood Green London N22 4SJ Phone 888-4474

POWER PACKS

PP1 Switched 3, 4½, 6, 7½, 9 and 12 volt @ 500 m/a. with on/off switch and pilot light. Size = 130 mm × 55 mm × 75 mm. ONLY = £6·00 + 8% VAT.

T1 MULTI-METER

Ideal tester for everybody interested in electronics. Weighing less than 100 grammes and only 60mm × 24mm × 90mm. Ranges: AC volts: 0-10v, 50v, 250v, 1,000v, D.C. volts: 0-10v, 50v, 250v, 1,000v. DC current: 0-1m/a, 0-100m/a. Resistance: 0·150K ohm.
PRICE £5·80 + 8% VAT.

"C100" 100 WATT AMPLIFIER

All built and tested, mounted on a plain aluminium chassis which measures 18" × 9½" × 4" and which you can mount into a cabinet of your choice. Four Controlled Inputs, Master Volume, Treble, Middle and Bass Controls. S/C protected output. 100 watts clean into 8ohm L/S. Ideal for Disco, Music, Groups, PA and Clubs. A Bargain at £52·50 + 8% VAT.

FERRIC CHLORIDE

Anhydrous ferric chloride in double sealed one pound Poly packs.
OUR PRICE—£1·25 + 8% per lb.

ABS PLASTIC BOXES

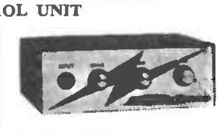
Handy boxes for construction projects. Moulded extrusion rails for P.C. or chassis panels. Fitted with 1mm front panels.

1005 = 105mm × 73mm × 45mm = 82p
1006 = 150mm × 74mm × 47mm = £1·00
1007 = 185mm × 124mm × 60mm = £2·20
1022 = 107mm × 85mm × 45mm = 82p
(sloping front) Plus 8% VAT

PIEZO ELECTRIC HORN UNITS

New High Quality High Power Tweeter. No form of crossover network is required as low frequency voltages simply have no effect on the Tweeter.
Specification:
Frequency Response: 3·8KHz to 28KHz ±3db. (Input 4V rms Pink Noise—Output 105db) Max. continuous RMS Input Voltage: 25V.
Minimum Series Resistor: 10 ohm at 1W.
Weight: 63 gm. (2·25 oz.).
Panel Cut Out: 76mm dia. (3in).
Size: 85mm × 85mm × 75mm.
Rating: Depending on connections up to 100W approx.
Price: £9·35 + 8% VAT.

3 K'WATTS PSYCHEDELIC LIGHT CONTROL UNIT



Three Channel Bass, Middle, Treble. Each channel has its own sensitivity control. Just connect the input of this unit to the loudspeaker terminals of an amplifier and connect three 250V up to 1000W lamps to the output terminals of the unit, and you produce a fascinating sound-light display. (All guaranteed).
£20·00 + 8% VAT.

MINI LOUDSPEAKERS

2½" 80 ohm £1·10
2½" 40 ohm £1·10 } +12½% VAT
2½" 8 ohm £1·10

BARGAIN PROJECT BOX

A plastic box with moulded extrusion rails for PC or Chassis panels with metal front plate fitted with four screws (all supplied). SIZE (internal) 81mm × 51mm × 28mm
OUR PRICE 70p + 8% VAT

ALL PRICES INCLUDE POSTAGE

All prices are excluding VAT. Please add to each item the VAT rate indicated to all orders

ACCESS AND BARCLAYCARD ACCEPTED

Projects... Theory...

and Popular Features...

Autumn is always a landmark in the constructor's year. For most enthusiasts it is the time when activity starts in earnest again after a lull during the summer months.

This particular autumn has a further significance as it sees the start of our latest *Teach-In* series. As our regular readers will know, *Teach-In* has become an established tutorial feature that appears in our calendar every other year. Following the traditional pattern *Teach-In '78* will run for 12 to 14 months taking the newcomer through the elementary stages of electronics theory right up to fully functional transistor circuits. This series offers more than mere textbook treatment of the subject, for it is orientated very definitely towards practical matters and is planned around exercises to be performed using a Module Board and Building Blocks designed specially for this series.

Another important fact is that *Teach-In* makes no great demands upon the pocket. Most important of all it provides a gateway into this exhilarating field of electronics for newcomers of all ages.

This month's projects are headed by a new version of the ever-popular metal detector, or *Treasure Locator*—to give it its more evocative title. This electronic instrument has of course many other useful, if more prosaic, applications than, say, beachcombing. For example, it could be of inestimable value to the handyman in locating the routes of hidden pipes or electrical wiring.

Then we have two projects each catering for quite different areas of specialist interest. Photography is one; this is a highly popular pastime and we are sure many amateur photographers who make their own prints will be interested in the *Enlarger Timer*.

The other is, by comparison, a minority interest, nevertheless model railway enthusiasts get a fair crack of the whip in our pages (as indeed do all specialist interests whenever electronics has something helpful to offer). Our *Model Train Controller* provides a power supply with a "constant voltage" characteristic. The advantages of this, especially for slow speed running, will be immediately appreciated by those who operate model railway systems.

And to complete this month's collection of projects we offer the *Transistor Tester* as a valuable piece of test gear for the constructor's own private use.

On top of all this there is an additional bonus for our readers, in the form of a Pocket Data Card, included with every copy of this month's E.E.

So now we should all be set for the exciting and busy season that lies ahead.

Fred Bennett

Our November issue will be published on Friday, October 21. See page 75 for details.

Readers' Enquiries

We cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. All letters requiring a personal reply should be accompanied by a stamped self-addressed envelope.

Telephone enquiries should be limited to those requiring only a brief reply. We cannot undertake to engage in discussions on the telephone, technical or otherwise.

Component Supplies

Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.

Everyday ELECTRONICS

VOL. 7 NO. 2 OCTOBER 1977

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

As from next month the cover price of Everyday Electronics will be 40p. We regret the need for this increase which is due to rising production costs.

Back Number Service and Binders

Back issues of EVERYDAY ELECTRONICS (June 1977 onwards) are available worldwide at a cost of 60p per copy inclusive of postage and packing. Orders and remittance should be sent to: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF.

Binders for Volumes 1 to 6 (state which) are available from the above address for £2·10 inclusive of postage and packing.

TREASURE LOCATOR

INTRODUCTION

METAL or treasure detectors may use pulse induction, induction balance, or beat frequency oscillator (b.f.o.) methods of operation. Pulse induction devices require the radiation and reception of a pulsed signal, while induction balance detectors require two coils, so arranged that the field is neutralised until a metal object is present. As both these systems introduce complications and difficulties for home construction, which are absent in the beat frequency locator, the latter method is used here.

Beat frequency metal detectors are popular and are employed in great numbers. They have the advantage that the only adjustment required is to the frequencies of the oscillators.

A b.f.o. metal detector can be constructed at much less cost than that of a similar commercially available detector, and its performance is identical to that of the same type of ready-made instrument. Building has been arranged to be as simple as possible, as difficult constructional details contribute nothing whatever to the ability of the instrument to locate metal objects.

START HERE FOR CONSTRUCTION

COMPONENTS

Capacitor values in the oscillator circuits are important. These include C1, C2, C3, C4 and C8 in particular. Here, precision values, such as 1 or 2 per cent silver mica, are recommended. Values elsewhere are not too important. As example, C6 and C10 may be 18pF, and C12, 50nF.

The speaker unit should not be less than 8 ohms, and types of 8 to 35 ohms will be found satisfactory. Headphones may be of somewhat higher impedance than this, if to hand.

CIRCUIT BOARD

Most of the components are assembled on a piece of 0·15 inch matrix board, see Fig. 1. Drill holes for C2, and bolts to hold the bracket for L2 and to secure the board when it is completed. In most places the wire ends of resistors and capacitors are long enough to reach the various points necessary. Note the polarity of C13 and C15, and the two diodes (which may be any similar general purpose detector types).

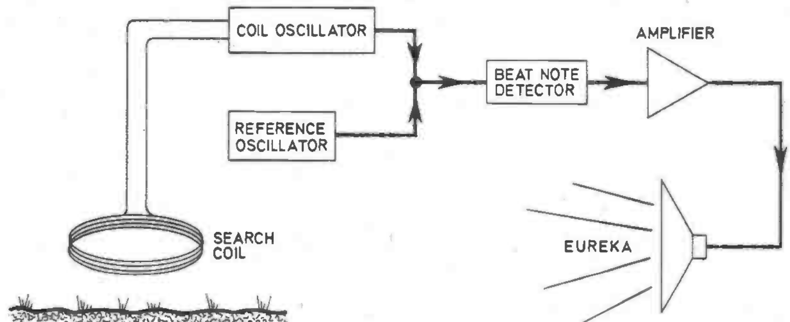
Pins can be inserted for the external leads, or long connections can be left for these. Fix L2 a little clear of the board.

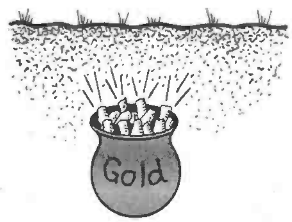
The case is a plastic box about 180×115×40mm Fig. 3. The circuit board, speaker and battery holder can be fixed directly to the case or to a piece of thin hardboard cut to fit inside it. Use spacers or extra nuts to raise the circuit board about 5mm above the case. An aperture, or a grille of 5mm holes, is made to match up with the speaker. Holes are required for the two sockets SK1 and SK2 (for L1), and for C16, VR1 and the phone socket, SK1 as shown.

Boxes of the kind used are generally of a quite strong but brittle material. Holes must be made with a sharp drill, without too much pressure. These can be enlarged with a round file where necessary. Without care, the box may be cracked when making holes.

HANDLE

The handle is about 82cm long, so that the search coil can be swept over the ground while walking. It was made from 25mm





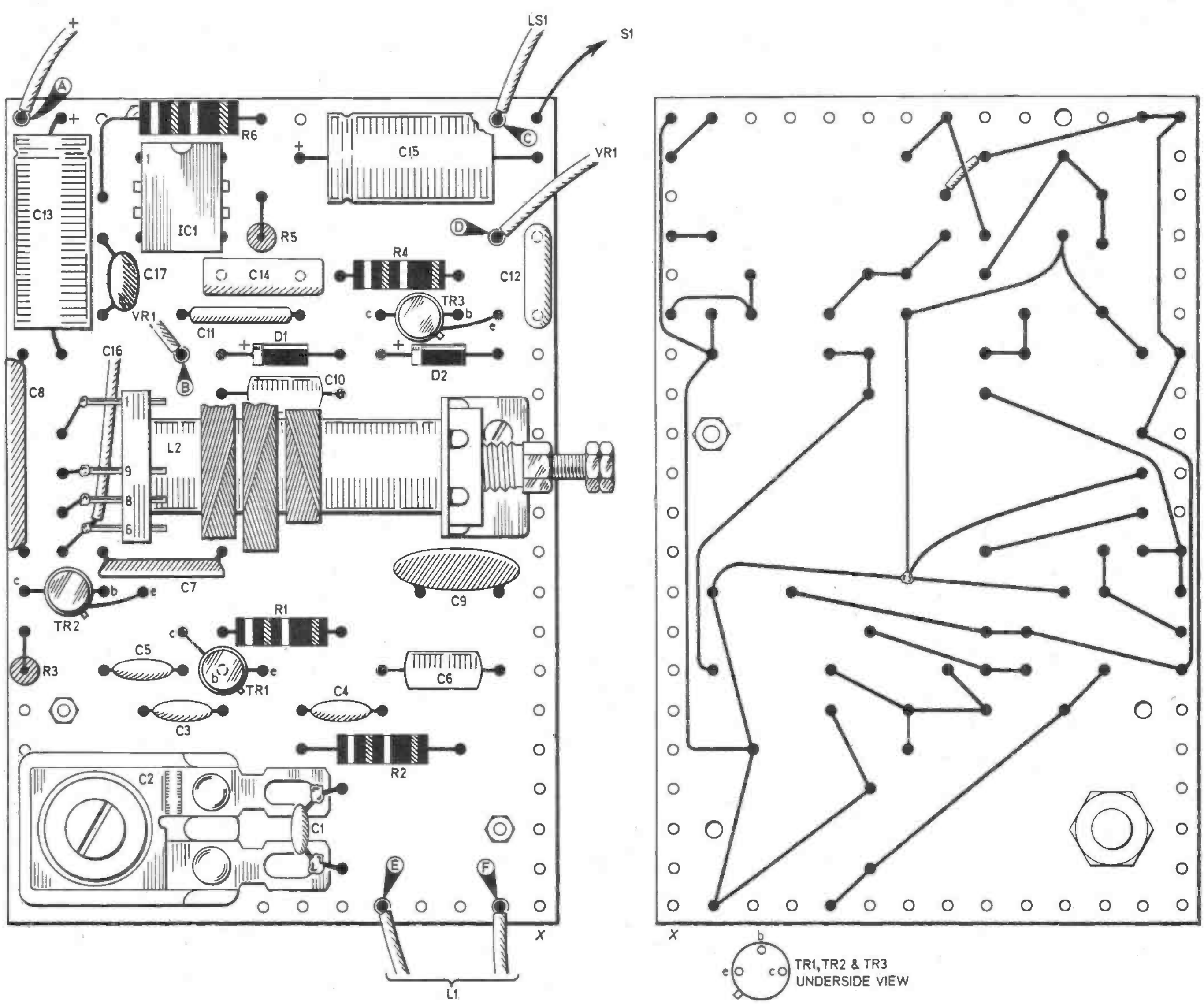
HOW IT WORKS...

The Treasure Locator incorporates two oscillators, an adjustable reference oscillator (approximately 5 per cent about 100 kilohertz) and the coil oscillator designed to operate within the same range, but whose frequency is dependent on the inductance of the search coil.

In the absence of any metal in the vicinity of the coil, the reference oscillator is set to be almost equal to the coil oscillator frequency. If now the coil is placed near to a metal object, the presence of the latter causes the inductance of the coil to alter which results in a change in frequency of the coil oscillator.

The outputs from the two oscillators are taken to a "detector" whose function is to produce an output signal with a frequency proportional to the difference in frequency of the two oscillators. The resulting signal is coupled to an amplification stage and is heard in the loudspeaker.

Fig. 1. The layout of the components on the topside of the matrix-board and wiring details on underside.



CIRCUIT DESCRIPTION

The complete circuit diagram of the Treasure Locator is shown in Fig. 2 and can be seen to consist of four distinct sections: (1) search coil oscillator; (2) the reference oscillator; (3) heterodyne detector; (4) audio amplifier.

SEARCH COIL OSCILLATOR

The search coil oscillator consists of TR1 and local components and is a Colpitt's type oscillator. A parallel resonant circuit is formed by components L1, C1, C2, C3 and C4 and their values determine the frequency of oscillation. Under the influence of a step function or pulse as results when the unit is switched on, the resonant circuit will begin to oscillate sinusoidally with exponentionally decaying amplitude. In our circuit this waveform is fed to the base of TR1.

Now the signal appearing at the emitter is fed back, in phase, to the resonant circuit and reinforces the generated waveform resulting in a sustained oscillation of constant frequency and amplitude. Trimmer C2 allows some frequency adjustment to compensate for slight changes in L1 as made.

The search coil L1 has a Faraday shield, helpful in reducing ground effects. This is recommended, but as some locators have an unshielded coil which is easier to make, alternative coils are described, see later.

REFERENCE OSCILLATOR

The reference oscillator comprises TR2 and local components, to produce a tuned-collector type oscillator. The parallel resonant circuit, L2 and C8 form the collector load of TR2. At switch on a decaying sinusoidal oscillation results across the resonant circuit (as in the search coil oscillator).

The signal appearing in the collector load is induced in the smaller secondary winding of L2 and this is fed to the base of TR2 via capacitor C7. The phase is arranged so that the result of the fed back signal is to produce an in-phase signal in the load thereby reinforcing the oscillations in the resonant circuit resulting in sustained oscillations of constant amplitude and frequency.

Values of L2 and C8 are chosen to produce oscillations within the range 95 to 105 kilohertz (allowing for component tolerance). By fitting a one per cent value for C8 and using the specified coil, it can thus be assured that working will be on a frequency approved for such apparatus. Variable capacitor C16 is included to allow the frequency of this oscillator to be finely tuned. Adjustment of this component is discussed later.

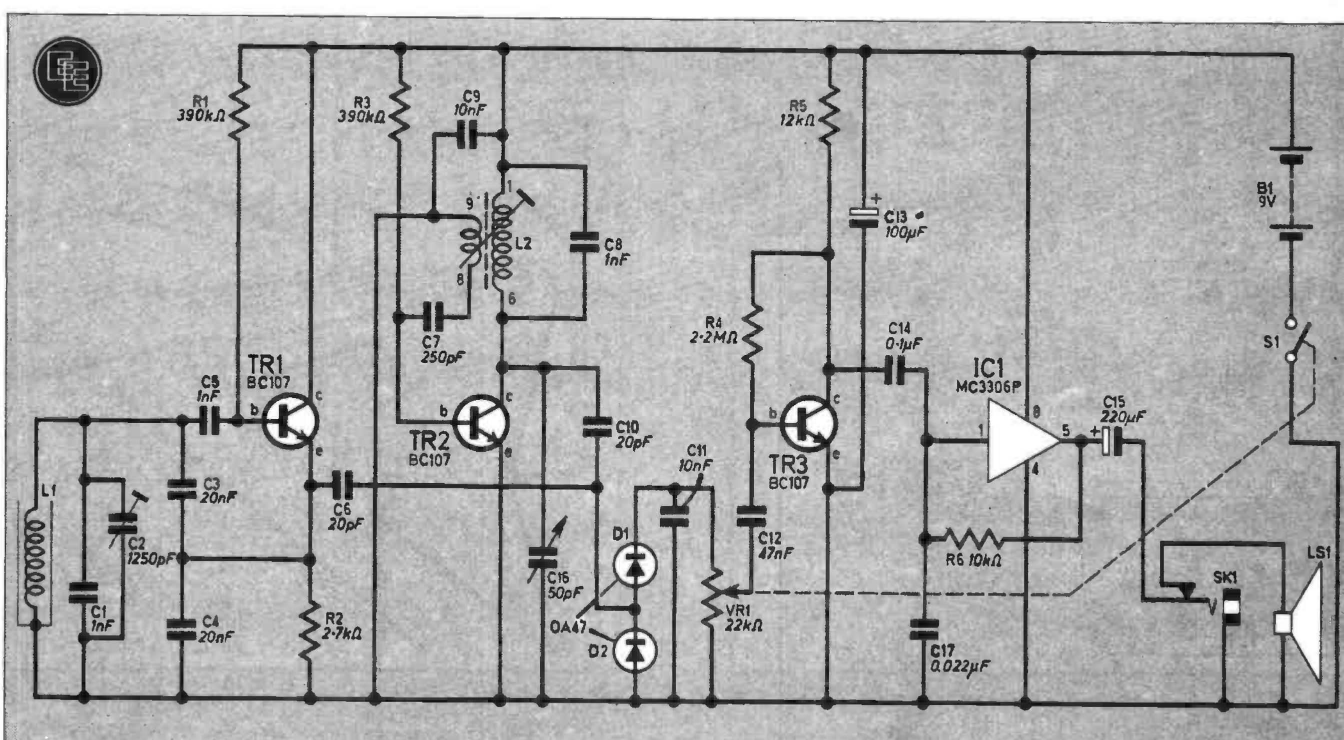
HETERODYNE DETECTOR

The two signal from the oscillators are mixed via capacitors C6 and C10 to produce a composite signal, composed of the sum and difference (and harmonics) of the two input frequencies. This is then detected and smoothed by D1 and C11 to produce only the difference signal. This is then made available across potentiometer VR1 wired to function as a volume control.

Diode D2 holds (clamps) the negative excursion of the difference signal at 200mV (with respect to the negative line).

When the two oscillators are operating on the same frequency (say 95kHz) no difference signal results. The presence of metal within the field of the search coil L1 changes the frequency of this oscillator and a "heterodyne" signal is produced at the wiper of VR1.

Fig. 2. The complete circuit diagram of the Treasure Locator.



AUDIO AMPLIFIER

Transistor TR3 functions as a common emitter type preamplifier to raise the level of the signal, and its output is coupled to IC1 by C14. This i.c. has driver and push-pull stages and easily gives enough volume with the small speaker incorporated, while being economical in battery current.

As the use of headphones will often be preferred to avoid being a nuisance to others, a switched jack socket SK1 has been included which accommodates these and at the same time disconnects the speaker from the circuit.

diameter plastic pipe, as used for plumbing. The top can be curved by heating the pipe in hot water. A cycle handlebar grip is cemented on here.

The case is fitted about 28cm from the top of the handle, by self-tapping screws through it and into the handle. A satisfactory handle could be made from a broomstick.

SEARCH COIL

The search coil assembly has a projecting dowel, which fits into the bottom of the plastic tube. If a broomstick were used instead, a hole to take the end of this can be made in the middle of the coil. As mentioned, a coil with a Faraday shield is recommended, though it is not quite so easily made as the unshielded coil.

Plain Coil

If tools are available, cut a disc of wood 17cm in diameter and about 10 to 12mm thick, and cut a slot 3mm wide and 3mm deep in this, as shown in Fig. 4. Alternatively, saw three discs of 3mm hardboard, two 17cm in diameter, and one 16·5cm in diameter. Clean up the edges with glasspaper and cement them together, placing the smaller disc between the two others. Provide a dowel stub or hole to suit the handle, and varnish the wood.

The winding is twenty two turns of 32 s.w.g. enamelled copper wire, in the slot. Bring the ends up to the top of the coil, and secure them with small screws or a tagstrip. Stouter leads are soldered on here, to run up the

OPERATING LICENCE

You are required to obtain a licence to operate this *Treasure Locator* in the British Isles.

The circuit shown has been designed to operate within the frequency band specified by the Home Office i.e. 16 to 150 kilohertz, and no alterations should be made to the published design that might alter the operating frequency.

An application form for the licence may be obtained from: The Home Office, Radio Regulatory Department, Waterloo Bridge House, Waterloo Road, London SE1. The cost of the licence is £1·20 for a five year period.

COMPONENTS

See Shop Talk page 67

Resistors

R1	390kΩ
R2	2·7kΩ
R3	390kΩ
R4	2·2MΩ
R5	12kΩ
R6	10kΩ

All ¼W carbon ± 5%

Potentiometer

VR1/S1	22kΩ log. with switch

Capacitors

C1	1nF silver mica 1 or 2%, or polyester 1%
C2	1250pF compression preset trimmer
C3	20nF silver mica 1 or 2%, or polyester 1%
C4	20nF silver mica 1 or 2%, or polyester 1%
C5	1nF plastic or ceramic
C6	20pF plastic or ceramic
C7	250pF plastic or ceramic
C8	1nF silver mica 1 or 2%, or polyester 1%
C9	10nF plastic or ceramic
C10	20pF plastic or ceramic
C11	10nF plastic or ceramic
C12	47nF plastic or ceramic
C13	100μF 10V elect.
C14	100nF plastic or ceramic
C15	10nF plastic or ceramic
C15	220μF 10V elect.
C16	50pF variable trimmer air-spaced Jackson type 804

Semiconductors

TR1	BC107 silicon *npn*
TR2	BC107 silicon *npn*
TR3	BC107 silicon *npn*
IC1	MC3306P 250mW audio amplifier
D1	OA47 or similar germanium diode
D2	OA47 or similar germanium diode

Miscellaneous

LS1	8 to 35 ohm approximately 60mm diameter
SK1, 2	Wander socket (2 off)
SK3	3·5mm switched jack socket
PL1, 2	Wander plugs (2 off)
B1	9V PP6
L1	see text
L2	Denco Range 1 valve type "blue"

Plain matrix board size 0·15inch matrix, 14 × 21 holes; battery connector; knobs (2 off); plastics case; materials for handle; 32 s.w.g. enamelled copper wire; three-core mains lead; aluminium foil; wire, solder.

TREASURE LOCATOR

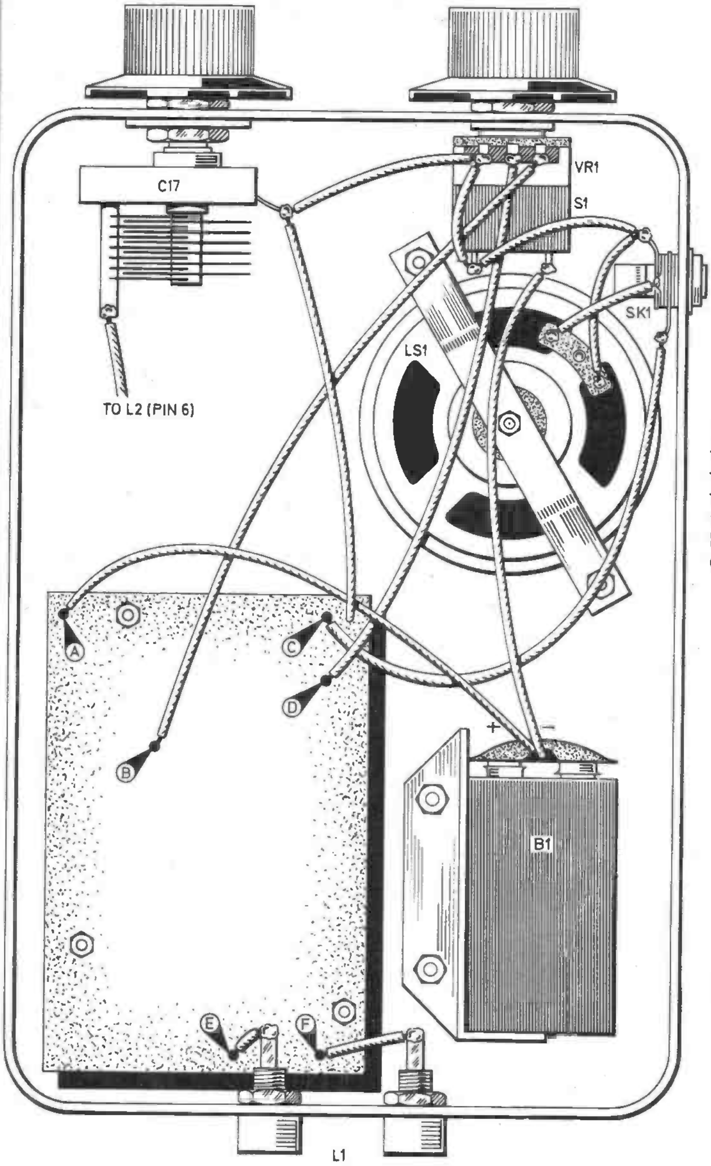


Fig. 3. The layout of the components and board within the case and complete wiring up details.

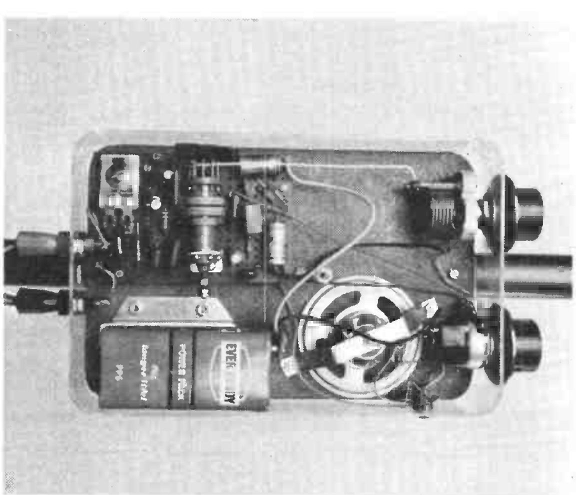


Fig. 4. Details of the coil former for the plain search coil. Note that this is made by laminating three discs. The upright doweling may be a stub for fixing to hollow tube handle, or the base of a broomstick handle.

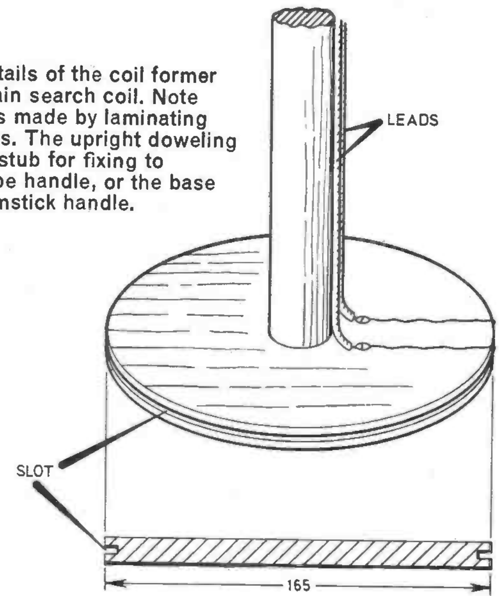
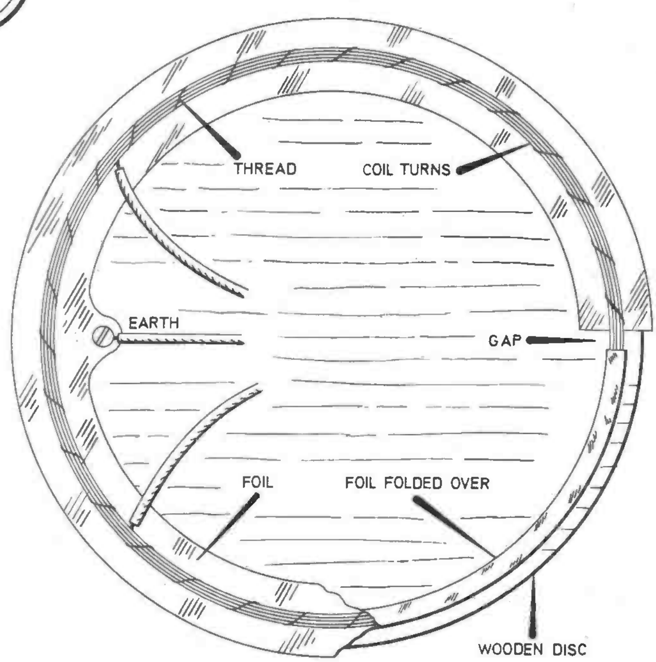


Fig. 5. Details for making the Farady earth on the shielded coil version.



handle, and these are fitted with plugs which go into the sockets on the case.

Shielded Coil

Find a household object 17·5cm in diameter for use as a temporary former, and wind twenty turns of 30 s.w.g. enamelled copper wire on this, in a compact pile. Slip the winding off the former, taking care that the turns do not separate, and bind them with thread to keep them together, as in Fig. 5.

Cut a hardboard disc 19cm in diameter, and a slightly larger circle of household aluminium foil. Cut a piece about 12·5cm across out of the foil, but leave the earth projection as shown. This gives a large washer-shaped piece of foil, and a piece about 3mm wide is cut out, to provide the gap shown. Fold the foil over the winding systematically so that it is completely enclosed, bringing the winding ends out through insulated sleeving. Cement the shielded coil to the hardboard, taking care that there is no short circuit of the foil across the gap.

Connection of the coil and shield to the rest of the circuitry was made with 3-core mains cable in the prototype. One end of the winding and the shield (earth) wire should be joined together at the plug end to fit SK1, and the remaining coil wire to SK2 via PL2.

ADJUSTMENT

No audio tone can be produced until both oscillators are working on nearly the same frequency. Set the core of L2 so that about fifteen threads of the 6BA rod protrude, and adjust C2 until a strong heterodyne or audio note is heard. This should fall in pitch, becoming zero beat or silence, with C16 half closed. Turning C16 either way should cause a tone, which rises in pitch.

Close C16 slightly, to produce a very low frequency tone with L2 operating below the frequency of L1. Bringing metal near L1 will then cause a rise in pitch.

An operating frequency of 100kHz can be found exactly by placing a radio receiver tuned to BBC Radio 2 longwave (200kHz) near the locator, and tuning with C2 and the core of L2 to produce a heterodyne from the 2nd harmonic of either oscillator. The locator frequency is then slightly off-set from this by adjusting C2 and L2, so that interference cannot be caused to reception of this transmitter. For somewhat similar considerations, headphones are better where the tone will be a nuisance to other persons nearby.

The case lid is held on by a long 6BA bolt, passing up through it, and fitted with a nut. A PP6 9V battery is used. ⌑

IT HAS always seemed to me that one of the great difficulties in producing a technical magazine such as EVERYDAY ELECTRONICS, is the need to cater simultaneously for readers at different levels of experience. The new reader starting this month, probably knows little or nothing of the subject, but you also have to remember the readers who started three, six and nine months previously. At almost every stage they need to be given something to build within their capabilities, if the magazine is to retain their interest.

It must be apparent to all readers new and old that the editor achieves this aim, with consummate skill. Even I, from time to time put forward constructional projects, though not being very brilliant I usually concentrate on the simple things. I well remember when I sent him an electronics puzzle, and the raised eyebrows when he saw it consisted of only six double-pole double-throw switches, a push switch, a lamp and a buzzer.

"Do you mean to tell me it has no diacs, diodes, triacs, transistors, or i.c.'s."

I hung my head in shame, "No, it has none of those things, but after all," said I, brightening visibly, "there are forty four connections to solder, think what good practice that will be, and in any case, newcomers to electronics want something simple to start with!" I won him over and it was published, and very successful it was too.

Kits For E.E. Projects

I was most interested to see that someone had written to ask why retailers did not produce complete kits for all the projects that appear. The short answer is that they do for some of them, and the long answer is, that all projects are not equally popular, and if the retailer is going to devote time and money to producing a kit, he wants to be reasonably sure that he is on a winner.

This is terribly hard to do, and they can only go by past experience. Certain things they know will be popular, for example the *Teach-In* series, and to that I would add, signal generators, resistance and capacitance bridges, simple short wave receivers and good quality amplifiers.

I have often wondered if the magazines have any statistical analysis themselves as to the type of project which is usually successful. The only time we ever know for sure, is if we are asked to supply a part for a design, and we know we are the only source of supply.

I have noticed myself that many suppliers advertise complete kits of parts for designs, giving a total price including VAT and postage. If you are contemplating building something that is not advertised, provided you have a few catalogues you can soon work it out for yourself, and if you do get stuck on a few items, the majority of the mail order firms will be only too pleased to advise you.

Finally do remember, I beg you, that most of them today are understaffed, so do not just try and push work on to them that you could do equally well yourself because while we all preach the old maxim "The customer is always right" as in everything else, there are exceptions!

MODEL TRAIN CONTROLLER

INTRODUCTION

The conventional method of controlling a model train is by means of a rheostat or variable resistor in series with the supply voltage. While this is a very simple method it has one notable disadvantage; the amount of series resistance in the supply circuit tends to give it a "constant current" characteristic, this largely defeating the beneficial effect of the back e.m.f. within the motor.

In other circumstances when a motor slows down, the back e.m.f. falls and the current in the armature rises, causing the torque of the motor to increase. Conversely when a motor speeds up, the back e.m.f. rises, the armature current falls thus reducing the torque.

When the supply has a "constant current" characteristic the ability of the motor to vary its torque is limited in certain ways. For example a model train becomes very sensitive to load variations. Low speed is a particular case, the train tends to slow down greatly on slight hills, and in some cases may even stall.

This problem of low speed can be overcome by providing a variable supply having a low impedance. Such a supply will appear to the train as a "constant voltage" rather than a "constant current" source.

START HERE FOR CONSTRUCTION

The unit is housed in a small aluminium box type AB13, 152mm x 102mm x 51mm. Using this size of box there is plenty of room and the components are therefore not cramped. Alternatively a box of smaller dimensions may be used.

All the wiring is carried out inside the box, as shown in Fig. 1. The input and output terminals are mounted at one end of the box, and the power transistor TR2 is mounted at the other end. Note that this transistor must be insulated from the case by a mica washer and bushes. The smaller components TR1 and R1 are mounted on a small 4-way tagstrip with one tag earthed. The lamp(s) are held in position by their own wiring, which must be fairly thick wire, so that when one lamp is positioned over the bezel it will give an indication if an overload occurs.

SETTING UP

The choice of lamp depends upon the power consumption of

FOR GUIDANCE ONLY

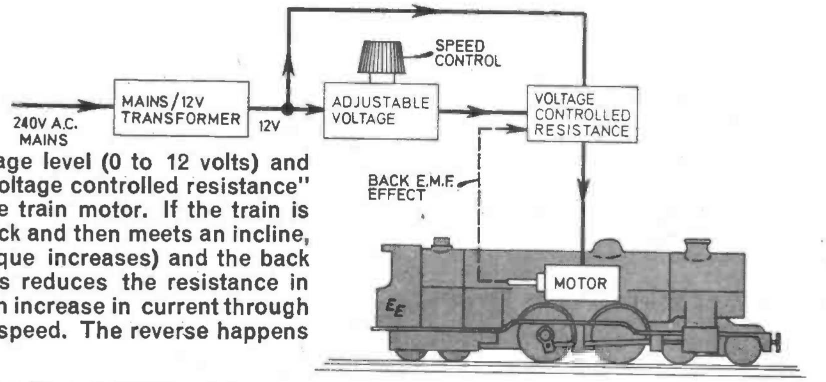
ESTIMATED COST OF COMPONENTS

£3·20

HOW IT WORKS...

The device uses the power supply already in use with the train set whether battery or mains derived via a step down transformer.

The speed control knob selects a voltage level (0 to 12 volts) and transfers this level to the output of the "voltage controlled resistance" presenting a constant voltage level to the train motor. If the train is travelling at a slow speed along a level track and then meets an incline, the motor will tend to slow down (the torque increases) and the back e.m.f. of the motor reduces. In effect this reduces the resistance in series with the power supply and causes an increase in current through the motor which maintains a steady slow speed. The reverse happens if now the train travels down an incline.



CIRCUIT DESCRIPTION

Looking at the complete circuit diagram, Fig. 2, the first thing to notice is the Darlington pair formed by TR1 and TR2. Using such a transistor configuration the current required from the variable resistor VR1 is greatly reduced. Supposing just a single transistor was used to provide the necessary regulation, such as TR2 on it's own. For the transistor to supply up to 1·5 amps which is normally required for model trains, and the transistor has a current gain of 20, then the required current at the base would have to be 75mA.

To minimise regulation problems in the potentiometer it would be necessary to arrange for about 1 amp to flow in this potentiometer. Such a high current in conjunction with the supply voltage the wattage of the potentiometer would be very high. This will cause wastage in terms of power lost, the life of the transistor would be severely limited, especially in the case of a short circuit. Therefore a Darlington pair is used to reduce the current required for the regulating transistor, this then brings all the current requirements down to a reasonable figure and the use of a low power variable resistor is then practicable.

Protection against short circuits is provided by a lamp LP1 placed in the collector circuit of TR2 and by a series resistor in the base of TR1. The lamp functions as non-linear resistor, so that under normal conditions the current through it is fairly small, this is because at "cold" the lamp has a low resistance. Therefore when a short circuit occurs, the current increases, the filament becomes hot and the resistance increases. Since the resistance has now increased this will limit the current allowed to flow in TR2, and thus keep down the power dissipated.

The purpose of the base resistor is to prevent the Darlington pair from becoming fully turned on before the speed control potentiometer reaches the full speed position. It also helps to limit the current during overload conditions.

COMPONENTS

Resistors
R1 (see text)

Potentiometers
VR1 1kΩ lin. carbon

See Shop Talk Page 67

Semiconductors
TR1 BFY51 silicon *npn*
TR2 2N3055 silicon *npn*

Miscellaneous
S1 d.p.d.t. standard toggle switch
LP1 25 or 50 watt car lamp (see text)
SK1, 2, 3, 4 4mm insulated screw terminals (2 red, 2 black); 4-way tag-strip; one red lamp bezel; insulated knob; insulating kit for TR2; four rubber feet; AB13 type case, 152mm x 102mm x 51mm; connecting wire; solder.

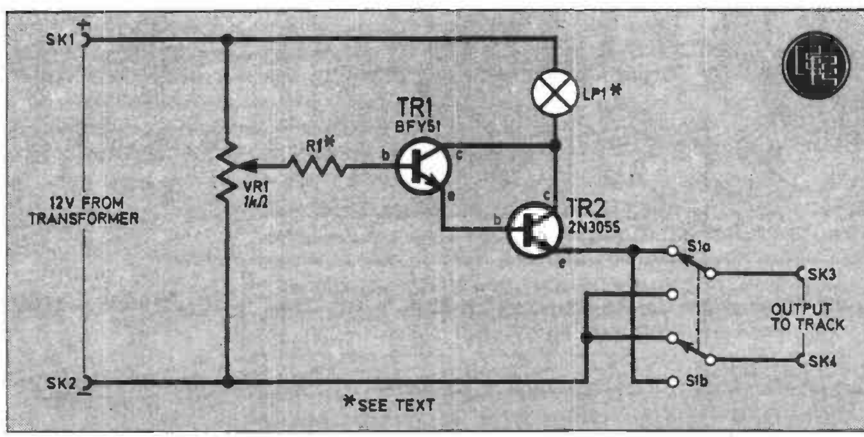
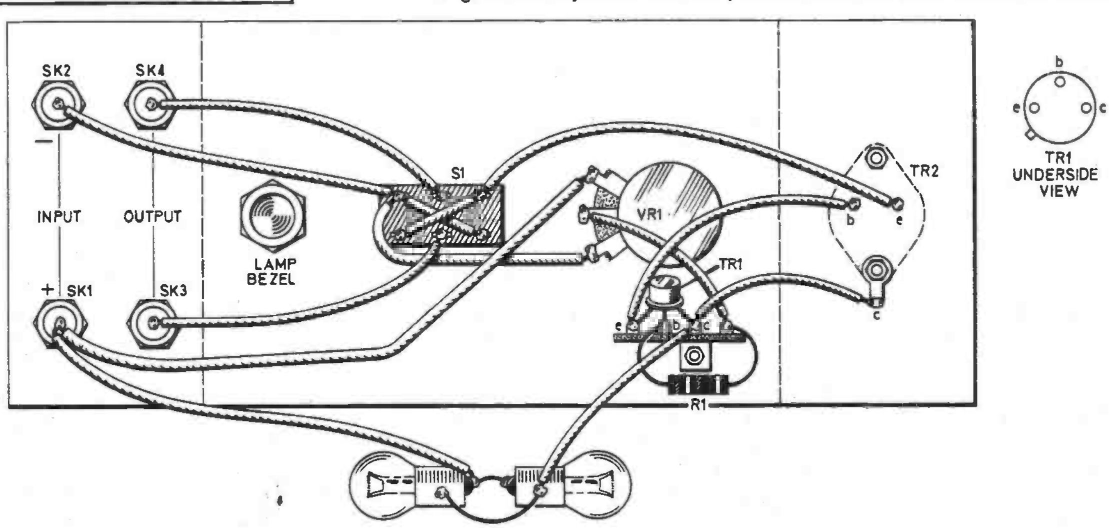


Fig. 2. The complete circuit diagram of the Train Controller.

Fig. 1. The layout of the components and complete wiring up details.



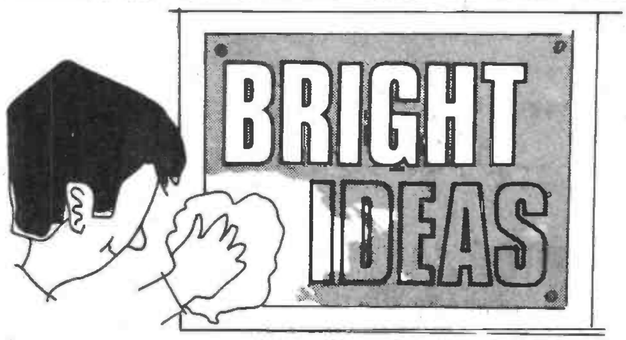
the train and any auxilary equipment being supplied. For a single train it is possible to use a 25 to 30 watt 12 volt lamp. A 27 watt lamp can be made up wiring the two filaments of the 21/6 watt car stop/tail light in parallel. If it is desired to run additional equipment then at least a 50 watt lamp would be needed. Again this value may be obtained from wiring up different wattage lamps. All the lamps should be obtainable from any car accessory shops.

The value of R1 depends on the wattage of the lamps used. For a 50 watt lamp a value of 2·7 kilohms is suitable, while for a 25 watt lamp a 5·6 kilohm resistor is suitable.

TESTING

When construction is completed the unit can be tested. Connect a suitable power supply to the input terminals, making sure of the polarity. Connect the output terminals to the tracks and place a train on them. When the speed control is advanced, the train should run smoothly and it should be possible to vary the speed over a wide range. When the train is at maximum speed, a screwdriver or some other insulated tool is used to short circuit the rails. The train should now stop, then the overload indicator should glow.

If this test is satisfactory then the speed controller is ready for use. ☐



Readers' Bright Ideas; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.

KEYBOARDS

When constructing stylus type electronic organs, the keyboard can present a problem, especially if you cannot etch your own printed circuit. A very effective substitute is to use a surplus component panel, often sold as reject computer boards.

They usually have a row of gold plated contacts which would normally fit into an edge connector. Being gold plated they make excellent contacts which require no cleaning. If a large enough board is purchased and the copper pattern is removed, the board can be drilled for the components and wired up underneath using point-to-point wiring. The *Mini-Organ* in the December 1976 issue was constructed by me in this way.

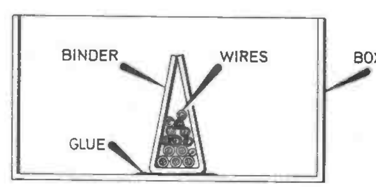
P. Edwards
S. Humberside

WIRE HOLDERS

When wiring up various projects a large number of interconnecting wires are visible. To hide these wires and making the wiring look neat, a plastic paper binder can be used stuck inside the box, see diagram below.

The advantage of using such binders are that they are cheap to buy and wires can be added or taken out at will.

J. Bagnall,
York



What do you know?

INDUCTIVE REACTANCE

1. Define inductive reactance and state the formula used.

2. What is the reactance of a coil at a frequency of 200Hz, if the coil has a value of 0·1H?

3. A coil has a reactance of 200 ohms at a frequency of 150Hz. What is the inductance of the coil?

4. Calculate the frequency necessary to cause a 25mH coil to have a reactance of 50 ohms.

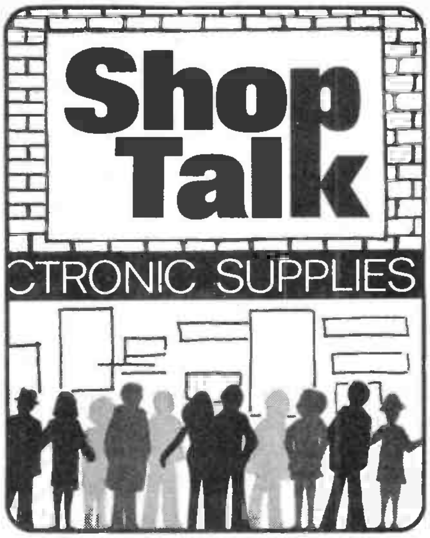
ANSWERS

1. Inductive reactance is that property of a coil which enables it to resist the passage of a.c. Reactance is directly proportional to the frequency, i.e. reactance increases as the frequency increases. $X_L = 2\pi fL$ ohms, where f is in hertz, and L is in Henrys.

2. 125·66 ohms.

3. 0·212H (220mH).

4. 318·3Hz.



By Brian Terrell

New products and component buying for constructional projects.

You are probably already aware of a new educational series starting this month. If not turn to page 68 for details. Called Teach-In '78 (because the majority of the series will be featured in 1978) it has been designed to introduce the newcomer to the world of electronics but will also be of interest to those wishing to add to their knowledge of this fascinating subject.

Basic theory is fully explained and then put into practice by way of experiments. To carry out all of these experiments in the twelve parts a fairly large number of components are required as can be seen in the component list on page 70. At first sight it may seem enormous—there are in fact 168 items—but when broken down it works out at 14 items per month.

Advance information of Teach-In '78 was circulated to electronic component suppliers to give them the opportunity of offering a complete kit of parts for the series. Response to this information was very good and resulted in 14 firms offering kits. As you can see costs vary tremendously, in fact the top price is almost double the lowest one. Our estimate based on an "average cost per component type" worked out at around £16 inclusive which compared well with quoted total cost. Tools and other materials are not included in these costings.

All the quoted prices are for a complete set of electronic components (except where stated) for Teach-in '78 including VAT and post and packing.

New Mail Order Firm

Readers will be pleased to hear of the formation of a new mail-order supplier of components to the electronics hobbyist. The name is ACE MAILTRONIX, and they are trading at Tootal Street, Wakefield, West Yorkshire WF1 5JR. Their combined catalogue/order form contains 500 of the most popular components required in modern electronics, and is available free of charge; it is obtained by sending a stamped self-addressed envelope to the above address.

The catalogue is constructed in the form of an order form with spaces for inserting the quantity alongside the unit price (includes VAT); post and packing charges are 20p on orders under £2, otherwise no charge.

It is claimed that every order will be despatched on the day it is received. Prices are to remain fixed throughout the life of the catalogue i.e. until the publication date of a new catalogue.

A new catalogue/order form is automatically replaced with each order.

Products include transistors, diodes, integrated circuits, resistors, capacitors, switches, lamps, plugs, sockets, and technical books. All products are guaranteed for twelve months from the date of purchase.

This Month's Constructional Projects

Most of the components for the *Treasure Locator* project should be easy to obtain. The integrated circuit employed, MC3360P is not to be found in many advertiser's lists, and if difficulty is experienced in obtaining this device stocks are held by Maplin Electronic Supplies, P.O. Box 3, Rayleigh, Essex (£1·19) and Arrow Electronics Ltd., Leader House, Coptfold Road, Brentwood, Essex (£1·19). Both prices include VAT and post and packing.

The coil used in this design is a Denco Dual Purpose Range 1 Blue type and is available direct from Denco (Clacton) Ltd., 355/9 Old Road, Clacton-on-Sea, Essex at an inclusive cost of £1·04.

There are quite a few components required to build the *Enlarger Timer*, but only the 1 per cent resistors may prove troublesome. Maplin can supply these.

No component buying problems are envisaged for the *Train Controller* or the *Transistor Tester*.

Another New Mail Order Firm

News of another newly formed mail order firm has reached us just in time to be included in this page. The firm emerges from RITRO ELECTRONICS UK LTD., an industrial supplier and is known as TIRRO ELECTRONICS (an anagram of the parent name) and can be contacted at Grenfell Place, Maidenhead, Berkshire.

They can supply a whole range of components including resistors, potentiometers, capacitors, switches, soldering irons, tools, semiconductors, linear, TTL and CMOS i.c.s. A 32-page illustrated catalogue including price list is available free of charge by sending a large SAE or 20 pence to cover postage and packing. Payment of goods will be accepted by cheque, postal order, Barclaycard and Access.

SUPPLIERS OF KITS FOR TEACH-IN '78

Supplier	Price
Ace Mailtronix Ltd., Tootal Street, Wakefield, West Yorkshire WF1 5JR. Tel: Wakefield 250375	£16·00
Barrie Electronics Ltd. 3 The Minories, London EC3N 1BJ. Tel: 01-488 3316/7/9	£16·00
Bi-Pak, P.O. Box 6, Ware, Herts. Excluding batteries.	£11·50
Crescent Radio Ltd., 164-166 High Road, Wood Green, London N22. Tel: 01-888 3206	£16·00
Electrovalue Ltd., 28 St. Judes Road, Englefield Green, Egham, Surrey TW20 0HB. Tel: Egham 3603	£12·50
Greenweld, 443 Millbrook Road, Southampton SO1 0HX. Tel: Southampton 772501	£13·50
Home Radio (Components) Ltd., 240 London Road, Mitcham, Surrey CR4 3HD. Tel: 01-648 8422	£19·00
H.B. Electronics, 22 Newland Street, Kettering, Northants, Tel: Kettering 83922	£16·00
J. Bull (Electrical) Ltd. 103 Tamworth Road, Croydon, Surrey CR9 1SG	£12·00
Magenta Electronics Ltd., 61 Newton Leys, Burton-on-Trent, Staffs. DE15 0DW. Tel: Burton-on-Trent 65435	£13·95
A. Marshall (London) Ltd., 42 Cricklewood Broadway, London NW2 3ET. Tel: 01-452 0161/2/3. Excluding ferrite rod, loudspeaker, batteries, m.e.s. lamps and holders, tinned copper wire.	£21·45
Radio Component Specialists, 337 Whitehorse Road, Croydon, Surrey. Tel: 01-684 1655	£20·00
The Components Centre, 7 Langley Road, Watford, Herts. WD1 3PS. Tel: Watford 45335	£11·00
Arrow Electronics Ltd., Leader House, Coptfold Road, Brentwood, Essex	£15·75

THE aim of this Teach-In series is to give newcomers to electronics enough theory and practical work to move on to other EVERYDAY ELECTRONICS articles. The ground covered will be limited to what is really necessary for a beginner, maths will be minimised and practical work will be given much emphasis. Readers will soon find themselves using transistors and building quite complex circuits.

Understanding will grow step by step alongside practical experience. Readers will first be given a rough general idea of how, say, a transistor works, and then some experience with a practical circuit. Later, as the series progresses, the rough idea will be refined and expanded, to enable the working of circuits to be better understood.

At the end of the series the reader will be able to turn back to the beginning and see things with a deeper understanding.

TOOLS

You must have a soldering iron of the miniature electric kind. You'll also need some thin resin-cored "60/40" solder, a pair of thin-nosed pliers with a wire cutting section (or a separate pair of wire cutters), a miniature hammer, a wood saw, a small screwdriver, and a hand drill (egg-beater type) and twist drills for it.

Electrician's pliers are very expensive these days. If you are short of cash you may be able to get by with a small sturdy short-bladed pair of scissors instead of wire cutters and a pair of tweezers instead of pliers for holding components. Nail cutting pliers from manicure sets will usually cut copper wire and may be cheaper than real wire cutters.

Sooner or later in electronics you will need a test meter of the multimeter type (also called a VOM) but this is not needed in this series because one of our first jobs will be to construct an *Electronic Voltage Indicator* which gives rough measurements of voltage. You will certainly need some flexible insulated connectors with a small crocodile clip at each end. These are for making temporary connections and ten are desirable. The best crocodile clips have plastic covers which insulate all but the tips of the jaws. They can often be bought as made-up connectors in assorted colours.

THE INEVITABILITY OF SOLDERING

Practical work calls for some form of constructional technique which is simple enough for a beginner to use and at the same time neat and flexible. Having thought hard about it we have come to the conclusion that no constructor will ever get far in electronics until he has mastered the art of making good soldered connections.

Soldering is the neatest, cheapest and with practice the quickest way of making reliable connections. What's more, you can learn to do it in an hour. So we shall specify soldered joints from the start, and give practice at making them.

MODULE BOARD TECHNIQUE

You need some form of base or chassis on which to build your circuits. In this series we shall go all out for simplicity, cheapness and adaptability. Our basic chassis will be a "breadboard", that is, a rectangular piece of board. The best kind of board is thick dense fibre-board, often sold by builders' merchants as Sundeala board. If this is not obtainable use one of the alternatives, which are plain softwood (make sure it's free from knots), plywood, and blockboard.

Blockboard, which is made of softwood blocks sandwiched between plywood skins, is easy to use.

LEARN ELECTRONICS THIS SIMPLE WAY!

☐ This series has been designed to introduce the newcomer to the fascinating world of electronics.

☐ Basic theory fully explained and then put into practise by specially designed experiments.

☐ Experimental work is carried out on our Module Board System that you construct yourself.

The board should be at least 12mm thick. The precise area is not important, but a piece the size of a sheet of A4 paper (295 x 210mm) or slightly larger will do very nicely.

You will also need some small pieces of three-ply wood or hardboard. These are for making circuit modules which we shall be using over and over again as if they were individual components. Also a strip of baseboard material about 200 x 40mm for soldering practice is required.

Building circuits and modules on baseboards like these has some outstanding advantages. First, all the components and wiring are on the same side of the base. Nothing is hidden. Secondly, you have great freedom in positioning your components, so you can make the actual construction follow the theoretical circuit diagram very closely. This is a help to understanding and also to testing and fault-tracing.

Finally, this form of baseboard construction is a useful half-way house to the more professional forms like Veroboard and printed circuits. You will find it relatively easy to change to these later if you want to. It will also be easy to change to temporary plug-in breadboards such as T-Dec, which can be very useful for experimental work.

MODULE BOARD ACCESSORIES

Apart from the actual boards you will also need wire, nails (or pins), and stiff white card. The card is required for mounting on top of the modules for identification.

The nails are standard 25mm long panel pins as sold by many do-it-yourself shops. Alternatively, ordinary domestic straight pins can be used as employed in the author's prototype system. This will be discussed fully later. These must be clean, bright and brand new, otherwise solder won't stick to them. Office stationers sell plated pins which take solder well and these are what you need. The most common size is 25mm and known to the trade as *Standard Short Whites*. A four ounce box will last years but you can get a smaller packet and reduce your initial expenditure.

Glue is also needed. To begin with, a tube of rubbery glue such as Copydex is useful. Later you will need some woodworking glue such as Evo-Stik woodworking adhesive, for making boxes and cabinets. Alternatives are a polystyrene glue such as Britfix and an impact adhesive for the woodwork. A few blobs of Blu-Tak are useful for holding the circuit modules to the base.

Now wire. For cheapness, most of the connections in our circuits will be made with bare (uninsulated) wire. For ease of soldering this should be of tinned copper. Thin wire is cheaper (per metre) than thick, but if too thin is hard to handle and breaks. We have found the thinnest which can be used is 30 s.w.g. which is about 0·3mm diameter. (Wire sizes in Britain are officially metric now but there's still a lot of the old s.w.g. stuff about.) The thickest which is easy to use is 22 s.w.g. which is about 0·7mm diameter. If you have a choice get 26 s.w.g. or 0·5mm.

To get started you can use 20 amp or 15 amp fuse wire which is usually tinned copper of a suitable thickness, but expensive in small quantities. Some electrical shops sell fuse wire on small reels: this may be the easiest way to get your plain wire.

Some of our connections will have to be insulated. Buy a few metres of thin plastic-insulated copper wire, the kind with a single core rather than several strands twisted together. Here again, tinned copper is preferable but plain copper will do.

COMPONENTS

Resistors

10Ω	5 off	¼W ± 5% carbon
33Ω	5 off	
100Ω	5 off	
330Ω	10 off	
1kΩ	20 off	
3·3kΩ	10 off	
10kΩ	10 off	
33kΩ	5 off	
100kΩ	10 off	
330kΩ	5 off	
1MΩ	5 off	¼W ± 10% carbon
3·3MΩ	5 off	

Potentiometers

100kΩ	log. less switch 3 off
1MΩ	log. less switch 1 off

Semiconductors

BC108	silicon *npn*	11 off
2N3702	silicon *pnp*	4 off
TIL209	red light emitting diode	3 off
OA90	germanium point contact diode	2 off
IN4001	rectifier diode	6 off

Capacitors

1nF, 10nF, 100nF — polystyrene or metallised polyester types 5 off each value

10μF 25V elect. 2 off
100μF 25V elect. 5 off
1000μF 25V elect. 2 off
— Maximum working voltage should not exceed that stated due to size restrictions. Axial types only.

300pF variable Dilecon solid dielectric

The following capacitors are only required if the capacitor substitution box is to be built; 1 off each value;

100pF, 330pF — polystyrene ± 5% or better

1nF, 3·3nF, 10nF, 33nF, 100nF, 330nF — metallised polyester ± 20% or better

1μF, 10μF, 100μF, 1000μF — Tolerance unimportant. Working voltage at least 10V, preferably higher. Size not too important. However, excessively large components should not be used.

Miscellaneous

Ferrite rod 4 inches × ⅜ inch or metric equivalent	1 off
20 to 80 ohm speaker 65mm diameter	1 off
26 s.w.g. tinned copper wire	10 metres
6·3V or 8V 300mA m.e.s. bulb	1 off
PP3 battery	1 off
PP9 battery	1 off
Small pointer knobs, any colour 30mm long	4 off
PP3 battery clip	1 pair
PP9 battery clip	1 pair
Batten mounting lamp holder for bulb	1 off
1-pole 12-way rotary wafer switches	2 off
1/0·6 solid core insulated wire in red, black, green, white and yellow	2 metres each 10 metres total

Alternatively 10 leads with crocodile clips termination (Eagle types or similar) and only 1 metre of each colour wire as above

MATERIALS

The following materials are required to build the module board and the individual circuit modules:

One piece of fibre board or similar material, 305mm × 216mm × 15mm; Plywood 4mm thick, sizes and quantity as required. A piece about 61cm × 61cm (24 inches × 24 inches) would suffice; Evo-stick woodworking glue or similar; Approximately 100 off 25mm long panel pins or standard domestic pins; Rubber solution glue such as Copydex; Sheet of white card about 450mm (18 inches) square; Solder.

TOOLS

The following list should be considered essential items for the Teach-In series;

- Small pin hammer
- Wood saw
- Hand drill with a small range of miniature drills
- Long nose pliers incorporating a wire cutting section, as an alternative ordinary household nail clippers would suffice
- Soldering iron, 240 volts no greater than 25 watt rating

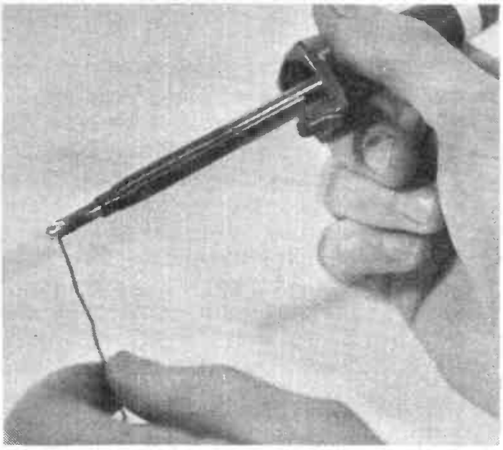
For cleaning up tarnished wire and component leads steal from the kitchen sink a small piece of pan-cleaning "cloth" which looks a bit like thick felt (usually green) but is hard to the touch.

Solder wire, which was mentioned earlier, must be of 60/40 composition, that is 60 per cent tin, 40 per cent lead, which is the composition with the lowest melting point. The thinner kinds are best (20 or 22 s.w.g.).

SOLDERING EXERCISE

You can now begin to do some practical work. Use a spare piece of baseboard about 200 x 40mm. Drive in a row of nails or pins as preferred an inch apart. Tin them, that is cover the shanks with a thin layer of solder. To do this, first make sure that the working surface of the "bit" of the soldering iron is itself tinned. If it is a new soldering iron, plug it in and as it warms up hold the end of a piece of solder wire against the tip of the bit. The resin flux from inside the solder will melt first then as the bit gets hotter the solder itself melts. Apply a liberal coating all over the last half inch of the bit, nearest the tip and leave it for a minute.

When the excess solder is wiped or brushed away the whole of the treated part of the bit should be bright and silvery. If the iron is not new and the bit is blackened scrape away the black crust before



Tinning the bit of a soldering iron.

plugging in the iron. In bad cases, use a smooth file to get down to clean bright metal.

Bits are made of copper, but on some new irons the bits are often plated with nickel or iron, which wears away in time. If you have a plated bit *do not* remove the plating.

When using the iron always wipe the bit clean immediately before and after use, every time you make a joint. In factories where hand-soldering is done the operatives usually have a pad of special high-temperature, sponge-plastic fixed on the bench, to wipe the bit on. Ordinary sponge plastic is no use, because the heat of the iron melts it and you are left with a sticky bit and a foul smell. Your pan-cleaning cloth melts, too, because it is plastic. But you can use a piece of cotton cloth (not man-made fibre such as nylon), a real bristle brush (not plastic bristle) or a brass-bristled suede brush.

To tin a nail (or pin), press the tinned surface of the bit against it and then touch the end of a length of resin-cored solder wire against it. The solder will melt on to the nail. (You may find it easier to touch the solder against the bit *and* the nail simultaneously.) Only a small amount of solder is needed. It can be spread by sliding the bit, keeping the nail hot.

Tin all the nails, then join them together with a length of bare wire, wrapping it three times round the end nails and once round the intermediate ones. Keep it moderately taut. Leave a short length of spare wire at the end. Solder the wire to each nail, using the minimum amount of solder which will do the job.

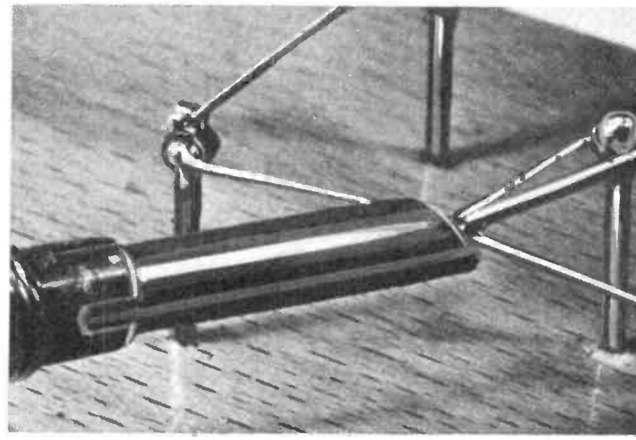
When you have finished admiring your work, test the firmness of the nails by tugging on the wire. This will give some idea how far they should be driven into this particular piece of board. If necessary, drive them in deeper.

Now to unsolder the wire. Take hold of the spare bit of end wire with pilers, hold the bit against it's nail to melt the solder, and unwrap it. Do the same all along the line, testing each connection first, by trying to unwrap the wire before applying the iron. It should resist this. You now have a row of nails again, some with nasty blobs of solder. Remove the surplus solder by pressing the freshly wiped bit against it wiping or brushing while the solder is molten.

Repeat the exercise until you can solder the wire satisfactorily in about three seconds. Speed is important because delicate components can be damaged by excessive heat.

When you are satisfied with your soldering performance, repeat the exercise with insulated wire. To do this you will need to strip off some of the plastic insulation to expose the ends of the copper conductor. This has to be done without cutting or nicking the wire at the point where the insulation is cut. (Wire stripping tools exist which can be set to do the job with precision but with practice you can manage with ordinary wire cutting pliers.)

We are now ready for our first real constructional task. This is to make a row of ten resistors. They will be soldered to a row of 11 nails spread 20mm apart —on the same piece of board you have been practising on if it is still in good condition.



Soldering a piece of wire to a nail. Note carefully how the iron and solder are applied.

RESISTOR CHAIN

In this series only two resistance values from each "decade" are used. So the values required are 1 ohm, 3·3 ohm and so on up to 3·3 megohm. Further, they can all be of the 330mW or ¼W carbon film type, the former being from the Mullard CR25 range. Your first task is to make a chain of ten 1 kilohm resistors; Fig. 1.1 shows how this looks physically and also symbolically in circuit diagram form.

In the diagrams the dotted line shows that some components are omitted. The middle drawing, with thin rectangles to represent resistors is the modern British (and Continental) way of drawing them. The alternative (lower diagram) zigzags are still found more frequently in British technical magazines.

To make the resistor chain, drive in 11 nails at intervals of 20mm, and a couple of extra ones at each end. (These will be handy for making connections when we use the chain.) Use the full length of leads on the 1 kilohm resistors, bending them into a U-shape to fit the nails. Interconnections between the spare pins at the ends are made with bare wire.

When soldering a resistor (or any other component) a useful trick is to grip whichever of its leads you are applying the iron to with pliers. This helps to absorb some of the heat which runs up the lead to the body of the resistor. Attach the resistors to the bottoms of the nails, where they enter the baseboard.

Inspect each joint after completion to make sure it is properly soldered.

Resistors connected head-to-tail in a line like yours are said to be in series. Later on we shall connect a 9V battery to the chain of resistors. We shall connect

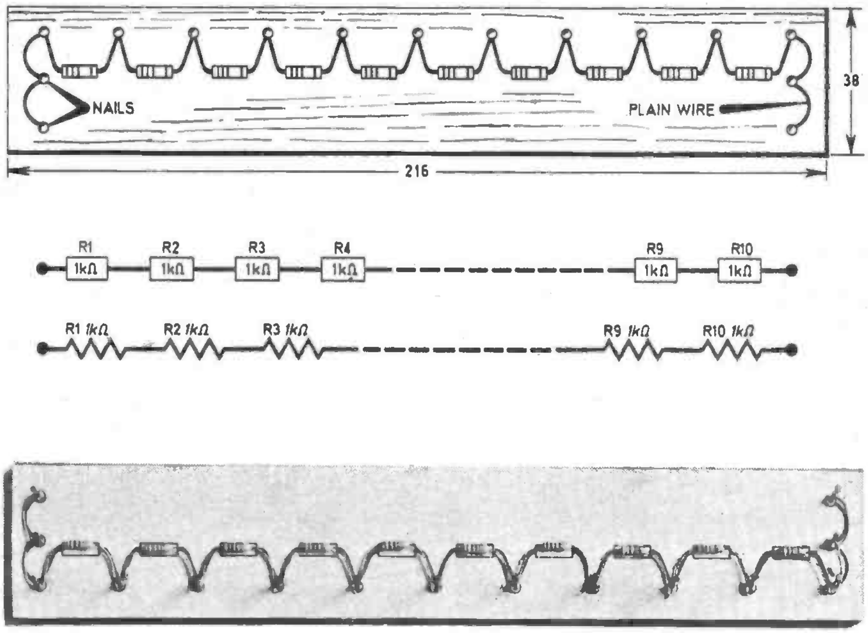


Fig 1.1. The resistor chain as used in this series. Shown here is the method of construction, and is represented by either of the two circuit symbols shown below.

the positive (+) terminal to one end and the negative (−) terminal to the other. Current will flow from the positive terminal, through the resistors, and back to the negative terminal.

An important question is: does the current get weaker as it passes along the chain? Before answering it we need to know what is meant by "positive" and "negative".

THE ELECTRON

In the early days, when the only electricity known was the kind made by rubbing insulating materials together, it became clear to experimenters that there were two kinds of electricity.

There was the kind you made by rubbing a stick of resin with silk, and the kind you made by rubbing a glass rod with cat's fur. You could tell they were different because if you charged something up with one kind, then added the other kind, the charge decreased instead of increasing. Evidently one kind cancelled the other.

Being mathematically minded the early experimenters called one kind positive electricity and the other kind negative electricity. Positive cancels negative. How does this fit in with the idea of an electric current running through wires as water runs through pipes? In the 18th century Benjamin Franklin assumed that every solid object contained an invisible, weightless, *electric fluid*. The flow of electric current was therefore a flow of the electric fluid. An object which contained an excessive amount of fluid was said to be positively charged. One with less fluid than would fill it was negatively charged. Bring a positively charged object into electrical connection with a negatively charged one, and you can see what will happen—charge will flow from positive to negative.

This theory is an example of what physicists nowadays call a *model*. A model is just a set of ideas invented to explain things that happen. There is no need to believe in the model. You just use it to help your understanding. Sooner or later you discover something which the model cannot explain. The model has now broken down, and you either discard it or alter it.

Franklin's model soon had to be replaced by a slightly more complicated one. This said that all things were filled with a *neutral* fluid. This neutral fluid could be split into two fluids, a positive fluid and a negative fluid. Whenever breakdown happened (e.g. by rubbing a glass rod with silk) equal quantities of positive and negative fluid were created. One fluid was concentrated in the glass, the other in the silk.

Every positive charge had a corresponding negative charge.

This model worked very well—quite well enough to enable electrical engineering to get going in the nineteenth century. Despite the fact that it seems old fashioned it contains some ideas which are still around: the idea that a current can be a flow of positive charges *or* a flow of negative charges; the idea that creating a positive charge also creates a negative one. Later, when the **electron** was discovered, it seemed that only one kind of charge—a negative one was needed to explain ordinary conduction through wires.

The theory of conduction in metals says that the outer electrons which orbit their atomic nuclei are easily detached and can hop from atom to atom, see Fig. 1.2. Under the influence of a voltage they all hop the same way, giving rise to current.

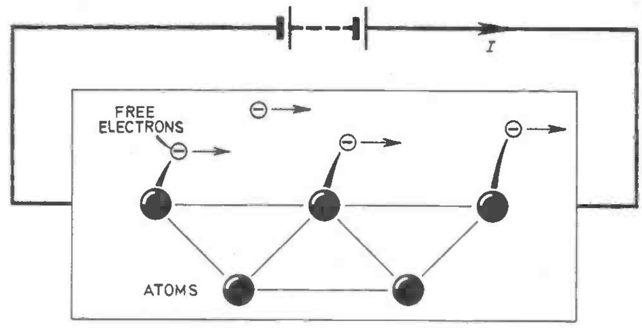


Fig. 1.2. Electron current flow in a metal. It is the electrons that become detached from their atoms and move under the influence of an applied voltage (the battery) that form this current. Note that "conventional" current flow I, is in the opposite direction.

When the transistor was invented, physicists found themselves dealing with certain types of crystals in some of whose atoms one outer electron was "missing". They found it convenient (for doing their sums) to call the space where the electron should have been a **hole**.

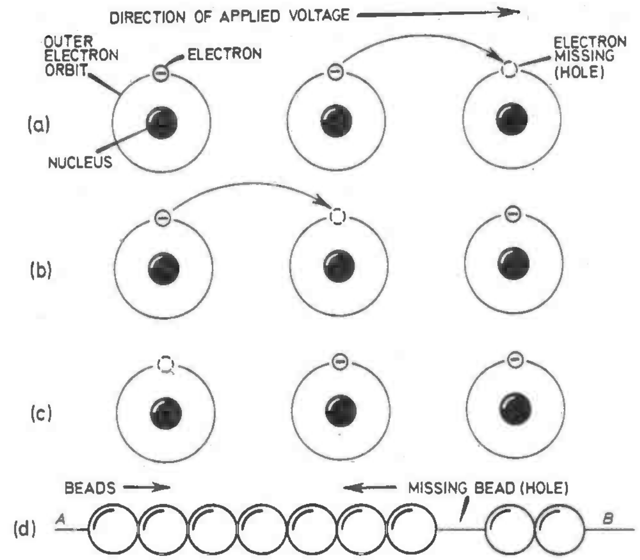


Fig. 1.3. Steps (a) (b) and (c) show that the effect of electrons hopping from atom to the next is equivalent to a hole (missing electron) moving in the opposite direction. This can be demonstrated by moving beads along a wire one at a time from *A* to *B*. The "hole" moves from *B* to *A*.

You could then think of a hole as something which hops from atom to atom under the influence of a voltage (an electric field, strictly speaking), see Fig. 1.3.

A hole, of course, has no real existence. It is just another model. But it's a very powerful one. In the last few years, physicists have discovered that in crystals of germanium and silicon, at very low temperatures, electrons and holes can meet without cancelling one another out. Instead, they go into orbit round each other, and since one is charged equally and oppositely to the other, together they form a *neutral particle*.

Millions of these neutral particles (called excitons) can accumulate and flock together, to form *droplets*. The droplets behave as if they were a liquid—a liquid able to flow easily through a solid crystal of germanium or silicon.

Maybe the old electric fluid idea wasn't such a bad one, after all!

One thing which emerges from all this is that the names positive and negative are artificial, part of the original model. It's a pity that, following the model the charge on an electron has to be labelled negative. In our circuits, we think of current as moving from the positive terminal of the battery, through the circuit, then back into the negative terminal. But the electrons, which carry the charges, are going the opposite way. Fortunately, taking a hint from transistor physics, we can now think of flows of holes instead.

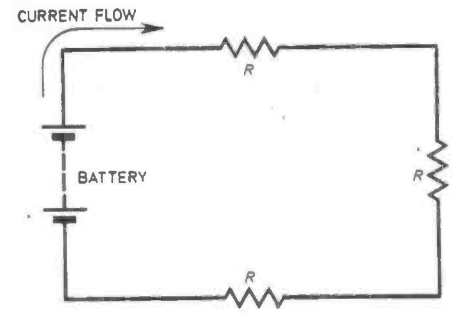
The hole flow then goes the same way as the current, which seems more reasonable.

CURRENT IN A CHAIN

Imagine a pump connected to a circle of piping, so that it pumps water into one end of the piping and gets the water back again from the other end. The water goes round and round the circuit. Obviously, exactly the same amount of water returns to the pumps as leaves it. The flow of water is the same at any point in the circle.

This is true even if the piping is not uniform but has narrow sections and wide sections. If the pump drives 10 litres of water per minute then each minute 10 litres pass through every section of pipe round the circuit, whether the pipe is wide or narrow.

This suggests that in an electric circuit with low resistances and high resistances in series the current should be the same at all points.



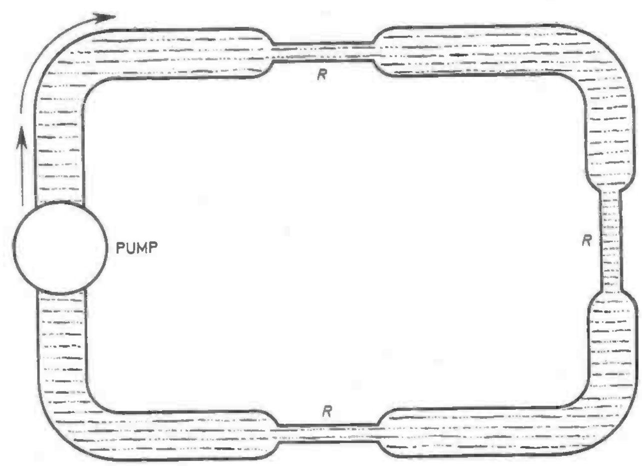


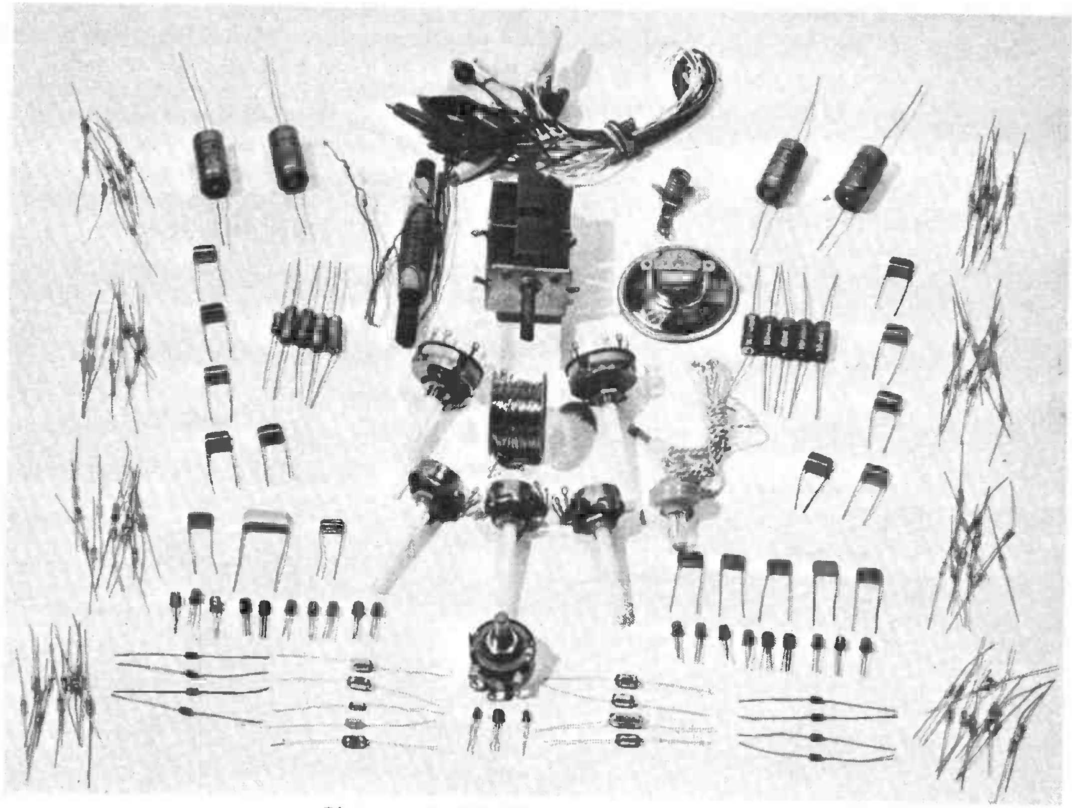
Fig. 1.4. The flow of current in a circuit can be likened to water being pumped through pipes. The battery can be thought of as a pump, and the resistors narrow sections along the pipe.

When a battery is connected to your string of 1 kilohm resistors, and current flows from the positive terminal to the negative, through all the resistances, the current should be the same all along the chain. It does not get weaker as it goes along. This can be proved in terms of the flow of electric charges. The charges here are carried by electrons.

An electron carries a fixed and definite amount of charge. It is always the same. You cannot have two electrons, one charged more strongly than the other. All electrons are charged with exactly the same quantity of electric charge.

If an electron, on its journey along the circuit, were to get tired and stop, its charge would stop with it. An electron's charge is negative, so the region around the point at which it stopped would be negatively charged. If six other tired electrons stopped nearby, the charge would be six times as negative. But this is unlikely to happen.

The early workers discovered that one negative charge repels another. So if one electron stops, others are pushed away from it. In the same way, if one stops and another comes near, the stopped electron



Photograph of the Teach-In components.

itself gets a little push which sets it moving again. So the charges keep one another moving round the circuit, even though one individual electron may stop from time to time, or even go backwards a little. The consequence is, that the current passing any point along the chain is the same.

The current does not get weaker as it goes along. *Current at all points in a chain is the same.*

Something however does get weaker—the voltage. If it is 9V at the positive end, that is, 9V positive, it is only 4·5V positive halfway along. It is not positive at all at the negative end of course, which is just another way of saying that all the voltage is used up in driving current round the circuit.

In our resistor chain the circuit consists of ten difficult stretches (the resistances) connected by other stretches (the wires) which are so easy that no effort to speak of is required to push the charges along them.

Since our ten resistances are equal, it stands to reason that each uses up one-tenth of the battery voltage. With a brand new 9V battery, which actually delivers nearly 10V, each resistance uses up nearly 1V. If we could measure the voltage at the junctions between adjacent resistors we would find that (starting from the +9V end) it went down to 9V, 8V, 7V, 6V, etc and of course finally 0V at the negative end.

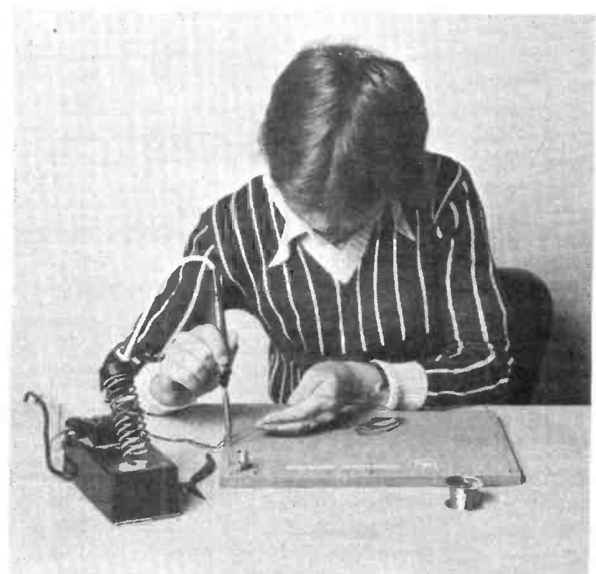
You have to take this on trust. Later we shall actually use this stepwise variation in voltage as a means of calibrating our *Electronic Voltage Indicator*.

In the meantime we shall just say how, in principle, it is possible to demonstrate that the current really is the same all along a series circuit. The key discovery was made by the Danish physicist Oersted (pronounced ursted) in 1820. He found that currents create magnetic fields. If a magnetic compass is held over a wire running north to south, so that the wire and the needle are in line, and then the current is switched on, the needle turns to one side.

The effect is not noticeable unless the current is several amperes, which is too much for a 9V dry battery to supply. However, in high current circuits which do deflect the compass strongly it is found that the deflection is the same at any point.

So the current must be the same, too.

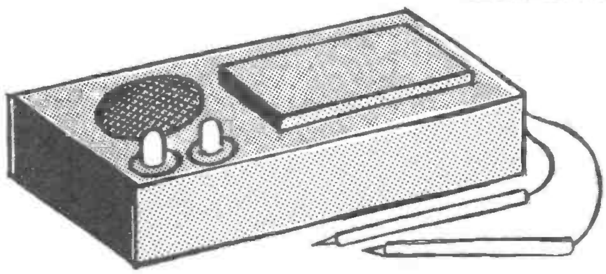
Next month we shall describe how to build some of the modules required for experiments.



...in Next Month's issue!

SPECIAL OFFER

SOLDERING IRON



FIND THE PAIR!

Frustrate your friends with this electronic game. Ideal for fund-raising at school fetes.

ULTRASONIC REMOTE CONTROL SYSTEM

For remote control of mains and battery powered electrical equipment such as garage doors drive motor, porch light . . . also an intruder alarm.

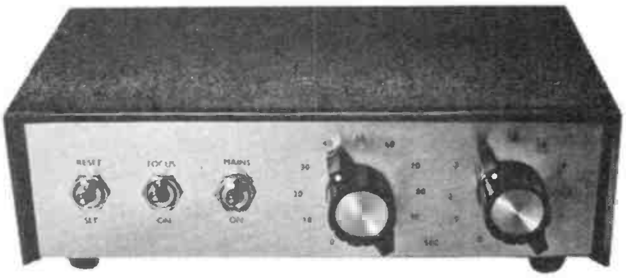
V.H.F. PORTABLE RADIO

A six transistor super-regenerative receiver for a.m. transmissions.

Everyday ELECTRONICS

OUR NOVEMBER ISSUE WILL BE ON SALE FRIDAY, OCTOBER 21
Price 40p

ENLARGER TIMER



By R. A. Penfold

THERE are many electronic photographic aids that can be produced by photographers who also have an interest in electronics, and probably the most useful of these gadgets is an electronic enlarger timer. A very worthwhile saving in cost can be made by building ones own rather than by purchasing a ready made item.

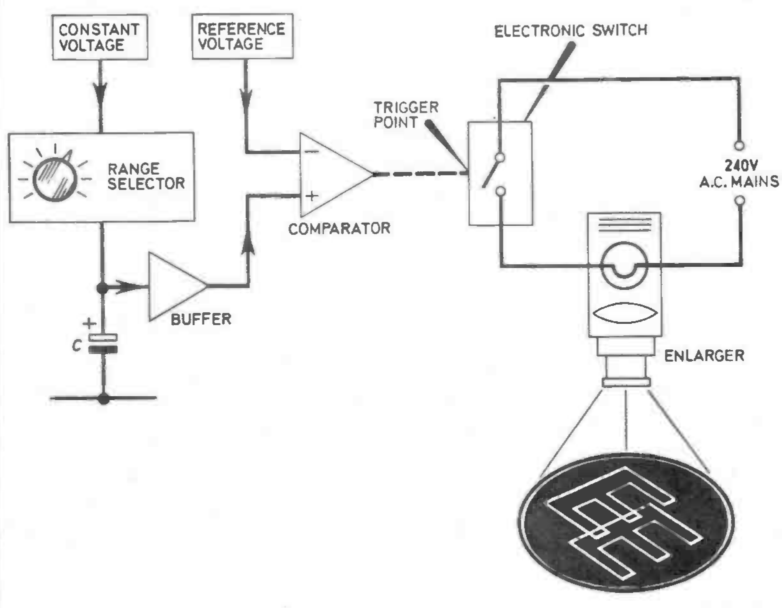
The Enlarger Timer described here has a switched range of 0 to 99 seconds in one second increments, and should thus fulfil all normal amateur requirements. It does not employ digital techniques, as do many timers having this type of time selection, and so the unit does not have the extremely high degree of accuracy associated with digital timers. Nevertheless, a degree of accuracy in excess of that required for this purpose can be obtained.

The unit has a high repeatability accuracy and so consistent prints are obtained.

A reasonably simple circuit is used, with a couple of operational amplifier i.c.s and a triac forming the basis of the unit. Since the unit is not only mains powered, but is also controlling a mains load, its circuitry is more directly connected to the mains than would normally be the case. For this reason the unit is not really a suitable project for a complete beginner.

START HERE FOR CONSTRUCTION

An instrument case type BV4 makes an excellent housing for the project, but any case of a similar



HOW IT WORKS...

When the Enlarger Timer is switched on, the enlarger lamp is turned on. At the same moment, capacitor C starts to charge up via a selected series resistance (range selector); the charging up time is proportional to the value of this series resistance. The voltage level on the capacitor is fed via a buffer stage to a comparator. The buffer stage is used to reduce the loading on the capacitor to a minimum so as not to interfere with charging time.

When the relayed capacitor voltage at the comparator fractionally exceeds the reference voltage level, an output voltage is produced which causes the electronic switch to turn off, thereby extinguishing the enlarger bulb.

TIMER

COMPONENTS

Resistors
R1 1·5kΩ
R2 10Ω
R3 3·3kΩ
R4 4·7kΩ
R5 8·2kΩ
R6 470Ω
R7 to R15 68kΩ ±1% (9 off)
R16 to R24 680kΩ ±1% (9 off)
All resistors are ¼ Watt carbon ±5% except where stated.

Potentiometers
VR1 10kΩ miniature horizontal preset

Capacitors
C1 250μF 16V elect.
C2 250μF 16V elect.
C3 47μF 16V elect.
C4 10μF 16V elect.

See Shop Talk
Page 67

Semiconductors
IC1 741 operational amplifier 8 pin d.i.l.
IC2 741 operational amplifier 8 pin d.i.l.
TR1 2N2219 silicon *npn*
TR2 BC109 silicon *npn*
D1 1N4001 rectifier
D2 1N4001 rectifier
D3 BZY88C12V 12V 400mW Zener diode
D4 BZY88C3V3 3·3V 400mW Zener diode
CSR1 2N5756 or similar triac

Switches
S1 d.p.d.t. standard toggle switch
S2 d.p.d.t. standard toggle switch
S3 s.p.s.t. standard toggle switch
S4, S5 1-pole 12-way rotary wafer type, with adjustable end stop if required (2 off)

Miscellaneous
T1 mains transformer, standard primary, one secondary winding of 6·3V at 500mA approx;
Instrument case type BV4 (Bi-Pak Ltd) or similar (230mm × 134mm × 65mm); stripboard 0·1 inch matrix 44 holes × 20 strips; veropins as required; two large pointer knobs; 6BA fittings; heatsink for CSR1 if required; 3-core mains lead; grommets; wire; solder.

size (230mm × 134mm × 65mm) can be used, provided it is constructed of metal. The drilling and layout of the front panel are shown in Fig. 5. Two holes are drilled at convenient points on the rear panel, one of these being for the mains input lead, and the other for the lead of the enlarger. Both these holes are fitted with grommets. The transformer is mounted on the left hand side of the chassis, and a solder tag is mounted under one of its mounting nuts.

The main earth lead is connected to this, *it is important that the case is properly earthed even if the enlarger only uses a twin mains lead.*

A 0·1 inch pitch stripboard having 44 holes by 20 strips contains much of the circuitry. Details of this panel are illustrated in Fig. 4. After a panel of the correct size has been cut out using a hacksaw, the two 6BA clearance mounting holes have been drilled, and the 15 breaks in the copper strips have been made, the various components are mounted and soldered in. Start with the resistors and capacitors and leave the semiconductors until last. Veropins are used at the points where connections to T1, the switches, etc. will eventually be made.

Be very careful not to bridge any of the gaps between the copper strips with blobs of excess solder, particularly when soldering in the i.c.s. The mains could touch the front panel and such short circuits could prove to be expensive mistakes. If possible, check with a continuity tester that there are no shorts between adjacent copper strips, as offending pieces of solder can often be so small as to be extremely difficult to see. Also check the panel very carefully for wiring errors.

The completed panel is mounted on the right hand side of the chassis using two fairly long 6BA bolts. Use spacers to hold the panel well clear of the chassis.

Finally, the unit is wired up using ordinary multistrand p.v.c. insulated connecting wire, and the mains and enlarger leads are wired in. This wiring is shown in Fig. 3, and this also shows how the timing resistors are mounted around S4 and S5. This wiring is all quite easy provided the ends of leads and tags are all well tinned with solder prior to making a connection.

CALIBRATION

The variable resistor VR1 must be adjusted to provide the correct timing periods before the unit is ready for use. Initially VR1 is set with its slider at about the centre of its track. Use an insulated tool to adjust VR1 and do not touch any of the wiring when the timer is connected to the mains supply.

Set S4 and S5 for a fairly short time, say about 10 seconds, and

CIRCUIT DESCRIPTION

The circuit diagram of the Enlarger Timer is shown in Fig. 1, and the range switching circuitry is shown in Fig. 2.

The mains transformer T1 is fed from the mains via the on/off switch, S1. The transformer reduces the 240V. mains to about 6·3volts. A 6·3V valve filament transformer is used for T1 on the prototype, but this can be any type having a secondary that supplies about 6V at 500mA or more.

The output of T1 is fed to a voltage doubling rectifier and smoothing circuit. This really consists of two half wave circuits connected in series, one using D1 and C1, and the other using D2 and C2. In the interest of good accuracy it is necessary to power the timer from a stabilised supply. Components R1, D3, C3, and TR1 form a conventional emitter follower series stabilisation circuit, and approximately 11·5 volts appears at the emitter of TR1. This is used to power the main circuit.

The stabiliser circuitry also provides a considerable amount of smoothing to the supply which, as a result, has a very low ripple content.

COMPARATOR

The timing circuitry is based on IC2 which is an operational amplifier, but is used here as a comparator. It's inverting input is taken to a reference voltage, the required voltage being set on VR1 which forms part of a potential divider connected across the supply rails. The non-inverting input is connected to an R/C timing network. It is necessary for very little current to be drawn from this network, and so IC1 is used as a unity gain buffer amplifier between the timing network and IC2. Integrated circuit IC1 boosts the input impedance to the non-inverting input of IC2 to an extremely high level, but because it has a voltage gain of only one, it does not otherwise affect the operation of the circuit.

Capacitor C4 is the timing capacitor and is fed from the positive supply via a resistor, or series of resistors when S2b is set to the right hand position. Simultaneously S2a connects the mains supply to the enlarging lamp by way of the triac. The triac will be turned on as it will be receiving a gate current through R6. Thus throwing S2 turns the enlarging lamp on.

The lamp will remain on until the voltage across C4, which is steadily rising exceeds the reference voltage at the inverting input of IC2. At this point the previously low output voltage of IC2 will swing to virtually the full positive supply rail voltage, and in consequence TR2 is turned hard on by the base current it receives through D4 and R5.

In doing so it diverts the current from R6 to the negative supply rail through it's collector and emitter terminals, and cuts off the gate current to the triac. The enlarger lamp is therefore turned off when the voltage at the non-inverting input exceeds that at the inverting input.

RANGE SWITCHING

In practice the voltage at VR1 slider is set to a level that gives a one second timing period with a timing resistence of 68 kilohms in circuit. The nature of the circuit is such that it will then give a timing period of two seconds with 136 kilohms in circuit (2×68 kilohms), three seconds with 204 kilohms (3×68 kilohms), and so on.

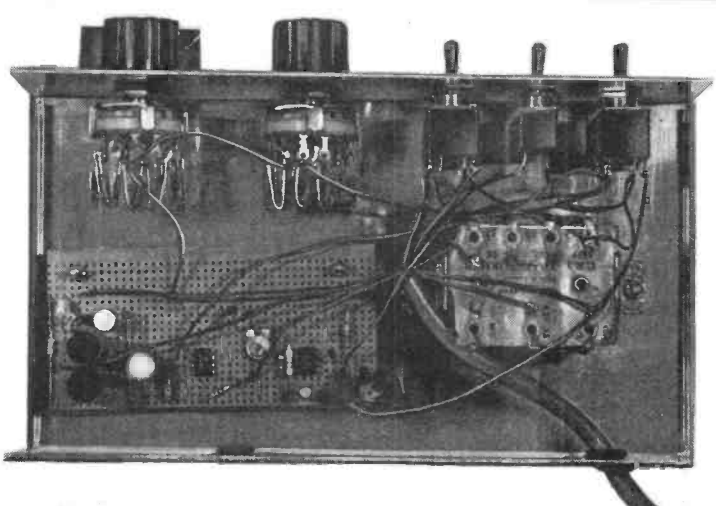
The range switching merely consists of a string of nine 68 kilohms resistors in series, and nine 680 kilohms resistors in series with these. Switch S4 can be used to select any of the 68 kilohm resistors that are not required, and S5 performs the same function with the 680 kilohms resistors. For every 68 kilohms resistor that is switched into circuit the timing period is increased by one second, and for every 680kilohm one it is obviously extended by ten seconds.

By switching in the appropriate resistors, any time (ignoring fractions of a second) between 0 and 99 seconds can be obtained. For instance, three 680 kilohm resistors and nine 68 kilohm ones will obviously give a time of 39 seconds.

If good accuracy is to be obtained, the timing resistors must all be close tolerance 1 per cent or 2 per cent types.

TRIGGER

It would be possible to arrange the circuit to operate without TR2, but there would then be the possibility that the triac would not switch cleanly, with spurious



General interior photograph showing the layout used.

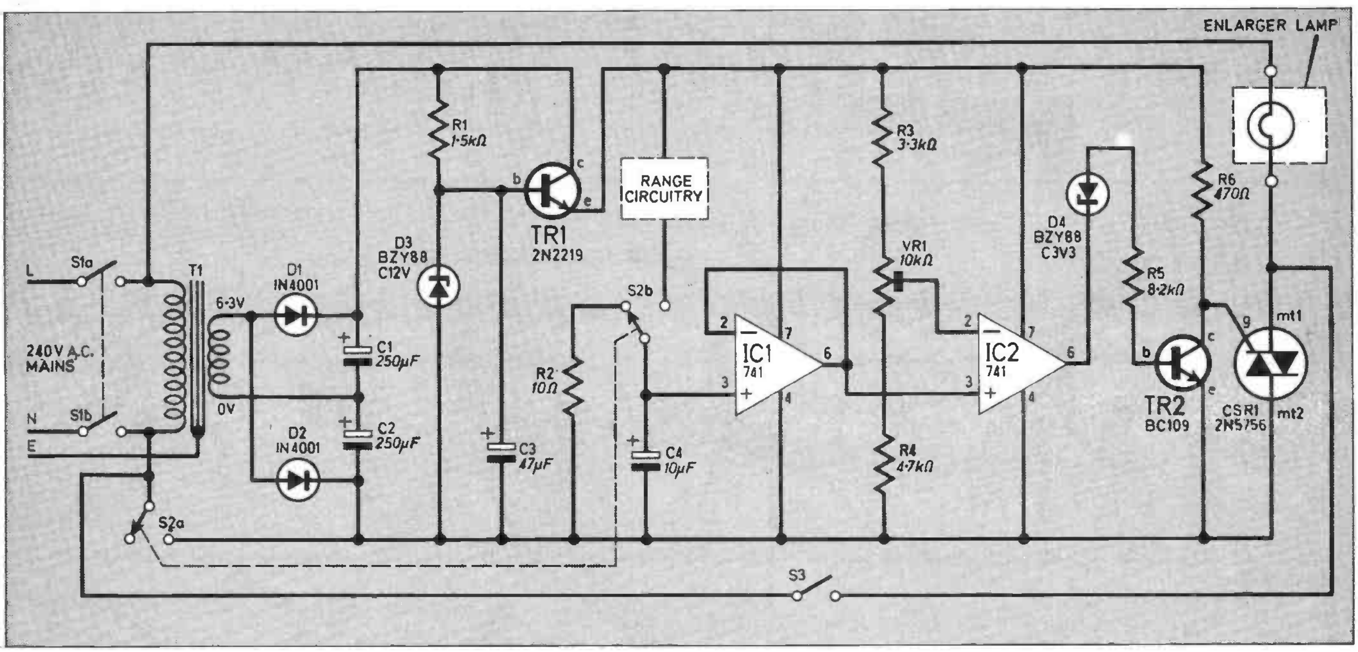


Fig. 1. Complete circuit diagram of the Enlarger Timer. The range circuitry is shown in more detail in Fig. 2.

flashes of the lamp towards the end of the timing period.

In effect, TR2 is used to speed up the voltage swing at the output of IC2 as it changes from the high to the low state, and it thus ensures clean switching by the triac.

The low output voltage of IC2 is about 2 volts, which would be sufficiently high to hold TR2 permanently on if it were not for the inclusion of D4. This will not begin to conduct until about 3 volts is developed across it's terminals, and so it prevents TR2 from receiving any base current with IC2 output in the low state; R5 is a current limiting resistor and is included for the protection of TR2.

Any time after the timing period has been completed, S2 can be returned to the left hand position. This causes C4 to be discharged through S2b and R2. Resistor R2 is needed to limit the discharge current and so prevent sparking at the switch contacts, which could otherwise reduce the life of the switch. When C4 has been discharged, the triac will turn on again, but the enlarger lamp will not come on as it is disconnected from one side of the mains by S2a.

The circuit is thus reset and ready to start a new run.

Switch S3 enables the lamp to be turned on while the enlarger is being focused.

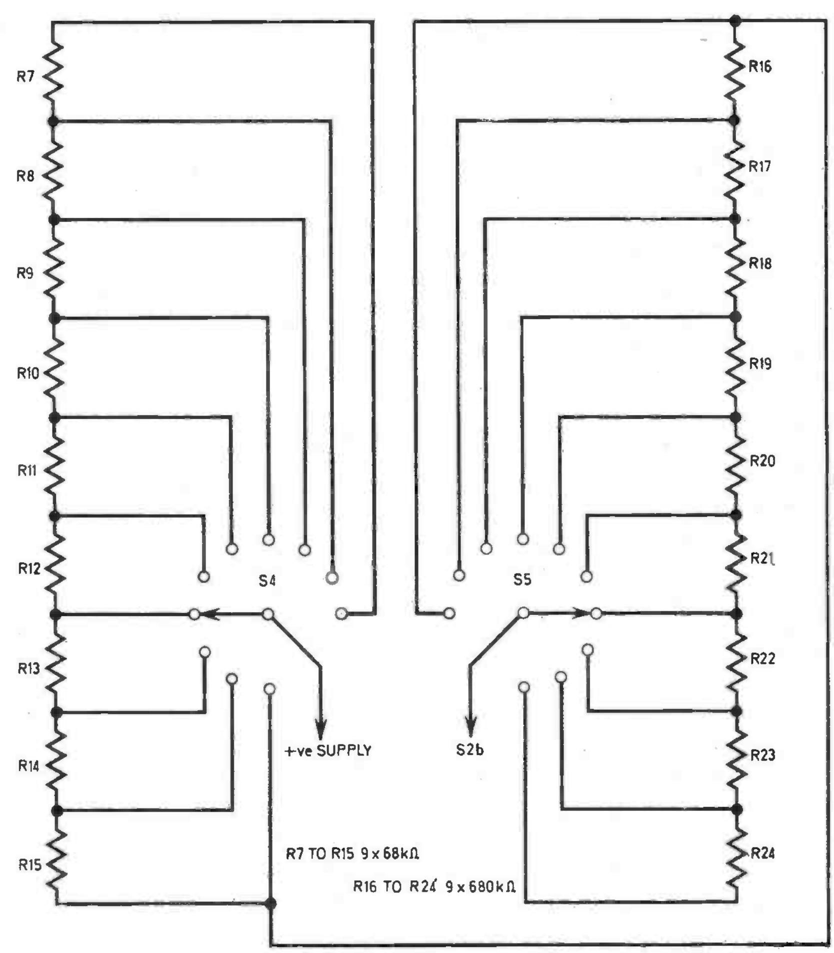


Fig. 2. The range switching circuitry for the Enlarger Timer.

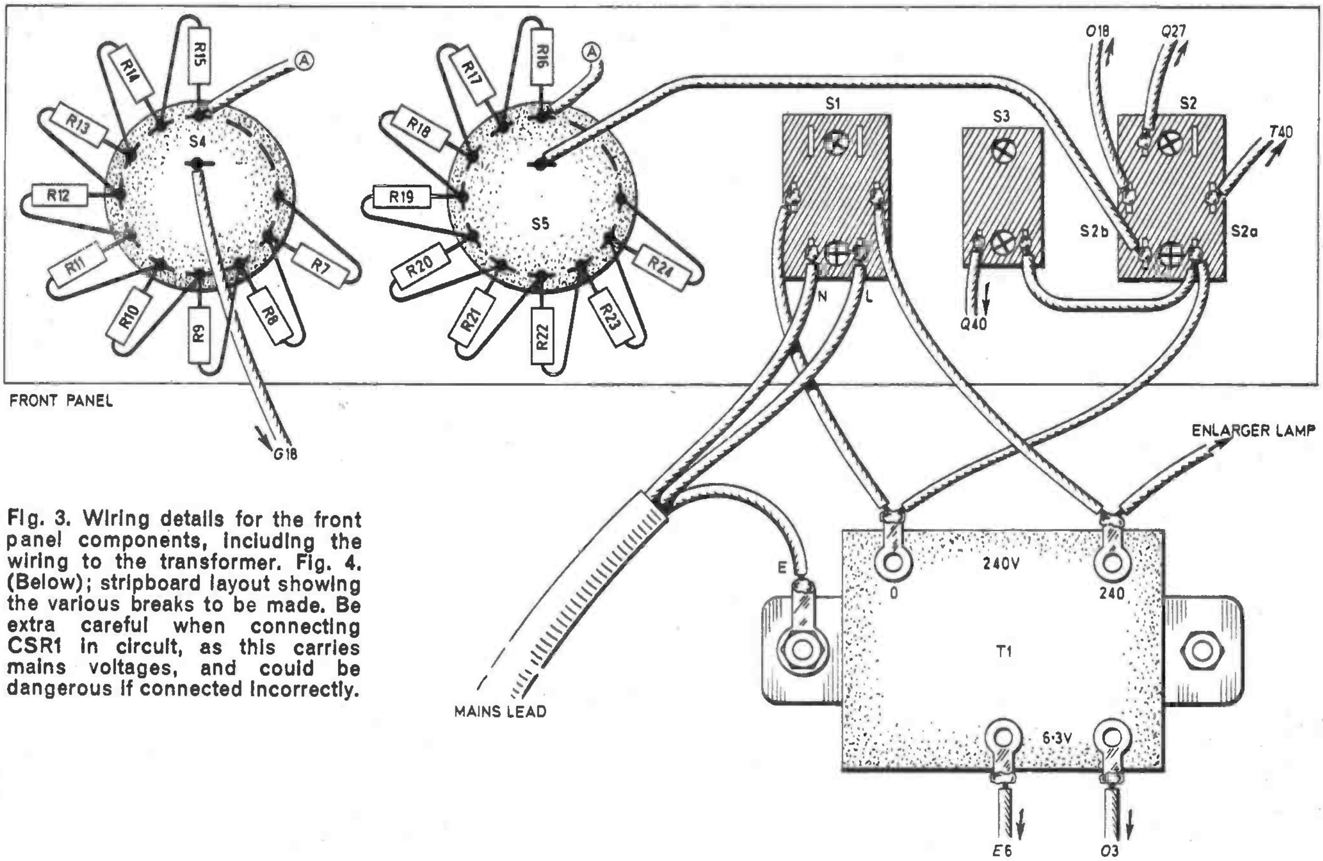
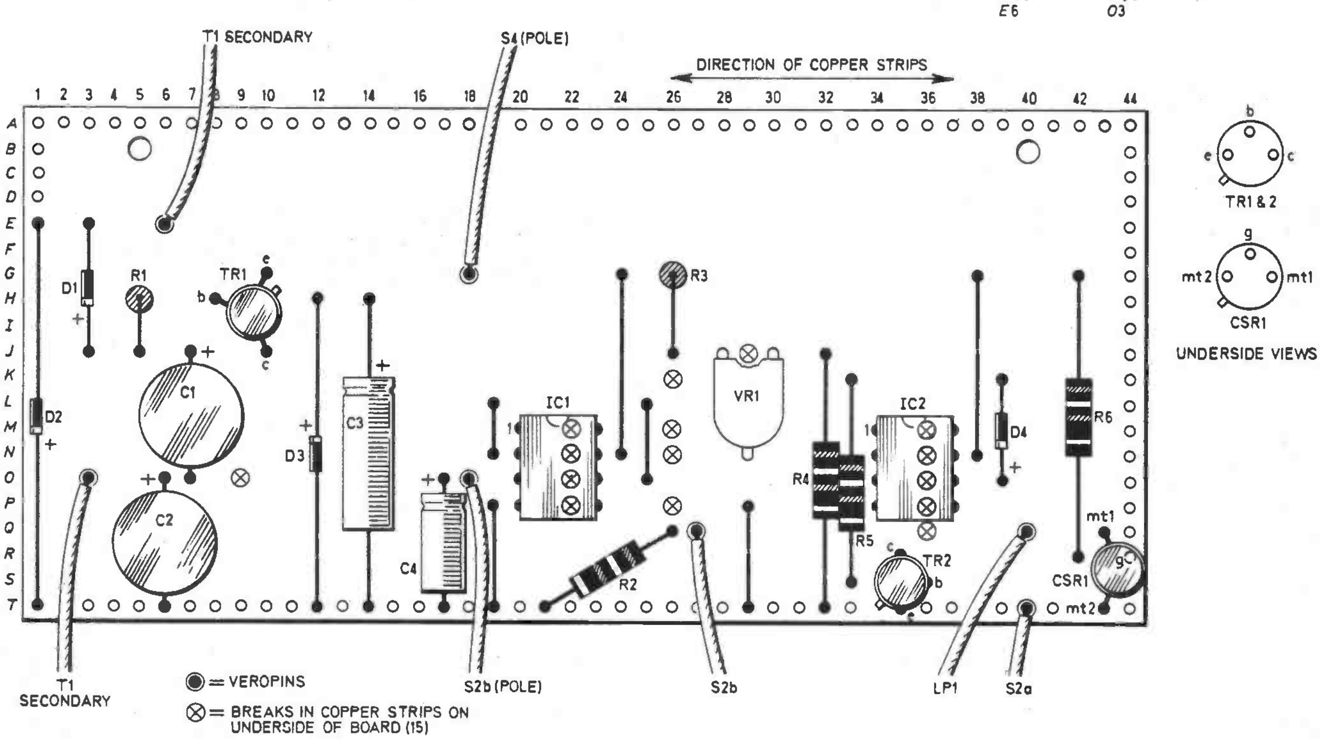


Fig. 3. Wiring details for the front panel components, including the wiring to the transformer. Fig. 4. (Below); stripboard layout showing the various breaks to be made. Be extra careful when connecting CSR1 in circuit, as this carries mains voltages, and could be dangerous if connected incorrectly.



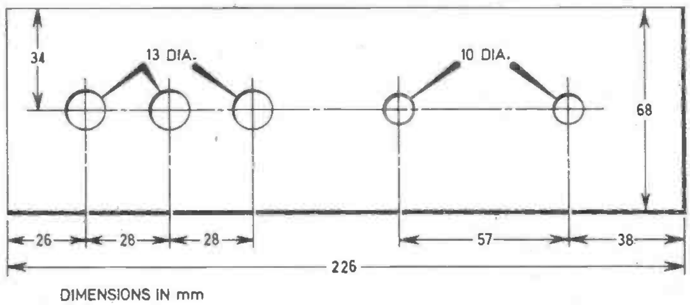
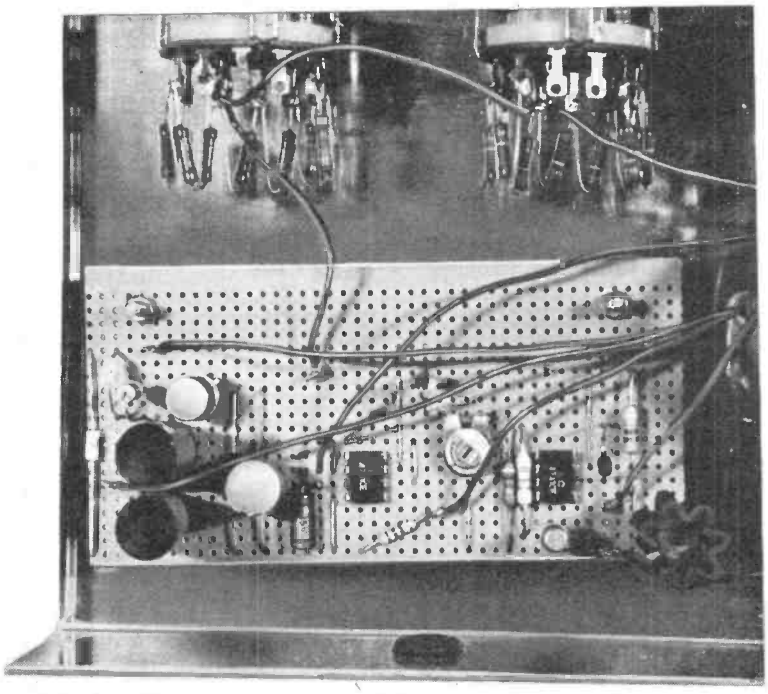


Fig. 5. Dimensions and drilling details for the front panel.



Detailed photograph showing the stripboard and in particular the method of wiring S4 and S5.

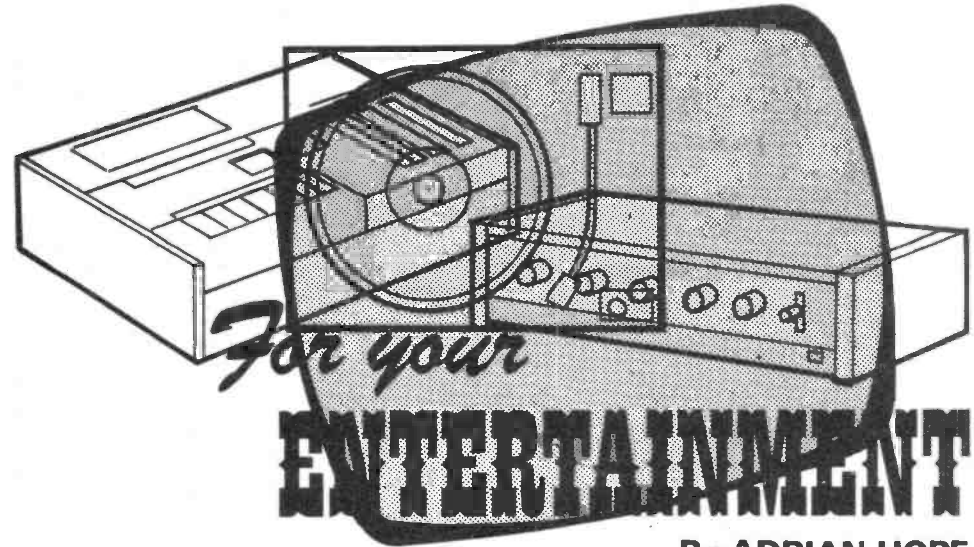
then switch S2 to the "set" position while measuring the time that the enlarger's lamp is illuminated. This procedure is then repeated as necessary with VR1 being adjusted by trial and error to find a setting that gives approximately the time set on S4 and S5. Then these switches are set for a 99 second timing period, and the same procedure of trial and error is used to bring the actual timing period to as close to 99 seconds as possible. It should be possible to obtain an error of less than half a second without too much difficulty.

Note that adjusting VR1 in a clockwise direction increases the output time, and turning it in the other direction has the opposite effect.

It is safe to use the timer with any normal size of enlarger bulb, and the prototype is used with a 150 watt bulb. The triac did run a little warm, and was therefore fitted with a small clip-on heatsink, but this is probably not really necessary.

Switches S4 and S5 can be 12 way single pole rotary switches of the type having an adjustable end stop. These would then be set for 10-way operation. The author used ordinary 12-way switches with two positions simply being ignored. This has the advantage that the control knobs are free to continuously rotate, and it is possible, for instance, to switch from position 9 to position 2 the quick way (i.e. clockwise). ⌑

JACK PLUG & FAMILY...



For your ENTERTAINMENT

By ADRIAN HOPE

It is interesting to see how hi-fi firms are going even deeper into the area of studio style equipment for the well-heeled domestic user. Technics recently demonstrated the battleship grey rack-mounted 9000 series (pre-amp, power amp, tuner, graphic equaliser and sophisticated signal-level meter unit) which is clearly aimed at the growing number of enthusiasts who like to feel at home in a studio. Of course, whether they can afford the £1,500 or so it will cost them is another matter. What interests me is what exactly people do with equipment like this. After all, hi-fi equipment is really only meant to reproduce music and other programmes as faithfully as possible.

When I interviewed John Bird last year, he summed up the dilemma very neatly: "There's a limit on what you can do with hi-fi equipment, except switch it on and off," he mused. Personally I am increasingly convinced that there are now two separate hobbies, both equally valid. One is using hi-fi equipment to listen to music. The other is playing around with hi-fi gear. And I don't mean building gear from basic components; I mean playing around with sophisticated ready-built equipment in studio fashion.

Re-mixing

If I'm right, then before long there will be some revolutionary and potentially highly profitable market trends. Take the Technics gear, for instance. The frequency equalisers and multi-tape dub facilities are ideal for altering the character of music as you dub it from one tape to another. But few people make their own original music recordings, because there is little opportunity to do so legally. After all, how many concert halls welcome an audience with tape recorders?

There is no fun in meddling with the sound of a commercially released stereo recording but there would be a great deal of fun for some people in re-mixing from a master-tape. So here's the train of thought. Sooner or later I'll bet that the record companies start releasing raw unmixed multitrack versions of recordings, probably on 4-track tape which can be replayed on Teac machines or modified cassette machines. The enthusiast will then be able to make his own stereo mix by dubbing onto 2-track cassette or open reel tape, while equalising and balancing each track in the process in creative fashion.

The record company vaults are filled to overflowing with multitrack masters for which they have little or no use and which are only kept for security. Although many of these are on 16 or 24-track tape, a selected few could easily be mixed down into 4-track, for issue to enthusiasts.

Of course there are plenty of older masters in the vaults, that were made on 4-track and could be issued in their original form—like Sergeant Pepper by The Beatles, for instance. I'll bet that if the raw 4-track masters for Sergeant Pepper were made available to the public, in limited edition, they'd sell like hot cakes to anyone who owns a 4-track deck of the type sold by Teac and there'd be a lot more 4-track decks sold in the future.

Frequency Equaliser

Another thought came out of a recent Technics demonstration. The real value of a frequency equaliser is not to roll off tape hiss or whatever, because, frankly, few people spending £1,500 on a system are playing records that need hiss rolled off. Even now the cheapest amplifiers have filters that will do the job equally well.

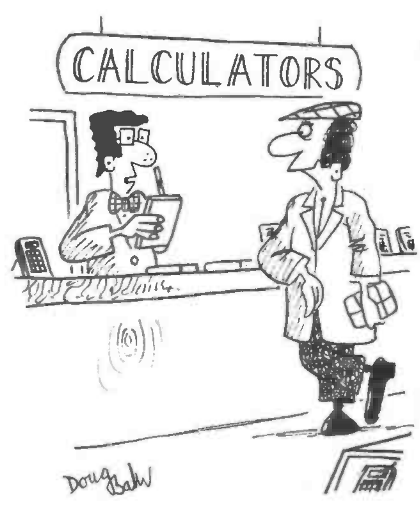
No, the real benefit of a frequency equaliser is to trim the output response of a domestic hi-fi system to the acoustics of the room in which it is used. For example, if the room is dead at the bass end, the equaliser can lift the bass just enough to level up the final sound. But the only way to equalise a room using a system like this is scientifically, which in its simplest form means generating pink noise and analysing the room sound in each frequency band independently. Adjustments are then made in those bands as necessary on the equaliser.

Sound Systems

I was out at Wembley recently, on two occasions. On one occasion the sound of a really quite competent band sounded abominable because they were playing through a totally inadequate sound system which was clearly not equalised to the hall. On the other occasion, Pink Floyd performed, through a laboriously and meticulously equalised system, and sounded superb.

Few rooms are as bad as the Wembley Empire Pool for acoustics; but most could be improved with a little judicious equalisation. By the same token they can, however, be made worse by random fiddling with an equaliser by ear and trial and error. Unfortunately the analysing equipment needed to equalise a room properly is very expensive, and sooner or later someone is going to make a fortune out of hiring themselves out on a day to day basis, to come in and equalise the listening room for anyone with an equaliser like the Technics SH9010.

Before this happens someone will need to show what equalising a room can do to its sound. This was vividly demonstrated at an Audio Engineering Society meeting several years ago, when the lecturer progressively corrected the appalling acoustics of the room during the course of his talk. Someone, perhaps Technics, might like to think about holding a demo in a room with bad acoustics and showing what their wares can do to improve them.



"If you'll just give me a few minutes, sir, I'll work out how much you've got to pay."

SQUARE ONE ...FOR BEGINNERS

WE ARE HERE TO HELP YOU – NO MATTER HOW NON-TECHNICAL YOU MAY BE, JUST READ ON!

ORDERING COMPONENTS

SO YOU'VE found a project in EVERYDAY ELECTRONICS that you could put to good use, and would like to build it.

"How do I go about this?" you may be asking yourself.

Your first task is to collect together all the components required to build the unit. In all of our constructional projects you will find such a list of requirements in a box headed COMPONENTS, see Fig. 1. This contains all the electronic components and hardware required.

Check this list against any components you may already have and make a new shopping list of the remainder.

Although not essential it is, in our experience, desirable to have all the components and parts to hand before embarking on the construction. However, when items such as cases and dials and labels are required, it may be prudent to delay the purchase of such items until the project is functioning satisfactorily.

If you are lucky enough to have a component dealer in your area, take your list of requirements along to him. He may not have all the components in stock but could possibly offer suitable replacements (equivalents). It may be a good idea to take along with you the copy of EVERYDAY ELECTRONICS featuring the project.

For those remote from component shops, you can order by post. There are many mail order firms as you can see in the advertisement pages of EVERYDAY ELECTRONICS.

Some components may not be available from an electronic component stockist, for example the lamp required in the *Train Controller* (page 64) will have to be purchased from a garage or car accessory shop.

Mail order firms prefer to handle orders made out on their "official order forms", but these will probably not be at hand for the newcomer unless he or she has previously purchased a catalogue (which encloses official order forms). In the absence of such a form, write out your order as clearly and concisely as possible, preferably typed, so as to avoid reading errors. A specimen "home-made" order form is shown in Fig. 2 and uses the component list from the *Train Controller* article, on page 64).

Mr SMITH
123 New Street,
Old Town

Dear Sirs, 16th September 1977
Please supply:

Quantity	Description	Cost
1	Resistor 2.7k ¼W carbon	2
1	Potentiometer 1k lin.	18
1	Transistor BFY51	25
1	Transistor 2N3055	70
1	Switch d.p.d.t. toggle	40
4	Insulated screw terminals 2 red, 2 black	60
1	5-way tagstrip	5
1	Lamp bezel (red)	10
1	Knob type CK2	20
1	Mica washer type TO-3 }	5
2	Insulating bushes TO-3 }	
	Total	£2.55
	Post & Pack	20
	Total	2.75
	8% V.A.T	22
Enclosed cheque No. 123456	TOTAL	£2.97

Fig. 2. A suggested layout for a "home-made" order form.

COMPONENTS

Fig. 1. You will find all the necessary components to build the project under this heading.

See **Shop Talk** Page 67

Fig. 3. Project discussed in *Shop Talk*.

You should only need to do this on your first order to a particular supplier as an official order form will (in most cases) accompany your goods. In some instances a prepaid addressed envelope is also sent to you for your next order.

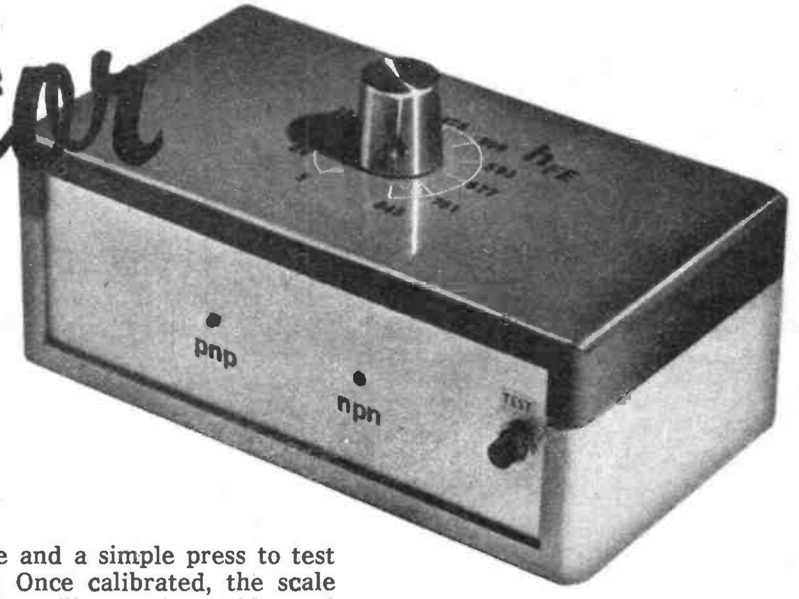
It is a good idea to mention the project you are building and the publication date as advertisers will have copies of EVERYDAY ELECTRONICS and can check that the components they supply are suitable.

Before making out your order form, it is important that you read *Shop Talk* because any components that we think may be difficult to obtain will have been investigated and a supplier's name and address given along with the inclusive cost. A "See *Shop Talk*" page 67 as shown in, Fig. 3 is included in all component boxes to draw your attention to this service.

Finally, before posting your order, ensure that you have enclosed your cheque or postal order to cover the total amount. Cash should not be sent. How long you wait for delivery will vary from firm to firm, but for an order sent by first class post on a Monday morning, under normal circumstances your components would arrive within a week.

When you receive your components the next step is to identify them and check the values and type numbers. This will be dealt with in next month's SQUARE ONE.

Transistor Tester



By D. J. Stephenson

INTRODUCTION

A TESTER, capable of measuring h_{FE} and distinguishing *pnp* from *npn* transistors, will always remain a useful item in the workshop.

A quick go/no-go test is of course the "back to front" resistance check across each junction although the electronic multimeters which are gaining polarity do not always perform well in this application. The current they deliver on ohms is often too small to bias a junction on sufficiently to produce a reliable test.

Although the actual value of h_{FE} is seldom critical in a reasonably designed circuit (except when matching pairs) there is no doubt that h_{FE} is essentially the primary "goodness" factor and it is always worth while in a one off project to pick the best specimen.

The present economic situation will soon be pressing some of us to send for those packs of unmarked, untested transistors and here, a simple h_{FE} and *pnp/npn* discrimination test is almost a necessity.

This model has no expensive meter, has only one knob to operate and a simple press to test button. Once calibrated, the scale readings will remain stable and reliable.

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS £4.50 excluding case

START HERE FOR CONSTRUCTION

The prototype was encased in a Verobox type 212. The two l.e.d. indicators and the PUSH TO TEST button are fitted to one of the side panels but the h_{FE} potentiometer VR1, and batteries occupy the lid as shown in the photographs.

The circuit is assembled on a piece of stripboard as shown in Fig. 1. The two i.c.s are mounted in sockets as are the three transistors.

Plastic edging strips obtainable from d.i.y. stores make excellent guides. Two pieces are cut and drilled to fit, and attached to the Verobox. The board is clipped into place and held quite firmly by a loop of single strand insulated wire. The same kind of strips keep the two batteries in position.

The flexible wiring from the stripboard can be soldered direct but some form of anchoring remains a better proposition. Veropins are well worth the additional soldering labour. The link *A* and the points used for the initial setting up procedure are also desirable pinning points.

The method of connection to the transistor under test may be a matter of personal choice. The prototype uses flexible leads into banana sockets but there is no reason why a cluster of suitable transistors sockets cannot be used —there is plenty of room for them.

SETTING UP PROCEDURE

The initial test is simple. With no transistor inserted, the two l.e.ds should flash alternately at all settings of VR1.

With a *pnp* under test, one l.e.d. should be on at low settings of VR1 and flashing should only commence at some critical value. With an *npn* transistor, the action should be the same except that the other l.e.d. should be steady at low settings of VR1. If these results are obtained, the preset VR2 can now be adjusted to obtain an accurate V_{REF} for the op amp.

(a) Remove link *A* and connect a milliameter in its place.
(b) Short TP1 to TP2 to stop the dual astable.
(c) Connect any *npn* transistor to the test probes.
(d) Adjust VR1 until a reading of 2 milliamps is obtained.
(e) Disconnect the meter and restore the link, taking care not to disturb the setting of VR1.
(f) Measure the voltage between link *A* and TP1.
(g) Set VR2 for an identical voltage voltage between TP3 and TP1.

Transistor Tester

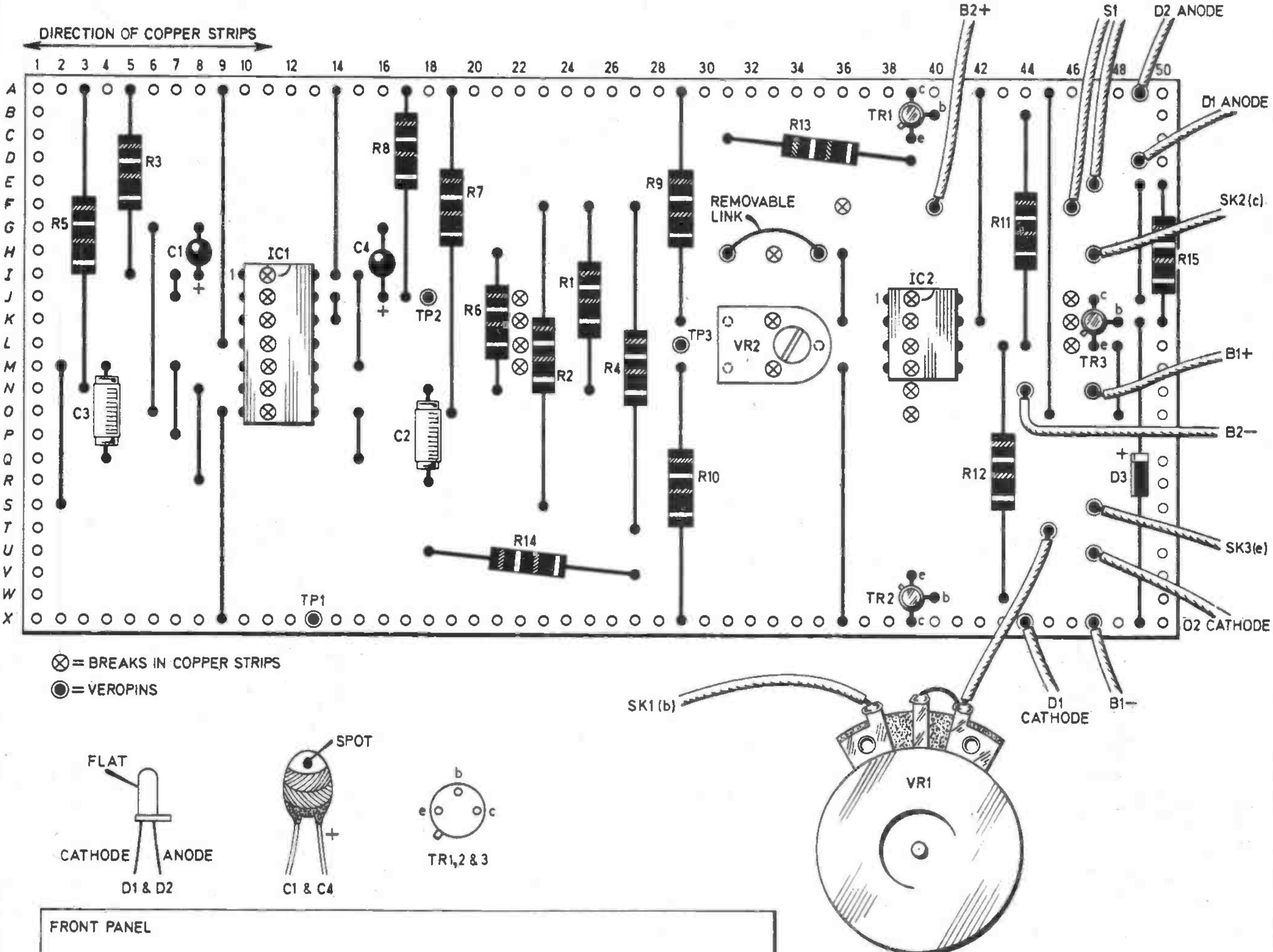


Fig. 1. (Above) stripboard layout showing the breaks to be made. Note carefully the position of C1 and C4, and their polarities. Sockets were used on the prototype for the transistors and i.c.s.

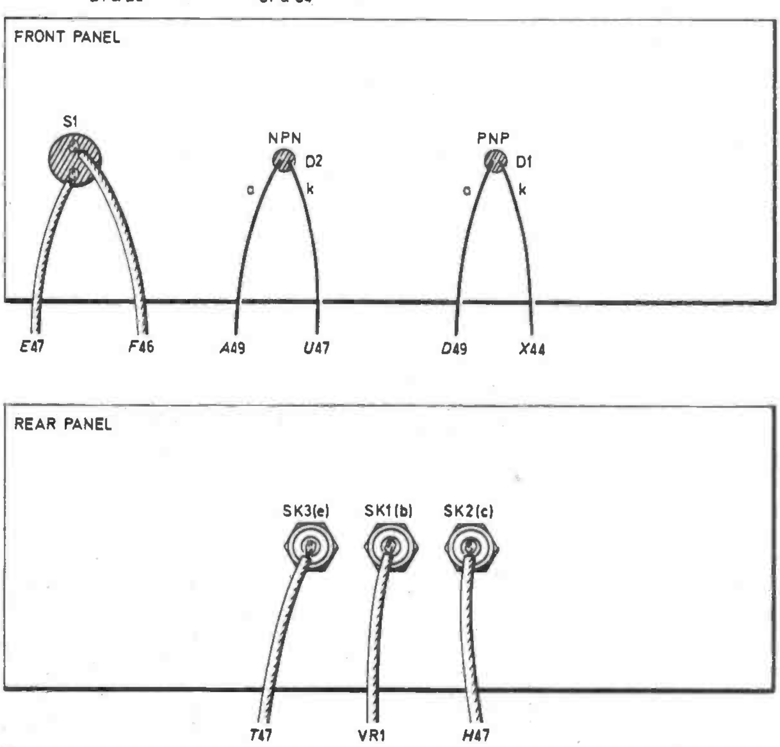


Fig. 2. The two panels showing the layout used. These should be used in conjunction with Fig. 1 to complete the wiring.

COMPONENTS

Resistors

R1	680Ω ±2%	R9	6·8kΩ
R2	680Ω ±2%	R10	5·6kΩ
R3	270kΩ	R11	12kΩ
R4	12kΩ	R12	12kΩ
R5	12kΩ	R13	1kΩ
R6	2·7kΩ	R14	1kΩ
R7	12kΩ	R15	820Ω
R8	270kΩ		

All resistors are carbon film ±5% ¼W, except 2% types which are metal-oxide.

Potentiometers

VR1 2MΩ lin. less switch
VR2 2·2kΩ miniature cermet preset

Capacitors

C1 1μF 35V tantalum
C2 1000pF polystyrene
C3 1000pF polystyrene
C4 1μF 35V tantalum

See Shop Talk page 67

Semiconductors

IC1 556 dual timer i.c.
IC2 741 operational amplifier 8 pin d.i.l. i.c.
TR1 BC107 silicon *npn*
TR2 BCY71 silicon *pnp*
TR3 BC107 silicon *npn*
D1, D2 TIL209 red light emitting diode
D3 BZY88C13V 13V 400mW Zener diode

Miscellaneous

S1 push-to-make, release-to-break single pole switch
B1, B2 PP3 9V battery (2 off)
SK1, 2, 3 small 2mm sockets (one off each colour; red, green, and blue).
Stripboard 0·1 inch matrix 24 strips × 50 holes; Verobox type 212 or similar; two battery clips; three small plugs to suit sockets; three miniature crocodile clips; Veropins (16 off); three transistor sockets, and one 8 pin i.c. socket; one round control knob; connecting wire; solder.

This completes the initial setting up and the instrument is now ready for testing any *pnp* or *npn* transistors.

CALIBRATION

There are two approaches to the problem of calibration.

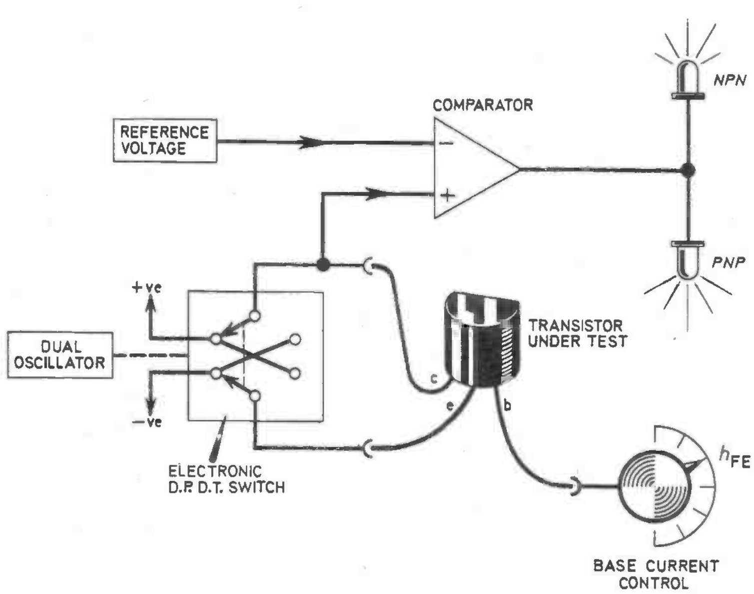
(a) Comparison with transistors of known h_{FE}.
(b) Using an equation derived from the circuit values which connects h_{FE} with the angle on VR1 scale.

It can be shown that if VR1 is in kilohms, then $h_{FE} \simeq 5 + 0{\cdot}42 \times$ VR1.

Because the potentiometer has a sweep of 300 degrees and is 2000 kilohms at maximum setting the relation between θ and VR1 is VR1 = 2000θ/300 which on substituting in the first equation gives:

$$5 + 2{\cdot}8\,\theta \simeq h_{FE}$$

Fig. 4 shows the scale used based on the equation for 30 degree steps which can be subject to tolerance errors in VR1. For higher accuracy, the actual value of VR1 can be measured and used in place of the nominal 2 megohms in the equations.



HOW IT WORKS...

Two oscillators in anti-phase produce in effect a double-pole double-throw electronic switch that supplies positive and negative supply lines to the transistor under test. The polarity of the supply lines alternates at a rate of about 3 hertz.

For an *npn* transistor, the potential at point *A* is negative with respect to *B* (set at about half rail level) when the supply line to the collector is negative, and also when this supply line is positive, because the transistor is now turned on and its collector voltage is just above that on the emitter. This causes a negative output from the comparator which turns on the NPN l.e.d. Similarly, a *pnp* test transistor always produces a positive level at *A* with respect to *B* thereby producing a positive voltage which turns on the PNP l.e.d.

Both l.e.d.'s will flash when the potentials at *A* and *B* are equal and will occur when collector current (base current *times* gain, h_{FE}) is 2 milliamps. Read h_{FE} on the dial.

CIRCUIT DESCRIPTION

DESIGN POINTS

The primary aim has been simplicity, so the only controls are PUSH TO TEST and one knob calibrated directly in h_{FE} which is rotated until two light emitting diodes flash alternately. Before this critical point is reached, one of the l.e.d.s will be on, indicating whether the transistor under test is *pnp* or *npn*.

The functional diagram is shown in Fig. 3. The collector and emitter supply rails of the transistor are supplied by the complementary outputs of a dual 556 timer operating in the astable mode. These two rails *A* and *B* are therefore alternating in relative polarity at some fixed frequency.

The base current is fed from a point exactly half way between *A* and *B* via the adjustable resistor R_B. The junction of R_C and the collector V_C forms the input to the non-inverting terminal of a 741 operational amplifier operating under open-loop conditions to give a gain in the order of 10^5 (100,000). The inverting terminal is held locked to a reference voltage which, like the transistor base, is exactly half way between *A* and *B*.

The test of an unknown transistor begins by setting R_B to maximum resistance, i.e. maximum base current. Suppose the specimen is *npn*. The heavy base current saturates the transistor when point *A* is positive to *B* causing V_C to fall to near the potential at *B*. This is negative to V_{REF} so the 741 output is saturated near the negative supply rail. The *pnp* driver is therefore hard on and the l.e.d. (marked NPN on the front panel) is illuminated. When point *A* switches negative to *B*, the test transistor is off but V_C *still remains negative* to V_{REF} so the output conditions remain unchanged, i.e. the NPN l.e.d. maintains a steady glow.

If the test transistor had been *pnp*, the explanation would follow an identical pattern, except that V_C would be held positive of V_{REF} and the 741 output would saturate near the positive supply rail turning the opposite l.e.d. on.

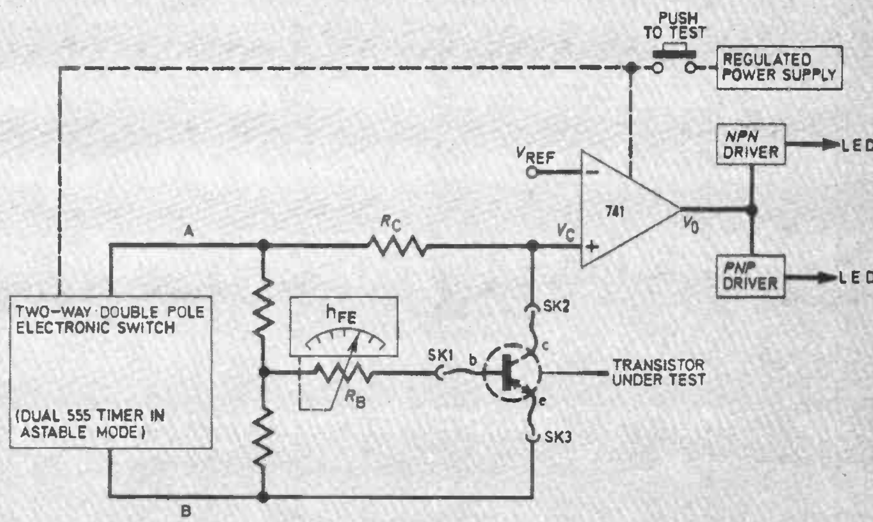


Fig. 3. Functional diagram to illustrate the working of the Transistor Tester.

The determination of h_{FE} is simple. The control is advanced (increasing R_B and lowering the base current) until V_C is within a fraction of a millivolt of V_{REF}. At this point the op-amp begins to swing up and down in sympathy with the timer frequency causing both l.e.d's to flash.

The onset of flashing is extremely sharp because of the very high open loop gain of the 741.

The value of R_C is dependant on the choice of collector current at which the h_{FE} is to be measured. A value of 2 milliamps is the most popular figuré used by manufacturers and is used here. This means that R_C is calculated to drop half the voltage at 2 milliamps and ensures that the flashing always starts at this constant value of I_C.

The higher the h_{FE}, the less base current is required to produce the 2 milliamp collector current, so the onset of flashing occurs at a higher R_B point on the scale.

DETAILED DESCRIPTION

The tester is powered by two 9V PP3 batteries but to maintain calibration accuracy, a transistor in conjunction with a Zener diode, is used to regulate the supply rail to 12·35V.

The 556 dual timer frequency is set at about 3Hz by C1/R3 and C4/R8. The capacitors are employed to maintain feedback between the two halves.

The calibration accuracy of the tester and the precise balance point between *pnp* and *npn* demanded a considerable degree of thought, and study of the output swing versus load current curves of the 556. To simplify the calculations, the total load current taken by the unknown transistor *TRX* and the base divider chain was arranged to be a nice round figure of 10 milliamps. *TRX* collector current takes 2 milliamps which leaves 8 milliamps to flow in the divider R1/R2. This is more than ample to supply the fixed half-way down point for the base feed.

The actual base current drawn is so small, even under worse case conditions, that it can safely be ignored in relation to the 10 milliamps total.

A graph of the 556 shows that with a 10 milliamp load, the output swings between 0·1 volt of ground when in the *low* state and 1·4 volts from V_{CC} when in the *high* state.

The voltage swings delivered to the *A* and *B* rails is therefore $(12{\cdot}35-1{\cdot}4-0{\cdot}1)V=10{\cdot}85V$.

Resistor R6 must therefore drop half this voltage at the critical 2 milliamps. It is calculated at (5·425V/2mA) which simplifies to a prefered value of 2·7 kilohms.

Resistor R4 is necessary to protect the base when VR1 is set to zero resistance and will therefore dictate the lowest h_{FE} which can be measured. The lowest h_{FE} was chosen to be 5, so allowing for the V_{BE} *of TRX*

$R4 = (5{\cdot}425-0{\cdot}65)V/0{\cdot}4mA = 12k\Omega$.

Note that when $I_C=2mA$ and $h_{FE}=5$, then $I_B=0{\cdot}4mA$.

At the other end of the scale, many transistors have an h_{FE} value almost reaching three figures so

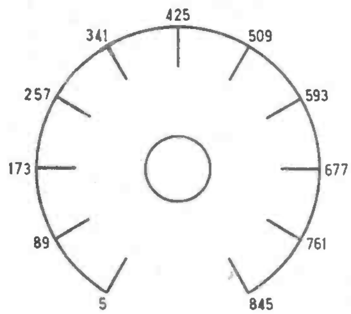
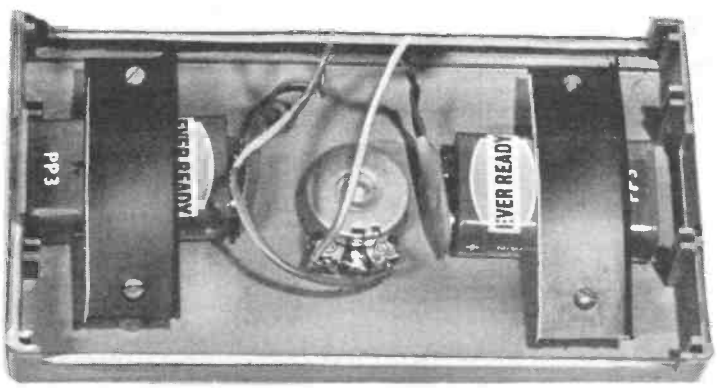


Fig. 4. Scale of h_{FE} used on the prototype unit. This is reproduced full size and may be traced.

Below: Photograph of the underside of the lid showing the positions taken up by the batteries and potentiometer.



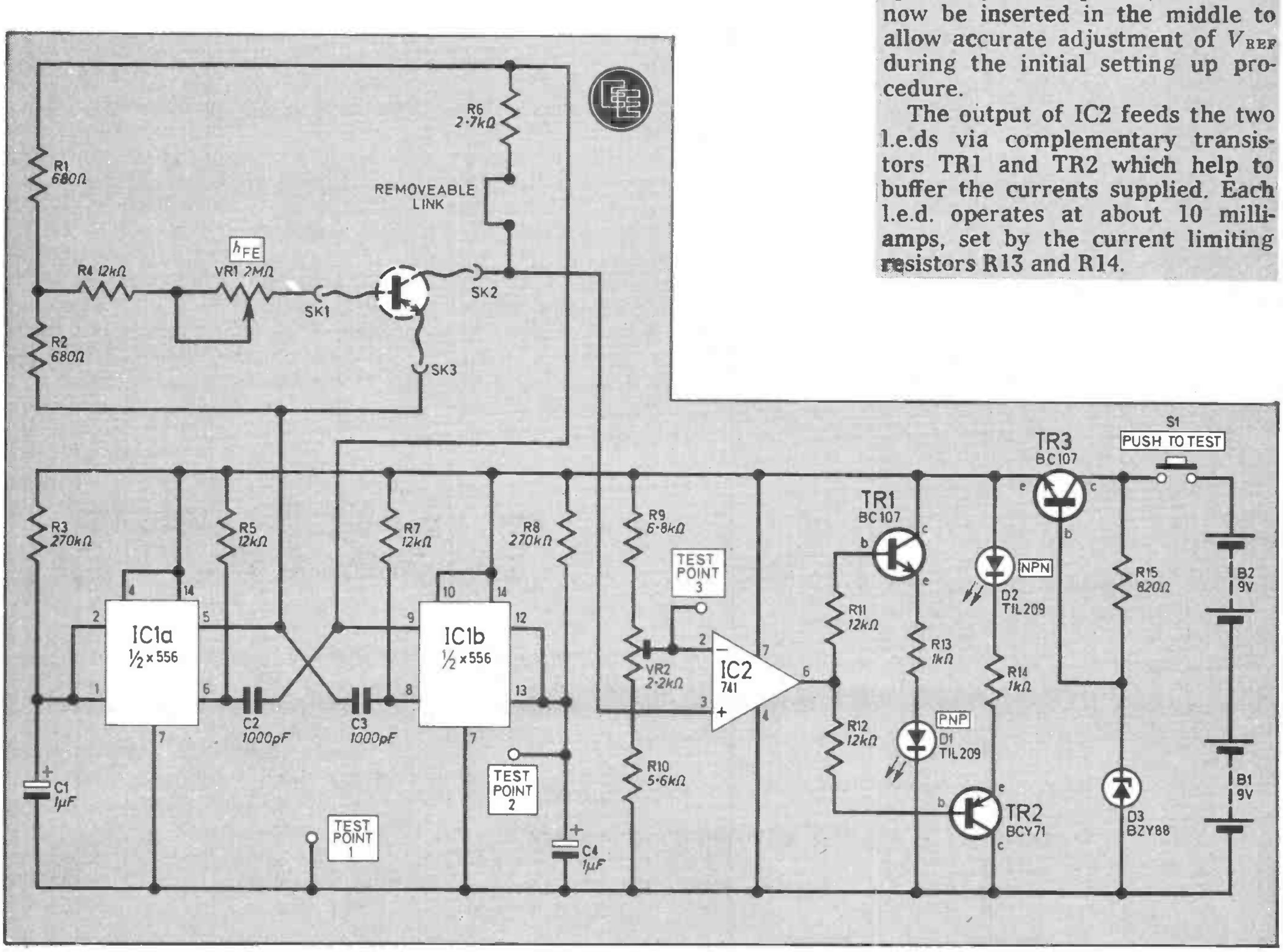
VR1 was chosen to be 2 megohm This gives the smallest base current of $(5\cdot425 - 0\cdot65)V/2\cdot012M\Omega = 2\cdot37\ \mu A$ which represents an h_{FE} of $(2000/2\cdot37)=843$.

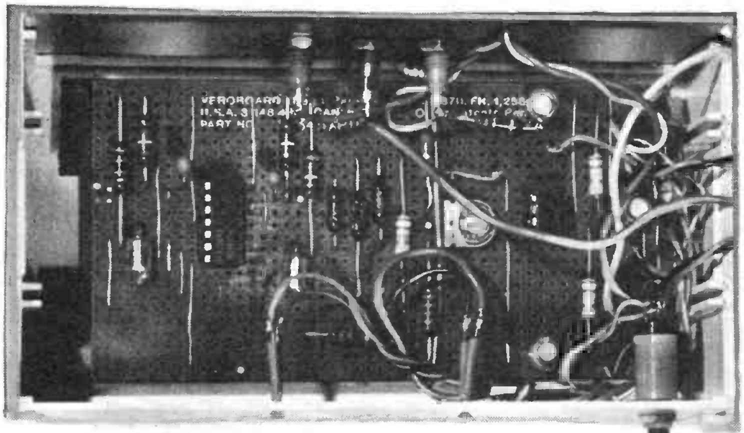
These calculations have been described in some detail as some readers might prefer a different h_{FE} range. It is fair to point out at this stage that the scale linearity is somewhat degraded at the low end due to the necessary inclusion of the fixed resistor R4. Fortunately, linearity errors need not effect the accuracy of calibration.

The calculation of the divider chain R9/VR2/R10 is best carried out by temporarily ignoring VR2. The purpose of this divider is to produce V_{REF} which, it may be remembered, must be equal to the half way point of the *A* and *B* rails.

Resistor R10 must drop $(5\cdot425+0\cdot1)V=5\cdot525V$ and R9 drops the remainder which is $(5\cdot425+1\cdot4)V=6\cdot825V$. Allowing a comfortable drain of 1 milliamp, the prefered values of the 6·8 kilohms and 5·6 kilohms arise for R9 and R8 respectively. The preset, VR2 can now be inserted in the middle to allow accurate adjustment of V_{REF} during the initial setting up procedure.

The output of IC2 feeds the two l.e.ds via complementary transistors TR1 and TR2 which help to buffer the currents supplied. Each l.e.d. operates at about 10 milliamps, set by the current limiting resistors R13 and R14.





General view of the completed Transistor Tester.

DERIVATION OF FORMULA

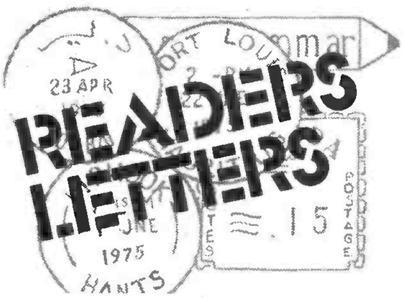
V_{AB} = 10·85V, so the voltage across the base resistors R4 and VR1 is $V_{AB}/2 - V_{be} = 4{\cdot}775V$. The base current is therefore given by $I_b = 4{\cdot}775V/(R4 + VR1)\Omega$.

At any setting of VR1, $h_{FE} = I_c/I_b = 2mA/(4{\cdot}775/R4 + VR1) = 2mA/(4{\cdot}775/12k\Omega + VR1)$. If VR1 is in kilohms, then this simplifies to $h_{FE} = (24 + 2VR1)/4{\cdot}775 = 5{\cdot}025 + 0{\cdot}419VR1$.

i.e.

$$h_{FE} \simeq 5 + 0{\cdot}42\ VRI$$

¤



Better Than Books

For many years I read, studied and enjoyed the articles in your magazine. I have built many of the projects given in the magazines and have gained a lot of knowledge. As I would like to do a little radio servicing as a hobby, I bought a number of books on the subject—at least a dozen, but to no avail. I just could not get the hang of transistor radios although I did a lot of servicing on valve jobs.

The recent series of articles on *Fault Finding* by Douglas Vere, is the best I have come across—far better than all the books put together. After studying the first two parts, I tackled a small amplifier that was not working and found the fault.

Therefore I would like to thank and congratulate your magazine and the writer of the article on the wonderful job you have done.

F. G. W. Botha,
S. Africa.

Add-On Modification

I am interested in building the *Add-On Capacitance Unit* featured in the September issue of EVERYDAY ELECTRONICS but do not wish to use it with my multimeter. Instead I want to connect it to a 6 microamp meter I have to make a self contained capacitance meter. Could you please suggest any modifications to be made.

W. L. Reid,
Dublin.

It is not our usual practice to give modifications to published designs but in view of the fact that such a piece of equipment is very useful to the constructor, and not all constructors may possess a multimeter, but may have such a meter or one less than 50 microamps at hand we are pleased to assist.

The unit is designed to operate when connected to a multimeter set to 50 microamps d.c. Therefore to use a 6 microamp meter needs the diversion of 44 microamps when connected to the unit. This is accomplished by putting a resistance in parallel with your meter equal to 6/44ths of the internal resistance of your meter, and re-numbering the scale to read 0 to 50.

Answering Machine

Have you at anytime published an article on how to make a Telephone Answering Machine. I am trying to obtain the necessary details so that I can make my own machine.

S. Johnson,
Surrey.

To install a telephone answering machine it is necessary to select one from a reputable manufacturer who will rent one to you. Once selected you must inform the Post Office of your choice. They will then tell you if the machine selected is suitable to connect to the Post Office system. Alternatively the Post Office will send you a list of manufacturers which have their approval. You are not allowed to build and/or install your own machine.

Vicious Video

It is perhaps a sobering thought that amusement arcades dotted across the country are now knee deep in video games. Now video games are quite harmless in themselves but some of the variations may cause concern among people. Upon visiting one of these arcades myself, I noticed some rather disturbing games, some involving tanks to eliminate battalions of troops, or photocell rifles to shoot down video jet planes.

One particularly nasty variation involved a car to be steered towards pedestrians crossing the track. A "hit" is indicated by an electronic "scream". The pedestrian is replaced by a tombstone. The score counter is incremented and the game continues.

I am not particularly given to psychology, but it may well be that this kind of violence, portrayed for fun, may have long term, rather disturbing implications.

There are plenty of video games that portray fun without violence; one such game involving steering a car around a tortuous track. Another prime example is the humble video sport machines. Remember, familiarity breeds contempt.

C. Stone,
Hull,
N. Humberside.

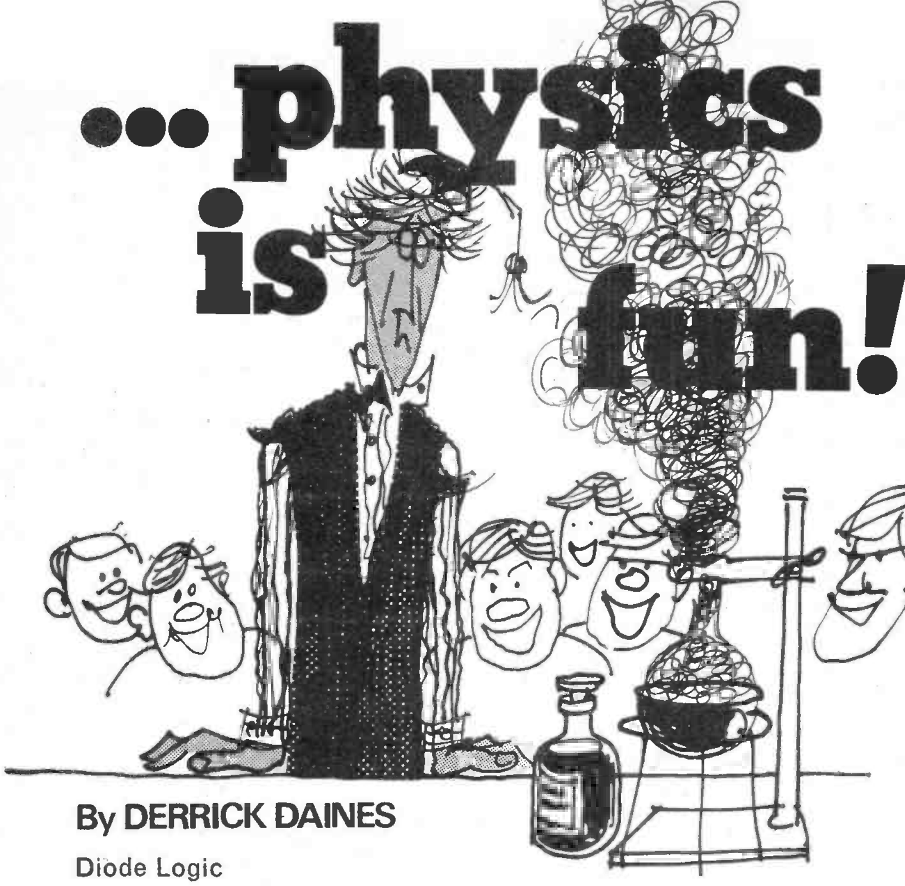
PLEASE TAKE NOTE

Soil Moisture Monitor *(June '77)*
The circuit diagram, Fig. 1 contains an error; the battery is shown the wrong way round. However, the wiring diagram of Fig. 2 is correct.

Fuzztone *(July '77)*
In Fig. 2 the input capacitor C1 is shown connected to pin 2 of IC1. It should of course go to pin 3 as per circuit diagram.

Add-on Capacitance Unit *(Sept. '77)*
The ranges specified are ten times to high and need to be re-labelled. Range 1: 0 to 0·005μF, Range 2: 0 to 0·05μF, Range 3: 0 to 0·5μF.

... physics is fun!



By DERRICK DAINES

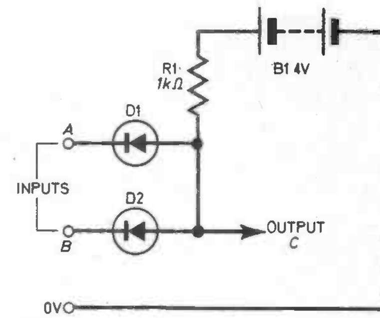


Fig. 2. Experimental AND gate.

Diode Logic

A DIODE is a semiconductor gadget that predominently allows current to flow in one direction only. I say, predominently because a tiny current will also flow in the opposite direction. Take any small point-contact glass diode (they are very cheap) and use a multimeter to measure the resistance across it. Then reverse the leads to measure the resistance across the other way. What do you notice? In one direction the reading is very high, while it is very small in the other.

Now the multimeter measures resistance by utilising its internal battery and measuring the current flow. The diode therefore has allowed a large current to flow in one direction (small resistance) and a small current (large resistance) in the other.

By the way, if the resistance measured in both directions is very high or very low, the diode is faulty and should be discarded. The high resistance direction is commonly better than 1 megohm, while the low resistance direction is of the order of 20 to 50 ohms, as measured from a sample batch of cheap devices.

From this we can draw two important conclusions: (1) There is always some resistance in the forward direction, (2) No diode is of infinite resistance in the backward direction. Perhaps a third conclusion should be pointed out: (3) there is a range of suitable resistances, depending upon the application.

Computer Language

A basic circuit of a whole family of computers may be demonstrated quite easily by only two diodes and one resistor. All computing and logic circuits process information that is presented to them in "bits". A bit is usually an electrical signal that can be in one of two—and only two—states. A good example is the electric lamp, which can be on or off.

INPUT A	INPUT B	OUTPUT C
0	0	0
1	0	0
0	1	0
1	1	1

Fig. 1. Truth table for an AND gate.

Scrumpi, a microprocessor kit regularly advertised in our sister magazine, PRACTICAL ELECTRONICS, is one example of a computer that presents its output of information in exactly that way, by means of a series of lamps either lit or unlit. In our experiments for this month a ground-level voltage is represented by "0", while a positive voltage is represented by a "1".

In the AND gate, an input should be present at both inputs before an output is rendered, as per the truth table of Fig. 1. If either input is 0 then the output is 0 also.

Make up the circuit of Fig. 2 and adjust the power supply for 4 volts. Temporarily return both inputs *A* and *B* to earth and measure the output. It will be found to be approximately 0·6 volts, which for this experiment is deemed to be 0. Leave input *A* connected to earth and connect input *B* to the source of 4 volts. Measure the output again and notice how it stays at 0·6 volts. Swapping the two inputs still does not change the output, hence satisfying the conditions of the third line of the truth table.

Finally connect both inputs to the 4 volt line and measure the output. As you might have expected by now, the output has jumped up to 4 volts, the 1 level, and the circuit has fulfilled the requirements of an AND gate. A simple application of such a circuit might be, "When the fridge door is open AND the tray is absent, sound the alarm," or, "When the kettle boils AND the time is after six, ring the bell."

Surprisingly perhaps, the circuit can be utilised to do much of the work of subtraction despite it's name, as the following experiment will prove.

Inhibit Experiment

Connect input *A* to the 4 volt supply and input *B* to an audio generator delivering a square wave 250Hz, 1·5 volts. Notice that the output from the gate is also square wave. Now remove input *A* from the 4 volt supply and ground it. The output also ceases. This indicates the so-called "inhibit" quality of the AND gate, where one input can be used to stop or inhibit another.

Install a two-way switch into input *A* so that it may be switched rapidly from ground to 4 volts and back again. Flicking the switch backwards and forwards very rapidly will allow the 250Hz from the generator to appear at the output in bursts.

The reader may now be in a position to consider Fig. 3, where two inputs are shown diagrammatically. Note that there is an output (bottom) only when the two inputs are at 1, hence my remark that the AND gate can do much of the work of subtraction.

The AND gate is capable of extension, commonly up to about 7 inputs, but notice that the inputs cannot be left floating—they must have either a high (1) or low (0) at each.

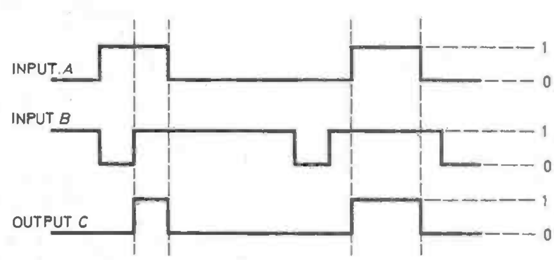


Fig. 3. The output is high only when *both* inputs are high.

SMALL ADS

The prepaid rate for classified advertisements is 16 pence per word (minimum 12 words), box number 60p extra. Semi-display setting £4·00 per single column centimetre. All cheques, postal orders, etc., to be made payable to Everyday Electronics and crossed "Lloyds Bank Ltd." Treasury notes should always be sent registered post. Advertisements, together with remittance, should be sent to the Classified Advertisement Manager, Everyday Electronics, Room 2337, IPC Magazines Limited, King's Reach Tower, Stamford St., London, SE1 9LS. (Telephone 01-261 5918).

CONDITIONS OF ACCEPTANCE OF CLASSIFIED ADVERTISEMENTS

1. Advertisements are accepted subject to the conditions appearing on our current advertisement rate card and on the express understanding that the Advertiser warrants that the advertisement does not contravene any Act of Parliament nor is it an infringement of the British Code of Advertising Practice.

2. The publishers reserve the right to refuse or withdraw any advertisement.

3. Although every care is taken, the Publishers shall not be liable for clerical or printers' errors or their consequences.

Receivers and Components

7lb ASSORTED COMPONENTS £2·95. Small audio amplifiers. 3 transistors equivalent to AC128, OC72, with circuit. 3 for £1. Goods post paid. List 15p. Refunds on purchase. Insurance add 10p. J. W. B. Radio, 2 Barnfield Crescent, Sale, Cheshire M33 1NL.

COMPONENTS AND HARDWARE — wide range of products—all in stock for prompt despatch. Details 2 x 7p stamps. MAGENTA. EF9. 61 Newton Leys, Burton on Trent, Staffs DE15 0DW.

GPO 4 Digit Counter 500 Ω 42p. Small Reed Switch 10p, Large 12p. 8Ω Earphone & Plug 18p. Miniature push to test switch 18p. Small slide switch DPDT 18p. Croc clips Red/Black 7p. Large red L.E.Ds 20p. Loud Sirens 6v D.C. £1·28. Buzzer Alarms 1½v 65p. Large Mains Neons 25p, Holders 12p. TV Coax plugs 8p. 90v Neons 8p. Resistors ¼W 10 Ω–10M 2p ea. Prices include VAT. Add 16p Postage.

GRIMSBY ELECTRONICS,
64 Tennyson Road, Cleethorpes, Humberside.
100's of bargains at our Lambert Rd. Components shop (open Saturdays). List No. 12 10p or S.A.E. Disconut for Quantity. Trade Supplied.

DISCOVER ELECTRONICS. Build twenty easy projects including; Metal Detector; Wireless Transmitter; Breathalyser; Miniature Radios; Stethoscope; Lie Detector; Touch, time switches; Burglar Alarms; etc. Circuits, plans all for £1·29 including circuit board. Mail only. Ridley photo/electronics, Box 62, 111 Rockspark Road, Uckfield, Sussex.

FREE STORAGE DRAWER—yours with our full value component pack. IDEAL FOR BEGINNERS. Send £3·95. Extra Drawers 49p. Details 2 x 7p stamps. MAGENTA. EG9. 61 Newton Leys, Burton on Trent, Staffs DE15 0DW.

NO LICENCE EXAMS NEEDED

To operate this miniature, solid-state Transmitter-Receiver Kit. Only £9·75 plus 25p P&P.
'Brain-Freeze' 'em with a MINI-STROBE Kit, pocket-sized 'lightning flashes', vari-speed, for discos and parties. A mere £4·30 plus 20p P&P. Experiment with a psychedelic DREAM LAB, or pick up faint speech/sounds with the BIG EAR sound-catcher; ready-made multi-function modules. £5·00 each plus 20p P&P.
LOTS MORE! Send 20p for lists. Prices include VAT. (Mail order U.K. only).

BOFFIN PROJECTS
4 Cunliffe Road, Stoneleigh
Ewell, Surrey. (E.E.)

TRANSISTOR TESTER. Contains all components, drilled case, construction details and transistor data. KIT—send £4·95. BUILT—£5·95. Details 2 x 7p stamps. MAGENTA. ED9. 61 Newton Leys, Burton on Trent, Staffs DE15 0DW.

TIRRO ELECTRONICS the mail order division of RITRO ELECTRONICS UK offers a wide range of components for the amateur enthusiast. Large SAE or 20p brings list. GRENFELL PLACE, MAIDENHEAD, BERKS. SL6 1HL.

I.C.s., TTL.C/Mos, Linear, Capacitors, Resistors (E12) SIL/Rectifiers, Diodes, LED, Thyristors, Zenors, Voltage Reg, DIL Sockets, Bridge Rectifiers, Potentiometers, Presets, Triacs, Diac, Plugs, Sockets, Cable, Vero. Carefully selected range, excellent despatch service. Same day turn round. S.A.E. List. Suppliers to A.E.R.E., U.K.A.E.A., Government Depts, Schools, Universities, Manufacturers. Accounts opened for trade and amateur. Join the professionals. Phone by 4 p.m. Goods out 1st class by 5p.m. Try us and prove it!

ORCHARD ELECTRONICS
Flint House, High Street, Wallingford, Oxon.
Telephone 0491-35529.

Books and Publications

SIMPLIFIED TV REPAIRS. Full repair instructions individual British sets £4·50, request free circuit diagram. Stamp brings details unique TV publications. Ausee, 76 Church Street, Larkhall, Lanarkshire.

Wanted

SURPLUS?? Turn it into cash. Phone: 0491 35529 (Oxon).

Service Sheets

SERVICE SHEETS for Radio, Television, Tape Recorders, Stereo, etc. With free fault-finding guide, from 50p and s.a.e. Catalogue 25p and s.a.e. Hamilton Radio, 47 Bohemia Road, St. Leonards, Sussex.

BELL'S TELEVISION SERVICE for service sheets of Radio, TV etc. 75p plus SAE. Colour TV Service Manuals on request. SAE with enquiries to BTS, 190 King's Road, Harrogate, N. Yorkshire. Tel: 0423 558855.

Educational

COURSES—RADIO AMATEURS EXAMINATION. City and Guilds. Pass this important examination and obtain your G3 licence, with an RRC home study course. For details of this, and other courses (GCE, professional examinations, etc.), write or phone: THE RAPID RESULTS COLLEGE, Dept. JR1, Tuition House, London SW19 4DS. Tel: 01-947 7272 (Careers Advisory Service), or phone for a prospectus only, ring 01-946 1102 (24hr recording service).

Miscellaneous

STYLI, CARTRIDGES & AUDIO LEADS ETC. For the best at keenest prices send SAE for free list to: FELSTEAD ELECTRONICS (EE), Longley Lane, Gatley, Cheadle, Cheshire SK8 4EE.

INSTRUMENT CASES, Loudspeaker cabinet kits, Teak sleeves for Amplifiers etc. Post today for free illustrated list to Curtis Furniture, Junction Road, Totton, Hants.

DOING IT DIGITALLY? 100 used T.T.L. £4 (90% good). J. BRUERE, 17 Heald Close, Shawclough, Rochdale.

INVENTORS. "Profit from Your Invention". Sources of Finance and other assistance. Details: Large S.A.E. Delta (EV), 15 St. Mary Street, Southampton, Hants.

FREE PACK OF COMPONENTS with our plans for 30 novelty circuits including touch switch, waa-waa, voltage controlled oscillator, slaveflash, mixer, radios, amplifiers, etc, etc. Build in minutes from surplus components! Send £1·20 today to DELOS ELECTRONICS, 76 Ber Street, Norwich, Norfolk.

RECHARGEABLE BATTERIES

'AA' pencell (HP7) £1·26; Sub 'C' £1·29; 'C' (HP11) £2·38; 'D' (HP2) £2·92; PP3 £4·98. Matching chargers £5·91 each except PP3 charger £4·99. Charging holders for 2, 3, 4, 5 or 6 pencells 40p. 'C' & 'D' size holders, 4 cell only 55p. Prices include VAT. Add 10% post package and insurance orders under £20. 5% over £20. SAE for full details plus 75p for 'Nickel Cadmium Power' booklet. Mail orders to **SANDWELL PLANT LTD.,** 201 Monmouth Drive, Sutton Coldfield, West Midlands. Tel 021 354 9764. Callers to T.L.C., 32 Craven Street, Charing Cross, London W.C.2.

See close-up work with less eye strain. Lightweight adjustable headband. Powerful optically ground lenses. Can be worn over normal glasses. Essential Industry, Home, Workshop, Collecting, Modelling, Jewellery, Watchmakers, any fine work. DE LUXE model with superior quality lens PLUS hinged lens mount 2x model £9·95 + 75p p&p. Also Headstrap Focusable Torch with pocket battery container, £8·70 post paid.

£9·95

Precision tool using combination of butane and compressed oxygen or micronox. A pencil lead thin flame size, adjustable to 5,000°F. Cuts metals, welds, brazes and solders gold, silver. Ideal ELECTRICIANS, opticians, dentists, silversmiths, modelling, jewellery, clockmakers, electronic and computer servicing. Up to 40 minutes use on fuel supplied. Replacement set of 2 micronox, 1 butane cylinders £1·98 extra inc. post, only £21·95 + £1·25 p&p. Send £23·20.

Access Accepted. Send Name. Address & No.
JOHN DUDLEY & CO. LTD. (Dept. EEt3),
301 Cricklewood Lane, Finchley Road, London, NW2. Tel. 01-458 5917. (Callers welcome)

TEACH-IN '78

Get a great deal from

Marshall's

A. MARSHALL (LONDON) LTD. DEPT. E.E.
LONDON—40-42 Cricklewood Broadway, NW2 3ET
Tel. 01-452 0161 Telex 21492
GLASGOW—85 West Regent Street, G2 2QD
Tel. 041-332 4133
BRISTOL—1 Straits Parade, Fishponds Rd. BS16 2LX
Tel. 0272 654201

NEW CATALOGUE 77

2ND EDITION FOR AUTUMN
OVER 8,000 LINE ITEMS
Plenty of New Products and Ideas
35p POST PAID (25p to callers)

TOP 400 SEMICONDUCTORS FROM THE LARGEST RANGE IN THE U.K.

EXPRESS M.O. SERVICE BY RETURN POST—all orders received despatched same day on stock items

2N696	·35	2N3703	·15	2N6126	·45	BC159	·76	BD116	1·20	BFX84	·35
2N697	·30	2N3704	·15	40361	·50	BC160	·35	BD131	·51	BFX85	·35
2N698	·62	2N3705	·15	40362	·55	BC161	·35	BD132	·54	BFX87	·30
2N699	·55	2N3706	·16	40363	1·30	BC167	·12	BD135	·37	BFX88	·30
2N706	·28	2N3707	·18	40406	·60	BC168	·12	BD136	·37	BFX89	1·25
2N706A	·28	2N3708	·13	40407	·52	BC169	·12	BD137	·38	BFY50	·25
2N708	·28	2N3709	·15	40408	·75	BC170	·18	BD138	·40	BFY51	·25
2N709	·50	2N3710	·16	40409	·75	BC171	·16	BD139	·40	BFY52	·30
2N718	·27	2N3711	·16	40410	·75	BC172	·14	DB140	·40	BFY53	·34
2N718A	·50	2N3712	1·20	40411	2·85	BC177	·20	BD239	·40	BFY90	1·20
2N720A	·80	2N3713	2·30	40594	·80	BC178	·20	BD240	·45	BRY39	·50
2N914	·35	2N3714	2·45	40595	·90	BC179	·23	BD241	·45	BSX20	·33
2N916	·30	2N3715	2·55	40673	·75	BC182	·11	BD242	·50	BSX21	·32
2N918	·38	2N3716	3·00	AC126	·45	BC182L	·14	BD243	·60	BO105	1·40
2N929	·25	2N3771	1·45	AC127	·45	BC183	·11	BD244	·65	BO205	2·20
2N930	·26	2N3772	2·00	AC128	·45	BC183L	·14	BD245	·65	MEO402	·20
2N1131	·30	2N3773	2·90	AC151V	·40	BC184	·12	BD246	·66	MEO404	·15
2N1132	·37	2N3789	2·90	AC152V	·50	BC184L	·14	BD529	·45	MEO412	·20
2N1613	·30	2N3790	3·10	AC153	·55	BC207	·16	BD530	·50	ME4102	·10
2N1711	·30	2N3791	3·10	AC153K	·55	BC208	·16	BDY20	1·00	ME4104	·10
2N1893	·38	2N3792	3·50	AC176	·55	BC212	·14	BF115	·38	MJ481	1·55
2N2102	·98	2N3794	·20	AC176K	·65	BC212L	·17	BF121	·45	MJ490	1·35
2N2218	·33	2N3819	·36	AC187K	·60	BC213	·14	BF123	·55	MJ491	1·85
2N2218A	·37	2N3620	·38	AC188K	·60	BC213L	·16	BF152	·55	MJ2955	1·25
2N2219	·35	2N3823	·80	AD161	1·00	BC214	·16	BF153	·25	MJE340	·58
2N2219A	·36	2N3904	·21	AD162	1·00	BC214L	·17	BF154	·25	MJE370	·58
2N2220	·35	2N3906	·22	AF106	·55	BC237	·14	BF159	·25	MJE371	·60
2N2221	·25	2N4036	·67	AF109	·75	BC238	·12	BF160	·35	MJE520	·45
2N2221A	·26	2N4037	·55	AF124	·65	BC239	·15	BF161	·30	MJE521	·65
2N2222	·25	2N4058	·20	AF125	·65	BC251	·16	BF166	·60	MJE2955	1·50
2N2222A	·25	2N4059	·15	AF126	·65	BC253	·22	BF167	·40	MJE3055	·95
2N2368	·25	2N4060	·20	AF139	·69	BC257A	·17	BF173	·35	MP8111	·35
2N2369	·25	2N4061	·17	AF186	·50	BC258A	·17	BF177	·35	MP8112	·40
2N2369A	·25	2N4062	·18	AF200	1·20	BC259B	·18	BF178	·35	MP8113	·45
2N2648	·75	2N4126	·17	AF239	·65	BC261A	·24	BF179	·25	MPF102	·30
2N1647	1·40	2N4289	·20	AF240	1·14	BC262B	·24	BF180	·35	MPSA05	·25
2N2904	·36	2N4919	·65	AF279	·80	BC263C	·30	BF181	·35	MPSA06	·25
2N2904A	·37	2N4920	·75	AF280	·85	BC300	·40	BF182	·35	MPSA12	·40
2N2905	·37	2N4921	·50	BC107	·15	BC301	·40	BF183	·35	MPSA55	·25
2N2905A	·38	2N4922	·55	BC108	·15	BC303	·50	BF184	·40	MPSA56	·25
2N2906	·28	2N4923	·60	BC109	·15	BC307	·15	BF185	·38	MPSU05	·50
2N2906A	·35	2N5190	·60	BC113	·20	BC308	·15	BF194	·35	MPSU06	·56
2N2907	·25	2N5191	·70	BC115	·20	BC309C	·15	BF195	·15	MPSU55	·55
2N2907A	·25	2N5192	·75	BC116	·19	BC317	·14	BF196	·15	MPSU56	·60
2N2924	·15	2N5195	·90	BC116A	·20	BC318	·13	BF197	·15	TIP29A	·45
2N2925	·17	2N5245	·34	BC117	·22	BC327	·20	BF198	·17	TIP29C	·60
2N3019	·55	2N5294	·40	BC118	·20	BC328	·19	BF200	·18	TIP30A	·49
2N3053	·26	2N5295	·40	BC119	·30	BC337	·19	BF225J	·25	TIP30C	·65
2N3054	·60	2N5296	·40	BC121	·45	BC336	·21	BF244	·25	TIP31A	·50
2N3055	·70	2N5298	·40	BC132	·30	BC547	·12	BF245	·35	TIP31C	·66
2N3390	·20	2N5447	·15	BC134	·20	BC548	·12	BF246	·40	TIP32A	·55
2N3391	·20	2N5448	·15	BC135	·20	BC549	·13	BF254	·75	TIP32C	·75
2N3391A	·20	2N5449	·19	BC136	·19	BCY30	1·00	BF255	·24	TIP33A	·80
2N3392	·16	2N5457	·32	BC137	·20	BCY31	1·00	BF257	·24	TIP33C	1·10
2N3393	·15	2N5458	·33	BC140	·35	BCY32	1·00	BF258	·37	TIP34A	·90
2N3394	·15	2N5459	·29	BC141	·40	BCY33	1·00	BF259	·45	TIP34C	1·20
2N3439	·59	2N5484	·34	BC142	·30	BCY34	1·00	BF459	·49	TIP35A	2·50
2N3440	·64	2N5486	·38	BC143	·30	BCY38	2·00	BFR39	·50	TIP36A	2·80
2N3441	·81	2N6027	·60	BC147	·12	BCY42	·60	BFS21A	·28	TIP41A	·70
2N3442	1·35	2N6181	·45	BC148	·12	BCY58	·25	BFS21A	2·60	TIP41C	·90
2N3638	·16	2N6107	·42	BC149	·14	BCY59	·25	BFS28	1·38	TIP42A	·80
2N3638A	·16	2N6109	·50	BC153	·27	BCY70	·25	BFS61	·30	TIP42C	1·00
2N3639	·30	2N6121	·38	BC154	·27	BCY71	·26	BFS98	·30	TIP2955	·65
2N3641	·20	2N6122	·41	BC157	·14	BCY72	·24	BFX29	·35	TIP3055	·55
2N3702	·13	2N6123	·43	BC158	·14	BD115	·80	BFX30	·35	TIS43	·43

INTEGRATED CIRCUITS

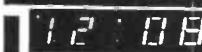
CA3020	2·00	LM748-8	·55	TAA570	2·30
CA3020A	2·29	LM748N	·55	TAA611B	1·85
CA3028B	1·29	LM1800	1·76	TAA621	2·15
CA3028A	1·08	LM1808	1·92	TAA661A	1·50
CA3030	1·35	LM1826	1·75	TAA661B	1·50
CA3030A	2·00	LM3301N	·85	TAA700	3·91
CA3045	1·40	LM3302N	1·40	TAA930A	1·30
CA3046	·89	LM3401	·70	TAA930B	1·30
CA3048	2·23	LM3900	·75	TAD100	1·95
CA3049	1·80	LM3905	1·60	TBA120	·75
CA3050	2·42	LM3909	·68	TBA400	2·00
CA3052	1·62	MC1035	1·75	TBA500	2·21
CA3080	·75	MC1303	1·03	TBA500Q	2·30
CA3080A	1·88	MC1304	1·40	TBA510	2·21
CA3086	·60	MC1305	1·40	TBA510Q	2·30
CA3088	1·79	MC1310	1·91	TBA520	2·21
CA3089	2·52	MC1327	1·54	TBA520Q	2·30
CA3090	4·00	MC1330	1·00	TBA530	1·98
CA3130	·98	MC1350	·90	TBA530Q	2·07
LM301A	·67	MC1351	1·20	TBA540	2·21
LM301N	·40	MC1352	1·10	TBA540Q	2·30
LM304	2·45	MC1458	1·91	TBA550	3·13
LM307N	·65	NE555	·40	TBA550Q	3·22
LM308C	1·82	NE556	1·10	TBA560Q	3·22
LM308N	·85	NE565	1·30	TBA570	1·29
LM309K	1·85	NE566	1·65	TBA570Q	1·38
LM317K	3·00	NE567	1·80	TBA641B	2·70
LM318N	2·26	SAS560	2·50	TBA651	2·20
LM323K	6·46	SAS570	2·50	TBA700	1·52
LM339N	1·40	S042	1·25	TBA700Q	1·61
LM348N	1·50	76001N	1·30	TBA720Q	2·30
LM360N	2·75	76003N	2·20	TBA750	1·98
LM370N	2·50	76008K	1·50	TBA750Q	2·07
LM371N	1·70	76013N	1·50	TBA800	1·25
LM372N	1·70	76013ND	1·30	TBA810	1·25
LM373N	2·80	76018K	1·50	TBA820	1·25
LM374N	3·10	76023N	1·45	TBA920	2·90
LM377N	1·75	76023ND	1·26	TBA920Q	2·99
LM378N	2·25	76033N	2·20	TBA940	1·62
LM379S	3·95	76110N	1·18	TCA160C	1·85
LM380-8	·90	76115N	1·51	TCA160B	1·61
LM380N	·98	76116N	1·66	TCA270	2·25
LM381A	2·45	76131N	1·20	TCA280A	1·30
LM381N	1·60	76226N	1·56	TCA290A	3·13
LM382N	1·25	76227N	1·20		
LM384N	1·45	76228N	1·41		
LM386N	·80	76530N	·75		
LM387N	1·05	76532N	1·40		
LM388N	·90	76533N	1·20		
LM389N	1·00	76544N	1·44		
LM702C	·75	76545N	1·65		
LM709C	·65	76546N	1·44		
LM709N	·40	76550N	·35		
LM710C	·60	76552N	·52		
LM710N	·60	76570N	1·65		
LM723C	·85	78620N	·90		
LM723N	·75	76650N	1·10		
LM741C	·85	76660N	·60		
LM741N	·40	76666N	·92		
LM741-8	·40	TAA320A	1·00		
LM747N	·90	TA350A	2·48		
		TAA521	1·00		
		TAA522	1·90		
		TAA550	·60		
		TAA560	1·75		

WE STOCK MORE

- CRYSTALS
- VALVES
- CHOKES
- KNOBS
- CABLES
- CASES
- FUSES
- METERS
- TOOLS
- SPRAYS
- PRESETS
- NEONS
- HEAT SINKS
- INDICATORS

FROM NATIONAL TEXAS MULLARD SIEMENS MOTOROLA SIGNETICS RCA, SGS

NATIONWIDE SERVICE



CLOCK MODULES *DIGITAL*

Built and tested—requires only switches and transformer to complete. 12 or 24hr alarm modules.

MA1002F 12 hr 5in display	£10·90
MA1002H 24hr 5in display	£10·90
MA1010E 12hr 84in display	£14·50
MA1010G 24hr 84in display	£14·50

CAR CLOCK MODULE
MA1003 Built Tested 12V supply and four-digit module. Crystal controlled 17·00. Data Sheet 5p + SAE.

NATIONAL

DIODES

AA116	0·12	BA158	0·38	BYX10	0·27	IN4005	0·10
AA118	0·12	BA159	0·51	OA47	0·13	IN4006	0·11
AA119	0·14	BA202	0·09	OA90	0·08	IN4007	0·12
AA129	0·09	BAX13	0·07	OA91	0·08	IN4148	0·07
AAZ17	0·18	BAX16	0·10	OA95	0·10	IN4150	0·19
BA100	0·18	BB103	0·30.	OA200	0·10	IN5400	0·14
BA102	0·18	BB104	0·40	OA202	0·14	IN5401	·165
BA144	0·12		0·30	IN914	0·07	IN5402	·175
BA145	0·18	BY126	0·29	IN916	0·07	IN5404	·185
BA154	0·10	BY127	0·38	IN4001	0·06	IN5406	·225
BA155	0·12	BY182	1·50	IN4002	0·07	IN5407	0·27
BA156	0·15	BY206	0·20	IN4003	0·08	IN5408	0·40
BA157	0·29	BY207	0·22	IN4004	0·09	IS44	0·07

OPTO ELECTRONICS

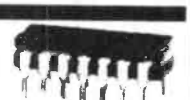
Full range of Opto devices In our New Catalogue

LEDS
Til 209 19p 100 + pcs 12p
3mm Red 18p, Green 25p, Yellow 25p
5mm Red 21p, Green 26p, Yellow 25p
MANY MORE TYPES LISTED IN OUR NEW CATALOGUE—SOLAR CELLS, LIGHT SWITCHES, etc.

DISPLAYS 7 segment

	Single	Double	Display
DL704	2·00	3·00	·3″ Red
DL707	2·00	3·00	·3″ Red
DL747	2·50	3·40	·5″ Red
DL750	2·50	3·40	·5″ Red

TTL FROM NATIONAL, ITT, TEXAS, SIGNETICS, ETC.

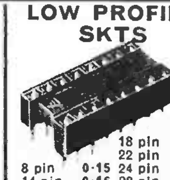


7400	0·16	7412	0·21	7438	0·55	7460	0·21	7485	1·85	74118	0·90	74160	1·41				
7401	0·16	7413	0·51	7440	0·21	7470	0·46	7486	0·41	74119	1·80	74161	1·41				
7402	0·16	7414	1·80	7441	1·03	7472	0·38	7490	0·61	74121	0·49	74162	1·41				
7403	0·16	7416	0·61	7442	0·76	7473	0·43	7491	0·98	74122	0·45	74163	1·41				
7404	0·26	7417	0·61	7445	1·35	7474	0·43	7492	0·61	74123	0·58	74164	1·23				
7405	0·26	7420	0·21	7446	1·23	7475	0·58	7493	0·61	74141	1·03	74165	1·23	74182	1·08		
7406	0·74	7423	0·39	7447	1·17	7476	0·51	7494	0·74	74145	1·06	74167	3·70	74184	2·46	74192	1·62
7407	0·74	7425	0·39	7448	1·17	7480	0·45	7495	0·78	74151	1·11	74174	1·52	74185	2·46	74193	1·62
7408	0·29	7427	0·39	7450	0·29	7481	1·10	7496	1·03	74153	1·11	74175	1·35	74188	2·00	74196	1·17
7409	0·29	7430	0·21	7451	0·21	7482	0·67	7497	4·60	74154	1·85	74176	1·23	74189	3·99	74197	1·17
7410	0·21	7432	0·39	7453	0·21	7483	1·33	74100	1·15	74155	1·11	74180	1·77	74190	1·91	74198	2·93
7411	0·29	7437	0·55	7454	0·21	7484	0·85	74107	0·43	74157	0·98	74181	3·70	74191	1·91	74199	2·93

74C MOS

74C00	0·26	74C85	1·90
74C02	0·26	74C86	0·68
74C04	0·26	74C90	0·91
74C08	0·26	74C107	1·30
74C10	0·28	74C151	2·62
74C20	0·26	74C157	2·35
74C30	0·26	74C160	1·18
74C32	0·26	74C161	1·18
74C42	0·92	74C162	1·18
74C48	2·30	74C163	1·18
74C73	0·58	74C164	1·04
74C74	0·69	74C173	0·95
74C76	0·58	74C174	0·95

LOW PROFILE SKTS



		18 pin	0·27
		22 pin	0·30
8 pin	0·15	24 pin	0·35
14 pin	0·16	28 pin	0·45
16 pin	0·18	40 pin	0·55

CMOS LOW POWER SCHOTTKY

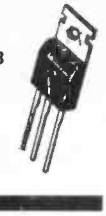
CD4000 0·24	CD4018 1·15	CD4041 0·96	CD4059 5·45	CD4081 0·25	74LS02 0·24	74LS138 1·27
CD4001 0·24	CD4019 0·70	CD4042 0·96	CD4060 1·27	CD4082 0·25	74LS04 0·27	74LS151 1·13
CD4002 0·24	CD4020 1·27	CD4043 1·15	CD4063 1·25	CD4085 0·81	74LS08 0·24	74LS157 1·17
CD4006 1·34	CD4021 1·15	CD4044 1·05	CD4066 0·80	CD4086 0·81	74LS10 0·24	74LS160 1·40
CD4007 0·24	CD4022 1·10	CD4045 1·59	CD4067 4·25	CD4089 1·77	74LS13 0·65	74LS161 1·50
CD4008 1·10	CD4023 0·24	CD4046 1·52	CD4068 0·25	CD4093 0·91	74LS32 0·25	74LS162 1·50
CD4009 0·64	CD4024 0·84	CD4047 1·15	CD4069 0·25	CD4094 2·13	74LS42 1·01	74LS162 1·50
CD4010 0·64	CD4025 0·24	CD4049 0·64	CD4070 0·65	CD4095 1·19	74LS74 0·48	74LS163 1·50
CD4011 0·24	CD4027 0·64	CD4050 0·64	CD4071 0·25	CD4096 1·19	74LS75 0·60	74LS164 1·52
CD4012 0·24	CD4028 1·02	CD4051 1·06	CD4072 0·25	CD4510 2·00	74LS76 0·40	74LS173 2.35
CD4013 0·60	CD4029 1·30	CD4052 1·06	CD4073 0·25	CD4511 2·30	74LS85 1·45	74LS174 1·20
CD4014 1·15	CD4030 0·64	CD4053 1·06	CD4075 0·26	CD4516 2·00	74LS86 0·48	74LS175 1·20
CD4015 1·15	CD4031 2·53	CD4054 1·32	CD4076 1·17	CD4518 2·00	74LS90 1·00	74LS
CD4016 0·64	CD4035 1·34	CD4055 1·50	CD4077 0·66	CD4520 2·00	74LS92 0·90	
CD4017 1·15	CD4037 1·10	CD4056 1·50	CD4078 0·25	74LS00 0·24	74LS107 ·44	

TRIACS plastic pack 400V

6 Amp	0·70	16 Amp	1·10
8 Amp	0·75	20 Amp	1·70
12 Amp	0·85	25 Amp	2·00

THYRISTORS Plastic C106 118

4A 100V	0·35	8A 100V	0·43	12A 100V	·57
4A 200V	0·40	8A 200V	0·49	12A 200V	·65
4A 400V	0·49	8A 400V	0·62	12A 400V	·81



VOLTAGE REGULATORS

500mA TO202 Positive 5, 12, 15, 24v 1·10
500mA TO202 Negative 5, 12, 15, 24v 1·05
1 Amp TO220 Positive 5, 12, 15, 24v 1·55
1 Amp TO220 Negative 5, 12, 15, 24v 2·00

VEROBOARD

·1 MATRIX COPPER BACKED BOARD

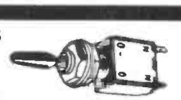
2·5″ x 5″	50p	3·75″ x 5″	55p
2·5″ x 3·75″	42p	3·75″ x 3·75″	50p
2·5″ x 17″	1·54	3·75″ x 17″	1·98

Spot Face Cutters 74p pkt. 36 pins 36p
Full range incl. ind. board in catalogue

SOLDERING EQUIPMENT

Antex Irons Mod "C" 15 watt	£3·40
Stand £1·40 Mod x 25 25 watt	£3·40
Spare tips & elements available	
Multicore solder dispenser	38p

SWITCHES



SPST 60p
SPDT 66p
DPDT 70p
DPDT C/off 80p
As above but micro
SPST 50p SPDT 55p DPDT 60p
Full range of rocker, slide and rotary switches always in stock.

WE ALSO STOCK MOST COMPONENTS FOR E.E. *PROJECTS*

CAPACITORS

Ceramic 63 volt 1pf to ·01 MFD 6p
Polyester C280 250v
·01 —·1 5p, —15·22 6p
·33, ·47, 10p 1µf 17p
Full range of mica Polystyrene, Tantalum, Polycarbonate, and electrolytics always in stock.

RESISTORS

10R-10Meg ·25w 2p each, ·5w 3p each also 1w 2w 2·5w 5w 10w + metoxide in stock. See catalogue for full details.

PLUGS- SOCKETS- COUPLERS

	PL.	SK.	Line
DIN 2 pin loudspeaker	10p	7p	10p
3, 4, 5, 6, 7 pin	15p	12p	15p
COAX Standard T.V.	10p	10p	30p
PHONO. Red, Bl., Wh., Gr. Yel	10p	7p	10p
JACK ¼″ mono plastic	16p	20p	20p
¼″ mono screened	25p	—	30p
¼″ stereo plastic	25p	25p	25p
¼″ stereo screened	35p	—	45p
3·5m standard	10p	12p	10p
2·55m standard	10p	10p	—
MAINS USA 2 pin flat	15p	15p	15p