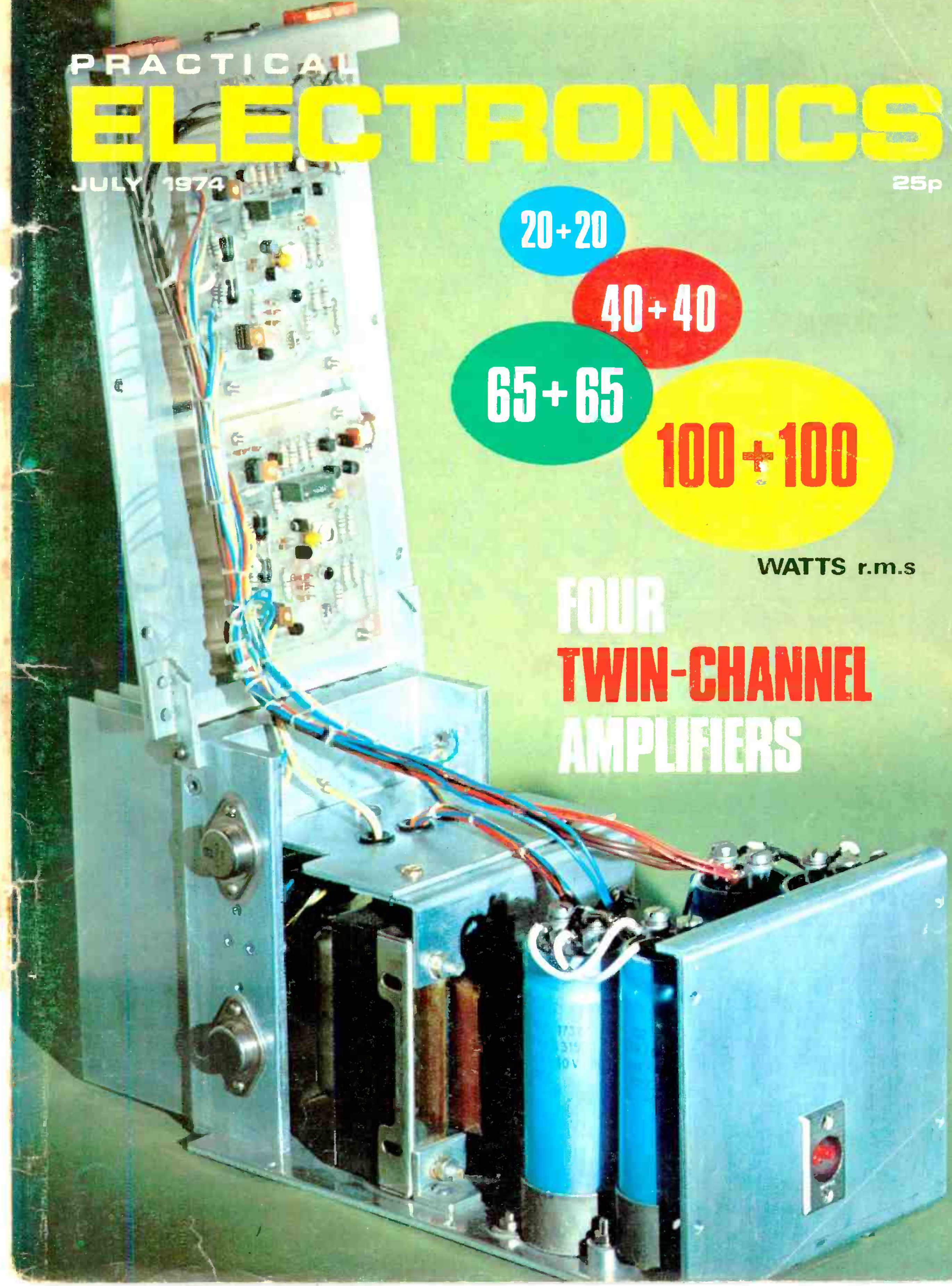
PRACTICAL ELECTRONICS

JULY 1974

25p



20+20

40+40

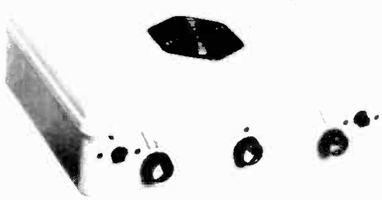
65+65

100+100

WATTS r.m.s

FOUR TWIN-CHANNEL AMPLIFIERS

NEW EDU-KIT MAJOR



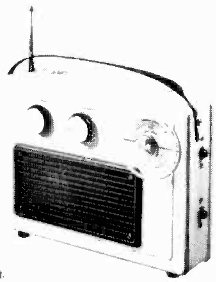
COMPLETELY SOLDERLESS ELECTRONIC CONSTRUCTION KIT
BUILD THESE PROJECTS WITHOUT SOLDERING IRON OR SOLDER

- 4 Transistor Earpiece Radio
- Signal Tracer
- Signal Injector
- Transistor Tester NPN—PNP
- 4 Transistor Push Pull Amplifier
- 5 Transistor Push Pull Amplifier
- 7 Transistor Loudspeaker Radio MW/LW.
- 5 Transistor Short Wave Radio
- Electronic Metronome
- Electronic Noise Generator
- Batteryless Crystal Radio
- One Transistor Radio
- 2 Transistor Regenerative Radio
- 3 Transistor Regenerative Radio
- Audible Continuity Tester
- Sensitive Pre-Amplifier

Components include:
● 24 Resistors ● 21 Capacitors ● 10 Transistors ● 3½" Loudspeaker ● Earpiece ● Mica Baseboard ● 3 12-way Connectors ● 2 Volume Controls ● 2 Slider Switches ● 1 Tuning Condenser ● 3 Knobs ● Ready Wound MW/LW/SW Coils ● Ferrite Rod ● 6½ yards of wire ● 1 yard of sleeving, etc. ● Parts price list and plans 50p (free with parts)

TOTAL BUILDING COSTS
£7·23 (+10% VAT 72p) P.P. & INS. 44p (Overseas P.P. £1·85p)

NEW ROAMER NINE



WITH V.H.F. INCLUDING AIRCRAFT

Nine Transistors. 9 Tunable wavebands as Roamer Ten. Built in ferrite rod aerial for MW/LW. Retractable chrome plated telescopic aerial for VHF and SW. Push Pull output using 600 mW transistors. 9 Transistors and 3 diodes, tuning condenser with VHF section, separate coil for aircraft, moving coil loudspeaker, volume ON/OFF and wavechange controls. Attractive all white case with red grille and carrying strap. Size 9¼in × 7in × 2¼in approx. Parts price list and plans **30p** (FREE with parts).

TOTAL BUILDING COSTS **£6·95** (+10% VAT 69p) P.P. & INS. 44p (OVERSEAS P. & P. £1·85)

NEW EVERYDAY SERIES

Build this exciting New series of designs

EV5 5 Transistors and 2 diodes. MW/LW. Powered by 4½ volt Battery. Ferrite rod aerial, tuning condenser, volume control, and loudspeaker. Attractive case with red speaker grille. Size 9in × 5¼in × 2¼in approx. Parts price list and plans **15p** (FREE with parts).

TOTAL BUILDING COSTS **£2·73** (+10% VAT 27p) P.P. & INS. 30p (OVERSEAS P. & P. £1·25)

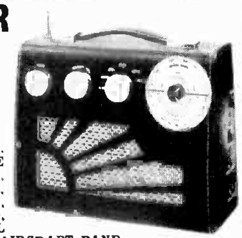
EV6 Case and looks as above. 6 Transistors and 3 diodes. Powered by 9 volt Battery. Ferrite rod aerial, 3" loudspeaker, etc., MW/LW coverage. Push Pull Output. Parts price list and plans **15p** (FREE with parts.)

TOTAL BUILDING COSTS **£3·60** (+10% VAT 36p) P.P. & INS. 30p (OVERSEAS P. & P. £1·25)

EV7 Case and looks as above. 7 transistors and 3 diodes. Six wavebands. MW/LW, Trawler Band, SW1, SW2, SW3, powered by 9 volt Battery Push Pull Output. Telescopic Aerial for Short Waves. 3" Loudspeaker. Parts price list and easy build plans **20p**. Free with parts.

TOTAL BUILDING COSTS **£4·08** (+10% VAT 40p) P.P. & INS. 31p (OVERSEAS P. & P. £1·85p)

ROAMER TEN



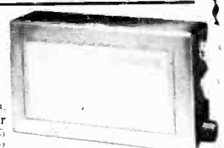
WITH VHF INCLUDING AIRCRAFT

10 TRANSISTORS. 9 TUNABLE WAVEBANDS, MW1, MW2, LW, SW1, SW2, SW3, TRAWLER BAND, VHF AND LOCAL STATIONS. ALSO AIRCRAFT BAND

Latest 4" 2 watt Ferrite Magnet Loudspeaker. Built-in ferrite rod aerial for MW/LW. Retractable, chrome plated 7 section telescopic aerial, can be angled and rotated for peak short wave and VHF listening. Push-pull output using 600mW transistors. Car Aerial and tape record sockets. 10 transistors plus 3 diodes. Ganged tuning condenser with VHF section. Separate coil for Aircraft Band. Volume/on/off, wave change and tone controls. Attractive case in black with silver blocking. Size 9in × 7in × 4in. Easy to follow instructions and diagrams. Parts price list and plans **30p** (FREE with parts).

TOTAL BUILDING COSTS **£8·50** (+10% VAT 85p) P.P. & INS. 52p (OVERSEAS P. & P. £1·85)

POCKET FIVE



3 Tunable wavebands. MW/LW and Trawler Band. 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, moving coil loudspeaker, attractive Black and Gold Case. Size 5½in × 1¼in × 3½in approx. Plans and parts price list 15p (FREE with parts).

Total Building Costs **£2·28** (+10% VAT 22p) P.P. & Ins. 26p (Overseas P. P. £1·25)

EDU-KIT

Build Radios Amplifiers, etc., from easy stage, diagrams.

Five units including master unit to construct.

Components include: Tuning Condenser; 2 Volume Controls; 2 Slider Switches; Fine tone 3" moving coil Speaker; Terminal Strip; Ferrite Rod Aerial; Battery Clips; 4 Tag Boards; 10 Transistors; 4 Diodes; Resistors; Capacitors; Three ½in Knobs. Units once constructed are detachable from Master Unit, enabling them to be stored for future use. Ideal for Schools, Educational Authorities and all those interested in radio construction. Parts price list and plans **25p** (FREE with parts).

TOTAL BUILDING COSTS **£5·50** (+10% VAT 55p) P.P. & INS. 33p (OVERSEAS P. & P. £1·85)

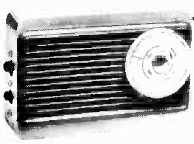
ROAMER EIGHT Mk. I

NOW WITH VARIABLE TONE CONTROL

7 TUNABLE WAVEBANDS: MW1, MW2, LW, SW1, SW2, SW3 AND TRAWLER BAND. Built-in ferrite rod aerial for MW and LW. Retractable chrome plated telescopic aerial for short waves. Push-pull output using 600mW transistors. Car aerial and tape record sockets. Selectivity switch. 8 transistors plus 3 diodes. Latest 4" 2 watt Ferrite Magnet loudspeaker. Air spaced ganged tuning condenser. Volume/on/off, tuning, wave change and tone controls. Attractive case in rich chestnut shade with gold blocking. Size 9in × 7in × 4in approx. Easy to follow instructions and diagrams. Parts price list and plans **25p** (FREE with parts).

TOTAL BUILDING COSTS **£6·98** (+10% VAT 69p) P.P. & INS. 47p (OVERSEAS P. & P. £1·85)

TRANSONA FIVE



Wavebands, transistors and speaker as Pocket Five. Larger Case with Red Speaker Grille and Tuning Dial. Plans and parts price list 15p (FREE with parts).

Total Building Costs **£2·50** (+10% VAT 25p) P.P. & Ins. 26p (Overseas P. & P. £1·25)

TRANS EIGHT 8 TRANSISTORS AND 3 DIODES

6 TUNABLE WAVEBANDS, MW, LW, SW1, SW2, SW3 AND TRAWLER BAND. Sensitive ferrite rod aerial for MW and LW. Telescopic aerial for short waves. 3in speaker. 8 improved type transistors plus 3 diodes. Attractive case in black with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2¼in approx. Push-pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker Parts price list and plans **25p** (FREE with parts).

TOTAL BUILDING COSTS **£4·48** (+10% VAT 44p) P.P. & INS. 33p (OVERSEAS P. & P. £1·25)

ROAMER SIX

CASE AND LOOKS AS TRANS EIGHT 6 TUNABLE WAVEBANDS: MW, LW, SW1, SW2, TRAWLER BAND PLUS AN EXTRA MW BAND FOR EASIER TUNING OF LUXEMBOURG, ETC. Sensitive ferrite rod aerial and telescopic aerial for short waves. 3in speaker. 8 stages—6 transistors and 2 diodes, etc. Attractive black case with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2¼in approx. Plans and parts price list **25p** (FREE with parts).

TOTAL BUILDING COSTS **£3·98** (+10% VAT 39p) P.P. & IN. 31p (OVERSEAS P. & P. £1·85)

RADIO EXCHANGE LTD

*Callers side entrance "Lavells" shop
*Open 10-1. 2.30-4.30. Mon.-Fri. 9-12 Sat.

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PE7

PRACTICAL ELECTRONICS

VOLUME 10 No. 7 JULY 1974

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our August issue will be published on Friday, July 12, 1974

ELECTROVALUE

Present **THIS MONTH'S SELECTION OF GUARANTEED-TO-SPECIFICATION COMPONENTS**

EVERYTHING BRAND NEW ★ ATTRACTIVE DISCOUNTS ★ FREE POSTAGE (U.K.)

TRANSISTORS
and semi-conductors of many types from simple diodes to ICs photo-sensitive devices, threshold switches, etc., etc.

MINITRON DIGITAL INDICATORS
30154F Seven segment filament, compatible with standard logic modules. 0–9 and decimal point; 9mm characters in 16 lead DIL, **£1·20**. Now available in 8mA or 15mA per segment rating.
Suitable BCD decoder driver 7447, **£1·15.**
3015G showing + or — and 1 and dec. pt, **£1·20.**

CAPACITORS

DALY ELECTROLYTIC
in cans, plastic sleeved
1,000mF/25V, **28p**; 5,000mF/25V, **62p**; 1,000mF 50V, **41p**; 2,000mF/50V, **57p**; 5,000mF/50V, **£1·18**; 5,000mF/100V, **£2·91.**

POLYESTER TYPE C280
Radial leads for P.C.B. mounting. Working voltage 240V *d.c.*
0·01, 0·015, 0·022, 0·033, 0·047, **3p** each; 0·068, 0·1, 0·15, **4p** each; 0·22, **5p**; 0·33, **7p**; 0·47, **8p**; 0·68, **11p**; 1·0, **14p**; 1·5, **21p**; 2·2, **24p.**

SILVERED MICA
Working voltage 500V d.c.
Values in pF—2·2 to 820 in 32 stages, **6p** each; 1,000, 1,500, **7p** each; 1,800, **8p**; 2,200, **10p**; 2,700, 3,600, **12p** each; 4,700, 5,000, **15p** each; 6,800, **20p**; 8,200, 10,000, **25p** each.

TANTALUM BEAD
0·1, 0·22, 0·47, 1·0mF/35V, **13p** each. 2·2/16V, 2·2/35V, 4·7/16V, 10/6·3V, **13p** each. 4·7/35V, 10/16V, 22/6·3V, **16p** each. 10/25V, 22/16V, 47/6·3V, 100/3V, **18p** each.

POLYCARBONATE TYPE B32540
Working Voltage 250V.
Values in mF: 0·0047, 0·0068, 0·0082, 0·01, 0·012, 0·015, **3p** each. 0·018, 0·022, 0·027, 0·033, 0·039, 0·047, 0·056, 0·068, 0·082, 0·1, **4p** each.

CERAMIC PLATE CAPACITORS
Working voltage 50V d.c.
In 26 values from 22pF to 6,800pF, **2p** each.

POTENTIOMETERS
ROTARY, CARBON TRACK.
Double wipers for good contact and long working life.
P20 SINGLE linear 100 ohms to 4·7M Ω, **14p** each.
P20 SINGLE log, 4·7k Ω to 2·2M Ω, **14p** each.
JP20 DUAL GANG linear 4·7k Ω to 2·2M Ω, **48p** each.
JP20 DUAL GANG log, 4·7k Ω to 2·2M Ω, **48p** each.
JP20 DUAL GANG log/antilog 10K, 22K, 47K, 1M Ω only, **48p** each.
JP20 DUAL GANG antilog 10k only **48p.**
2A DP mains switch with any of above **14p** extra.
Decades of 10, 22 and 47 only available in ranges above. **SKELETON CARBON PRESETS 6p** each.

SLIDER
Linear or log, 4·7k Ω to 1M Ω in all popular values, **30p** each.
Escutcheon plates, black, white or light grey, **10p** each.
Control knobs blk/wht/red/yel/grn/blue/dk. grey/lt grey, **7p** each.

JACKS AND PLUGS

Sockets

2-circuit, unswitched, S1/SS	11p
2-circuit/2 break contacts, S1/BB	13p
3-circuit, unswitched (not GPO), S3-SSS	15p
3-circuit with 3 break contacts, S3/BBB	20p
2 circuit with chrome nut and black/white/red/green or grey unswitched, S5/SS	14p
2 circuit with chrome nut and black/white/red/green with 2 break contacts, S5/BB	17p
Miniature, 3·5mm, 2-circuit (black), 2 br. cont., S6/BB	8p

EV CATALOGUE 7
2nd Printing
112 pages, thousands of items, illustrations, diagrams, much useful technical information. The 2nd printing of this catalogue has been updated as much as possible on prices. It costs only 25p post free and includes a refund voucher for 25p for spending when ordering goods list value £5 or more.

Plugs

2 circ. screened, top entry, P.1	24p
2 circ. screened, side entry, SEP1	36p
Line socket, mono, 231	40p
Line socket, stereo, 244	40p
3-circuit, unscreened, bl/grey/wh, P.4	36p
2-circuit, unscreened, bl/whi/red/bl/grn/grey, P2	18p
3-circuit, screened, top entry, P3	53p
3-circuit, screened, side entry, SEP3	55p
Miniature, 3·5mm, 2-cir., screened, P5	13p
Miniature, 3·5mm, 2-circ., unscreened, various colours, P6	10p

INSULATED SCREW TERMINALS
In moulded polypropylene, with nickel plate on brass. With insulating set, washers, tag and nuts. 15A/250V. In blk/brwn/red/yel/grn/bl/grey/wh, Type TP.1, **14p** each.

RESISTORS

Code	*Watts*	*Ohms*	1 to 9	10 to 99 (see note below)	100 up
C	1/3	4·7–470K	1·3	1·1	0·9 nett
C	1/2	4·7–10M	1·3	1·1	0·9 nett
C	3/4	4·7–10M	1·5	1·2	0·9 nett
C	1	4·7–10M	3·2	2·5	1·9 nett
MO	1/2	10–1M	4	3·3	2·3 nett
WW	1	0·22–3·9	9	9	8
WW	3	1–10K	7	7	6
WW	7	1–10K	9	9	8

Codes:
C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.

Values: All E12 except C ⅓W, C ¾W, and MO ½W.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

Tolerances:
5% except WW1 10%
±0·05 Ω below 10 Ω and MO ½W 2%

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.) Prices for 100 up in units of 100 only.

BAXANDALL SPEAKER KIT
As designed by P. J. Baxandall and described originally in "Wireless World." Simple to assemble, fantastically good results and a greater money saver. Carries 10 watts RMS, 15 ohms impedance. Size 18in × 12in × 10in. Complete kit, including pack-flat cabinet, **£14·90.**
The size and weight of this product obliges us to charge 70p part cost of carr. in U.K.
Equaliser Assembly: **£2·30.**
Loudspeaker Unit 59RM109, **£2·45.**
Cabinet Kit (to Baxandall design), **£10·45.**
Cross-over choke included in full kit above, **£1·30.**

ELECTROLYTICS

Axial Lead

uF	3V	6·3V	10V	16V	25V	40V	63V	100V
0·47	—	—	—	—	—	—	11p	8p
1·0	—	—	—	—	—	11p	—	8p
2·2	—	—	—	—	11p	—	8p	9p
4·7	—	—	—	11p	—	8p	9p	9p
10	—	—	—	—	8p	9p	8p	8p
22	—	—	8p	—	9p	8p	8p	10p
47	8p	—	9p	8p	8p	8p	10p	13p
100	9p	8p	8p	8p	9p	10p	12p	19p
220	8p	8p	9p	10p	10p	11p	17p	28p
470	9p	10p	10p	11p	13p	17p	24p	45p
1,000	11p	13p	13p	17p	20p	25p	41p	—
2,200	15p	18p	23p	26p	37p	41p	—	—
4,700	26p	30p	39p	44p	58p	—	—	—
10,000	42p	46p	—	—	—	—	—	—

ZENER DIODES full range E24 values: 400mW: 2·7V to 36V, **14p** each; 1W: 6·8V to 82V, **21p** each; 1·5W: 4·7V to 75V, **48p** each. Clip to increase 15·W rating to 3 watts (type 266F) **5p.**

VEROBOARD
Copper clad 0·1 in. matrix—2·5 × 3·75 ins. **27p.** 3·75 × 3·75 ins., **30p.** 2·5 × 5 ins., **30p.** 3·75 × 5 ins., **33p.**
Copper clad 0·15 in. matrix—2·5 × 3·75 ins., **20p.** 3·75 × 3·75 ins., **30p.** 2·5 × 5 ins., **30p.** 3·75 × 5 ins., **36p.**
Vero spot face cutter (any matrix), **43p.** 0·040 pins (for 0·1 matrix) per 100, **35p.** 0·052 pins (for 0·15 matrix) per 100, **35p.**

KNOBS
In a great variety of modern types, for ¼ in. shaft, from plastic to solid aluminium, from typically **63p** per pack of two (Catalogue 7, page 62).

CONNECTORS
DIN from 2-way to 7-way plugs and sockets; phono types, mains connectors, etc. (Catalogue 7, page 88).

This is EV Service

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Available on all items except those shown with NETT PRICES. 10% on orders from £5 to £14·99. 15% on orders £15 and over.

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in U.K. for pre-paid mail orders. For orders £2 and under, there is an additional handling charge of 10p.

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All goods are sold on the understanding that they conform to manufacturers' specifications and satisfaction is guaranteed as such—no rejects, "seconds" or sub-standard merchandise is offered for sale.

PRICES QUOTED DO NOT INCLUDE VAT,
for which 10% must be added to total nett value of order. Every effort is made to ensure correctness of information and prices at time of going to press. Prices are subject to alteration without notice. S.A.E. with written enquiries please.

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Telephone: Egham 3603 Telex 264475 *Shop hours—9-5.30 daily. Saturdays 9-1 p.m.*

Northern Branch: 680 BURNAGE LANE, BURNAGE, MANCHESTER M19 1NA
Telephone 061-432 4945
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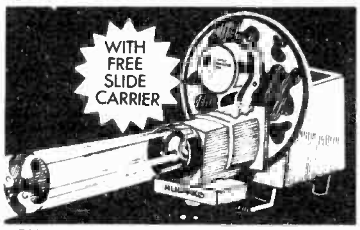
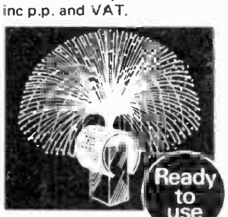
At the head of our fibre optic kingdom stands the unique genesis. This fantastic model incorporates the largest mares tail you can buy. Now combined with the most sensational kinetic light base ever designed in this field. This lamp is unique in the way that the base is opaquely translucent. The tinted upper section allows one to see a slowly rotating eight coloured sculptured wheel, that seems to be floating on a blue haze, that radiates a warm mystic glow.
Thousands of optical fibres energized with colour. Fibre tips flash like stars, bright with all the changing colours of the rainbow. Available in blue or green. M.M. Discount price £22.95 inc p.p. and VAT.

CASCADE Height 18".
Cascade, the fibre optic that's also a beautiful corner light, M.M. Discount price £16.65 inc p.p. and VAT.



AQUARIUS 100
A star for home parties, this budget priced 100-watt projector will transform your room into a swirling image of continuously changing liquid colour of reds, blues, yellows and greens.
This machine is supplied with one six inch liquid wheel and includes lamp and lead. Complete with free 2 x 2 slide projection carrier.
M & M discount price £19.95 post free.



LITTLE GEM
Little Gem, complete with the smaller mares tail, (8mm approx, 18" x 10" high, overall height from table approx 14") With a single white light display, housed in a red translucent base, cowled with a special moulded three dimensional filter that throws light in array. It's amazing, we have completely shattered the style of conventional optics with the fabulous little gem. ONLY £10 inc post and VAT.

OILWHEEL PROJECTORS
Multi-coloured, For projecting psychedelic colours 6" or 4" diameter Ideal for fibre optics
6" oil wheel £5.00 + p.p. 15p.
4" (suitable for optics) £2.65 + p.p. 10p.

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THE SENSATIONAL MARES TAIL
Three sizes to choose from:
18mm ferrule, 11" high x 22" dia. 7,500 fibres, £10.50 +20p p.p.
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Complete instructions supplied.

Display bunching of various types of fibres at low cost. TYPE A 1320. Fibres contained in a tough flexible sheath. Makes delightful displays. M.M. Discount Price 40p per ft. £1.10 per yd. +5p p.p.
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SLOW SPEED MAINS MOTOR
to rotate oil wheel and static wheel 70p inc p.p.

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Bulb and batton kit plus 6ft of flex 75p inc post and VAT.

Terms: C.W.O. cheques/po's
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A unique drafting aid for the electronics engineer enabling him to prepare in minutes a perfect PCB.
A fine-tipped marker charged with a free-flowing etch-resist ink. **Simply draw the desired circuit onto copper laminated board—etch—clean.**

The circuit is ready to use.

NO MESS—NO MASKING
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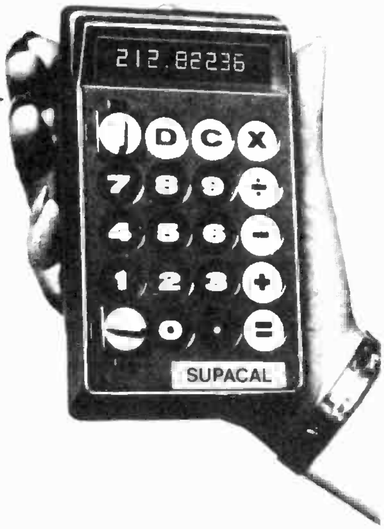
48½p

A POCKET CALCULATOR FROM S.C.S.
£4 DISCOUNT TO READERS OF P.E.



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- 8 digit, fully floating decimal point.
- 4 function with a constant on all functions.
- Does not limit on over or underflow.
- Provides 8 significant figures plus decimal point position over 99 decades.
- Rechargeable batteries.
- Carrying case.
- Charger.
- Touch key board.
- Weighs just 8 oz.
- Measures $5\frac{1}{2}'' \times 3'' \times 1\frac{1}{2}''$.
- Full after-sales service.
- 1 year guarantee.

A unique, three-way link up between S.C.S., a major calculator manufacturer and Practical Electronics allows us to offer you a fully guaranteed pocket calculator. Powered by a second generation MOS LSI chip from General Instrument Microelectronics.

Available for £24 + V.A.T. (tested and guaranteed). LESS SPECIAL £4 DISCOUNT TO ALL P.E. READERS – don't forget to use your discount voucher.

A limited number of home constructor kits are available at £15 + V.A.T. (no discount).

£4 DISCOUNT VOUCHER

I enclose a cheque to the value of £20 + V.A.T. to cover the cost of the S.C.S. Pocket Calculator. (All cheques should be made payable to S.C.S. Components Ltd.) Total £22.

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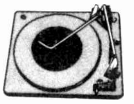
S.C.S. Components Ltd. P.O. Box No. 26, Wembley, Middlesex HA0 1YY
Registered in London No. 888454.

£20 + VAT

ALL OUR PRICES INCLUDE V.A.T.

BSR HI-FI AUTOCHANGER
STEREO & MONO



Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. AC 200/250V. Size 13¾ × 11¼in. Above motor board 3¼in. Below motor board 2½in.

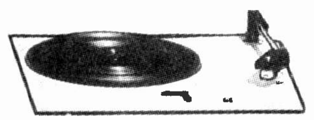
with STEREO and MONO XTAL **£6·75** Post 25p.

PORTABLE PLAYER CABINET

Modern design. Black rexine covered. Silver front grille. Padded Lid. Chrome fittings. Size 17in × 15in × 7in. Few only in red rexine. Motor board cut for BSR deck **£4·50** Post 25p

4 Transistor Mono Amplifier

Powerful 3 watt output. 15 ohm. AC mains operated with transformer. 3-Controls, volume, treble, bass and On/Off switch with knobs. Ready made on printed circuit board. Fused inputs and outputs. Famous make. Size 8in wide × 4in deep × 3in high. Suitable 7in × 4in speaker, £1. **£5·95** Post 25p



R.C.S. DISCO DECK SINGLE RECORD PLAYER

Fitted with auto stop. Acos stereo/mono cartridge. Baseplate. Size 11in × 8¼in. Turntable. Size 7in diameter. A/C mains. 200/250V motor has a separate winding 14 volt to power a small amplifier.

£5·50 Post 25p

METAL PLINTH AND PLASTIC COVER

Cut out for most Garrard or B.S.R. Most will play with cover in position. 12¼ × 14¼ × 7¼in. Covered in black leatherette. **£4·95** Post 45p

ALSO AVAILABLE IN SOLID NATURAL MAHOGANY WAX POLISHED FINISH—£5·95

COMPACT PORTABLE STEREO HI-FI

Two full size loudspeakers 13¾ × 10 × 3¾in. Player unit clips to loudspeakers making it extremely compact, overall size only 13¾ × 10 × 8¼in., 3 watts per channel, plays all records 33 r.p.m., 45 r.p.m. Separate volume and tone controls. 240V AC Mains.

Attractive Teak finish Weight 13 lb.

Bargain Price **£25** 85p Carriage

SPECIAL OFFER! SMITH'S CLOCKWORK 15 AMP TIME SWITCH 0 TO 60 MINUTES

Single pole two-way Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Fully insulated. Makers' last list price £4·50. Brand new and fully guaranteed.

OUR PRICE **£1·65** Post 25p

BLANK ALUMINIUM CHASSIS. 18 s.w.g. 2½in sides 6 × 4in 45p; 8 × 6in 53p; 10 × 7in 65p; 12 × 8in 85p; 14 × 9in 90p; 16 × 6in 90p; 12 × 3in 50p; 16 × 10in £1.
ALUMINIUM BOXES 3 × 3 × 3in 60p; 4 × 4 × 4in 70p; 6 × 4 × 4in 80p; 9 × 4 × 4in £1; 12 × 4 × 4in £1·30.
ALUMINIUM PANELS 18 s.w.g. 6 × 4in 12p; 8 × 6 in 19p; 14 × 3in 20p; 10 × 7in 24p; 12 × 5in 25p; 12 × 8in 34p; 16 × 6in 34p; 14 × 9in 40p; 12 × 12in 47p; 16 × 10in 60p.
PAXOLIN PANEL 10 × 8in 20p.
1¼ inch DIAMETER WAVECHANGE SWITCHES, 30p ea.
2 p. 2-way, or 2 p. 6-way, or 3 p. 4-way.
1 p.1. 2-way, or 4 p. 2-way, or 4 p. 3-way.
TOGGLE SWITCHES, sp. 14p; dp. 22p; dp. dt. 25p.
Sub-miniature, sp. 33p; dp. dt. 50p.

BRITISH FM/VHF TUNING HEART

88 to 108 Mc/s British made. 2 Transistors ready aligned requires 10·7 Mc/s I.F. Complete with tuning gang. Connections supplied but some technical experience essential. Our price **£3·95** Post 20p

R.C.S. STABILISED POWER PACK KITS

All parts and instructions with Zener Diode, Printed Circuit, Bridge Rectifiers and Double Wound Mains Transformer input 200/240V a.c. Output voltages available 6 or 9 or 12 or 15 or 18 or 20V d.c. at 100mA or less PLEASE STATE VOLTAGE REQUIRED. Details S.A.E. Size 3½ × 1½ × 1½in. **£2·20** Post 20p

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER BRITISH MADE

Ideal for Mike, Tape, P.U., Guitar, etc. Can be used with Battery 9-12V or H.T. line 200-300V d.c. operation. Size: 1¾ × 1¼ × ¾ in. Response 25 c/s to 25 kc/s. 26 dB gain. For use with valve or transistor equipment. Full instructions supplied. Details S.A.E. **99p** Post 10p

NEW TUBULAR ELECTROLYTICS				CAN TYPES	
2/350V	14p	250/25V	14p	50+50/300V	50p
4/350V	14p	500/25V	20p	60+100/350V	85p
8/450V	18p	1000/25V	35p	32+32/250V	20p
16/450V	22p	1000/50V	47p	32+32/450V	60p
32/500V	50p	8+8/450V	22p	350+50/325V	55p
25/25V	10p	8+16/450V	25p	16+16+16/275V	45p
50/50V	10p	16+16/450V	40p	32+32+32/350V	65p
100/25V	10p	32+32/350V	40p		

LOW VOLTAGE ELECTROLYTICS.
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V 10p.
500mF 12V 15p; 25V 20p; 50V 30p.
1000mF 12V 20p; 25V 35p; 50V 47p; 100V 70p.
2000mF 6V 25p; 25V 42p; 50V 57p.
2500mF 50V 62p; 3000mF 25V 47p; 50V 65p.
5000mF 6V 25p; 12V 42p; 25V 75p; 35V 85p; 50V 95p.
CERAMIC 1pF to 0·01mF, 4p. Silver Mica 2 to 5000pF, 4p.
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SILVER MICA. Close tolerance 1%. 2·2-500pF 8p; 560-2,200pF 10p; 2,700-5,600pF 20p; 6,800pF-0·01, mfd 30p each.
TWIN GANG. "0-0" 208pF + 176pF, 65p.
Slow motion drive 365pF + 365pF with 25pF + 25pF, 50p; 500pF standard 65p; small 3-gang 500pF £1·60.
SHORT WAVE SINGLE. 10pF, 30p; 25pF, 55p; 50pF, 55p.

SHORT WAVE SINGLE GANG. Precision Silver Plated Gangable Tuning Condensers. Values up to 100pF. **50p** each
Section Couplers supplied FREE with two or more gangs.

NEON PANEL INDICATORS 250V AC/DC. Amber 20p.
RESISTORS. ¼W, ½W, 1W, 20% 1p; 2W, 5p. 10Ω to 10M.
HIGH STABILITY. ½W 2% 10 ohms to 6 meg., 10p.
Ditto 5%. Preferred values 10 ohms to 10 meg., 4p.
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt, 10 ohms to 100K 10p each; 2 watt, 0·5 ohm to 8·2 ohms 10p.
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FERRITE ROD 8 × ⅜in 20p; 6 × ⅜in 20p; 3 × ⅜in 10p.

MAINS TRANSFORMERS

ALL POST 25p each

Eagle MT12 12-0-12V 50mA 90p
250-0-250 80 mA, 6·3V 3·5A 6·3V 1A or 5V 2A .... £2·50
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300-0-300V 120mA, 6·3V 4A C.T.; 6·3V 2A ...... £4·25
MINIATURE 200V 20mA, 6·3V 1A 2½ × 2½ × 2in 75p
MIDGET 220V 45mA, 6·3V 2A 2¾ × 2¼ × 2in 90p
HEATER TRANS. 6·3V ½ amp 65p, 1½ amp 75p
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30V £3·00
1 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £3·00
2 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £4·00
5 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 £9·75
3 amp, 5, 8 and 13V £1·00; Ditto 5 amp £1·20, 3 amp, 3, 5, 8, 10, 13 and 5-0-5V £1·30, Ditto 5 amp. £1·50; 6-0-6V 500mA 90p 9V 1 amp 95p 12V 300mA 75p 12V 500mA 85p 12V 750mA 95p. 40V 1 amp £1·75.
AUTO TRANSFORMERS. 115V to 230V or 230V to 115V 150W £2·80; 500W £6·25; 750W £10; 1000W £15
CHARGER TRANSFORMERS. Input 200/250V. for 6 or 12V, 1½ amp £1·50; 2 amp £1·80; 4 amp £2·50
BATTERY CHARGERS. Ready built with leads and clips 1½ amp £2; 4 amp £4; 5 amp. £4·50.
FULL WAVE BRIDGE CHARGER RECTIFIERS: 6 or 12V outputs. 1½ amp 40p; 2 amp 55p; 4 amp 85p.

MAINS ISOLATING TRANSFORMER

Primary 0-110-240V. Secondary 0-240V 3 amps 720 watts. Insulated terminals. Varnish impregnated. Fully enclosed in steel case with fixing feet. Famous make (Value £19) OUR PRICE **£10** Carr. 50p
Can be used as 800 watt auto transformers 240-110V.

SET OF 3 MOTORS FOR COLLARO STUDIO 115 VOLT TAPE DECK

£2·50 Post 50p

VOLUME CONTROLS

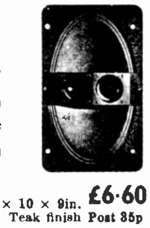
Long spindles. Midget Size 5 K. ohms to 2 Meg. LOG or LIN. L/S 15p. D.P. 25p. STEREO L/S 55p. D.P. 75p. Edge 5K. S.P. Transistor 25p.

80 Ohm Coax 5p yd.

BRITISH AERIALITE AERAXIAL-AIR SPACED 40 yd £1·40; 60 yd £2. FRINGE LOW LOSS Ideal 625 and colour. **10p** per yd

Wire Wound controls 1¼in diam. 3 Watts. 10 ohms to 100K British Made with long spindles ¼in dia. 45p each.
HELICAL POT 10K LIN. List £3. Bargain 75p.
DUAL CONCENTRIC POT 500K LOG AND 500K LIN D.P. switch. Inner spindle 3¼in; outer spindle 2¼in 75p.

E.M.I. 13½ × 8in. SPEAKER SALE!

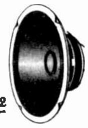


With twin tweeters. And crossover. 10 watt. State 3 or 8 or 15 ohm. As illustrated. **£4·50** Post 25p

With flared tweeter cone and ceramic magnet. 10 watt. Bass res. 45-60 c/s. Flux 10,000 gauss. State 3 or 8 or 15 ohm. **£2·75** Post 25p

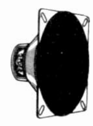
Bookshelf Cabinet 16 × 10 × 9in. Teak finish **£6·60** Post 35p

E.M.I. 6½in. HI-FI WOOFER



8 ohm. 10W. Large ceramic magnet. Special Rubber cone surround. Frequency response 30-12,000 c/s. Ideal P.A. Columns. Hi-Fi Enclosure Systems, etc. **£4**
Suitable Cabinet 12 × 8 × 6 £4 Suitable Tweeter £2

ELAC CONE TWEETER



The moving coil diaphragm gives a good radiation pattern to the higher frequencies and a smooth extension of total response from 1,000 c/s to 18,000 c/s. Size 3½ × 3½ × 2in deep. Rating 10W, 3 ohm. Crossover £1·25 **£1·90** Post 20p.

GOODMANS 8 in. WOOFER

8 ohm 12 watt. Deep cone. Heavy ceramic magnet. Bass resonance 35 cps. Frequency response 30-8,000 cps. Ideal bass unit for Hi-Fi system. **£3·75**

SPECIAL OFFER LOUDSPEAKERS
ALL BRAND NEW

3 ohm, 2½in; 2¾in; 3½in; 5in.
8 ohm, 2½in; 2¾in; 5in × 3in; 5in.
15 ohm, 3½in; 5in; 6 × 4in; 5 × 3in; 7 × 4in; 8 × 5in.
25 ohm, 2½in; 3in; 5 × 3in; 5in.
35 ohm, 2in; 3in; 5in.
80 ohm, 2½in; 2¾in.
£1 EACH

LOUDSPEAKERS P.M. 3 OHMS. 7 × 4in £1·25; 6½in £1·50; 8 × 5in £1·60; 8in £1·75; 10 × 6in £1·90; 10in £2·50
RICHARD ALLAN TWIN CONE LOUDSPEAKERS. 8in diameter 4W £2·50, 10 in diameter 5W £2·50; Post 25p. 12in diameter, 6W, £2·95; 3 or 8 or 15 ohm models.
SPEAKER COVERING MATERIALS. Samples Large S.A.E.
Horn Tweeters 2-16Kc/s. 8W 8 ohm or 15 ohm £2·20.
De Luxe Horn Tweeters 2-18Kc/s, 15W, 15 ohm £3·50.
TWO-WAY 3,000 c.p.s. CROSSOVERS 3, 8 or 15 ohm £1·25.

TWO-WAY CROSSOVER NETWORK 3,000 c/s

With variable tweeter attenuator giving accurate high/low frequency balance. Mounted on panel 5¼in × 4in with control knob, tweeter and woofer leads and input terminals. Suitable for 3 to 8 ohm impedance. **£3·80** Post 20p

VALVE OUTPUT TRANSFORMER 40p.
MIKE TRANSFORMER MU metal 100-1 £1·25.
PUSH-PULL VALVE OUTPUT TRANSFORMERS.
50 watt .... £12·50 100 watt .... £15·00

ELECTRO MAGNETIC PENDULUM MECHANISM

1·5V d.c. operation over 200 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 20p

R.C.S. RECORD PLAYER AMPLIFIER

2 stage triode pentode valve. 3 watts output. Volume on/off and tone controls. Printed circuit A.C. mains complete and tested. **£4·50** Post 25p

COAXIAL PLUG 10p. PANEL SOCKETS 10p. LINE 18p
OUTLET BOXES, SURFACE MOUNTING 25p.
BALANCED TWIN RIBBON FEEDER 300 ohms, 7p yd.
JACK SOCKET Std. open-circuit 14p. closed circuit 23p; Chrome Lead Socket 45p. Phono Plugs 7p. Phono Socket 7p
JACK PLUGS Std. Chrome 20p; 3·5mm Chrome 12p DIN SOCKETS Chassis 3-pin 10p; 5-pin 10p DIN SOCKETS Lead 3-pin 18p; 5-pin 25p. DIN PLUGS 3-pin 18p; 5-pin 25p.
VALVE HOLDERS 5p; CERAMIC 10p; CANS 5p.

ALL PRICES INCLUDE VAT ● 20p MINIMUM POST AND PACKING ● CALLERS WELCOME ●

RADIO COMPONENT

Illustrated Colour Brochure, Radio Books & Components Lists 10p Written guarantee.

ALL OUR PRICES INCLUDE V.A.T.

E.M.I. WOOFER AND TWEETER KIT

£6·75 THE PAIR, Post 25p. (Available separately. Woofer £5·25; Tweeter £1·90)

Comprising a fine example of a Woofer 10¾ × 6¼in with a massive Ceramic Magnet. 44oz Gauss 13,000 lines. Aluminium Cone centre to improve middle and top response. Also the E.M.I. Tweeter 3½in square has a special lightweight paper cone and magnet flux 10,000 lines. Crossover condenser and full instructions supplied.

Impedance Standard	8 ohms
Maximum power	12 watts
Useful Response	35 to 18,000 cps
Bass Resonance	45 cps

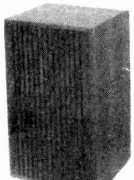
SUITABLE ENCLOSURE 20 × 13 × 9in. MODERN DESIGN. TEAK WOOD FINISH. **£9·90** Post 45p

8″ or 10″ x 6″ ELAC HI-FI SPEAKER

Dual cone plasticised roll surround. Large ceramic magnet. 50–16,000 cps. Bass resonance 55 cps. 8 ohm impedance. 10 watts. **£3·75**

10in round £4·50.

TEAK VENEER HI-FI SPEAKER CABINETS
Fluted Wood Fronts



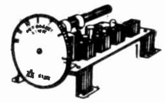
MODEL "A". 20 × 13 × 9in For 12 in. dia. or 10in speaker. **£9·90** Post 25p

MODEL "B". 16 × 10 × 9in For 13 × 8in. or 8 in. speaker **£6·60** Post 25p

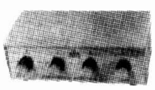
MODEL "B" 2 ditto. Triangular Corner Version.

MODEL "C". 16 × 8 × 6in. For 8 × 5in. speaker **£4·95** Post 25p

LOUDSPEAKER CABINET WADDING · 18in wide, 15p ft.



BARGAIN AM TUNER. Medium Wave. Transistor Superhet Ferrite aerial. 9 volt. **£4·95**



BARGAIN 4 CHANNEL TRANSISTOR MONO MIXER. Add musical highlights and sound effects to recordings. Will mix Microphone, records, tape and tuner with separate controls into single output. 9 volt battery operated. **£4·50**

STEREO VERSION OF ABOVE £5·95.

BARGAIN FM TUNER. 88–108 Mc/s Six Transistor. 9 volt. Printed circuit. Calibrated slide dial tuning. Walnut Cabinet. Size 7 × 5 × 4in. **£12·85**

BARGAIN FM TUNER. As above less cabinet. **£8·85**

BARGAIN 3 WATT AMPLIFIER. 4 Transistor Push-Pull Ready built with volume, treble and bass controls. 18 volt battery operated. **£4·50**

THE "INSTANT" BULK TAPE ERASER & HEAD DEMAGNETISER. Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. **£3·50** Post 20p

WAFER THIN HEATING ELEMENTS

OFFERING 1001 USES for every type of heating and drying applications in the home, garage, greenhouse, factory (available in manufactaring quantities). Approx. size 10¾ × 8¼ × 1/16in. Operating voltage 200/250V. a.c. 250 watts approx. Printed circuit element enclosed in asbestos fitted with connecting wires. Completely flexible providing safe Black heat. British-made for use in photo-copiers and print drying equipment.

Ideal for home handymen and experimenters. Suitable for Heating Pads, Food Warmers, Convector Heaters, etc. Must be clamped between two sheets of metal or asbestos, etc., to make efficient clothes dryers, towel rails—ideal for airing cupboards. Ideal for anti-frost device for the garage—preventing frozen radiators or acting as oil sump heater. Use in greenhouse for seed raising and plant protection. Invaluable aid for bird houses, incubators, etc., etc. Can be used in series for lower heat. Or in parallel for higher heat applications.

ONLY **40p** EACH (FOUR FOR £1·50)

ALL POST PAID—Discounts for quantity.

BAKER MAJOR 12″ £9·90

Post Free

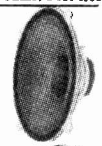
30–14,500 c/s, 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s Rated 20 watts. NOTE: 3 or 8 or 15 ohms must be stated.

Module kit, 30–17,000 c/s with tweeter, crossover, baffle and instructions. **£12·50** Post Free

Please state 3 or 8 or 15 ohms. Post free

BAKER "BIG SOUND" SPEAKERS

Robustly constructed to stand up to long periods of electronic power. As used by leading groups. Useful response 30–13,000 cps. Bass Resonance 55 cps.



GROUP "25" 12in 25 watt 3, 8 or 15 ohms. **£8·80** Post Free

GROUP "35" 12in 35 watt 3, 8 or 15 ohms. **£9·90** Post Free

GROUP "50" 15in. 50 watt 8 or 15 ohms. **£22·00**

50 watt 12in VERSION £17·60

MAJOR 100 WATT ALL PURPOSE TRANSISTOR AMPLIFIER

All purpose transistorised. Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing. Output 8/15 ohm a.c. Mains. Separate treble and bass controls. Guaranteed. Details S.A.E. **£49** Carr. £1·00

CALLERS ONLY! DE-LUXE 100 WATT AMPLIFIER CHASSIS. 7 Valve version, 4 inputs, 10 wide range controls. For Mikes, Discos, Organs, Guitars, etc. 4, 8 and 15 ohm Loudspeaker matching. **£69**

Q MAX CHASSIS CUTTERS
A die, punch and Allen Screw

Sizes	Price
3/8"	74p
7/16"	83p
Key "T" for above	6p
1/2", 9/16", 5/8"	90p
11/16", 3/4"	92p
13/16", 7/8"	99p
Key "A" for above	6p
15/16", 1", 1 1/16", 1 1/8"	£1·00
13/16", 1 7/32", 1 1/4"	£1·15
1 5/16", 1 3/8"	£1·20
1 1/2"	£1·35
1 5/8"	£1·55

Sizes	Price
1 3/4"	£1·70
Key "B" for above	10p
2"	£2·25
2 3/32"	£2·50
2 1/8"	£3·30
Key "C" for above	13p
2 1/4"	£4·50
2 3/4"	£5·75
3"	£9·00
Key "E" for above	20p
1" Square, with key	£2·10

SPECIAL OFFER

20 Watt 100 ohm Rheostat 2½in dia. Ceramic former screw terminals ¼in dia. spindle. 95p. Post 25p.

SPECIAL OFFER £1·75. Post 25p.

3in Panel Meter 50 μA. Unusual scale requires re-calibration. Few only 25μA same price.

WEYRAD COILS

P50/1AC	40p	RA2W	85p
P50/2CC	40p	OPT1	65p
P50/3CC	40p	LFDT4	65p
PCA1	60p	Twin gang	75p

DELUXE 4 POLE MOTOR

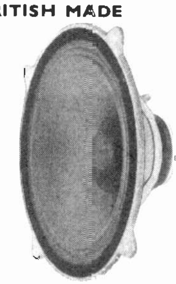
1,400 r.p.m. reversible 42 Watt, spindle 1¼in × 7/32in, size 3¼in × 3in. As illustrated. 240V a.c. mains. **£1·95** Post 25p

E.M.I. GRAM MOTOR

120V or 240V a.c. 2,400 rpm. 2-pole 70mA. Size 2¾ × 2¼ × 2¼in. **£1·00** Post 25p

BAKER HI-FI SPEAKERS
HIGH QUALITY—BRITISH MADE

REGENT
12in. 15 watts



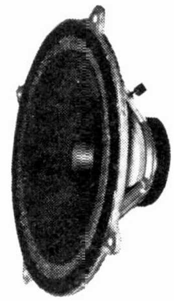
An inexpensive unit for the beginner in high fidelity and for general purposes. May be used to improve any Radio, Amplifier, Hi-Fi or Television receiver.

Bass Resonance	45cps
Flux Density	12,000 gauss
Useful response	45–13,000cps

3 or 8 or 15 ohm models.

£8·80 Post Free

DE-LUXE Mk II
12in. 15 watts



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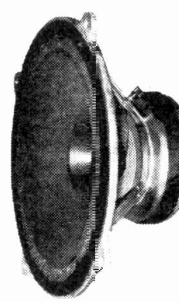

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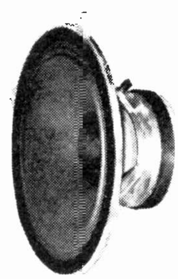

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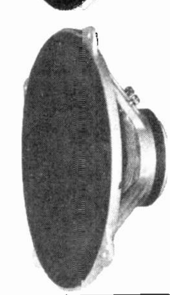

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PE

SOUND POWER

AUDIO power amplifiers find their way into a very extensive and diverse range of equipments and systems, quite apart from the domestic entertainment area. The exuberant folk music of today, whether originated "live" or recreated from discs, is borne along on hundreds of watts. Public Address systems reach out as never before to cajole or inform captive audiences or, just as probably, innocent passers by. Just two of the more blatant uses of sound power.

No one can avoid the fact that amplified sound is very much part of the contemporary scene. The propriety of its widespread use can be argued about but its presence is real and, presumably, permanent.

Those concerned with technical matters can, at any rate, do their best to ensure that the amplifying medium, for its part, is beyond reproach and does not introduce gratuitously any (further) distortion. In fact, it is generally agreed that this branch of the technology has made impressive progress and audio engineering has reached almost the ultimate in the quest for faultless performance. The evidence lies among the huge variety of amplifier designs which have been developed.

Yet the question could well be posed: are there not too many designs?

The need for off-the-shelf designs to meet the constantly occurring demands for certain basic units (such as audio power amplifiers and power supply units) which form indispensable sections of many electronic systems, has been a theme of discussion among electronics people over the years. The logic behind this thought is undeniable, but the ideal general purpose design has never materialised, save in certain rather limited areas. So designs for standard routine functions still proliferate.

The continual up-dating of the technology through the introduction of new components is the stumbling block. Electronics is synonymous with change. A well proven standard device, equipment, or system is likely to have a limited life before the inevitable innovation or improvement happens.

Yet even within this volatile field there has perhaps been a rather excessive outpouring of amplifier designs than is altogether warranted.

There is still a reasonable life expectancy for many designs; and when considering a widely used item such as an a.f. amplifier there is good sense in stabilising the position as long as possible by fully exploiting one single design. If the design is capable of being produced in a number of different "sizes" so catering for the majority of power requirements commonly called for through the simple expedient of changing component values, the attractiveness of this policy is unquestionable.

This idea materialises in our pages with the introduction of a family of audio power amplifiers. The P.E. Power Slaves comprise a family of four amplifiers having outputs of 20, 40, 65 and 100 watts respectively, suitable for use with hi fi pre-amplifiers. Furthermore any unit can easily be built in a two-channel form with a doubling of output power. Good performance, with low harmonic distortion and good signal to noise ratio, justify the claim that the P.E. Power Slaves are a step towards that goal of a universal power amplification block for embodiment in all kinds of sound reinforcement systems.

F.E.B.

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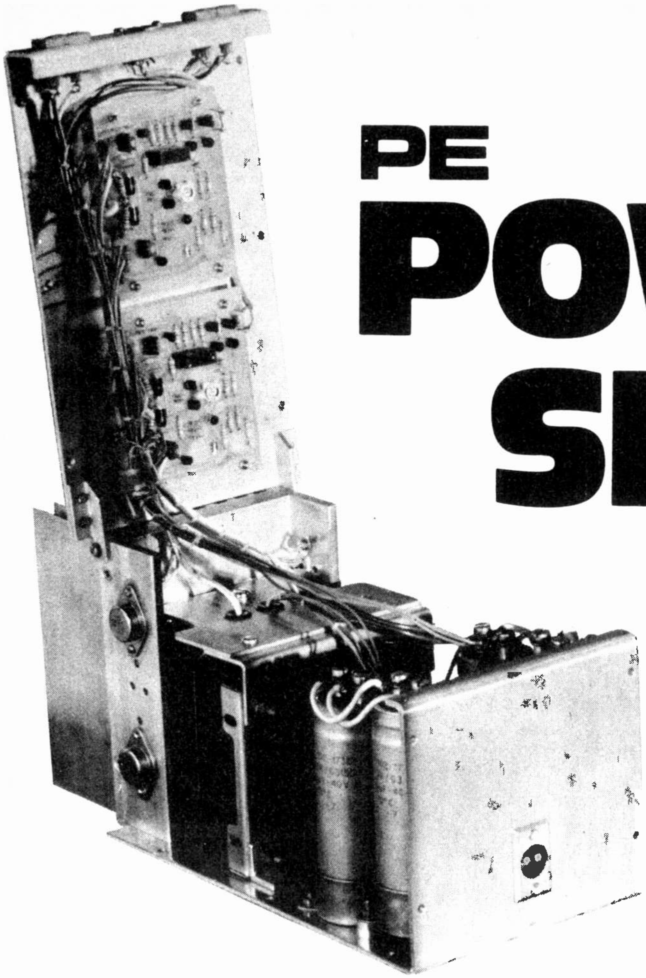


PE POWER SLAVES

BY R.B. REESON

THE purpose of any audio chain is the accurate reproduction of live or recorded information, be it speech, music or just plain "sound".

Due to the low efficiency of transducers generally, with the possible exception of horn loaded systems, considerable power must be expended in order to produce sounds at an acceptable level; this level will obviously be different for different transducers in different applications. As the basic function is the same, it was felt that, rather than produce a flood of designs for specific purposes, a better approach was to produce a single basic design to fulfil all requirements.

From this article four amplifiers can be built all of them being based on a single circuit configuration. To realise the range of outputs of 20W, 40W, 65W and 100W component changes should be made according to the relevant parts lists.

Although a single amplifier is described the prototype units were designed as double channel, that is, where two amplifiers are contained on a single chassis. This, of course, means a doubling of output capability to 20 + 20W, 40 + 40W, 65 + 65W and 100 + 100W in each case.

DESIGN CRITERIA

Where a low power system is required, there is little to be gained, and much to be lost in producing a power amplifier with an output capability of less than twenty watts into eight ohms, as cost and physical size will not be significantly affected, and performance criteria such as transient handling capability, signal to noise ratio and distortion are not likely to improve.

Turning to the upper end of the power scale, choice of maximum power can be arrived at by examination of the transducers to be driven. Modern composite high power speakers, and individual drive units, will accept continuous sine wave outputs of between 10 and 50 watts r.m.s. Unfortunately audio signals are rarely as predictable as sine waves, but it can be assumed that twice the continuous power can be handled on transients of short duration, thus a power capability of 80 to 100 watts will be required.

When two or more speakers are connected in series, or series-parallel to maintain impedance, then the power requirement can be greatly increased. No allowance has been made for this method of use, as the damping effect of the amplifier is lost, except when units are connected by separate leads to the amplifier terminals, and thus it is felt to be a bad policy.

A further problem arises when two speakers in parallel are driven to a peak level of 100 watts each, that is, a current handling capability of at least 10 amps is required, both in the amplifier and power supply unit, and this is dangerously close to the maximum current of a TO3 transistor (generally 15 amps).

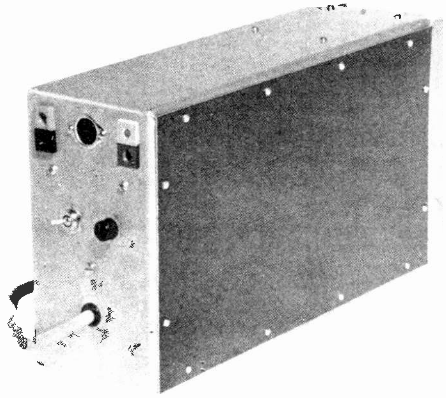
Thus a high quality amplifier should be capable of driving up to 100 watts into a single 8 ohm load, and, to satisfy the requirements of all applications, must have very low harmonic and intermodulation distortion figures, be overload protected, have a high damping factor, and a very high signal to noise ratio.

This final parameter is often neglected, and in most designs a figure of 80dB is considered good. However, a better figure to aim for is 100dB.

Power amplifiers can be functionally split into two sections, namely a voltage amplifiier with low current gain, followed by a current amplifier with unity voltage gain, and at this stage the two sections will be considered separately.

Specification . . .

Power bandwidth -6dB from 8Hz to 45kHz
Total harmonic distortion 0·02%
Intermodulation distortion 0·04%
Signal/Noise ratio 100dB
Input sensitivity into 200kΩ 1V r.m.s.
Input matched to 600Ω line
Overload protected
May be d.c. coupled throughout for use as a servo amplifier
Full bridge output to eliminate "turn-on plop"



PROVIDING OUTPUTS OF 20, 40, 65, & 100 WATTS ..... FROM ONE COMMON CIRCUIT CONFIGURATION

VOLTAGE AMPLIFIER

The basic voltage amplifier configuration used for the power amplifiers is shown in Fig. 1. It has the advantage of providing adequate performance without undue complexity and requires no setting up.

The input resistor R1 provides bias current for TR1 and defines the slave amplifier input impedance.

R12, R2 and C2 form an attenuator which determines the proportion of the output fed back to TR2 and hence defines the gain of the amplifier. C2 allows full d.c. feedback to stabilise the output at, or close to 0 volts. Transistors TR1 and TR2 form a differential amplifier, as do TR3 and TR4, the output of this second stage being fed to a common emitter amplifier TR5.

The overall combination will have a very high open loop gain, and will be non-inverting, as a positive going input tends to increase current in TR1 at the expense of TR2, so that TR4 turns on and TR3 off. This reduces the current drawn by TR5 base and gives a positive going output at TR5 collector. Resistors R4, R5, R7, R8 and R9 enable a sensible standing current to be established in each stage, and eliminate any chance of leakage currents unbalancing the amplifier.

The problem of non-linearity in TR5 is overcome by operating this transistor at a constant collector current by bootstrapping the junction of R10 and R11 to the output by means of C3, providing an almost constant current in R11.

COMPOUND TRANSISTORS

The output stage is basically a Class AB compound amplifier using quasi-complementary transistors being made up of groups of three as seen in Fig. 3.

These triplet configurations have a number of advantages chief of which are (a) high current gain, (b) the inputs are presented through a single base

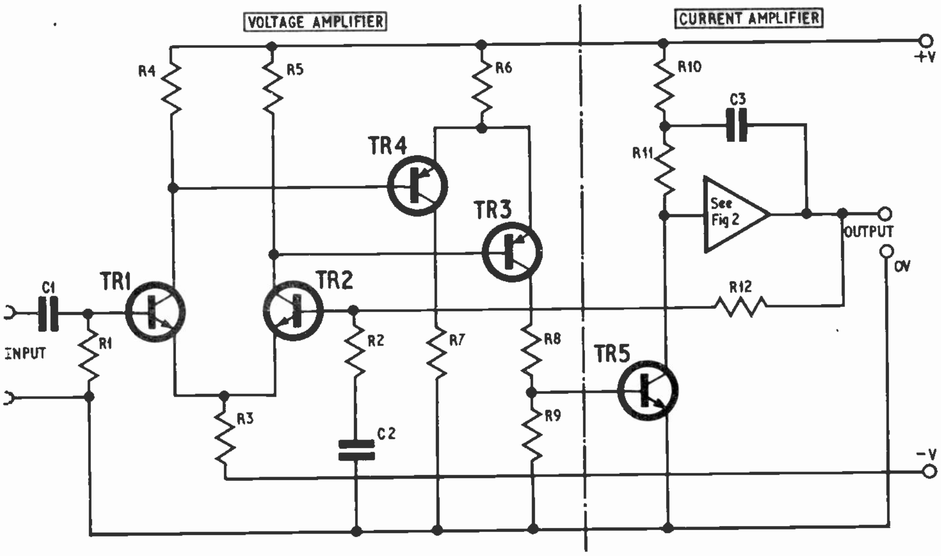


Fig. 1. Basic circuit arrangement for voltage amplifier

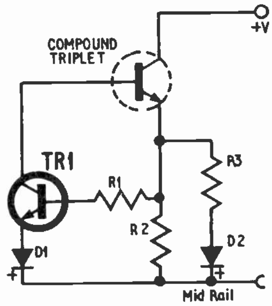


Fig. 2. Showing how current limiting is achieved

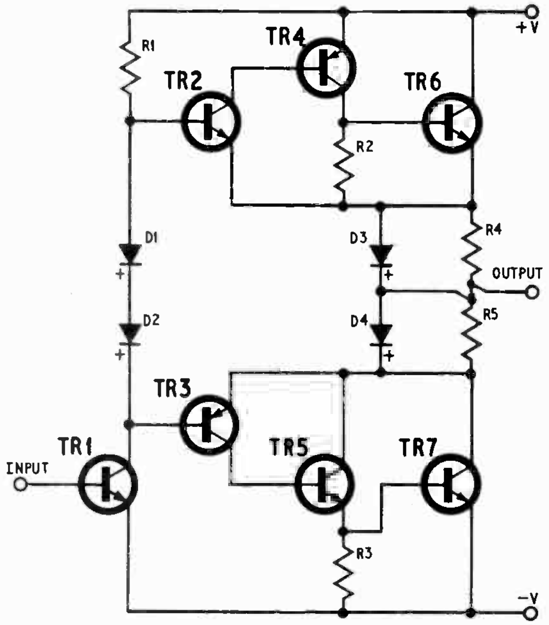


Fig. 3. Compound triplet arrangement for current amplifier

emitter junction which means that the output transistor junction temperature will not affect stability and (c) *npn* output transistors are relatively cheap and readily available.

In the quiescent condition the driver transistor TR1 is biased to provide a mid-rail voltage at the output. With a signal applied the collector applies alternate drive conditions to the compound triplets so that first one group is conducting and then the other.

A "two stage" resistor is used to link the triplets to the output terminal, consisting of a fairly high value resistor shunted by a power diode and resistor.

The high value of resistance gives good quiescent stability, and the diodes limit the voltage drop under full drive conditions. To ensure reliable operation of the overload protection, a low value resistor is connected in series with each diode, and maximum current can be adjusted by means of this resistor.

OVERLOAD PROTECTION

Overload protection is provided by limiting the output current supplied by either compound triplet. The circuitry that achieves this is shown in Fig. 2 for one triplet only, a complementary circuit being used on the other.

The current supplied to the output terminal generates a voltage across the combination of R3, R2 and D2 which is related to the current flowing. When the current rises to a level sufficient to provide approximately 1·5V, base current is directed through TR1 and D1. Conduction of this transistor means that bias is removed from the triplet so that the output current is limited.

The peak current available before limiting must be higher than the peak current to be supplied to the load, and as this may be 5A, a dissipation of 225W can occur with a short circuit at the output. Because of this, a fuse circuit must be inserted (FS1) to give protection.

The complete circuit configuration for the basic amplifiers is given in Fig. 4.

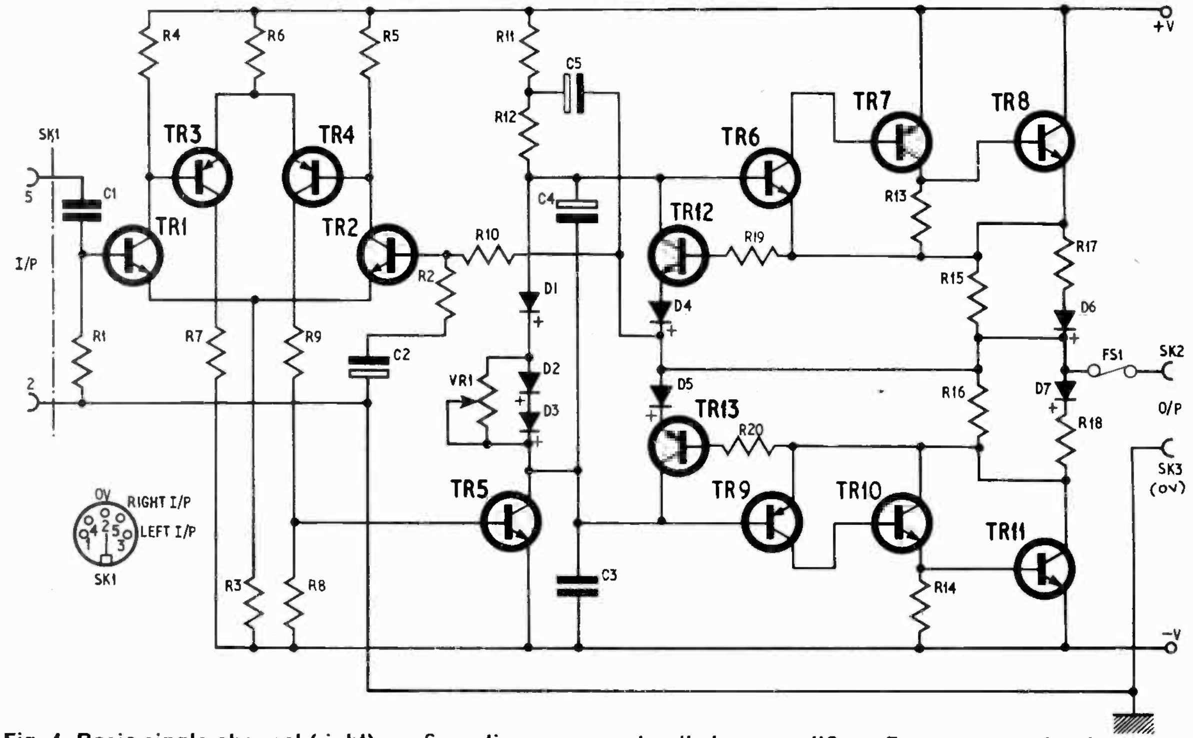


Fig. 4. Basic single channel (right) configuration common to all slave amplifiers. For component value variations, see components lists. The inset shows wiring for a 180 degree, 5 pin socket for two channel. When connecting a remote preamplifier the screen is connected to earth (0V) only at the slave to obviate hum loops

POWER SUPPLIES

Power supplies in a design such as this must provide a fairly steady supply voltage, with a high current capacity when required. As an example, 100 watts into 8 ohms will require a peak current of 5 amps per channel. This implies that for a stereo amplifier with a common power supply a peak requirement of 10 amps is necessary. The mean current drain will be 1/2·8 of this value, or 3·5 amps, and so a transformer rated at 4 amps continuous current would be suitable.

Decoupling should maintain the supply within about two volts of nominal, at full power, for one half cycle of mains current so that:

$$C = \frac{IT}{V} \text{ at peak output}$$

where I is in amps, T in seconds and V volts. The equation then is:

$$C = \frac{10 \times 0{\cdot}01}{2} \text{ Farads} = 50{,}000\mu F$$

A composite musical signal can be shown to have a short term mean level at least 12dB below maximum output. Occasional transients will reach maximum output, but these will generally be of short duration, two milliseconds or less being typical.

From similar calculations as above the decoupling requirement for music at −12dB is 5,000μF and for a 2mS transient, 6,000μF.

DESIGN CHOICE

If the amplifier is intended for home entertainment (domestic) reservoir capacitors of 6,000μF are

COMPONENTS . . .

AMPLIFIERS

Resistors	20W	40W	65W	100W
R1	200kΩ	200kΩ	200kΩ	200kΩ
R2, R6	39kΩ	56kΩ	68kΩ	86kΩ
R3, R4, R5	430kΩ	620kΩ	750kΩ	910kΩ
R7	91kΩ	120kΩ	150kΩ	160kΩ
R8	6·2kΩ	6·2kΩ	6·2kΩ	6·2kΩ
R9	82kΩ	110kΩ	130kΩ	150kΩ
R10	200kΩ	200kΩ	200kΩ	200kΩ
R11, R12	15kΩ	20kΩ	24kΩ	27kΩ
R13, R14	100Ω	100Ω	100Ω	100Ω
R15, R16	10Ω (1W)	10Ω (1W)	10Ω (1W)	10Ω (1W)
R17, R18	0·11Ω	0·08Ω	0·07Ω	0·06Ω
	0·03Ω/cm, 26 s.w.g. resistance wire			
R19, R20	4·7kΩ	4·7kΩ	4·7kΩ	4·7kΩ

All ½W 5% metal oxide except where stated

Capacitors	20W	40W	65W	100W
C1	0·1μF	0·1μF	0·1μF	0·1μF
		All 30V ceramic		
C2	10μF	10μF	10μF	10μF
		All 16V tantalum		
C3	100pF	100pF	100pF	100pF
		All silver mica		
C4	22μF	22μF	22μF	22μF
		All 16V tantalum		
C5	1μF	1μF	1μF	1μF
		All 63V polyester		

Potentiometers	20W	40W	65W	100W
VR1	2·2kΩ	2·2kΩ	2·2kΩ	2·2kΩ

Diodes	20W	40W	65W	100W
D1–D5	1N914	1N914	1N914	1N914
D6–D7	1N5401	1N5401	1N5401	1N5401

Transistors	20W	40W	65W	100W
TR1, TR2	2N2484	2N2484	2N2484	2N2484
TR3, TR4	BC212	MPS-L51	MPS-L51	MPS-L51
TR5	ME1120	ME1120	ME1120	ME1120
TR6	BC182	MPS-L01	MPS-L01	MPS-L01
TR7	MPS-U57	MPS-U57	MPS-U57	MPS-U57
TR8, TR11	2N3055	2N3055	SDT9203	SDT9203
TR9	BC212	MPSL51	MPSL51	MPSL51
TR10	MPS-U07	MPS-U07	MPS-U07	MPS-U07
TR12	BC184	BC184	BC184	BC184
TR13	BC214	BC214	BC214	BC214

Miscellaneous	20W	40W	65W	100W
FS1—	1A	1A	1A	1A
Heatsink	60D-0600-A-1 (Marston) (100W and 65W)			

POWER SUPPLIES

Resistors	20W	40W	65W	100W
R1	12kΩ	15kΩ	18kΩ	20kΩ
R2	100Ω	100Ω	100Ω	100Ω
R3, R4	200Ω	300Ω	360Ω	470Ω
R5	300Ω	300Ω	300Ω	300Ω
R6	10Ω	10Ω	10Ω	10Ω
R7 see text				
R8	10kΩ	12kΩ	15kΩ	18kΩ
R9	1kΩ	1kΩ	1kΩ	1kΩ
R10, R11	2kΩ (1W)	2kΩ (1W)	2kΩ (1W)	2kΩ (1W)

Potentiometers	20W	40W	65W	100W
VR1	1kΩ	1kΩ	1kΩ	1kΩ
		all carbon linear		

Capacitors	20W	40W	65W	100W
C1, C2	10,000μF (40V)	10,000μF (50V)	10,000μF (63V)	10,000μF (63V)
C4, C5	10,000μF (40V)	10,000μF (50V)	10,000μF (63V)	10,000μF (100V)
		All electrolytic		
C3	100pF	100pF	100pF	100pF

Transistors	20W	40W	65W	100W
TR1	BC204	BC204	BC204	BC204
TR2, TR3	MPS-U01	MPS-U01	MPS-U01	MPS-U01
TR4	MPS-U51	MPS-U51	MPS-U51	MPS-U51
TR5	2N3055	SDT9203	SDT9203	SDT9203

Rectifiers
D1–D4 REC46 (150V, 10A)
D5 BZY88—C6V8

Transformer	20W	40W	65W	100W
T1	24-0-24V @ 4A	30-0-30V @ 4A	33-0-33V @ 5A	36-0-36V @ 6A

Changes for Standard Supplies (Domestic and Monitoring versions)

Capacitors	20W	40W	65W	100W
C1, C2 (Domestic)	6,000μF (25V)	6,000μF (35V)	6,000μF (40V)	6,000μF (50V)
C1, C2 (Monitoring)	10,000μF (25V)	10,000μF (35V)	10,000μF (40V)	10,000μF (50V)

Rectifiers
D1–D4 REC 43A (100V, 4A)

Transformer	20W	40W	65W	100W
T1	18-0-18V @ 3A	22-0-22V @ 4A	25-0-25V @ 4A Douglas MT106	30-0-30V @ 4A Douglas MT123

Miscellaneous
S1—Double pole mains on/off, LP1—mains neon
FS1—1A

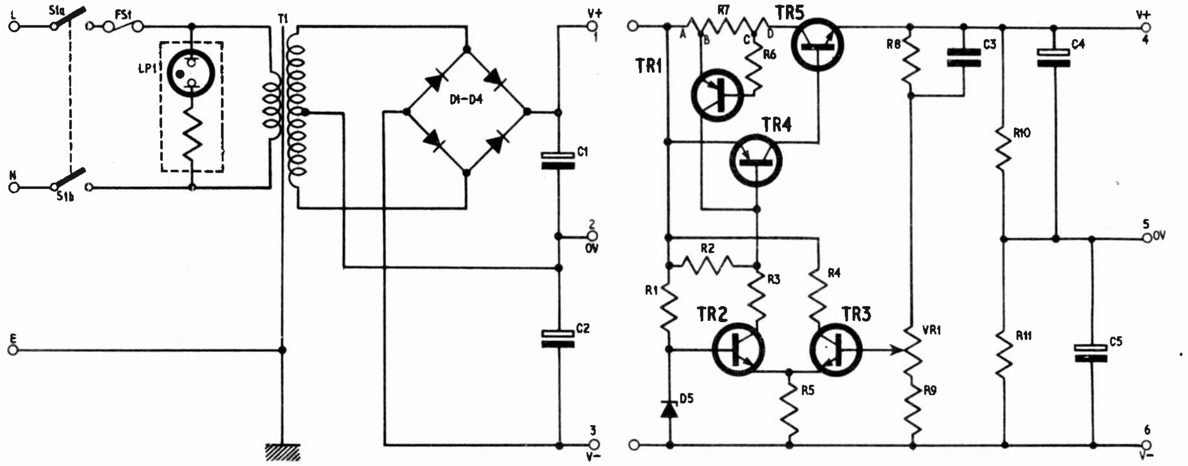


Fig. 5. Circuit for p.s.u. For the domestic version of amplifier the power rails are pins 1, 2 and 3. The monitoring version takes its supply from pins 4, 5 and 6. The current sensor R7 is made up from 26 s.w.g. Constantan resistance wire (0·03 ohm/cm). The tapping resistances are as follows: A to B ⩽ 0·02 ohms; B to C = 0.07 ohms; C to D ⩽ 0.02 ohms. Supply voltages for the 20, 40, 65 and 100W versions are approximately ±25V, ±32V, ±36V and ±46V respectively

adequate assuming that neither transients nor very loud passages coincide exactly in time if two channels are being used.

For "monitoring" quality, a higher value capacity, possibly 10 or 15,000μF should be used, or alternatively a stabilised supply particularly when used for stereo to reduce cross talk.

A composite circuit diagram for the domestic and monitoring versions of the p.s.u. is shown in Fig. 5.

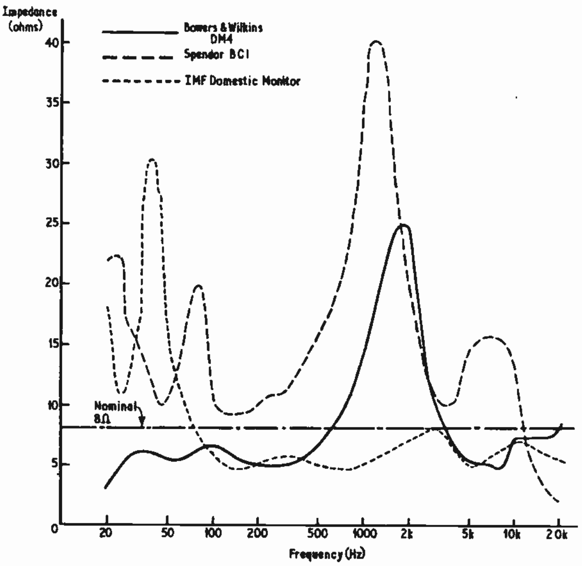


Fig. 6. Showing how speaker impedance changes with frequency

For the former points 1, 2 and 3 are connected to the amplifier. For the latter points 1 and 2 connect to the stabiliser circuit; no connection is made to 2.

The output mid-point in this case is derived using resistor and capacitors.

OPTIMUM LOAD

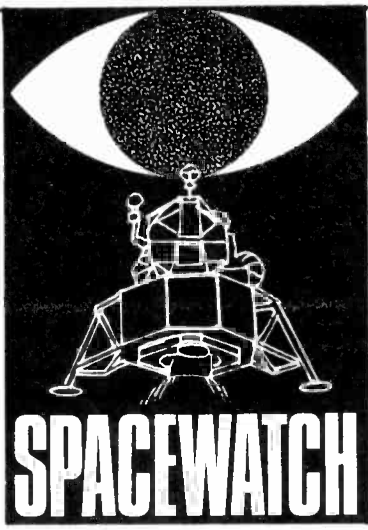
Optimum load impedance for all versions is 8 ohms but any load can be accommodated at reduced power, bearing in mind the peak voltage and current limitations.

Fig. 6 shows typical impedance curves for high quality domestic speakers demonstrating that the impedance is anything but constant. Indeed, it is not unusual to find dips of impedance as low as 1·5 or 2 ohms, causing severe current overload at critical frequencies.

IMPORTANT

Two BA148 diode suppressors MUST be added to Fig. 4 as follows—Cathode and anode to + V and SK2 and SK2 and − V respectively. In Components List for all versions TR7 and TR10 should be MPS-U57 and MPS-U07; for the p.s.u. TR2, TR3 should be MPS-U07 and TR4, MPS-U57. (See next month.)

Next month constructional details for the amplifiers will be given



BY FRANK W. HYDE

THE SUN, BY SKYLAB

From the last of the experiments aboard *Skylab* has come new knowledge and exciting data. There is no doubt that a new era has opened for astronomers and as a result of what has been noted many programmes will be instituted in solar physics.

Much of the success is due to the (ATM) Apollo Telescope Mounting. It enabled a new view of the solar system, the galaxy and, most important, the Sun itself.

Free of the atmospheric absorption the telescope showed that the Sun, far from being "quiet" at the near sunspot minimum was extremely active. This alone has justified the mission and also confirmed the need for man in space.

Practical Electronics received an invitation from the Institution of Radio and Electronic Engineers to attend the Clerk-Maxwell Lecture, "Man in Space" by Werhner von Braun. More than twice the number of persons attended than the seats available. Before the lecture began the writer had a conversation with Werhner von Braun and certain definite conclusions regarding the progress of physics emerged. In his words ". . . the time has come for another Maxwell to re-order our thoughts and set in their proper place the ever increasing number of particles, the black holes and the quasars." He also gave some information based on the early examination of some of the data.

The medical evidence is now clear and it is accepted that man could live in space indefinitely. The adaptability is not confined to man for the spider which was taken aboard *Skylab* was able to spin a perfect web. The pictures of the first attempts were not only comic but extremely interesting. It needed only a short while of accommodation before things were under control. The peculiar zigzag of the circles and the cross ties soon assumed the familiar shape and life went on.

The astronauts also attempted to move round the walls at a high rate to set up artificial gravity. In this they were not successful.

GREAT BALLS OF FIRE

One of the most spectacular events was a pulsing stream of plasma from the Sun which had a regular rhythm. More than forty of such events were recorded. An unexpected bonus was the ability to observe with the coronagraph these great blobs, as large as the Sun itself, as they moved up through the corona at a speed of 400km per second.

The variation of the intensity of the corona over the two hemispheres of the Sun were not anticipated. One section of the Sun seemed to be in the nature of a hole at a lower temperature than the rest of the surface. This was borne out by the X-ray pictures. It also appears that the corona is composed of closed loops which fit the magnetic line structure. In both the X-ray measurements and the white light coronagraph pictures this appears.

There were a number of instances, where the conditions for sunspot appearance appeared outside the normally observed belts. Some of the "holes" indicate the source of disturbances of the solar wind which effect terrestrial conditions.

There have been tens of thousands of frames taken of the coronal conditions, more than has been observed in a thousand years of eclipses. Continuous observations with the facility to select and also combine different types of telescope, made the *Skylab* control console a sort of astronomical organ on which the melody of the heavens could be produced. Nothing like this success was expected and now the knowledge of what can be done in this field must ensure that the next decade will add an unprecedented amount of data for study.

More than 600 pictures a day were recorded and the number of bits in each picture amounted to 10^8. Among the many and continuous hours of study covering everything in the vicinity of the Sun there were two solar eclipses, many eruptions and flares on the Sun itself, the perihelion of Kohoutek and a transit of Mercury.

The combination of control from the Johnson Spaceflight Centre and the astronauts aboard *Skylab* resulted in a magnificent scientific achievement. It is worth noting that the planned tasks for the crew were restricted to the pointing of the telescopes, target control and to collect and replace cameras and film. But, in fact, the crew did much more than that and it was their resource that made possible the full speed running of the observations. Despite some early difficulties, which were overcome, the crew settled down to do a job for which posterity must ever be grateful.

The cost of this mission was high and many thought wasteful. None would say this now and indeed, there is in this very extensive period of man in space, the certainty that money for the future missions will be forthcoming.

MORE OF VENUS

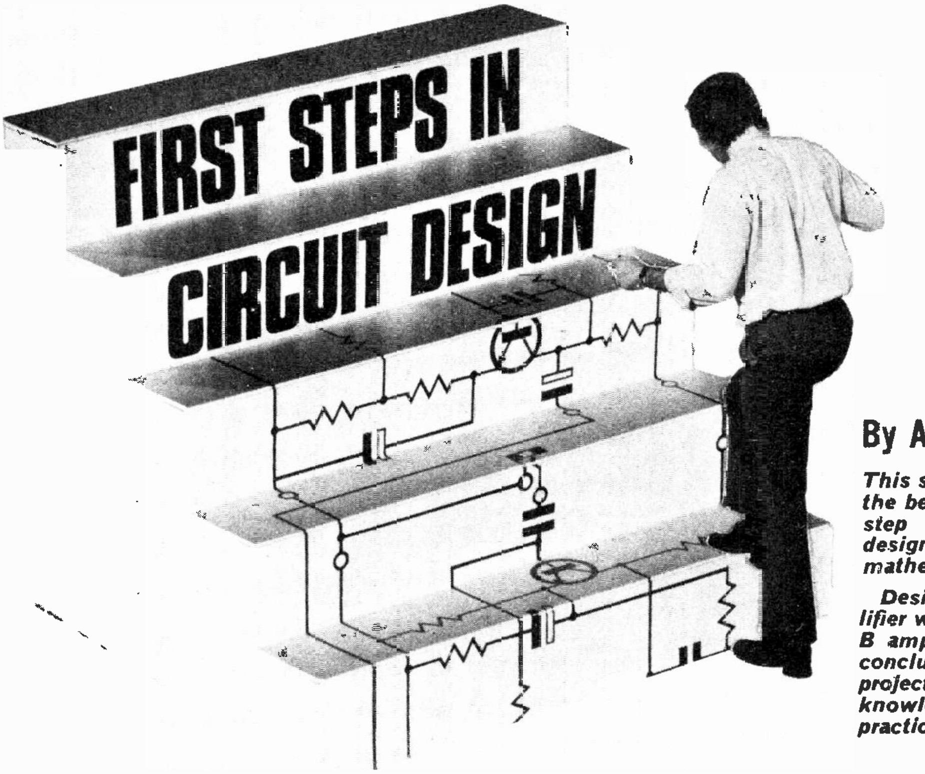
The Venus fly-by of *Mariner 10* has been a successful mission. But some of the data obtained will need months to extract the information sought.

The spacecraft approached Venus from the dark side and the first pictures showed the cusps which appear extended far beyond the normal. This is thought to be due to the atmospheric refraction. The scattering of light beyond the terminator will help to an understanding of the upper atmosphere. Haze shells were observed and these will reveal more data after computer processing.

One important aspect is the layering observed in the atmosphere. This is not yet understood nor is the material of the cloud strata.

There was great penetration of the atmosphere by the two radio probe signals. Though physical occultation began at about 10.17a.m. radio signals were still being received up to 17 minutes later. The aerial on *Mariner 10* was designed to change its pointing direction in order to compensate for the bending of the radio waves which takes place when travelling through the Venus atmosphere.

Much is expected of this technique in the observation of the density of the atmosphere and it is hoped also to resolve the differences of temperature given by earlier *Mariner* missions and by the USSR spacecraft *Venera*. Helium is known to be a constituent but it would have to be at least 3 per cent to account for the differences of temperature found.



4

By A. P. Stephenson

This series, specially written for the beginner, takes you step-by-step through transistor circuit design in a simple, non-mathematical way.

Design of a small signal amplifier will be followed by a Class B amplifier and the series will conclude with a constructional project so that your theoretical knowledge can be put into practice.

SO FAR we have only looked at the voltage divider method of biasing a transistor stage. This month we will look at another method which is simple and economical. These advantages are, however, at the expense of other parameters.

Once we are satisfied with a single stage amplifier, the problem then arises of how to connect this into the system so that it does not disturb the driving or driven circuits. Sometimes direct coupling is possible but often we must make use of a d.c. blocking capacitor. The value of this component must be such as to maintain the required bandwidth of the system.

4.1. ALTERNATIVE BIASING ARRANGEMENT

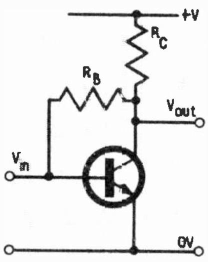
There is an alternative to the R1, R2 divider (Part 3) known as "collector to base feedback bias". Only one resistor is needed instead of two and some bias stability is possible even without the inclusion of R_E (see Fig. 4.1).

The resistor R_B provides bias and also some negative feedback which tends to stabilise the collector current against changes in h_{FE}.

Suppose that h_{FE} is higher than predicted: this would tend to increase I_C which in turn would cause the output voltage to fall. This fall would be passed via R_B to the base causing a decrease in I_C. The base bias conditions are therefore stabilised.

HIDDEN FEATURES

Although the method appears delightfully simple and economic, there are certain hidden features which the designer must understand.



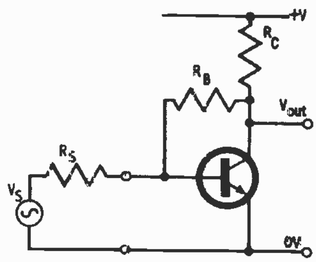


Fig. 4.1 Simple circuit illustrating collector to base feedback (left)

Fig. 4.2 The source resistance can be seen to be an important parameter in the calculation of the circuit gain (right)

(a) The feedback is in parallel with the input signal and therefore requires extra current drive from the signal input to the stage. In other words, the stage input resistance R_{IN} is lowered. In fact, the input resistance consists of two resistors in parallel, one of them being the normal $r_{IN} = h_{fe} \times r_e$ and the other equal to R_B divided by the gain A. This is easily understood when it is realised that the signal voltage is at one end of the R_B and the output voltage (A times the input signal) is at the other.

Thus A times as much current must be provided by the signal, which is equivalent to saying that R_B behaves as if it were $A + 1$ times smaller and across the signal input.

(b) There is no actual reduction in voltage gain, as far as the gain from base-in to collector-out is concerned. The voltage gain is still

$$A = R_C/r_e \quad \text{or} \quad R_C/(r_e + R_E)$$

(If R_E is present).

However the lower input resistance has the effect of lowering the gain measured from signal e.m.f. to collector output. The source resistance of the signal (R_S) in conjunction with R_B forms a kind of operational amplifier configuration (see Fig. 4.2).

If A was very high, the total gain from V_s to V_{out} would be approximately

$$A' = R_B/R_S$$

where A' is defined as the gain with feedback. Thus the gain is independent of the transistor.

This, however, is a gross oversimplification of the situation because the transistor gain A in such a simple single stage amplifier would not be "very high" and $A' = R_B/R_S$ would be greatly incorrect.

This analogy with the operational amplifier was only given as an aid to comprehension. It is always good practice to view circuit ideas from widely differing angles.

4.2. AN ALTERNATIVE EQUATION FOR GAIN

The previous circuit had no emitter resistor R_E which was the reason why the gain A was so high. Although a high gain may often be a desirable feature, there are two main reasons against achieving it by the omission of R_E.

(a) The gain is not too predictable because of its absolute dependency on r_e. The equation $r_e = 25/I_C$(mA) is very useful as a rough guide but it is well to remember that the equation is only approximate. The inclusion of R_E in the gain formula, although lowering the gain increases the accuracy of the equation (particularly if $R_E \gg r_e$).

(b) A more important reason is the rather remarkable twist of the gain equation when the bias is set to allow the collector to rest at half the supply voltage.

If $V_{out} = \frac{1}{2}V_{ce}$ then $R_C = \frac{1}{2}V_{cc}/I_C$. Now

$$A = R_C/r_e = \frac{\frac{1}{2}V_{cc}}{I_C} \div \frac{25}{I_C} = V_{cc}/50.$$

But remembering that the figure "25" is millivolts, we must multiply by 1,000, giving

$$A = \frac{V_{cc} \times 1{,}000}{50}, \text{ thus } \boxed{A = 20V_{cc}}$$

This means that the gain of any grounded emitter stage operating without an emitter resistor is simply <u>20 times the supply voltage</u> (assuming the collector is at half the supply voltage).

This applies whatever collector current we use, so it is impossible to set the gain at any other value than $20V_{ce}$ (unless of course we use negative feedback).

It is easy to see why R_E is almost always present in grounded emitter amplifiers.

4.3. COUPLING CAPACITORS

It is often required to connect two stages together by allowing the output signal of one stage to become the input signal of the next.

Sometimes the coupling can be achieved without disturbing the d.c. bias conditions, but this is sometimes unavoidable.

This problem can be overcome with the use of a "coupling capacitor" which enables the signal to pass relatively easily but blocks any d.c. from affecting the next stage.

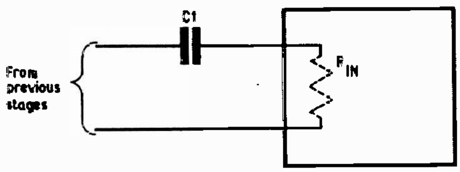


Fig. 4.3 The calculation of the coupling capacitor value is determined by the input resistance R_{IN} of the following stage

CAPACITOR VALUE

The question is how big must the capacitor be. The answer depends on two pieces of information—the lowest frequency that the signal is likely to be, and the input resistance of the stage which the capacitor is to feed.

The skeletal circuit is shown in Fig. 4.3.

The capacitive reactance (X_C) and R_{IN} form a voltage divider, so it is clear that X_C should be considerably less than R_{IN} at the lowest frequency which it is desired to pass.

The simplest way is to find the value of C which makes $X_C = R_{IN}$ and then use the next highest preferred value.

Suppose the lowest frequency to be passed is 100Hz and $R_{IN} = 1\text{k}\Omega$.

Then if $X_C = R_{IN}$, then $1/2\pi fC = R_{IN}$ which gives $C = 1/2\pi fR_{IN}$.

Inserting values gives $C = 1{\cdot}59\mu$F so the next highest preferred value, 2μF would be used.

RULE OF THUMB

A neat little rule of thumb to save a lot of fiddling with powers of ten is

$$C = 0{\cdot}2/f \times R_{IN}$$

where f is in kHz, R_{IN} in kilohms and C in μF.

The value for C is in no way critical, providing it is *at least* the value calculated by the method above. Twice or even ten times larger will not matter apart from the cost.

4.4. USE OF THE EMITTER FOLLOWER STAGE

An emitter follower stage provides an easy solution to the problem of matching from a high resistance signal source to a low resistance load.

Unlike the normal grounded emitter stage, the emitter follower has no voltage gain, in fact, there is a slight voltage loss. There is, however, a substantial current gain as a signal is passed through, because of the apparent change in source resistance.

Treating the emitter follower as a black box, the effect on the input signal is as shown in Fig. 4.4.

The figures shown in the figure are purely arbitrary and are chosen only to illustrate how the source resistance can be substantially lowered by passing through the stage.

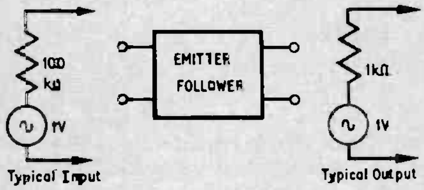


Fig. 4.4 An emitter follower transforms a high input impedance into a low output impedance

CURRENT GAIN

The concept of current gain can be appreciated by calculating the two short circuit currents.

If the original circuit was shorted out the current would be

$$i = 1\text{V}/100\text{k}\Omega = 0{\cdot}01\text{mA}$$

If the output was shorted, the current would be

$$i = 1\text{V}/1\text{k}\Omega = 1\text{mA}$$

This shows that a theoretical current gain of 100:1 has been achieved. (The short circuit current dodge is used on paper only—don't take it literally and start sticking screwdrivers across the terminals.)

It must not be supposed that an actual emitter follower would provide a magical solution. The successful design of such a stage requires quite a bit of fiddling with values to get the input resistance as high as possible.

For example, Fig. 4.4 presupposes that the input resistance of the emitter follower stage is much higher than the 100kΩ signal resistance. Unless this is so, it is clear that the signal would be attenuated by voltage divider action between the 100kΩ and R_{IN} of the emitter follower.

4.5. TYPICAL CIRCUIT AND EQUATIONS OF THE EMITTER FOLLOWER

An emitter follower circuit using voltage divider feed for base bias is shown in Fig. 4.5.

We are not concerned with the design factors for setting up the correct d.c. conditions, this problem is dealt with elsewhere. Instead, we state some important equations which decide the voltage gain, input resistance and output resistance.

1. VOLTAGE GAIN

For most practical purposes, the voltage gain is nearly unity, though it is as well to know the following formula in case some badly chosen values for R_E lower the gain to a small fraction.

Voltage gain from V_{in} to $V_{out} = R_E/(r_e + R_E)$.

Since r_e is the internal emitter resistance and will seldom be in excess of 100Ω or so, it it easily seen that the gain will be about 1, providing R_E is in excess of 1kΩ.

2. INPUT RESISTANCE (R_{IN})

This is the same basic formula which has already appeared in connection with the grounded emitter stage

$$R_{IN} = \text{R1, R2 and } r_{in} \text{ in parallel}$$

(remember that $r_{in} = h_{fe}(r_e + R_E)$).

3. OUTPUT RESISTANCE (R_{OUT})

This is a bit complicated unless dealt with in two parts.

$$R_{OUT} = R_s/h_{fe} \text{ in parallel with } R_E$$

where R_s = R1, R2 and r_s in parallel.

If this is too wearisome to calculate and a very rough equation is all that is needed, then use

$$R_{OUT} = r_s/h_{fe}.$$

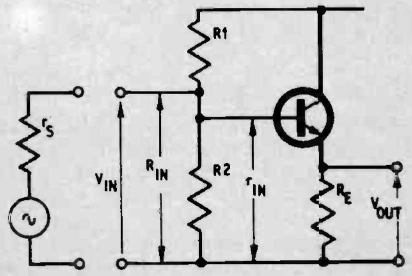


Fig. 4.5 Typical emitter follower with voltage divider for base bias

4.6. D.C. COUPLING

Two stages may be coupled together directly *only* if the d.c. voltage output of the first stage is compatible with the d.c. bias requirements of the second stage.

A typical example which serves to illustrate the system is the circuit of Fig. 4.6 which shows a normal grounded emitter amplifier feeding an emitter follower stage.

Transistor TR1 provides the voltage gain and TR2 provides a low resistance (high current) output.

The gain of the first stage $= R_C/r_e + R_E = (84k\Omega/1k\Omega + 250\Omega) = 67$.

The second stage contributes no further voltage gain.

STAGE INPUT RESISTANCE

The stage input resistance is r_{in}, R1 and R2 in parallel, although it is reasonable to ignore R1.

Now, $r_{in} = h_{fe}(r_e + R_E) = 100(250\Omega + 1k\Omega) = 125k\Omega$, which, in parallel with R1 gives a value for R_{IN} of about 45kΩ.

Currents through TR2 would be determined first. 1mA is chosen for collector current, so assuming a pessimistic h_{FE} of 100, the base current of TR2 would be 10μA.

The divider feed for the bias of TR2 is the chain R_C, TR1 and R_E of the first stage which is passing 0·1mA (which is ten times the base current of TR2).

Again taking an h_{FE} of 100 for TR1, the base current would be 1μA, which is fed by a divider chain taking 10μA.

The "rule of ten" has thus been used throughout.

OUTPUT RESISTANCE

The output resistance of the emitter follower is a bit tricky. The equation, as stated previously, is $R_{OUT} = R_S/h_{fe}$ in parallel with R_E. The term R_S is the source resistance of the signal feeding the base, which, in this case, is the output resistance of the first stage.

To a rough approximation this may be taken as the collector resistance, R_C, which is 84kΩ. Thus $R_{OUT} = 84k\Omega/100 = 840\Omega$. (The 9kΩ R_E which strictly is in parallel may be disregarded.)

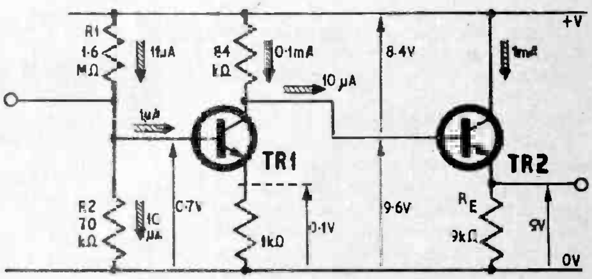


Fig. 4.6 A two stage d.c. coupled amplifier showing typical component values

4.7. D.C. FEEDBACK LOOPS

Leaving the emitter resistor unbypassed has so far been the only example of negative feedback. A more obvious example is frequently used in direct-coupled stages and, to illustrate such a system, the circuit previously discussed will be modified to include a d.c. feedback loop (see Fig. 4.7).

The circuit, including the voltages and currents are exactly the same, apart from the method of biasing the first stage.

Instead of the customary divider across the supply rail, the bias feed is taken from across the output resistor.

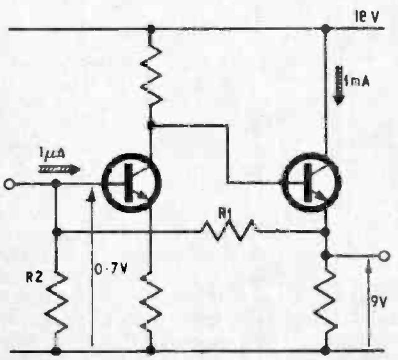


Fig. 4.7 Negative feedback stabilises the output voltage but reduces gain

This is not such a violent change as appears at first sight. After all, there are nine volts available so why not use them and obtain the added advantage of a d.c. feedback loop?

In choosing the values for R1 and R2 we must be careful not to disturb the output circuit too much. It is drawing 1mA so it will hardly be aware of the theft if we divert say 10μA from R_E to feed a divider.

Since R2 must drop 0·7V, R1 must drop the remaining 8·3V which means that if 10μA is flowing the values of R1 and R2 are calculated as follows:

$$R1 = 8{\cdot}3V/10\mu A = 830k\Omega$$
$$R2 = 0{\cdot}7V/10\mu A = 70k\Omega$$

STABILITY

Such a circuit has very good stability in spite of wide tolerances in the resistors R1 and R2. In fact, it is astonishing how the output appears to lock at 9V.

Suppose that the output tends to drift downwards: this will pull the base of TR1 down which causes the collector of TR1 and base of TR2 to rise. The output tendency is therefore to rise which, due to the feedback loop is providing a correcting influence on the tendency for the input to fall.

The original gain before feedback is, of course, reduced from its previous value. This is one of the penalties to be paid for the benefits of negative feedback.

Continued next month

THERE must be many PE readers who would never call themselves musicians but who have an interest in music, be it as listeners or as vamping-left-hand pianists. Some of them are no doubt in the throes of building the units which go to make up Mr. Shaw's Synthesiser and are wondering what on earth to do with it when it's completed. Others may not want to begin any musical project because they feel that their creative or recreative talent is nil.

Yet others may be musicians like myself who have a smattering of electronic theory and practice up their sleeves but are afraid to launch any large-scale project because they fear they may never get the finished article to function. I hope this feature may allay the fears of all these people and, indeed, offer some constructive help.

Facilities in the U.K.

Until quite recently the musician, particularly the composer and/or arranger has had to sit on the periphery of technological progress, using a small amount of electronic equipment in a limited kind of way, unable, through lack of know-how, to extend his innate creativity.

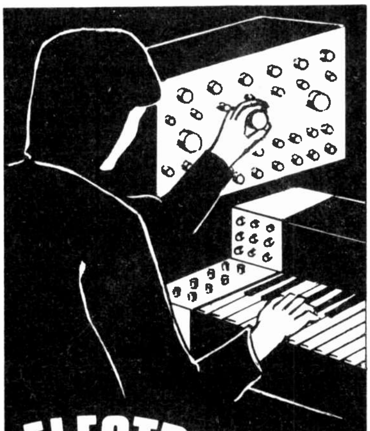
In this country it is not just know-how that has been lacking, but the facilities needed to acquire expertise. Although there has been a tremendous surge of interest in electronically produced or processed sound over the past decade or so we still have not managed to produce a chain of national studios where the musician can work with first-rate equipment and expert technical assistance.

It is true that we have the BBC Radiophonic Workshop, well-equipped and staffed by experts, but, alas, Auntie Beeb tends to hog the show by restricting its output to broadcast material in the shape of incidental music and sound effects and a few (all too rare) commissions from composers outside the Corporation.

Numerous private studios exist too — those of Tristram Cary, Daphne Oram and Peter Zinovieff immediately spring to mind, along with such institutions as the University of York and Goldsmith's College, London—yet most of us cannot hope to experience this kind of Utopian dream. Those of us who live and work away from the metropolis are, as in many things, particularly poorly off.

A studio at home

However, having said that, there is not too much cause for gloom. Magazines like PE have made it abundantly clear that the imaginative person can build quite a sizeable and versatile studio at home, quite apart from the commercial market.



ELECTROMUSE

By Malcolm Pointon

Over the past few years PE has included in its pages features dealing with some of the electronic equipment available to the musician. More frequently there have appeared constructional projects specifically geared to the amateur musician: Waa Waa, Fuzz, Phase, and Sound Bender effects units; and complete instruments such as the Electronic Organ, Electronic Piano, and the Voltage Controlled Synthesiser.

The time is ripe, then, for the musician to join in and help bring the electronics engineer or experimenter and the creative artist together. As a professional musician whose creative work calls increasingly for more and more electronic equipment, I welcome the appearance of this page as a meeting place for the exchange of information, ideas, and ventilating of nagging questions.

Until projects such as the PE Synthesiser appeared (as far as I know the first design to be published for the home constructor to build from scratch) most of us tended to sink further into the slough of despond in the belief that only a fabulous win on the pools could get us reasonably well-equipped.

By beginning in a modest way, building our equipment module by module, we can now keep pace with our pockets whilst steadily increasing our versatility in the creative music sense.

Getting started

I am often asked, particularly by secondary school music teachers who (quite rightly) feel that there is an honourable place for electronic music in the curriculum, what is necessary by way of basic equipment in order to get started.

Assuming that "canned" rather that "live" electronic music is envisaged, then I would suggest a decent half-track stereo tape machine with three or more speeds, sound-on-sound facilities and a couple (maybe only one at first) of reasonable quality microphones; this should keep you going for quite some time.

You may be wondering why I recommend a half-track tape machine when the present-day quality of quarter-track machines is very high indeed. It's not a matter of quality in this instance. Amongst the tricks used in the manipulation of recorded sound one of the simplest is reverse playback, and on a standard quarter-track machine, stereo or mono, or a half-track mono machine, reversal of the tape direction merely gives playback of the recorded material on the new channel(s) in a forward direction. On a half-track stereo machine turning the tape over reverses the material on both channels, incidentally reversing the stereo direction too.

Tape manipulation

Strictly speaking, using only microphones, you are not going to produce electronic music, since the microphone will only pick up air-borne sounds, most of which may well be "natural" in origin—dried peas in a can, hand claps, vocal sounds, or the jangle of keys, and maybe acoustic musical instruments. But by varying the tape speeds in recording, superimposition and reverse playback an amazing variety of sounds can be achieved. For the price of an editing block and a reel of splicing tape the sounds can be linked together to form a satisfactory sequence.

Anyone who has persevered with this kind of tape manipulation—and it is, believe me, a time-consuming activity—will tell you that the results can be miraculously electronic in effect.

In case you think this approach to creative sound a bit limiting, then I suggest you go out and buy a recording of "Variations for a door and a sigh" by Pierre Henry (Philips 4 FE 8504). Henry is one of the leading lights in the French movement which began in the early post-war years and produces so-called "musique concrète".

What can be more limiting than the creakings of an old barn door? Yet Pierre Henry manages, through careful handling of the granary door and a bit of superimposition back at the studio, to produce an incredibly wide range of sounds which are as musical as they are amusing.

There is a little paperback, too, by Terence Dwyer entitled "Composing with Tape Recorders" which offers invaluable advice.

42p

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BFX 86	40	50 MHz	17p
BFY 53	30	50 MHz	10p
2N 697	60	40 MHz	12p
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2N 718	60	60 MHz	12p
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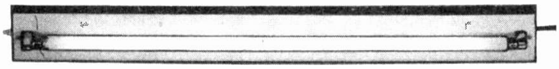

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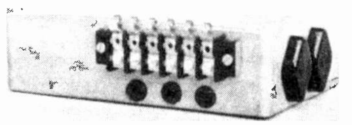

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A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.
This is YOUR page and any idea published will be awarded payment according to its merits.

PATCHBOARDS FOR SYNTHESISER

SYNTHESISER patchboards consist of a matrix of jack sockets by which any combination of input and output signals may be connected by inserting a shorted jack plug into the appropriate socket. A patch board for a medium sized synthesiser would require about 14 inputs and 20 outputs, making a total of 280 jack sockets which at 10p each plus the cost of plugs adds up to around £30.

The system to be described has two advantages: a system as previously described would cost only £6, and this type of patchboard can be used to programme the synthesiser.

The patchboard is made from 20 sixteen-way edge connectors, the 0·15in matrix size being the most practical. Each connector has its first and last pins wired to the output (Fig. 1). The remainder are wired to separate inputs.

In practice a piece of Veroboard also of 0·15in matrix is plugged into the connector. The first and last copper strips on the board are joined by means of a link wire which also connects to one or more intermediate strips. This forms a link between the output and one or more of the inputs according to how the board is wired.

By removing the board it can be turned over and plugged into the same connector making a completely different link or patch between the inputs and outputs. The opposite end of the board can also be used in this way making a total of four different connections available from each board (see Fig. 2).

The programme cards can be numbered for their particular function, e.g. board No. 5 will connect output 3 to input 7, etc.

J. A. Knife,
Dagenham, Essex.

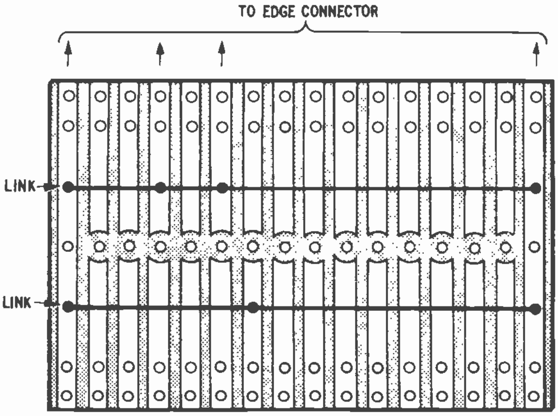

Fig. 2. Wiring details for a programme card

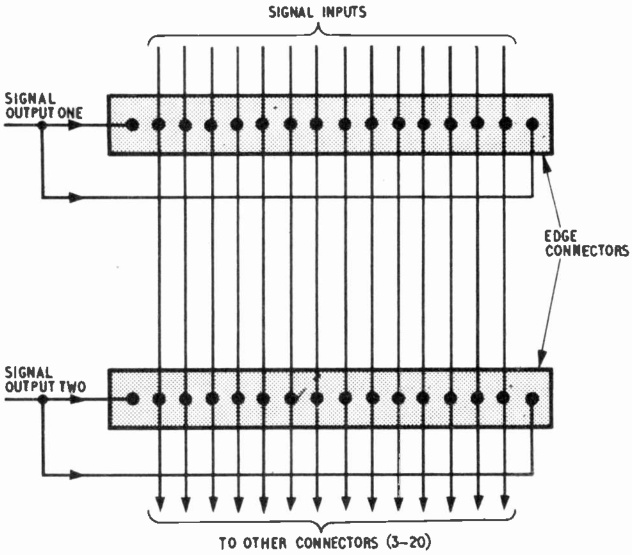

Fig. 1. Suggested wiring for the edge connectors

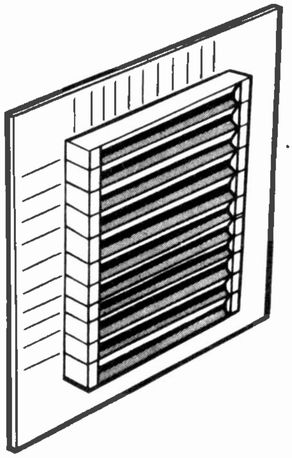

Fig. 3. Typical arrangement of connectors mounted on panel of synthesiser

BOOK REVIEWS

ELECTRONICS — A handbook for Engineers and Scientists

By G. H. Olson
Published by Butterworths
482 pages. Price £7

Ever increasingly the influence of electronics is felt by more and more people whose disciplines would traditionally have been unrelated. Probably the biggest contribution to this has come in the application of electronic techniques to measurement and control in various forms of sophisticated instrumentation. All of this has demanded an understanding of the subject, be it ever so superficial.

As a lecturer with an awareness of the "language" problem of the non-electronic specialist the author has provided a course which is qualitative and informative and will be prized as a valuable reference. The depth of subject treatment is not superficial nor does it lean towards being an examination textbook. In these, usually very little attention is paid to practical details in rigorous analyses. In the handbook these aspects are common and some useful circuits are given with details of the components.

From an introductory chapter on passive components, simple circuits containing them are analysed. Semiconductor devices are then examined (thermionic valves are eschewed throughout) followed by a chapter on indicating instruments. Next comes power supplies, then a massive chapter on the various genre of amplifier.

The concluding chapters embrace oscillators, an introduction to logic and digital circuits and measuring instruments.

Useful references for further reading are included after chapters and appendices provide the means to resolve some of the finer points mathematically.

At £7 pricey, but a good investment for the d.i.y. tyro.

G.G.

RECORDING WITH COMPACT CASSETTES

Published by Agfa-Gavaert
91 pages, 210mm × 150mm. Price 65p

The theory and practice of cassette tape recording are combined in this concise, non-technical, well-illustrated book.

Besides the cassette itself there is an excellent description of the theory behind tape recording, from the conversion of sound into an electronic signal to the actual recording of the signal by the head.

The book is full of hints and suggestions for getting the most out of a cassette recorder.

Many of the illustrations are in full colour, and overall the book seems excellent value for money.

This book is just one of a series on tape recording and photography and can be obtained direct from Agfa-Gavaert Ltd., Great West Road, Brentford, Middlesex.

S.R.L.

QUESTIONS AND ANSWERS ON INTEGRATED CIRCUITS

By R. G. Hibberd
Published by Newnes-Butterworths
96 pages, 6½in × 4½in. Price 75p

As any regular reader of Practical Electronics will realise, the integrated circuit is now a well-established component in modern electronics. However, the development of these devices from the unusual to the commonplace has been so rapid that many people will no doubt be feeling a little left behind.

For anyone in this position, this little book provides an excellent introduction to the field. In the form of questions and answers it gives the reader information about how integrated circuits are made, their advantages and disadvantages over discrete components, and their uses, both in the area of digital and linear electronics.

In the section on Digital Integrated Circuits there is a useful introduction to logic which is essential to the understanding of digital systems.

The book is written for students and technicians who require a simple, mainly non-mathematical, text on this rapidly widening facet of electronics.

S.R.L.

INSTRUMENT TECHNOLOGY (Volume 1)

By E. B. Jones
Published by Newnes-Butterworths Ltd.
402 pages, 9½ in × 6½ in. Price £5·00

This is a new (third) edition of a book which was first published in 1953 and forms the first volume of a three volume set dealing with Instrument Technology. The coverage of this volume is restricted to the measurement of pressure, level, flow and temperature and the treatment uses S.I. units throughout. The presentation is lucid and the mathematics have been kept as simple as possible. Together with the other two volumes of the set, this book should provide a good coverage of much of the material normally found in technician and craftsman level courses dealing with process control and instrument technology and should also prove useful as a reference text for engineers and other personnel who are not experienced in this field.

The text is well illustrated with clear diagrams, photographs and exploded views of numerous instruments which should prove useful to students especially, since they do not normally have access to such a comprehensive range of instrumentation.

Electronic devices and techniques such as the pressure sensitive transistor and the application of lasers to level measurement are not covered and the brief section on transistors, diodes and photocells does not reflect present day technology. In a work such as this the selection of material is difficult due to the wide range of instruments in current use. The author's stated aim has been to give a reasonably complete picture of the more common and more important devices in present use and this has been achieved. It is unfortunate that the price of this book will put it out of the range of the average student's pocket.

P.R.A.

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EMI 13 × 8in t/tw, 3, 8 or 15 ohm	£3·60
EMI 13 × 8in type 350, 8 ohm	£8·25
EMI 8 × 5in cer. mag., 8 or 15 ohm	£1·65
EMI 8 × 5in, 10 watt, d/c roll, surr., 8 ohm	£2·50
EMI 6½in, 93850, 4 or 8 ohm	£2·80
EMI 5in, 98132CP, 8 ohm	£2·30
Elac 9 × 5in, 59RM109 15 ohm, 59RM114 8 ohm	£2·65
Elac 6½in d/c roll surr., 8 ohm	£3·35
Elac 6½in d/cone, 8 ohm	£2·65
Elac Tweeter TW4 4in	£1·21
Elac 10in, 8 ohm	£2·65
Fane Pop 100 watt, 18 in	£22·50
Fane Pop 60 watt, 15in	£13·00
Fane Pop 50 watt, 12in	£11·00
Fane Pop 25/2, 12in	£6·40
Fane Pop 15 watt, 12in	£4·40
Fane Crescendo 12A or 12B	£29·00
Fane Crescendo 15	£36·00
Fane Crescendo 18	£47·50
Fane 807T 8 in d/c roll surr., 8 or 15 ohm	£3·85
Fane 808T 8in d/c, 8 or 15 ohm	£2·75
Goodmans 8P, 8 or 15 ohm	£4·49
Goodmans 10P, 8 or 15 ohm	£4·70
Goodmans 12P, 8 or 15 ohm	£11·65
Goodmans 15P, 8 or 15 ohm	£18·00
Goodmans 18P, 8 or 15 ohm	£31·00
Goodmans 12P-D, 8 or 15 ohm	£15·25
Goodmans 12P-G, 8 or 15 ohm	£14·50
Goodmans 12AX Audiomax, 8 or 15 ohm	£39·65
Goodmans Audiom 100	£9·50
Goodmans Axent 100	£6·60
Goodmans Axiom 401	£15·10
Goodmans Twinaxiom 3, 8 or 15 ohm	£6·79
Goodmans Twinaxiom 10, 8 or 15 ohm	£7·61
Kef T27	£4·75
Kef T15	£5·75
Kef B110	£6·75
Kef B200	£7·50
Kef B139	£11·75
Kef DN8	£1·92
Kef DN12	£4·12
Kef DN13	£2·75
Richard Allan 12in d/c, 3 or 15 ohm	£2·50
Richard Allan CG8T 8in d/c, 8 ohm	£6·35
WMT1 speaker match, trans., 3–15 ohm	£1·10
Wharfedale Super 10 RS/DD	£9·80
2½in 64 ohm, 70mm 8 ohm, 70mm 80 ohm	65p
7 × 4in, 3, 8 or 15 ohm	£1·38
8 × 5in, 3, 8 or 15 ohm	£1·38
10 × 6in, 3, 8 or 15 ohm	£1·92
S.T.C. 4001G Super Tweeter	£6·19

Speaker Kits

Wharfedale Linton 2 (pair)	£19·25
Wharfedale Glendale 3 (pair)	£34·50
Wharfedale Dovedale 3 (pair)	£52·00
Richard Allan Twinkit (each)	£8·25
Richard Allan Triple 8 (each)	£13·00
Richard Allan Triple (each)	£18·50
Richard Allan Super Triple (each)	£21·50
Goodmans DIN 20 (each)	£8·75
Fane Mode 1 (each)	£9·90
Peerless 3-15 (3SP.) (each)	£15·00
Kefkit 2 (each)	£23·50
Kefkit 3 (each)	£34·00
Helme XLK25 (pair)	£18·17
Helme XLK50 (pair)	£37·18
Helme XLK30 (pair)	£14·95
Baker Major Module	£10·75

P.A. and Hi-Fi speaker cabinets. Send for Free booklet "Choosing a Speaker". Carr. and Insurance 75p per kit (£1·50 pair).

PA/Disco Amplifiers

(Carriage and Insurance £1)

Baker Major 100 watt	£46·00
Linear 30/40	£25·00
Linear 40/60	£30·00
Linear 80/100	£55·00

Radios/Cassettes

Grundig Solo Boy	£16·00
Grundig Top Boy	£17·75
Grundig Party Boy 500	£22·75
Grundig Melody Boy 500	£26·75
Grundig Elite Boy 500	£26·75
Grundig Signal 500	£26·50
Grundig Yacht Boy 210	£34·00
Grundig Melody Boy 1000	£38·75
Grundig Satellite 2000	£121·00
Grundig C410 Cassette	£28·50
Grundig RF430 mains radio	£26·75
Grundig RF310 mains radio	£22·00
Tanberg TP41	£43·00
ITT Weekend Auto	£18·00
ITT Golf Preset	£24·50
ITT Colt	£11·50
ITT Europa	£20·50
ITT SL53 cassette	£25·75
ITT Studio 60M cassette	£32·75
ITT Studio 73 cassette	£48·00
Bush VTR178, 5 band (inc. air)	£29·00
Koyo KTR1770 11 band	£58·95
Koyo KTR1663 or 1664, 8 band	£42·00
Koyo KTR1883, 5 band	£22·00
Murphy BA209 radio/cassette	£32·75

Carriage and Insurance 75p. FREE with each radio—World radio stations book.

Free with speaker orders over £7—

"Hi-Fi Loudspeaker Enclosures" book. All units guaranteed new and perfect. Prompt despatch.

Carriage 35p per speaker (tweeters and crossovers 20p).

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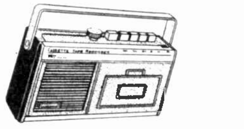
Dept. PE

Loudspeakers: Swan Works, Bank Square, Wilmslow, Cheshire, SK9 1HF.

Radios, etc.: 10 Swan Street, Wilmslow, Cheshire. Telephone: Wilmslow 29599

The items below are from the April Supplement to our 1974 Catalogue. You can receive this Catalogue and the next 12 supplements by sending 66p.



THIS MONTH'S SNIP

Cassette Tape Player Recorder

With dynamic microphone. First class Jap. made tape recorder and player. Pushbutton operated and with automatic level control of recording. Standard cassettes clean jacks for mic. (which has motor stop/start switch) for recording from radio and for being powered by mains. A bargain at **£8·95** plus 35p post, etc.

Mullard Unilex. The 4 Mullard modules—2 EP9000, 1 EP9001, I EP9002, for **£7·50** plus 30p post. The control panel kit, with spun aluminium faced knobs and silk screened front plate cannot be reduced, but at least we will hold the price at **£3·30** despite increases in prices.

Spartan Portable Radio. Long and medium wave band, telescopic pull up aerial, leather carrying case, size approx. 6in × 4in × 2in. 7 transistors ferrite rod aerial. Uses comparatively large speaker, so tone better than average. Brand new in original packing case, untested, only **£1·95** each.

Instant Start Fluorescent Lighting bargains. Starter-less control gear, resin filled, super-silent cool running, by very famous maker. 4ft 40W **£1·50**, 5ft 65W **£1·60**, 5ft 80W **£1·75**, 6ft 85W **£1·95**. These are about one half of maker's current prices and can't be repeated once stocks are cleared: Add 20p per piece carriage.

Bulk head aerial lead out. 2 cone shaped porcelain insulators with cork wafer for waterproofing and OBA brass rod passing through centre, terminal heads top and bottom. Price **75p** each.

Message tapes. 250ft best quality PVC tape (USA made) on a 3in spool. Packed in small mailing box. **30p** each. 3 for **75p.**

Mains transformer 12V-0-12V ½ amp. Small construction for instruments, size approx. 1in cube, upright mounting with fixing lugs. **£1·54.**

Output Transformer. Ratio 140-1 midget size 1in × ¾in × ¾in. Primary impedance 450 ohms, connections by flying leads, upright mounting. **46p.**

Output Transformer. Ratio 80-1, small size, approx. 1¼in. × 1in × 1in, printed circuit board connection. **56p.**

Light cell. Has almost no resistance in sunlight but increases to over 200k in the dark. Size not much more than the top of a pencil with wire leads. **22p.**

Clock movement has hour and minute hands which are fairly easy to extend in any length required. Mains operated, has switches but these are easy to remove. The movement made by Smiths, very reliable, price **£2.**

Planning for your holiday! Don't forget your *mini immersion heater* to make your hot drinks. Room service is usually not all that can be desired in holiday hotels and you will save the cost of your immersion heater on your first holiday, even though they have gone up slightly in price Post and VAT paid, **£1·90** each. If going camping, we have a 12V battery model, 10p more.

Mains induction motor. 1in stack with ¼in diameter spindle protruding from each end. This motor is particularly well made and quiet running, good quantities in stock. Price **65p.**

0-100 micro amp meter. Large oblong, full vision front, size 4¼in × 3¼ in approx. Good quality Japanese made, moving coil meter. **£3·85.**

Mains suppressor adaptor for preventing or reducing interference caused by office machines, vacuum cleaners, sewing machines, etc. This plugs into a 5 amp socket and takes a 5 amp plug. Its rating, however, is 4 amps. Limited quantity. **45p each.**

50 cycle to 60 cycle inverters. For operating American instruments and other equipment made for 60 cycles 115V from 230/240 50 cycle mains. These units have an output of 115V a.c. and will handle a load of up to 100W. These are precision made and have a reed type frequency meter which vibrates when the frequency is exactly 60 c.p.s. Adjustment of the frequency is by a knob on control panel. Input by 3 core output from 3 pin socket. Original cost of this in excess of £60. A limited quantity available **£25** each.

Reed Relay. Glass encapsulated reed switch in 24V solenoid, neatly enclosed in neat metal case, size 2¼in × ¼ × ¼in. Operates from 24V d.c. or from a.c. mains. Price **35p** each.

Battery Model, Balfour Auto-changer. As mains model but for 24V operation, also these are new ex-factory stock not returned export. Less cartridge **£6** each plus £1 post and insurance.

TERMS: Add 10% V.A.T.
Send postage where quoted-other terms, post free if order for these items is £6·00, otherwise add 20p.

J. BULL (ELECTRICAL) LTD.

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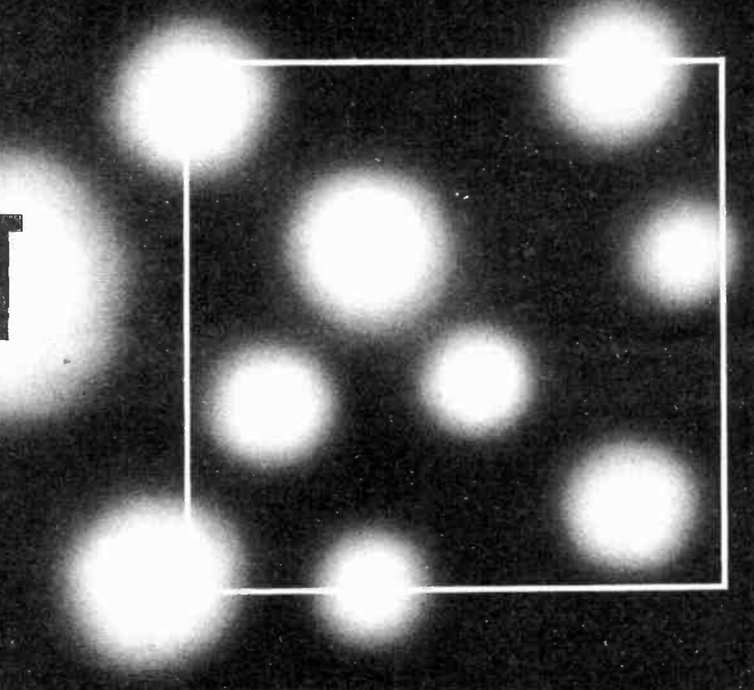
RANDOM LIGHT DISPLAY



By K.L. SPENCE

THIS article describes a Random Light Display which, unlike most light displays, is not driven by an audio signal.

The unit consists of nine or more coloured lamps positioned behind a semi-transparent screen. Each lamp flashes on and off in an apparently random manner, without an overall fixed sequence. The resulting effect is to fill the screen with a blaze of mixing and changing colours forming a fascinating display.

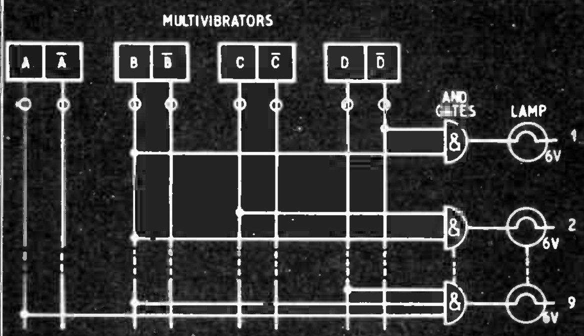


Fig. 1. Block diagram showing the arrangement of the multivibrators and AND gates

METHOD OF OPERATION

The apparent random effect is achieved by using four slow-running multivibrators each with different frequencies and mark-space ratios.

Each lamp is driven by gating together the outputs of two or more multivibrators using a logic AND gate. The system is illustrated in Fig. 1, which shows the overall arrangement of the multivibrators and AND gates.

It can be seen that lamp LP1 will only light when multivibrator outputs B and D̄ are high, i.e. logic 1; lamp LP2 requires outputs B and C high, and lamp LP9 requires A, B and D high.

CIRCUIT DETAILS

The circuit diagram of a multivibrator is shown in Fig. 2. Four of these are required, the values of the timing capacitors C1 and C2 being given in the table.

The AND gate and lamp driver circuit is shown in Fig. 3.

The gate may have two, three or four diode inputs. If any of the inputs is taken to 0V by a multivibrator output then current will flow down resistor

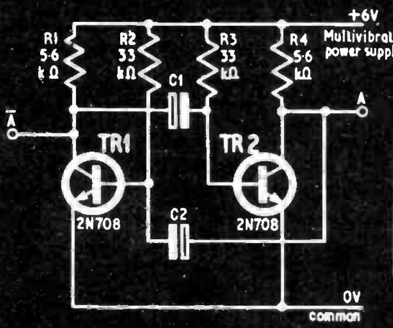
COMPONENTS . . .

MULTIVIBRATORS—4 OFF REQUIRED

Resistors
R1, R4 5·6kΩ (2 off) }
R2, R3 33kΩ (2 off) } ¼W 10% carbon

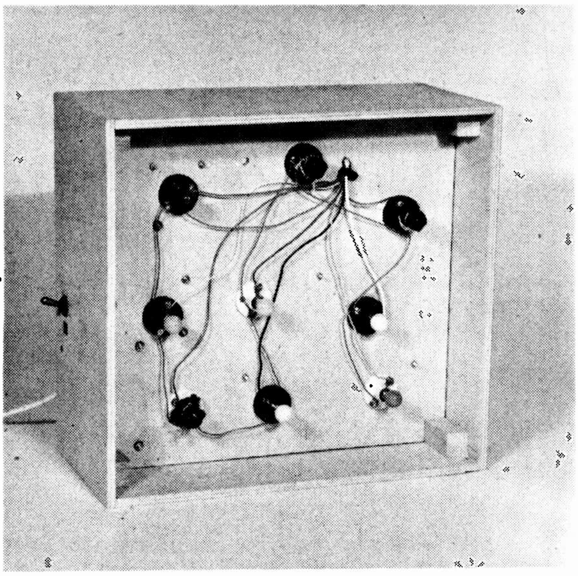
Capacitors
C1, C2 see table

Transistors
TR1, TR2 2N708 (2 off)



MULTI VIBRATOR	C1 µF	C2 µF	CYCLE TIME secs
A	100	50	3½
B	250	150	9
C	50	25	2
D	250	100	8

Fig. 2. Circuit diagram of a single multivibrator circuit. The table shows the values of the timing capacitors for the four multivibrators required



Photograph showing a front view of the completed unit with the cover removed

R1 and the voltage at TR1 base will not be sufficient to switch on transistors TR1 and TR2 which need about 1·4V to be forward biased.

However, if all inputs are at 6V then the diodes will be reverse biased and the current through R1 will flow into the base of TR1 causing it and TR2 to conduct and the lamp to light.

COMPONENTS . . .

AND GATE/LAMP DRIVERS—9 OFF REQUIRED

Resistors
R1 8·2kΩ ¼W 10% carbon
Diodes
D1–D4 OA200 (4 off, or as required)
Transistors
TR1 2N708
TR2 BFY52
Lamps
LP1 6V 0·3A m.e.s. with lampholder

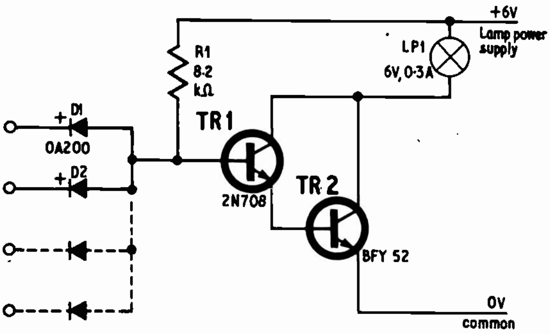


Fig. 3. Circuit diagram of a single AND gate/lamp driver circuit. Nine of these are required. The number of diode inputs may be two, three or four

COMPONENTS . . .

POWER SUPPLY

Resistors
R1 82Ω ¼W 10% carbon
Capacitors
C1 500μF 12V elect.
C2 250μF 12V elect.
Diodes
D1–D4 50V 5A bridge rectifier
D5–D8 50V ½A bridge rectifier
D9 6·2V 400mW Zener
Transformer
T1 Mains primary, 6·3V 3·6A secondary
T2 Mains primary, 6·3V ½A secondary
Miscellaneous
S1 2 pole mains on/off

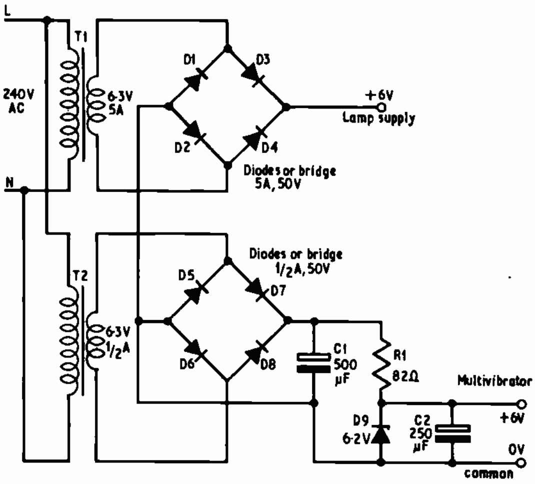


Fig. 4. Circuit diagram of the power supply. This provides a smoothed supply for the multivibrators and unsmoothed supply for the lamps

POWER SUPPLY

The power supply is shown in Fig. 4. It has two 6V outputs, one is smoothed for the multivibrators and the other is unsmoothed for the lamps.

The components specified are widely available, though discrete diodes instead of a bridge may be used if desired.

CONSTRUCTION

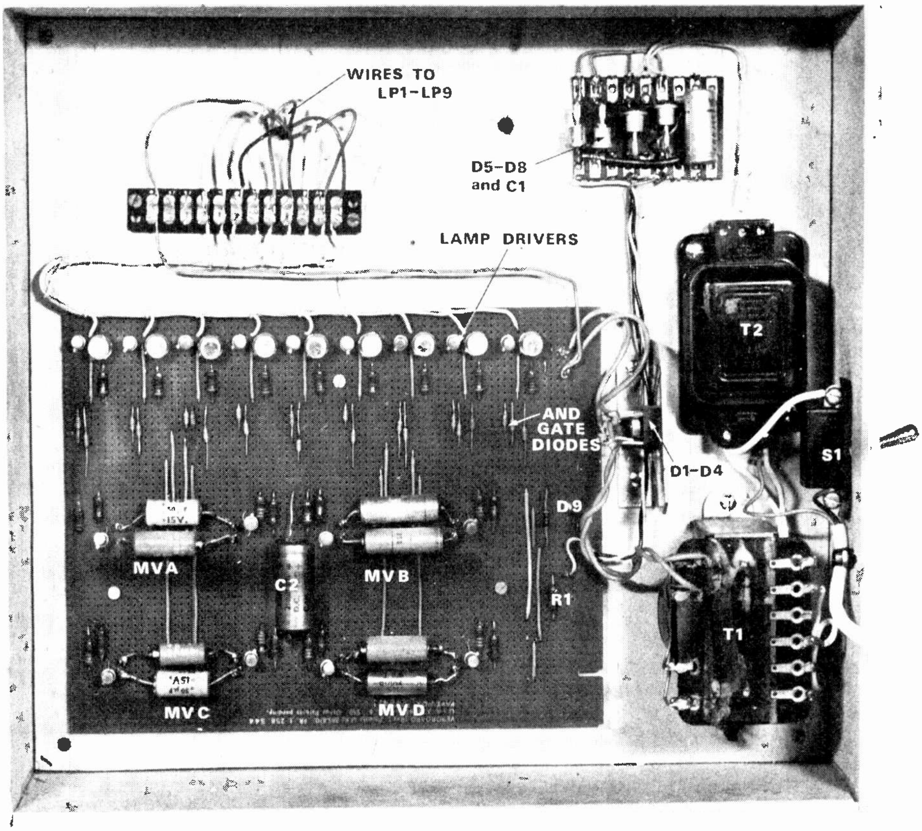
Component layout is not at all critical and the circuits may be built on any type of wiring board.

The author used a large piece of 0·1in Veroboard, the general arrangement being seen in the photograph. Fig. 5 shows the multivibrator circuits and the lamp driver circuits in more detail. Four of the multivibrators and nine lamp drivers are required.

It is useful to provide a wiring pin for every multivibrator output and gate input as this greatly simplifies the cross-connections.

It is advisable to first construct and test all the multivibrators and gates and then make the connections between them.

The constructor is free to choose for himself which outputs to connect to each gate, the only restriction being that both the outputs of a particular



Photograph showing the general arrangement of the components at the rear of the box. The power supply Zener diode, resistor R1 and capacitor C2 are mounted on the Veroboard which carries four multivibrators (MVA to MVD) and nine AND gate/lamp drivers

multivibrator must not be connected to the same gate, as this would mean the lamp would never light.

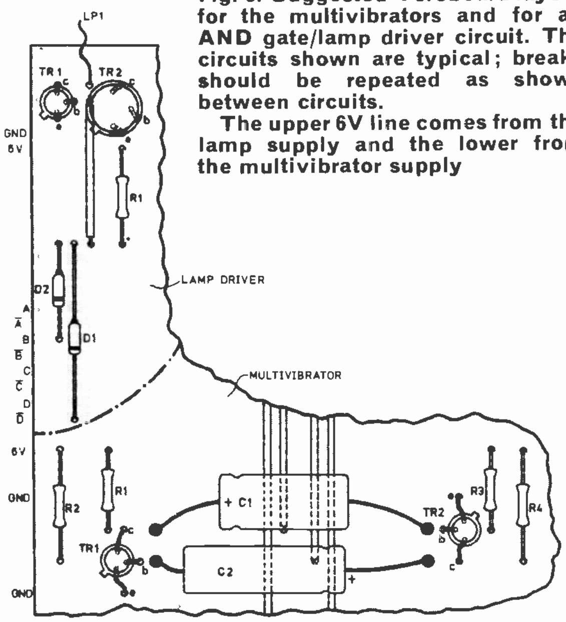


Fig. 5. Suggested Veroboard layout for the multivibrators and for an AND gate/lamp driver circuit. The circuits shown are typical; breaks should be repeated as shown between circuits.

The upper 6V line comes from the lamp supply and the lower from the multivibrator supply

The gates may have two, three or four inputs but it should be remembered that gates with four inputs will only be enabled very infrequently compared with the two-input gates.

Photographs illustrate the general manner of construction with lamps in the front of the box and the circuits behind.

The overall size is governed by the number of lamps the constructor decides to use. The prototype measured 15in × 15in × 6in and had nine lamps.

FRONT SCREEN

The front screen consists of a wooden frame covered with thin white cloth or tracing paper. A sheet of Perspex is then fixed on the front for protection.

The lamps may be any 6V types and they may be covered with coloured Cellophane or painted.

MODIFICATIONS

The unit described in this article may be extended to many more lamps and multivibrators providing the transformer can handle the power output.

Higher wattage lamps could be used by incorporating thyristors in the lamp driver circuits. It could also be interesting to have a mixture of AND and OR gates instead of only AND gates.

The values of the timing capacitors can be changed to give more rapid or slower changes as the constructor desires. ★

PE RONDO PART 8

F.M. STEREO TUNER

BY R.A. COLE

THE Rondo system is designed specifically to accept a variety of inputs to suit individual constructor's tastes. However, the initial design concept included the basic idea of providing as many facilities as possible within the one unit. One of the most important to many constructors will of course be the stereo tuner and associated decoder and Part 8 will initiate the discussion of these two items.

GENERAL CIRCUIT

The basic system for an f.m. tuner and decoder is shown in block form in the accompanying Fig. 8.1 and the complete circuit in Fig. 8.2. A varicap-tuned head feeds its output to a wide-band amplifier, a ceramic filter, a further i.f. amplifier and finally to the stereo decoder. Movement of the varicap potentiometer VR1 is indicated on a suitable tuning dial and a tuning meter indicates signal level.

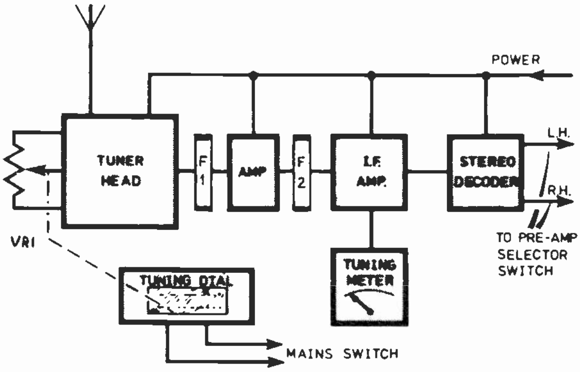


Fig. 8.1. Block diagram of the f.m. stereo tuner/decoder arrangement for the Rondo system

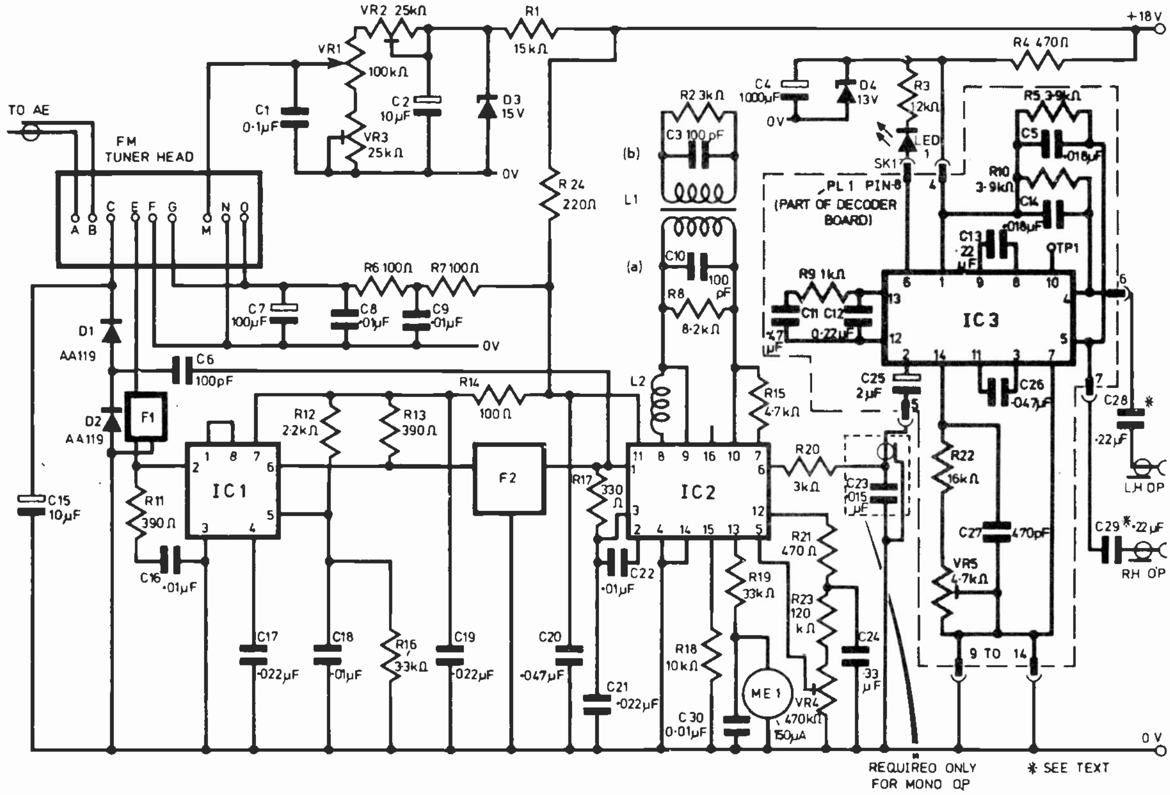


Fig. 8.2. Full circuit diagram of the tuner and decoder with the decoder board shown shaded

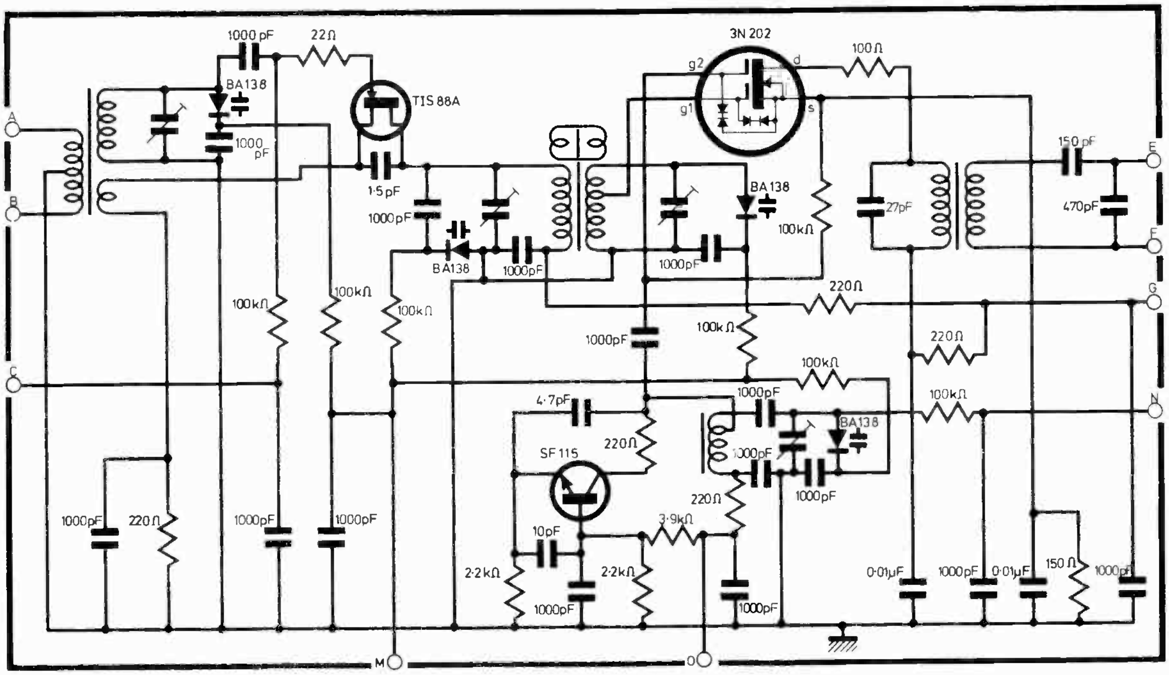


Fig. 8.3. Detail circuit of the Larsholt tuner head as used in the Rondo system

The tuning head used in the Rondo is a Larsholt unit, pre-built in Denmark, which makes use of j.u.g.f.e.t., m.o.s.f.e.t. and bipolar devices to give a high standard of performance

The head feeds via a ceramic filter F1, amplifier IC1 and filter F2 into the i.f. section. This latter is the monolithic amplifier TDA1200 or the equivalent CA3089E.

I.F. AMPLIFIER

In the i.f. amplifier there are three stages of amplification and associated level detectors that feed both delayed a.g.c. for the r.f. amplifier in the tuner, and the tuning meter. The amplification stages then feed the detector section.

The detector, a quadrature detector, requires tuning using one or two external coils and in practice this involves only peaking for maximum audio output. In fact, the use of one or two inductors is optional. A single tuned inductor L1 (a) gives distortion levels around 0·5 per cent whilst the use of a double inductor configuration L1 (a + b) allows levels as low as 0·1 per cent to be reached.

Audio output from the detector is fed to a further stage of amplification whilst, at the same time, a signal is fed to a level detector which in turn controls the mute drive circuits. This latter is connected externally of the chip to a muting sensitivity control and fed back to an audio mute control amplifier which is coupled to the audio output amplifier.

The quadrature detector also feeds an a.f.c. drive amplifier.

Finally, the output of the tuner is fed to a stereo decoder which in the present case uses the well-known Motorola MC1310P or the RCA CA1310E phase-locked loop monolithic integrated circuit.

The circuit of the whole system is shown in Fig. 8.2, the i.c.s and tuner head being shown in outline only.

TUNER HEAD

The tuner head circuit is shown for interest in Fig. 8.3. This Larsholt product was chosen for its sensitivity and the quality of output. Heads of this type are of course pre-aligned by the manufacturer and require no further attention from the user apart from perhaps some peaking of the output by tuning to suit the external circuitry. In the present instance this is limited to peaking of the output inductor connected to terminals E and F of the head.

The head and most of the associated circuitry are mounted on one circuit board which is located within the trough assembly of the Rondo directly beneath the pre-amplifier board but orientated parallel to the bottom of the trough.

The stereo decoder i.c., IC3 in Fig. 8.2, and associated components are mounted on a further board which is suspended under the fascia and master tone board to the top right of the assembly when viewed from the front.

STEREO DECODER

For ease of description we will consider one of the two alternative decoders as they are virtually identical.

The MC1310P is a phase-locked loop decoder with typical channel separation figures of 40dB and total harmonic distortion typically 0·3 per cent. It is carried in a 14-pin d.i.l. package.

This decoder does not require any inductors and in fact the only adjustment it might require in practice is the setting of the voltage controlled oscillator (v.c.o.). This is achieved by adjustment of VR5.

The chip automatically detects the presence or absence of stereo by detecting the presence of the 19kHz pilot tone at the input. The input circuit includes a threshold circuit which sets the detection of the pilot tone at about 16mV so as to stop the

STEREO DECODER

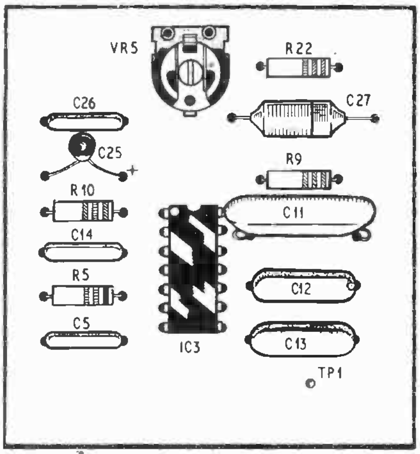


Fig. 8.4. Component layout on p.c.b. for the stereo decoder

Fig. 8.5. Master p.c.b. copper layout for the decoder board

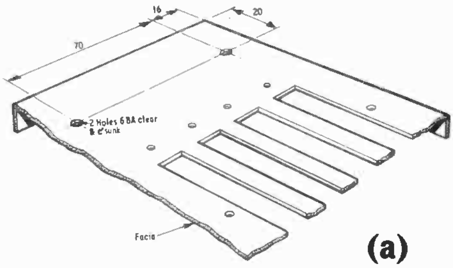
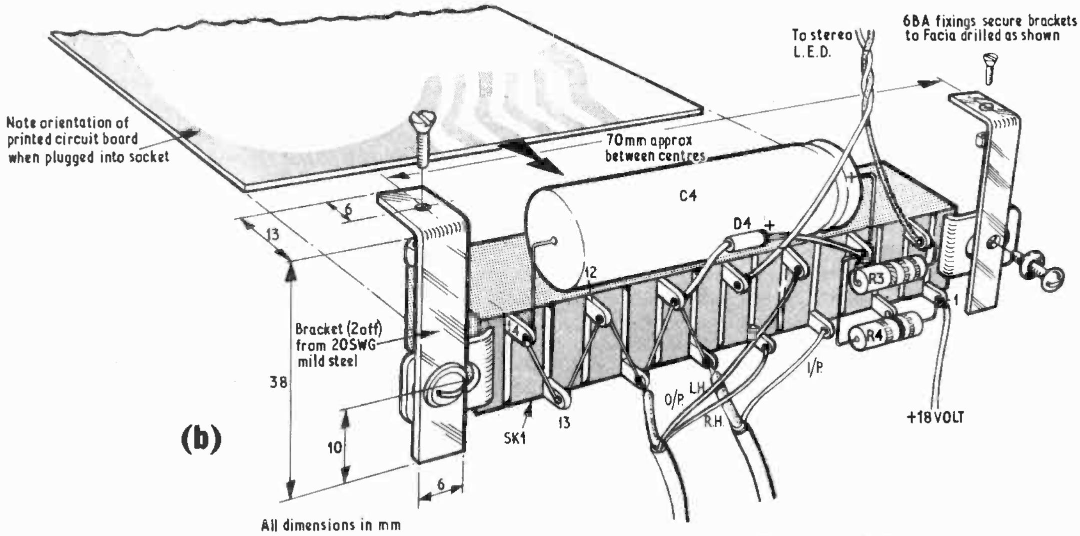


Fig. 8.6. (a) Rear right-hand corner of fascia panel (see Fig. 4.1). (b) Details for the mounting of the decoder board edge connector and associated carrying brackets, their location in the main assembly, and the positioning of some off-board components



PE RONDO

COMPONENTS . . .

Resistors

R1	15kΩ	R13	390Ω
R2	3kΩ	R14	100Ω
R3	1·2kΩ	R15	4·7kΩ
R4	470Ω	R16	3·3kΩ
R5	3·9kΩ	R17	330Ω
R6	100Ω	R18	10kΩ
R7	100Ω	R19	33kΩ
R8	8·2kΩ	R20	3kΩ
R9	1kΩ	R21	470Ω
R10	3·9kΩ	R22	16kΩ, ¼W, 2%
R11	390Ω	R23	120kΩ
R12	2·2kΩ	R24	220Ω

All ¼W, 5% except where stated

Capacitors

C1	0·1μF	C18	0·01μF
C2	10μF, 25V	C19	0·022μF
C3	100pF Polystyrene	C20	0·047μF
C4	1,000μF	C21	0·022μF
C5	0·018μF	C22	0·01μF
C6	100pF Polystyrene	C23	0·015μF, De-emphasis
C7	100μF, 16V		
C8	0·01μF	C24	0·33μF
C9	0·01μF	C25	2μF or greater. Tantalum bead preferred
C10	100pF		
C11	0·47μF	C26	0·047μF
C12	0·22μF	C27	470pF, 2% Polystyrene
C13	0·22μF		
C14	0·018μF	C28	0·22μF
C15	10μF, 25V	C29	0·22μF
C16	0·01μF	C30	0·01μF
C17	0·022μF		

Potentiometers

VR1 100kΩ Lin
VR2 25kΩ Lin preset
VR3 25kΩ Lin preset
VR4 470kΩ Lin. preset
VR5 4·7kΩ Lin. preset

Diodes

D1 AA119
D2 AA119
D3 BZY88, 15V Zener, 400mW
D4 BZY88, 13V Zener, 400mW
LED1 Light emitting diode

Integrated Circuits

IC1 CA 3053
IC2 CA 3089E or TDA 1200
IC3 MC1310P or CA1310E

Inductors

L1 Single quadrature, KACS K586 HM *or* Double quadrature TKACS 34343 AVO and TKACS 34342 AVO from Toko U.K.
L2 R.F. Choke, 22μH

Miscellaneous

Head — Larsholt 8317-501 stereo tuner head, f.m.
Tuning meter MEI — 0–150μA Full-View panel meter
Ceramic Filters F1, F2 — CFS 107M (Toko)
Assorted wire, co-axial cable, p.c.b., 14-way edge connector, metalwork brackets, nuts and screws etc.

decoder switching to stereo mode when the audio is too weak to give good signal-to-noise ratio.

Indication of stereo presence is given by the light emitting diode LED1 which is wired in series with a 1·2kΩ resistor. This latter drops the voltage across the diode to around 1·6V at 20mA. As most diodes give adequate light emission at this current this seems sensible even though the i.c. is capable of driving up to 100mA if necessary.

The decoder and associated de-emphasis components are mounted on one board as shown in Fig. 8.4. The master negative for this board is shown in Fig. 8.5 and two combined scrap views show the orientation of the board in its edge connector and the mounting of this latter under the master tone control board in Fig. 8.6.

Assembly of the decoder board follows normal p.c.b. assembly procedure although it will be noted that several components from the decoder and tuner-associated circuitry are in fact mounted in the wiring, as it were. Thus R3 and R4, C4 and D4 are all mounted on the edge connector carrying the decoder board. The l.e.d. is mounted in the tuner fascia just above the tuning meter. C28 and C29 can be mounted on the pre-amplifier board.

Wiring from the decoder board is passed down the side of the fascia to the fanning-strip/switch assembly described in the last part for interconnection to the remainder of the looming.

OSCILLATOR ALIGNMENT

When the tuner/decoder system has been completed it is necessary to set the decoder oscillator. This is a simple procedure requiring that one tunes to a known broadcast and then adjusts VR5 until the pilot light illuminates. This of course assumes a stereo broadcast is taking place.

Stereo output should now be heard from the loudspeakers.

If an oscilloscope is to hand the adjustment can be made perhaps more accurately by connecting the 'scope to the v.c.o. test point TP1 (pin 10 of the i.c.) and adjusting VR5 until a 19kHz waveform (55μs cycle time) appears. Equally, a counter/timer could be used to register 19kHz.

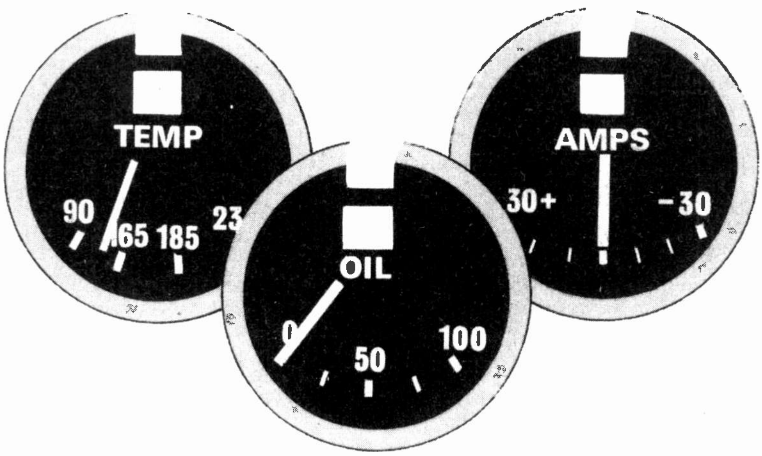
Tolerance of this value is ±3 per cent or 580Hz either side of 19kHz.

I.C. HOLDERS

An important point is the use of i.c. holders with these types of i.c.s. It is always advisable to use holders since this gives the obvious advantage of being able to remove the i.c. later and in any case some manufacturers revoke their guarantee if their particular products have been soldered in position as there is always the risk of thermal damage occurring.

It will be appreciated that each additional item of equipment inserted in the Rondo is an extra load applied to the power supply. In general terms this is no problem since the p.s.u. is well able to deal with the demand placed on it. However, the problem is easily overcome if it does arise by simply turning TR6 of Fig. 3.1 in Part 3 "on" a little more. This can be achieved by simply lowering the value of R32 in the same figure to 470Ω.

Next month: Construction details for the tuner board and mechanical assembly



CAR SYSTEMS MONITOR

BY J.P. PERRY

EVEN in this day and age it is not unusual to find cars stranded at the side of a motorway after having suffered boiling perhaps through loss of a fan belt or a burst hose.

Remembering that most vehicles are fitted with some form of temperature indicator for water temperature this sort of event only serves to indicate just how little attention is paid to the various dials by a driver, particularly when coping with things like motorways.

Oil, water and indeed battery charge, are all indicated visually and their loss, which can occur quietly and seemingly unnoticed, can have very damaging results including seized engine bearings or the like. So clearly what is needed is some form of audible indication in the event of failure of these parameters.

The present circuit was designed to give an instantaneous audible alarm if water temperature, oil pressure or generator output assume a fault condition.

The circuit is fairly simple and would probably cost in the region of £3 which is cheap in comparison with the cost of replacing a damaged engine or even carrying out a minor repair with labour costs in the £3 per hour region.

PRACTICAL CIRCUIT

A circuit is shown in Fig. 1. Three inputs can be connected to detect the presence or absence of voltage at for example the car temperature gauge, the ignition warning light and the oil pressure switch. In each case if the respective point is connected to chassis (earth) an alarm condition can be said to exist.

If this occurs current is taken by the associated one of the three diodes D1, D2 or D4. TR3 becomes saturated and 12V is applied to the astable TR4/TR5. Protection diodes D6 and D7 prevent the breakdown of the base/emitter junctions of these latter devices.

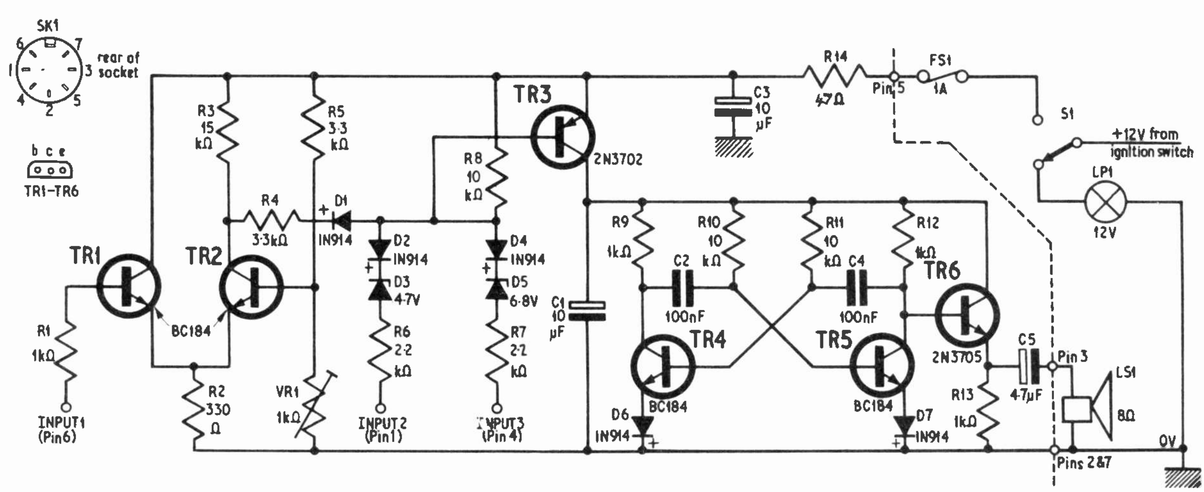


Fig. 1. Circuit diagram of Monitor

The astable is connected to a final transistor TR6 to drive a loudspeaker which may be any 2 to 3 inch 3 to 30 ohm device. The level of output is variable by choice of a suitable value for R13, 1kΩ being a suitable value to start with.

LAYOUT

Veroboard is used for the layout and cutting pattern and component locations are shown in Fig. 2.

No particular problems exist as far as the board is concerned except perhaps with the diodes with which care should be taken when bending the leads to avoid cracking the glass bead.

Whilst the circuit is shown for negative earth vehicles, the positive earth version can be catered for quite simply. It only requires that the *npn* transistors be replaced with *pnp* and the *pnp* with *npn*, that the diodes be reversed and the electrolytic capacitors similarly turned round.

Whilst BC184's are specified together with 2N3702's and 1N914's almost any small signal transistors and diodes can be used.

TESTING

Before wiring in to a vehicle it is best to check that all is functioning properly. Simply apply the 12 to 15V supply and temporarily connect input 1, the water temperature gauge input, to +12V. There should be no output.

If now any one of the inputs are connected to ground, an output should be obtained at the loudspeaker.

The volume of this buzz can be varied by selecting R13 to suit requirements.

CASE

Thus far we have only discussed a Veroboard assembly which, for use in a vehicle, should obviously

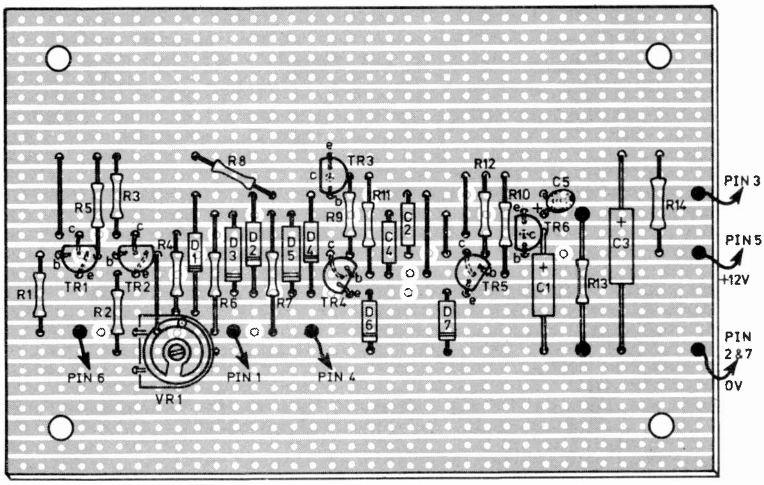


Fig. 2. Component layout on Veroboard, the copper track cuts being shown as white cut-outs

COMPONENTS . . .

Resistors

R1	1kΩ	R8	10kΩ
R2	330Ω	R9	1kΩ
R3	15kΩ	R10	10kΩ
R4	3·3kΩ	R11	10kΩ
R5	3·3kΩ	R12	1kΩ
R6	2·2kΩ	R13	1kΩ (see text)
R7	2.2kΩ	R14	47Ω

All ⅛W carbon film

Potentiometers

VR1 1kΩ preset

Capacitors

C1 10μF electrolytic 16V
C2 100nF ceramic
C3 10μF electrolytic 16V
C4 100nF ceramic
C5 4·7μF Tant. bead. 35V

Transistors

TR1, TR2, TR4, TR5	BC184 or BC182, BC183, BC107, BC108, BC109
TR3	2N3702 or 2N3703
TR6	2N3705 or 2N3704, BC182, BC183, BC184, "L" types

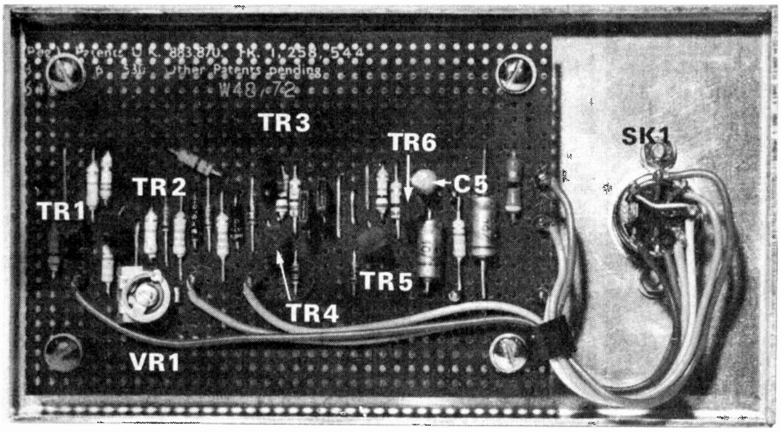
Note that when selecting alternatives care should be taken with the pin connections.

Diodes

D1, D2, D4, D6, D7	1N914 or 1S914, 1S44, 1N4148
D3	BZY88 4·7V Zener, 400mW
D5	BZY88 6·8V Zener, 400mW

Miscellaneous

SK1 6-pin DIN.
Veroboard, Veropins, aluminium box, connecting wire, fuseholders, switch and lamp if required, solder, etc.



Interior view of Systems Monitor showing completed unit

be cased in some form of protective box. In the prototype this took the form of a simple aluminium case and lid, with the Veroboard mounted on support pillars in the lid.

Wiring access to and from the circuit is provided via a 6-pin DIN socket SK1 mounted in the lid. As the whole assembly of lid and board is only a matter of an inch deep clearly the box can be quite shallow but it is best to use a box which can be screwed up and properly sealed against ingress of moisture from the engine compartment or wherever it is located on the vehicle.

INSTALLATION

It is probably wisest when installing any equipment in a vehicle to first of all disconnect the battery so as to avoid any damage from inadvertent shorts. Power supply to the unit is connected from the ignition switch, switched side and the inputs 1, 2 and 3 are connected respectively to the water temperature warning light or thermometer, the oil pressure warning light or block switch and the generator output terminal or terminal "A" on the ignition light.

The battery may now be reconnected and no output should be obtained.

If the constructor has wired in the extra components S1, FS1 and LP1, then when the ignition is switched on LP1 should come on but there should still be no output. Switching S1 to the "on" position should extinguish LP1 and the unit is now "armed" for operation. In fact an ouput should be obtained because of course there is no oil pressure or generator output.

Starting the car should silence the output but if this fails it may be necessary to adjust VR1.

The vehicle should now be driven round for a while till engine temperature reaches its normal level and VR1 is again adjusted till the output buzz is just extinguished. This is all the setting up required with the possible exception of small adjustment to make up for the difference between summer and winter temperatures.

★

BOOK REVIEWS

I.E.E. REGULATIONS FOR THE ELECTRICAL EQUIPMENT FOR BUILDINGS
224 pages. Price £1·50

In Great Britain, the Institute of Electrical Engineers has, since 1882, issued rules and regulations relating to electrical installations in general.

The regulations delineate the essential requirements for inspection, installation, testing and maintenance of consumers installations.

From time to time these are revised and amended, and this reprint incorporates all those amendments up to May 1974.

They are completely accepted by the Electricity Board, Local Authorities, Insurance Companies and consulting engineers as standard practice in the industry.

Issues are available from I.E.E., P.O. Box 8, Southgate House, Stevenage.

NEWS BRIEFS

OBITUARY

The name Bulgin must be one of the best-known in the electronics field in Britain. Certainly every follower must have used plugs, sockets and so on bearing this name.

Thus it is with great sadness that we mourn the passing of Arthur F. Bulgin, O.B.E. the founder of the company bearing his name. He has served our industry for 51 years and, indeed, his country as well, and it is a mark of his astute judgement that the A. F. Bulgin company is the only one in the industry to show a steady rate of growth since the last war.

Chairmanship of the company continues in Mr Bulgin's son, Mr Ronald Bulgin, M.A., C.Eng., M.I.E.E., who also shares joint managing directorship with A.F.B.'s brother, Mr Stanley Bulgin.

.....tuning in to ESP

Our correspondent, Peter Verwig, recently attended the IEEE Intercon show in New York. Among the usual mass of technical and marketing papers read at the conference was a session on "New Advances in Parapsychology".

The chairman of the technical programme committee, Jack Raper, was one of the doubters on the advisability of including a parapsychology session in the International Convention and Exposition of the Institute of Electrical and Electronic Engineers in New York. In the end, the session went ahead and, if not exactly a sensation, it certainly caused a stir among the coolly-calculating, logically-minded scientists and engineers who formed the audience.

LECTURERS

The one aspect in favour of the session was that though the speakers may have had odd ideas, some of which might be classified as kinky, they did at least have the credibility of being engineers with normal levels of engineering objectivity and were clearly not the crankier type of mystic living on emotion rather than scientific fact.

Two of the speakers, E. Douglas Dean and John Mihalasky were from the Newark College of Engineering and the third, James B. Beal, hails from NASA, Huntsville, though he was careful to point out that he was speaking as a private person and NASA was in no way involved.

All three speakers were firmly convinced that such phenomena as extrasensory perception (ESP), precognition and telepathy were not only possible but also capable of detection and measurement in the scientific sense although much remains to be done.

TELEPATHY

The main practical work of E. Douglas Dean has been in telepathy. For his experiments he uses the plethysmograph, an instrument used in medicine for over a hundred years. It records a change in volume with correlation against blood circulation in the extremities of the body, for example the finger tip.

In the ordinary way a person has no control over any variations, but it has been shown that what we might loosely term "emotion" causes involuntary vaso-constriction leading to a lowering of blood volume in the measured part of the body. Dean's apparatus is considerably more sensitive than the old medical plethysmograph and incorporates a pressure capacitance diaphragm pick-up and a continuous chart recorder which records the normal pulse of the heartbeat and any vaso-constriction as a pronounced dip below the average baseline.

The "subject" lies on a couch with a finger connected to the instrument and in an adjacent room the "agent" picks up a card on which is inscribed a name which may or may not have significance for the subject. Some cards are blank. The subject doesn't know what is on the cards, or the order in which they are shuffled.

The agent looks at each card for twenty seconds. Blank cards showed no response and cards with names only showed subject response on the recording pen when they had some emotional significance, for example a close relative, and the pen deflection was most pronounced when there had been recent anxiety or other strong emotion in connection with the name.

In one test the subject's two-day old new-born baby's name was on the card and the resulting vaso-constriction was so severe it took over a minute for the recorder to return to baseline.

The experiments were repeated with the agent enclosed in a fully electrically screened room and this had no effect, indicating that whatever the communication medium between agent and subject it was not affected by screening. Long distance tests have been completed north to south from New York to Florida, a distance of 1,200 miles, and east-to-west from Newark, New Jersey, to Bordeaux, France. Amazingly, the effect was also recorded with the agent 35ft under water in Florida and the subject 4,000 miles away in Zurich, Switzerland.

The underwater test opens up the possibility of communicating with submarines submerged at great depth, of greatest potential value in the event of disabling disaster. The technique would involve the use of pre-arranged time slots and the Morse code with stimulus, for example, representing a dot and non-stimulus being a dash. The data rate would be very slow but over a period of hours it is thought that comprehensible communication could be possible.

An important finding by Dean is that using electronic equipment to establish emotional response shows scientifically that one person in every four has some level of ESP ability.

FIELD EFFECTS

James B. Beal maintains that electric fields have important effects on the body. He has gone as far as to fit a 500V positive field generator in his car to alleviate fatigue. He has also reared beans in a 2,000V positive electrostatic field and recorded a four-day earlier germination compared with a control group outside the field.

The same apparatus was used on a badly asthmatic child with beneficial results. Tests on typists showed an enormously lowered error-rate if they sat in a strong field.

Beal recalls that the ancient Chinese knew, perhaps instinctively, that beneficial health, mental and spiritual qualities could be obtained by proper geophysical orientation of homes and religious shrines in relation to the earth's magnetic poles, subterranean streams, geology and topology. It is even suggested that many mental patients are not ill but merely hypersensitive to field effects and, of course, it is well established that natural phenomena such as hot winds containing an excess of positive ions, especially in the Middle East, induce both physical and mental maladies in the population.

It was also suggested by Beal that ESP can be developed in suitable subjects by teaching machines. One such is commercially available.

SEEING THE FUTURE

Working on precognition (seeing into the future), especially in the realm of creative ideas in engineering and business has been studied for many years by Dr. John Mihalasky.

The successful engineer or businessman is often said to have intuition or insight in addition to ordinary levels of logical thought. The brilliant solution to a problem is often conceived "in a flash" from the unconscious mind spontaneously and frequently at very odd times and in peculiar circumstances.

SOLAR POWER AND ITS APPLICATIONS FOR TODAY

BY P.S. WOODCOCK*

THE oldest known power source is the sun and there have been many ways devised to use its energy. Until very recently none have withstood the march of technological progress. Modern technology is now able to provide ways of making use of a very small fraction of that power that is always available.

The utilisation of solar energy has also been limited by economic reasons; the techniques for many applications have been known and fully proven but the cost of using them has made it totally uneconomic.

PHOTOCELLS AND SATELLITES

The basic component for the conversion of solar power into electrical power is the photocell and this was introduced, as a production device, in 1957.

This cell, in the form of a silicon photovoltaic semiconductor diode, has been the prime power source on earth orbiting satellites since the first was launched in 1957. It is therefore not surprising that industry is now using this well established, fully proven space technology as a source of pollutionless terrestrial power.

GROWING SILICON CRYSTALS

The photovoltaic cell is produced from silicon, the second most abundant element on earth.

A seed of pure single crystal silicon is dipped into a bath of molten silicon and rotated and slowly withdrawn, in an inert atmosphere, producing a bar of almost pure single crystal silicon.

The silicon is required to be doped with small quantities of impurities to control its conductivity. These impurities are introduced into the bath of molten silicon so that the withdrawn bar contains the correct level of dopants.

Early technology imposed a limit on the diameter of bar that could be pulled of about one inch, but recent developments have seen this increased very significantly, and it is now usual for 2¼in diameter bars to be used.

The bar of silicon is then cut so that circular slices of defined thickness are produced. The majority of cells produced for satellite applications have used silicon slices 300 micron (one micron = 10^{-6} metre) thick but a new generation requires cells of 200 micron thick. The thickness of silicon used does not affect production processing.

Almost all silicon produced for cell applications is boron doped so that it will conduct by means of positive charges or holes, and for this reason is called *p*-type.

PHOTOCELL PRODUCTION

The production of a photocell involves several basic steps and these may be listed as follows:

1. Diffusion of *pn* junction
2. Contact formation
3. Coating

The creation of the *pn* junction is achieved by the controlled diffusion of an impurity into the *p*-type silicon slice. The impurity used is phosphorus which is introduced into the diffusion furnace as a vapour, the depth of the diffusion being a function of time and temperature.

The basis of operation of the photocell is such that when photons (light particles) strike the cell surface, close to the *pn* junction, positive charges (holes) and negative charges (electrons) are produced. The electrons will tend to travel towards the *n*-type silicon and the holes towards the *p*-type silicon. If connections are made to the *n*- and *p*-regions electric current can flow into an external load.

METALLISED CONTACTS

The next vital production stage is thus the deposition of a metallised contact structure. The *p*-contact, on the rear face of the cell, can cover the total cell area, but the design of the *n*-contact, on the front or active surface, is critical to the performance of the cell.

*Electronic Components Division, Ferranti Ltd.

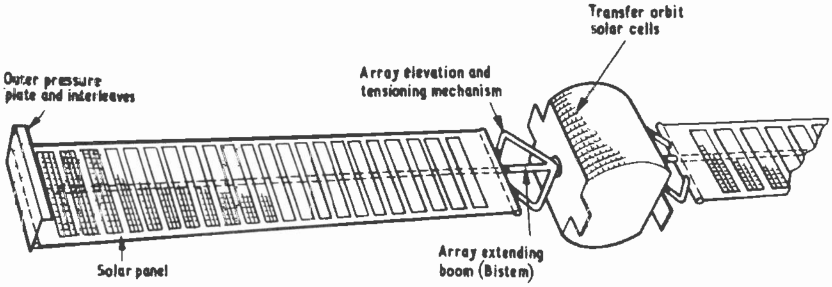


Fig. 2. Drawing of a flexible fold-up solar array. Each paddle is about one metre wide by five metres long

The requirements are many and varied and, in some cases, conflicting. For maximum cell output the contact must mask minimum cell area but must have sufficient cross-sectional area to handle the photon generated current.

Thick metallisation must be avoided as severe stresses can be set up on thermal cycling and, in the extreme, this stress could be sufficient to break the silicon. The metallisation must have good electrical and thermal conductivity, must be easily contactable, and should not degrade or cause degradation in any encountered environment.

The process by which the metallisation pattern is defined must also be of sufficient accuracy that overall pattern tolerances are maintained. Pattern definition is achieved by a photographic mask and the metallisation used on the satellite cell is a composite structure of nickel, copper and gold.

The nickel gives the ohmic contact to the cell, the copper gives the electrical conductivity and the gold prevents contact tarnishing.

The pattern defined on the satellite cell is a narrow top contact bar and then 24 narrow fingers running down the length of the cell. These fingers are typically 25 microns wide and five microns thick. The multiplicity of these fingers optimises the collection efficiency of the photon generated electric current.

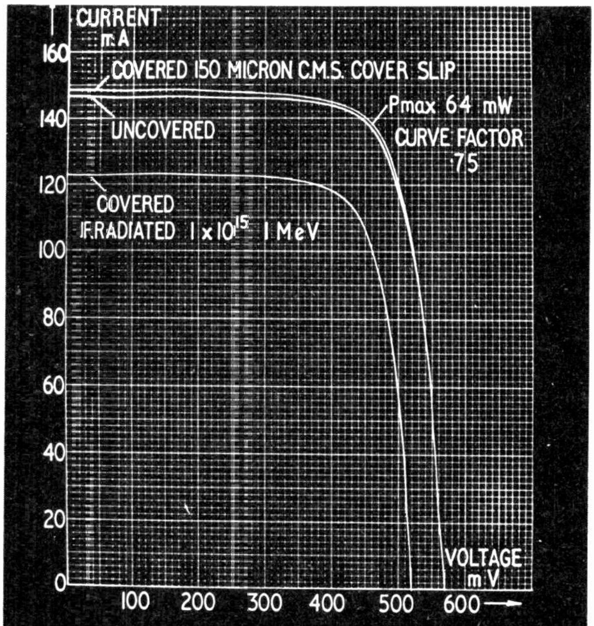


Fig. 1. Power output characteristics of a typical solar cell

OPTIMISING CELL PERFORMANCE

On bare silicon, light striking the active cell surface will be partially absorbed but a certain percentage will be lost due to reflection. This percentage can be significantly reduced if a quarter wavelength thick transparent dielectric layer is deposited on the cell surface.

The refractive index of this layer is chosen to optimise cell performance. Early cells used either silicon monoxide or dioxide but the latest technology uses titanium oxide.

The almost universally used cell size for satellite applications has been 2 cm sq and the output power from a cell of this type is typically 62mW at 25°C when illuminated with air mass zero sunlight at $140mW/cm^2$. This gives an overall power conversion efficiency of 11 per cent.

Fig. 1 shows the output characteristics of a typical solar cell.

The power requirements for a satellite have always demanded a cell of maximum power, from minimum area, at minimum weight and this has dictated that the cell produced to satisfy this requirement is of the highest possible performance.

SATELLITE SOLAR ARRAYS

Satellite solar array design has followed two distinct channels, both of which offer advantages and disadvantages in the satisfying of an overall system requirement.

In one case the cells are mounted on a cylindrical body which spins with its axis perpendicular to the sun. In the other case the cells are mounted on deployed paddles which are sun orientated.

To give some idea of sizes involved, the recently launched communications satellites designated *Intelsat 4*, each carry 50,000 cells mounted on a cylindrical body, nine feet in diameter and ten feet high.

This initially will provide almost 900W of power and will provide power for 5,000 simultaneous telephone channels or ten colour television transmissions. To provide 1kW of power from a deployable array would require approximately 17,000 cells and, using two paddles, each paddle being typically one metre wide and five metres long (see Fig. 2).

THE ADVANTAGES OF SILICON

The justification for the choice of silicon is simple. As previously stated it is the second most abundant element and it has been the foundation of the semiconductor industry. As such it has seen an investment in its technology many orders greater than all other basic semiconductor materials.

The basis of using the experience gained from developing and producing solar cells for satellite

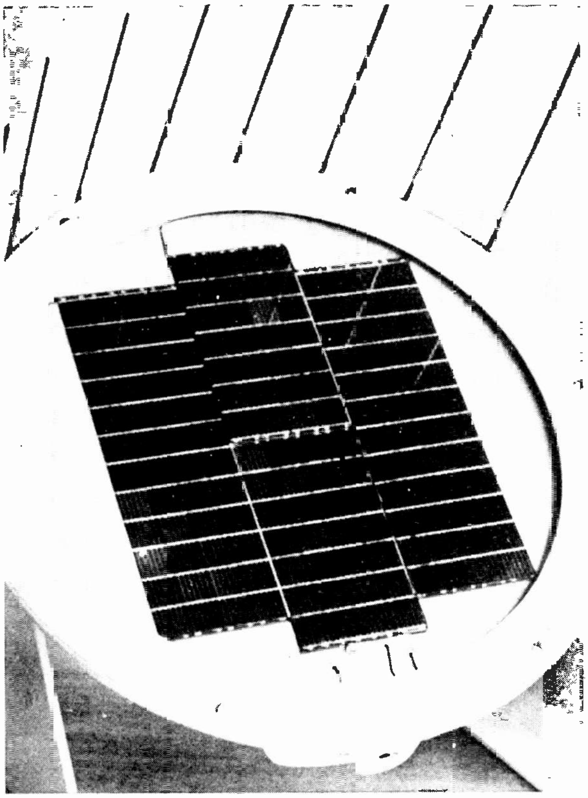


Fig. 3. A terrestrial solar panel as used for marine applications

applications is that the silicon voltaic cell has been the prime power service in over 700 American and some 500 Russian spacecraft of varying type.

From this background the selection of a silicon photovoltaic cell as a design start point for terrestrial power applications was inevitable and inarguable.

POSSIBLE ALTERNATIVES TO SILICON

It should not be thought that silicon is the only material suitable, and some effort has been devoted to other semiconductors.

The most notable of these have been gallium arsenide and cadmium sulphide. The former is able to withstand high temperatures and thus is able to generate at intensities 1,000 times greater than sunlight. The problems of heat dissipation must still be solved, however, before it can be considered to be technically competitive, but on cost it must be extremely doubtful if it can ever be considered to be an economic alternative.

Cadmium sulphide offers a cheap means of producing a photocell of considerable area in a flexible sheet form. It does, however, suffer the disadvantage of much lower conversion efficiency, and hence will only ever be able to be suitable for that market segment that can accept no restrictions on area.

TERRESTRIAL SOLAR POWER

The initial choice of cell for terrestrial use was dictated by availability, and 2 × 2cm reject satellite cells were used. These were cells that failed to fully satisfy the most stringent electrical and physical requirements of a space satellite specification but which would work quite happily when mounted on a terrestrial panel.

The panel was designed to provide 400mA at 15V in the equivalent of bright sunlight, and required for this output 156 cells interconnected as 39 cells in series with four cell strings in parallel.

MARINE ELECTRONICS

The design and construction of this panel, ideal for off-shore repeater or navigation aids, is not really suitable for the larger volume commercial business. A fast expanding market is that of marine power generation. The use of instrumentation and electronics on yachts and power boats is ever increasing with very little regard for the state of the onboard battery.

A small solar panel permanently mounted on the boat is extremely attractive from an economical and environmental standpoint. The use of solar panels in marine applications will, however, be limited by price considerations and only when a panel can be produced at a low enough price will full market penetration be achieved.

LARGER SLICES

The techniques for the production of refined single crystal silicon have not stayed stationary and manufacturers now have readily available large area slices. This realises a slice diameter of typically 6cm and allows the use of cells of this size and proportional power rating.

Based upon expected conversion efficiencies the output from a circular cell of diameter 6cm should be 500mA at 470mV when measured under 100mW/cm^2 simulated sunlight at 25°C.

The front active cell surface will have a simple metallised contact pattern and the back face will be fully metallised. The interconnection of cells must be performed simply, easily and reliably, to permit the building of the basic power modules.

Based upon the major market requirement for recharging nominal 12V batteries the voltage capability of the module is defined as greater than 13·8V. Thus a basic power module can be defined as 30 cells interconnected in series.

The expected output from the package under simulated bright sunlight conditions will be 500mA at 12V. The calculation for overall charging rate must be subject to some hypothesis as to expected weekly hours of sunlight and at what illumination intensity.

AVERAGE SUNLIGHT

The average daily hours of daylight during summer can be considered to be 15 hours. The Meteorological Office estimate for hours of sunshine on the South coast of England is a daily average of 7 hours. Assuming this to be at 75 per cent intensity, this is equivalent to 5·25 hours at full sun.

Thus the daily output charge from the panel will be 2·6amp-hours. Based upon a five-day week for charging and the boat being in use the other two days this gives an average weekly charging capability of 13amp-hours, neglecting any charging that can still take place during the time the boat is in use.

The expected current drain, based upon estimated usage of electronics and ancillary electrical equipment, is of this same order, 10 to 15amp-hours, so the projected panel size would seem suitable for this market.

OTHER APPLICATIONS

Usage of this type of panel is by no means limited to marine applications. A similar application, and one that is being studied closely, is for use with caravan trailers.

The power output requirements for a solar panel in this application are almost the same as on board a boat and hence the market can, hopefully, be catered for with an identically produced product.

Remote or unmanned automatic operation of road signs is receiving great attention, especially in the use of danger signs for such hazards as road works. The often seen flashing amber lights denoting road repairs could be easily solar powered.

Built-in rechargeable batteries could be charged during daylight hours for operation at night. The use of this type of power source could easily be extended to cover motorway hazard lights, emergency telephone systems and many monitoring devices.

Solar power gives to these applications the advantage of freedom from main power links and must improve their suitability for utilisation in many more wide ranging areas.

FORESTRY AND METEOROLOGY

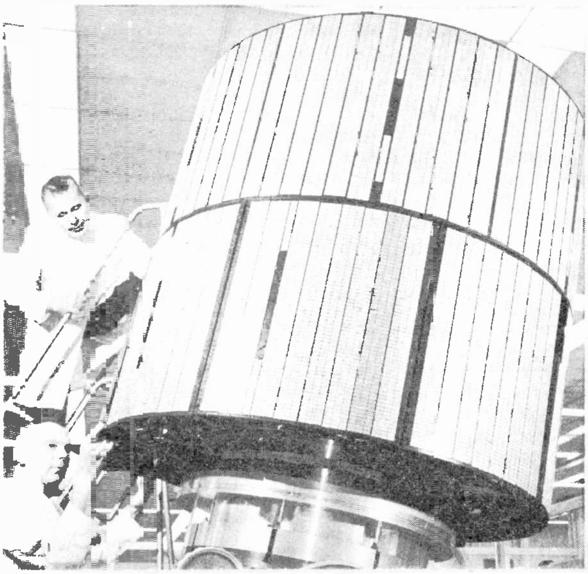
These applications are ones that are commonly encountered by a wide cross section of the public but extensive markets exist in less well known areas. Forestry requires extensive use of remote automatic equipment for such applications as firewarning and portable or remote communications. The use of this type of power source is also available for weather monitoring, rain gauges, flood warning, seismic detection. The list can be almost endless.

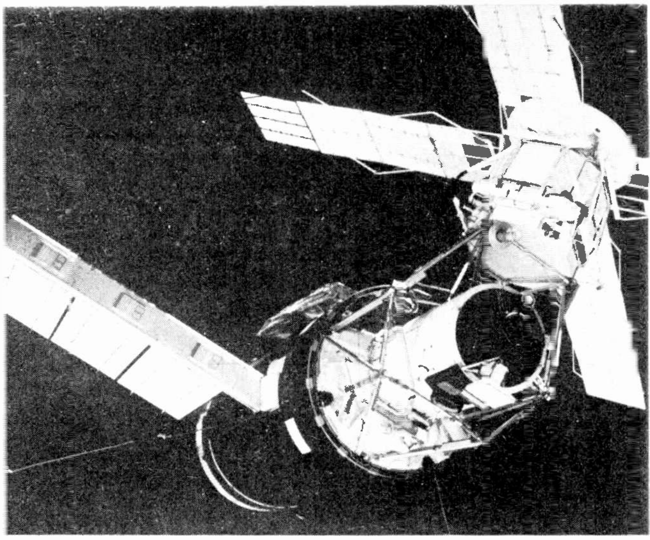
Two application areas that will demand a high reliability factor are those of remote area repeater links for communications and off-shore navigation aids.

REPEATER STATIONS

Microwave relay stations and telephone repeater stations are often situated in some of the remotest parts of the world and are required to remain in unattended trouble-free operation for periods of a year or longer. It can cost a great deal of money to transport people and spares to these sites for servicing and repair and it is therefore essential that frequency of visits is as low as possible.

Photograph of a satellite built by the Hughes Aircraft Company for NASA and launched in 1966





Photograph taken from *Skylab 3* showing the deployed solar arrays

POWER PRODUCTION

The present major energy crisis has spurred even greater discussion and thought towards ways of producing, economically, consumer electrical power, such that it can be considered a realistic alternative to power produced from fossil fuels.

Two ideas, once considered close to science fiction, are being discussed. One involves a large solar farm in a flat desert region and the other a large solar array in synchronous orbit above the earth beaming r.f. power to a terrestial station.

Power would be taken away on a National Grid type system. The problems of maintaining the solar blankets can be imagined and no acceptable solution has been found.

ORBITING SOLAR ARRAYS

The orbital power station having two large arrays, totalling 7·3 × 2·7 miles, is the current design thought and these would flank a microwave transmitting antenna that would be 0·63 miles in diameter.

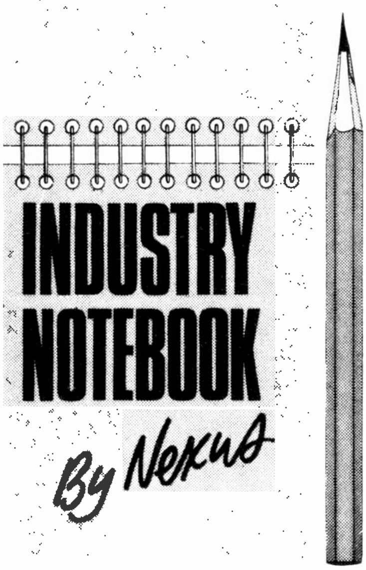
It is intended to try and fly a prototype satellite in 1990 and a commercial version could be flying at the end of the century.

THE SOLAR POWER AGE

The world markets for small commercial systems currently demand a high technology product in large volume at low cost but this is only the smallest tip of some vast technological iceberg. A technological miracle is in the making and it is one that could revolutionise our outlooks.

The photovoltaic cell and the solar array will become everyday commodities known to all. They offer a method of saving our precious and dwindling stocks of fossil fuels for processes that require these and they will provide an economic pollution free energy solution based upon a natural power source that will never be diminished.

We have seen the Stone Age, the Iron Age, the Industrial Revolution, the Space Age. The possibility of a Solar Power Age must not be dismissed or taken lightly. ★



WHAT'S IN A NAME?

We are all certain to be subjected during the next few months to growlings, grumblings, even open hostility directed towards the so-called multinational companies. In fact the very word multinational has now joined other political jargon words like racist, fascist, red, speculator, capitalist, terrorist in a fully emotive sense.

Multinational, in short, has become a word of abuse. Nothing to do with injection of capital and creating employment and wealth in underdeveloped or otherwise needy areas, and everything to do with faceless (indeed, probably heartless as well) exploiters counting their gold in plush offices thousands of miles away. No wonder some of the great multinational companies are keeping a low profile and, for one or two of them, with very good reasons.

Most of the outcry is directed against US-based multinationals but it has to be remembered that nearly all the great British companies operate multinationally, as do those of France, Germany and Italy.

I rather liked the argument put forward recently by the German Siemens group to an American audience in defence of their penetration of the US market by acquisition of US companies as well as direct sales from Germany. Siemens, said their spokesman Bernard Mayer, is a World Company and this has been true ever since the company was founded by Werner von Siemens, 126 years ago. He quoted the installation by Siemens of the 7,000 mile London to Calcutta telegraph completed in 1870 as an example of operating on a world scale. And he pointed out that Siemens' advanced technology products, which demand two million dollars R and D expenditure alone every working day, could not be supported by domestic sales alone.

In the United States, Siemens has now grown from a handful of market research men 20 years ago to a sales and production force of 2,000. Steady, rather than dynamic growth, and still only a drop in the vast ocean of the US electronics and telecommunications industry.

My own rough guide lines for goodness factor in multinationals operating in Britain are that they should be British-managed, have good export potential, have some element of in-house R and D (i.e. not be just an overseas production unit), and make a genuine contribution to the economic and social life of the country. Fortunately, there are more companies like this than of any other sort.

I suppose Mullard (Dutch-owned) is the most notable example and of the more recently established companies, Hewlett-Packard (US-owned) has an impeccable record. But there are many others and it will do us all good when confronted with mindless political slogans to pause and think.

CUTTING THE COST

Electronics, because of its steady advance in solid-state technology, is uniquely running against the tide of rising world prices. You get more value per unit cost every year. The electronic watch which last year cost £100 will cost you £30 by 1978 according to industry forecasts.

It's all to do with volume. Last year solid-state watch sales were 250,000 in a world market of 185 million watches, only 0·14 per cent. But by 1978, say the pundits, in a projected market of 227 million watches, the solid state watch will have 51 million sales or 22·46 per cent of the total market. By that time the cost of the C/MOS LSI chip will have dropped from 10 US dollars to 2·50 dollars, the digital display from 9 US dollars to 2 dollars, the quartz crystal from 3 US dollars to 2 dollars and even labour (presumably through automation) from 5 US dollars to 2 dollars.

Take a single-chip electronic calculator. In 1970 the semi-conductor manufacturers made an "introductory offer" at 30 US dollars per chip. Last year, the price of the chip had plummeted to 5 dollars. This year the price is 4·50 dollars and the l.e.d. display is now 50 cents a digit instead of a dollar. The complete handheld calculator, albeit of the simplest type, is expected to fall in cost to 20 US dollars by 1975, well under £10 at UK prices, the limiting factor being promotional costs because intense competition encourages heavy expenditure on advertising.

The cost of a single planar transistor in 1959 was 50 US dollars. By 1976, when it should be possible to buy the cheapest calculator chip of some 3,000 transistors for 3 US dollars, the cost per transistor will work out at 0·001 of a US dollar. That's not the end of the story because if all these transistors were discrete and had to be hand-wired with external wiring at a cost, say, of 10 US cents a wire installed, then the total cost would be astronomical.

The big question now is whether the semiconductor wizards can achieve the same order of cost reductions in solar cells for commercial and domestic use to alleviate the energy crisis? One line of research is to fabricate the cells in continuous ribbons instead of individually, but even the optimists concede that it may be another ten years before a hundredfold reduction in cost is achieved. This is the order of cost reduction needed to make economic the direct conversion from solar to electrical energy.

INSPIRATION

We could all kick ourselves at times for not spotting the obvious. The trembler bell in a telephone has been around ever since the telephone was patented by Alexander Graham Bell in 1876. If ever a mechanism needed up-dating it's that "oldy" in the base of your phone.

Mitel Canada Ltd. have come across with the answer, and it's an answer with enormous market potential. A replacement panel incorporating a 2-inch loudspeaker, amplifier and control circuits.

The all-electronic bell gives a pleasant ringing tone, as good or better than any electro-mechanical bell, and it has the advantage that it can also be used for ordinary loud-speaking messages. On a PABX system in a hotel, for example, the operator can make an emergency announcement to all rooms simultaneously or individual announcements to selected guests without the receiver being off its rest. If you are using the phone at the time, then the announcement automatically breaks into your conversation.

It is claimed that the Mitel "Mitone" signalling system can be manufactured to sell at the same cost as the old-fashioned single-purpose bell. Another advantage is that drive voltage is much lower and more in line with the requirements of modern electronic switchboards.

NEWS BRIEFS

MARCONI CENTENARY EXHIBITION

To mark the centenary of Guglielmo Marconi's birth, the Science Museum in Exhibition Road, London, is holding a special exhibition which will run throughout the summer to about October.

The exhibition consists of a large selection of documents, and a display of early apparatus together with many of Marconi's personalia and commemorative material.

Experiments with radio waves were carried out in 1888 by Hertz and were extended by various physicists in following years. It was not until 1894 when Hertz died, that the young Marconi, 20 years of age, appeared on the scene.

After reading a commemorative article on Hertz he began experimenting in the attic of his parents' large villa near Bologna, Italy. By the summer of 1895 he had transmitted a signal over a few yards using a simple spark gap transmitter, and coherer type detector.

By August 1895 Marconi had achieved transmission over $1\frac{3}{4}$ miles. The Italian government remained unimpressed and so Marconi set sail for England.

Following preliminary demonstrations in his laboratory the chief engineer of the Post Office, William Preece, to whom Marconi had been introduced by his cousin, arranged formal demonstrations to Post Office officials.

Observers were suitably impressed and in a second demonstration six months later the range was extended to seven kilometres. An historic lecture at Toynbee Hall followed this and Marconi soon became a celebrity.

The scientific community was, however, less enthusiastic suspecting Marconi of plagarism. In particular, Professor Oliver Lodge, who first developed the coherer and had in fact transmitted Morse signals over 60 metres before Marconi began his experiments, was deeply offended.

In 1897 Marconi established "The Wireless Telegraph and Signal Company Limited" much to the disgust of the Post Office who did not favour experiments being carried out without their involvement.

In 1899 cross-channel transmissions were successfully achieved and the possibility of transatlantic radio was soon realised.

On the 12th December, 1901 the first transatlantic message, a single Morse letter S, was transmitted from England to Newfoundland giving Marconi success against all the odds.

Photograph of Marconi in London in 1896, showing the original apparatus brought by him from Italy. *(Marconi Company Ltd.)*

PRACTICAL ELECTRONICS NEXT MONTH...

PROJECT

HIGH IMPEDANCE VOLTMETER

Simple circuitry opens up a world of sophisticated measurement. Examine biophysical and physiological potentials, look at the outputs of high impedance transducers. All with two operational amplifiers.

PROJECT

UNDERWATER PHOTOGRAPHY

This Sub-Aqua Colour Temperature Indicator has been specially designed for the underwater photographer. It is compact, uses very little power, and has no external controls so that it is easily waterproofed. The indicator is perfectly suitable for colour work on dry land.

SPECIAL FEATURE

ELECTRONICS IN SEISMIC EXPLORATION

Seismic exploration is a quest for the world's subterranean sources of natural wealth. Oil and gas, as we know, are two of our most eagerly sought after resources. What are the techniques used to achieve these discoveries? To answer this you must read next month's feature article.

AUGUST ISSUE ON SALE JULY 12, 1974

PRACTICAL ELECTRONICS

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Or, why not take out a yearly Subscription (Inland £3·25, Overseas £3·50). Orders should be addressed: Subscription Dept., IPC Magazines Ltd., 66-68 Great Queen Street, London, W.C.2.

NIM MACHINE

BY R.D. MOUNT

AN INFALLIBLE COMPUTER FOR PLAYING THE GAME OF NIM

NIM is a game for two players. At each move a player may take any number of sticks from one, and only one, of several piles. He must remove at least one stick and the winner is the person to take the last stick. In an alternative form of the game it is the loser who is forced to take the last stick.

The game reputedly comes from ancient China, but was first analysed at the beginning of this century at Harvard, U.S.A. Clearly one or other of the players must win—there can be no draw—and it transpires that the winning strategy is closely related to the binary representation of the number of sticks in the piles.

Various designs for Nim playing machines have appeared over the years since the development of the digital computer and this article presents a contemporary one using readily available TTL digital integrated circuits.

WINNING STRATEGY

The prescription for winning at Nim relies on the fact that any arrangement of piles may be categorised as either a winning or a losing position. Further, if the arrangement represents a winning position the next move is certain to create a losing position, whilst it is always possible to play so that a losing combination is converted to a winning one again.

Thus if player A starts with a winning position, player B is bound to leave a losing one after his move. At this point A is able to convert the position to a winning one by making the correct move. The game is now back where we started and will continue to cycle in this way until A finally wins.

Should A make a wrong move at any stage the way is open for B to take over the winning strategy. As there are many more losing combinations than winning ones it is unlikely that even a player who commences with a winning position in his favour should make all the moves appropriate to his being sure of winning.

BINARY REPRESENTATION

To discover whether a given arrangement represents a winning position or not we must first write down the numbers in the piles in the binary notation. For example, suppose that there are three piles containing 3, 6 and 7 sticks then we can write these numbers in binary form as three columns

3	0	1	1
6	1	1	0
7	1	1	1
	2	3	2

Each column of this binary set should now be summed so that in this case we find the numbers 2, 3, 2, as shown. Now, a winning combination is one in which each power of two is represented an even number of times. Hence our example is a losing position because the second column, indicating the number of times that 2^1 occurs, adds up to 3 which is an odd number.

To convert such a losing position to a winning one a player must remove sticks from any pile containing the highest unpaired power of 2. In this example the highest unpaired power is 2^1, the middle column, and as each pile contains this power it is possible to produce a winning combination by taking sticks from any pile. In fact the combinations 1,6,7 3,4,7 and 3,6,5 are all winning positions.

Should the players choose the alternative game in which the last player loses, then the above strategy follows through unchanged until no pile contains more than one stick. In this case a winning position is one in which there is an *odd* number of piles of one match each. It will be seen that this is the opposite condition to that imposed by the normal game in this case.

BASIC DESIGN

Fig. 1 presents a block diagram for a machine which will implement the principles outlined. Rotary wafer switches represent the numbers of sticks in four piles 1 to 4, containing up to seven sticks each. These switches give outputs in binary coded form, so that, for example, if switch S1 is set to 5 then A_0 will be a logical 1 representing 2^0, A_1 will be a logical 0 representing 2^1 and A_2 will be a logical 1 representing 2^2. For each power of 2 the four outputs from the four switches are taken to a Summer which produces an output equal to logical 0 if the sum is even and logical 1 if it is odd.

The Analyser takes these outputs and decides whether a winning or a losing position is set. In the former case the win output goes low and the 'Your Move' indicator lights. In the latter case the 'My Move' indicator lights and the Analyser initiates a search of the switches to find one which has the highest unpaired power of two present at its output. When this switch is found the appropriate lamp indicator lights.

The last-to-play (L.T.P.) circuitry simply tests for the simultaneous occurrence of no pile containing more than one stick and S5 being set to 'Loser'. In such a situation the control line L goes to logical 1 and the quantity NOT Σ_0 is presented to the Analyser in place of Σ_0. A little thought will show that this fits the prescription outlined above.

METHOD OF PLAY

The challenger is free to set any initial combination on the switches S1 to S4. The machine should now be switched on and one of the move indicators will immediately light. If 'Your Move' lights the challenger should make some legal Nim move. If the 'My Move' indicator lights then one of the lamps will also be lit and the player should turn the corresponding switch back until the 'Your Move' lamp lights. This represents the machine's move. By continuing in this way, the challenger will invariably lose.

Fig. 2 shows the suggested arrangements of one of the four Encoders S1 to S4, all of which are wired in the same way.

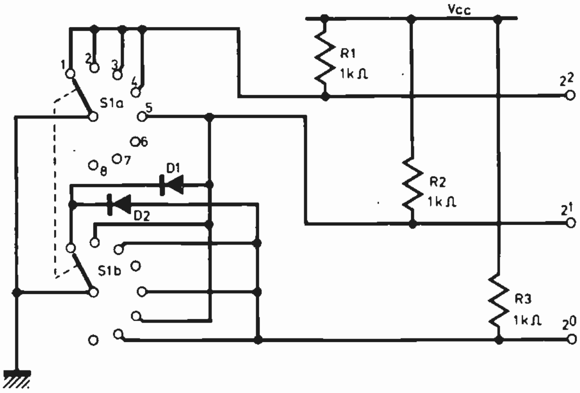

Fig. 2. Wiring detail for one of the decimal to binary switch encoders. Four such arrangements are needed

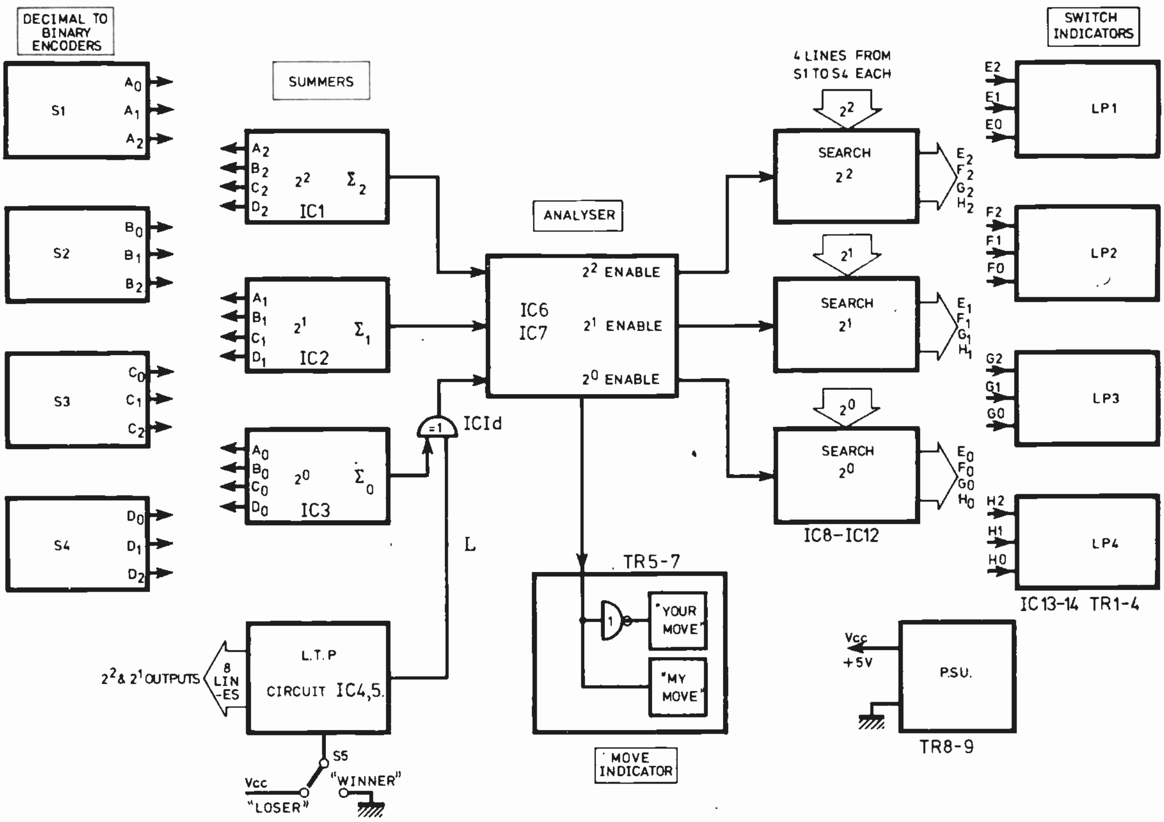

Fig. 1. Block diagram of NIM machine. For detailed wiring of sub-assemblies, see following figures

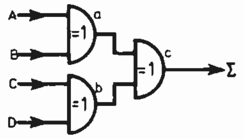

Fig. 3. Three exclusive OR gates make up each Summer. Three such circuits are required

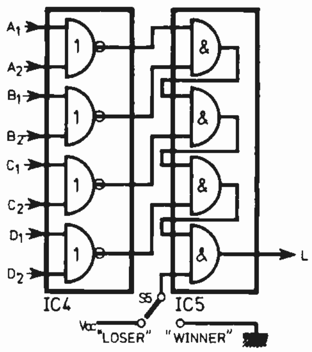

Fig. 4. Arrangement for last-to-play (L.T.P.) circuitry. See Fig. 1 for interwiring detail

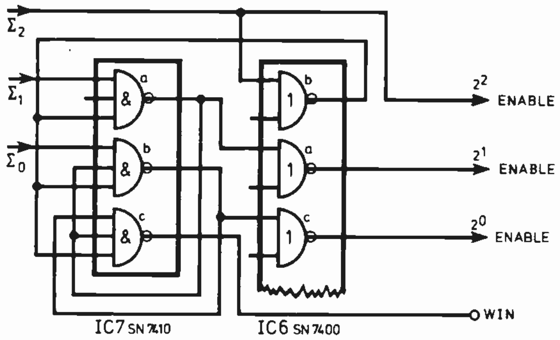

Fig. 5. Circuit diagram of Analyser gates

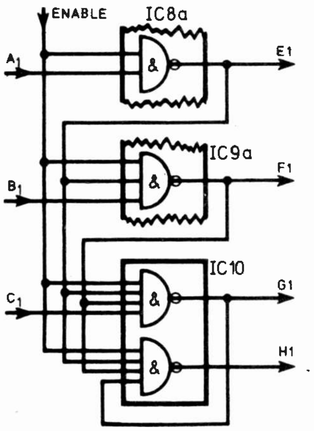

Fig. 6. The Search circuit. Three of these are required

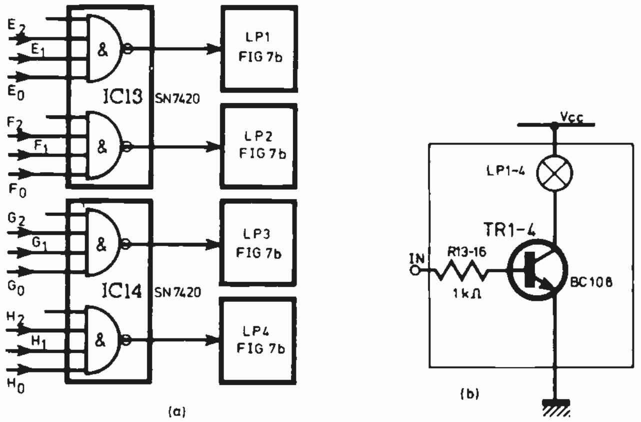

Fig. 7. Switch Indicator circuit (a) output lamp logic (b) lamp driver circuit

SUMMER

It will be seen from Fig. 3 that the Summer is a very simple circuit block. Each gate employed here is the exclusive OR gate, or half adder. Whenever the inputs are identical, the output is 0 but when the inputs differ the output is 1. That this is the function we need may be seen by realising that for our purposes all even numbers are equivalent to 0 and all odd numbers to 1.

Repeated application of the truth table to this arrangement of three gates will show that the final ouput is 1 if the power of 2 is represented an odd number of times and 0 otherwise.

L.T.P. CIRCUITRY

The control line output, L, of the L.T.P. circuit comes from IC5 which is wired as a five input AND gate (Fig. 4) needs only to invert Σ_0 when no pile contains more than one stick and the last person to play is deemed the loser. IC4 recognises the former condition by testing the 2^2 and 2^1 outputs from each switch. Only if these are simultaneously zero can that switch be displaying nought or one, and in this case the NOR output is a logical 1.

When the output from each of the NOR gates is 1 and the selector is set to "Loser" a control level 1 is produced which causes IC1d (Fig. 1) to invert the Σ_0 output.

ANALYSER

The purpose of the Analyser circuit (Fig. 5) is to find the highest unpaired power of 2. If all powers are paired then the game is set in a winning position, and the Analyser indicates accordingly.

Working from the top we see that if Σ_2 is high then the 2^2 enable line is high also, but IC6b inverts this level which forces both the other enable lines to stay low and forces the 'Win' output high. Similarly if Σ_2 is low but Σ_1 is high the 2^1 enable line is high but the 2^2 and 2^0 enable lines are low and the 'Win' output is high. Only if Σ_2, Σ_1 and Σ_0 are all low does the 'Win' output go low and, in this case, all the enable lines are also low. Thus a logical 0 at the 'Win' output corresponds to a winning arrangement.

The Win output controls the Move Indicator directly.

SEARCH CIRCUITS

Suppose that the 2^1 enable line is high (this explanation follows in the same way for both of the other enable lines) then one of the three search circuits in Fig. 1 will be activated. These work in much the same way as the Analyser circuit once they are enabled.

Consider one search circuit in Fig. 6. If the A_1 level is high then E1 goes low and the other gates in the circuit are disabled forcing a high condition

COMPONENTS . . .

Resistors
R1–R17 1kΩ (17 off) R20 68Ω
R18 6·8kΩ R21 1kΩ
R19 2·7kΩ

Capacitors
C1–C3 0·1μF (line supply decoupling capacitors for every five i.c.s)
C4 3,300μF elect. 16V

Potentiometer
VR1 1kΩ preset

Diodes
D1–D8 OA81 (8 off)
D9–D12 W005 full wave rectifier (50 p.i.v., 1A)
D13 ZL3·3, 3·3V, 1·5W Zener

Transistors
TR1–TR7 BC108 (7 off) TR8 2N3054 TR9 BC109

Integrated Circuits
IC1–IC3 SN7486 (3 off) IC8 SN7400
IC4 SN7402 IC9 SN7410
IC5 SN7408 IC10–IC14 SN7420 (5 off)
IC6 SN7400
IC7 SN7410

Switches
S1–S4 2 pole, 8 way rotary wafer switches (4 off)
S5 Single pole change-over
S6 Double pole mains on/off toggle

Transformer
T1 Mains transformer—primary 240V; secondary 6·3V, 1A

Lamps
LP1–LP6 6V, 0·04A filament lamps (6 off)

Miscellaneous
Contil Case No. 975—West Hyde Developments

at each of the other outputs F1, G1 and H1. This will cause lamp LP1 to light. Similarly, if B_1 is high then F1 goes low and the other outputs are forced to stay high so that only LP2 will light.

If A_1, B_1 and C_1 are all low then H1 goes low and LP4 lights, since the enable line tells us that one of the switches must be presenting a 2^1 contribution.

SWITCH INDICATORS

Each Switch Indicator comprises a NAND gate coupled to a lamp driver and lamp as in Fig. 7. When all three inputs are high the output of the NAND gate is low and the lamp stays off. When a low condition is received from one of the search circuits the output of the NAND gate goes high, and so the lamp lights up. So long as no fault exists, only one lamp can be lit at any one time.

The driver transistors should have a current gain of at least 50—the higher the better—and should be capable of passing up to 100mA. The power dissipation is very small, however, since each transistor is either fully conducting or completely off.

MOVE INDICATOR

The Move Indicator (Fig. 8) consists of two lamp driver circuits coupled by an inverter. The philosophy here is that if it isn't your go, it must be mine!

A discrete circuit is used for the inverter in the prototype, but one of the odd unused gates from the main circuit would work just as well.

The same comments as above apply to the characteristics of the driver transistors used here.

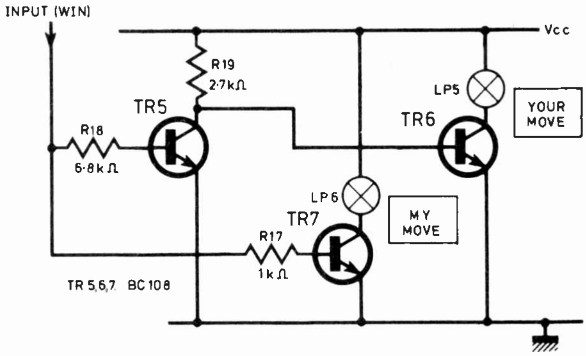

Fig. 8. The Move Indicator consists of two lamp drivers coupled by an inverter

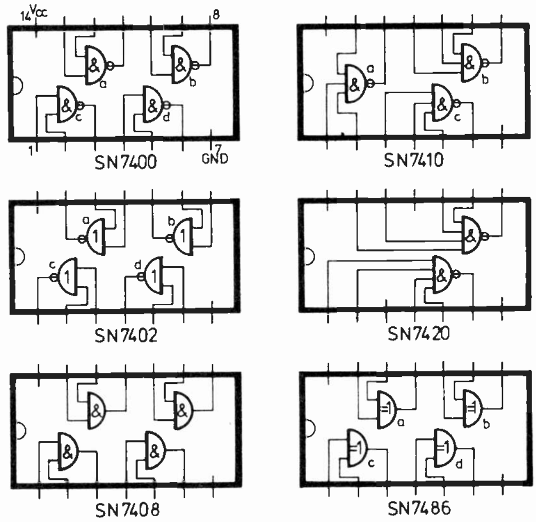

Fig. 9. Pin diagrams for the i.c.s used

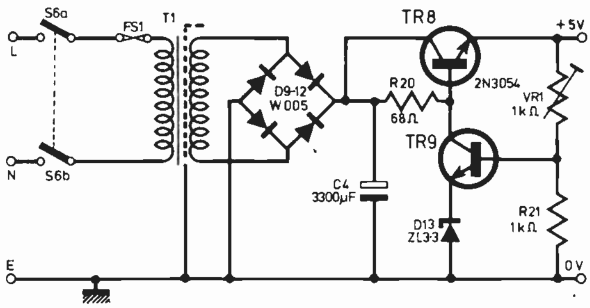

Fig. 10. Suitable power supply for the NIM machine

CONSTRUCTION

Providing all interconnecting leads are kept below 10in component layout is not critical. The sub-assemblies given in the figures should be individually assembled and checked electrically before interwiring the complete machine according to Fig. 1.

The pin wiring for the i.c.s is given in Fig. 9 and a suitable power supply in Fig. 10.

The normal i.c. practice of decoupling every 5 to 10 packages with a capacitor of about 0·1 microfarads should be followed.

The use of i.c. holders is not recommended on grounds of cost. The simple gates used in these circuits are available very cheaply, often at prices comparable with the cost of holders. ★

PATENTS REVIEW...

PATENTS LIBRARY

Some remarks and reminders on general patent matters bear making. As most readers will understand, the British Patents reported in these columns are selected from the latest batches published (at the rate of around 4,000 a month) by the British Patent Office.

Once a week a new issue of patent specifications is laid out for public inspection in the library attached to the British Patent Office in Southampton Buildings, just off London's Chancery Lane. Similarly, issues are laid out at other libraries round the country. At the same time copies of the specifications are made available for purchase from the Patent Office Sales Branch by any member of the public at 25p each, post free.

At first sight this publishing of protected ideas seems a contradiction in terms. A patent application is made by an inventor who wishes to protect or monopolise his idea for a number of years. While the application is examined by the British Patent Office it is kept rigidly secret from the public; only the title, name and application date are listed in the public card indexes kept in the library. But when the application has been accepted and is published, its content is there for all to read. So what protection is a patent providing for the inventor? And would it not have been better for them simply to keep the details of his invention secret and not involve himself in the expense of securing a patent (likely to be at least £100 if handled by a Patent Agent)?

PATENT CONTENTS

A patent specification is worded in a language which many people regard as an incomprehensible mixture of legal and technical jargon. After a legally worded preamble, every specification launches into a general description of the invention and then moves on to a specific description (usually with drawings) which explains in detail how one or more practical embodiments of the invention actually work.

Every patent specification ends with a set of claims which are the most important part when monopoly and infringement are considered. The claims define the scope of monopoly which the Patent Office has agreed to allow the inventor, having carried out searches through previously published patents.

If a claim is too broad, it may "catch" a large number of "infringing" articles, but it may also embrace articles that are known to be old. So the claim is in practice invalid. And anyone concerned and believing that the claims of a freshly published patent are obviously invalid can either ignore them or legally oppose them at a Patent Office Hearing.

ADVANTAGES OF PUBLISHING

Publishing patents also serves to enhance the richness of human knowledge and once a patent has expired (even if the full £300 worth of annual renewal fees are paid, a British patent can only last 16 years) all that it discloses and claims becomes part of the public domain. The basic reasoning is that the inventor is granted a limited monopoly in return for disclosing his idea rather than keeping it secret. Incidentally, laying open the details of an invention to the public also serves as something of an advertisement for the owner of the patent, who may be approached by manufacturers who wish to make what he claims under a licence.

It is a basic canon of patent law throughout the world that (subject to a very few exceptions) no one can patent an invention once it has been disclosed to the public. Thus, usually, once an invention has been published (e.g. in a book or magazine, or offered for sale) no one, the inventor included, can subsequently patent it. But it is perfectly safe for an inventor to lodge an application (even if it is accompanied only by a Provisional Specification, which simply lies fallow at the Patent Office for a year) and *then* immediately publish his invention. Making the patent application generates a priority date which safeguards subsequent disclosure.

Where details of a circuit or construction are given in a magazine with d-i-y slant, e.g. Practical Electronics or Everyday Electronics, it would not normally be possible for anyone to apply for a patent, for anything disclosed, after publication. However, if a contributor had already applied for a patent before the appearance of the article describing his design, then the appearance of that article would not in itself invalidate any patent subsequently granted.

LEGAL ACTION

Because the long arm of patent law moves slowly, there is often a gap of several years between original application and final acceptance and grant. Thus it is perfectly possible that a circuit or design published in a magazine such as this could already be the subject of a pending patent application which will not come into legal force until months or even years *after* the appearance of the relevant magazine issue.

Usually no action for infringement can ever be taken on a pending patent application (remember, they are kept secret so it would be grossly unreasonable if such action could be taken) this could under certain circumstances mean that designs to be found in some back numbers are only now protected by patents.

In practice these circumstances have never presented problems and are unlikely ever to do so, largely because the law is not often an ass. For instance, it is so unikely as to be inconceivable that the owner of a patent would ever be in a position to know who was making a "one-off" model of his design in the privacy of his own home or garden shed.

But anyone considering an expensive production run of any construction should always try and discover whether or not patent rights (perhaps owned by some completely different third party) are involved before embarking on such a project. For this reason it would seem in the interests of everyone if contributors with d-i-y projects included a reference by number to any relevant patents or patent applications.

Finally, readers believing that they have a patent problem on their hands should seek advice from a Patent Agent; no one on Practical Electronics can enter into correspondence on such matters.

Copies of Patents can be obtained from the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price 25p each

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The Sinclair Cambridge kit is supplied to you direct from the manufacturer. Ready assembled, it costs £27·45 – so you're saving £11! Of course we'll be happy to supply you with one ready-assembled if you prefer – it's still far and away the best calculator value on the market.

Features of the Sinclair Cambridge

- Uniquely handy package. $4\frac{1}{3}$" x 2" x $\frac{11}{16}$", weight $3\frac{1}{2}$ oz.
- Standard keyboard. All you need for complex calculations.
- Clear-last-entry feature.
- Fully-floating decimal point.
- Algebraic logic.
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- Constant acts as last entry in a calculation.
- Constant and algebraic logic combine to act as a limited memory, allowing complex calculations on a calculator costing less than £17.
- Calculates to 8 significant digits.
- Clear, bright 8-digit display.
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A complete kit!

The kit comes to you packaged in a heavy-duty polystyrene container. It contains all you need to assemble your Sinclair Cambridge. Assembly time is about 3 hours.

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1. Coil.
2. Large-scale integrated circuit.
3. Interface chip.
4. Thick-film resistor pack.
5. Case mouldings, with buttons, window and light-up display in position.
6. Printed circuit board.
7. Keyboard panel.
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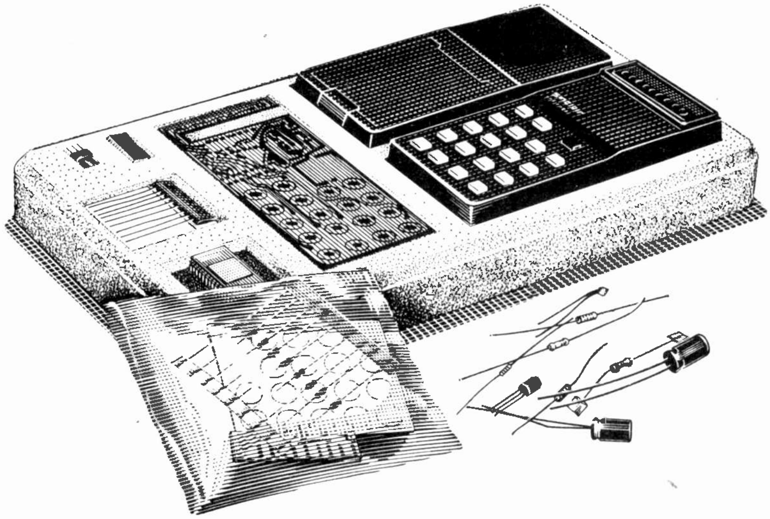
9. Battery clips and on/off switch.
10. Soft wallet.



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If you just use your Sinclair Cambridge for routine arithmetic – for shopping, conversions, percentages, accounting, tallying, and so on – then you'll get more than your money's worth.

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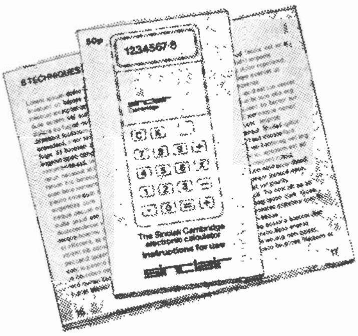

How? It's all explained in this unique booklet, written by a leading calculator design consultant. In its fact-packed 32 pages it explains, step by step, how you can use the Sinclair Cambridge to carry out complex calculations.

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Readout—
A SELECTION FROM OUR POSTBAG

Good olde days!

For over twenty years, I have been an inveterate constructor. In my early days they were the designs of people more clever than myself. Then, with increasing knowledge and experience, I began to try my hand at designing my "own" circuits.

An essential part of my apprenticeship was acquiring the expertise essential if one was to become a skilful "chassis basher", out of aluminium, mild steel or tin plate. A chassis was an essential prerequisite for use with valves, which were, for the benefit of those who haven't seen one, made of glass with bits of metal inside them. The valves usually glowed dull red (that's the filament, son), sometimes got very hot, and sometimes "bit" hard if one got careless. I ended up in hospital once when I got careless whilst working on high power transmitters.

A well laid out, and carefully constructed chassis, imbued its constructor with a feeling of euphoria, whilst he sniffed at the delicate aroma of hot valves, warm Bakelite and warm transformer impregnant, occasionally enlivened by over heated resistors.—What joy! What contentment!

Then along came the transistor. I had to discard most of my painfully acquired wisdom and start learning again. Early results were most discouraging, but I persevered, and, slowly, success came my way. But some of the pleasure had gone. A tag board here, a turret tag there. The resulting rat's nest on an s.r.b.p. board possibly worked, but it looked ghastly and meant that one less skill to be exercised.

To cap it all, along came i.c.s, and, again, less skill was required on the part of the constructor. A few i.c.s, and sundry components mounted on a bit of "holey" s.r.b.p. board (Veroboard) and there it was. It may have worked, but did it really take much "constructing"?—I personally don't think so.

Over the period of time since I first entered the world of electronics, the individual constructor has had to exercise less and less skill, more and more is done for him. In this world of "instant" instants, who has the time to learn a new set of skills to really build or construct something different, something unique?

It is a chastening thought, and, I think, a saddening one, to reflect on the electronics constructors lot in, say, ten years' time. You want to "build" a radio, son? You'd like to build a 50W stereo amplifier? Here are three "cubular modules", press the top of that one, there's the radio you built. Plug the other two into the mains, plug in your sound source and there's the stereo amplifier you built.

Where's the fun? Where's the pleasure of actually constructing something with your own hands? Fun? Pleasure? I for one, mourn the passing of the valve; the passing of the early transistor days.—Those were the days.

H. T. Kitchen,
Bulkington, Warks.

Fog warning system

Sir,—With the perennial concern for Motorway safety I feel you should know about a fog warning system I have devised after a considerable period of experimentation.

In principle it monitors the whole of the Motorway, is automatically triggered by fog or smoke and provides advance warning to motorists 300m prior to the affected area.

The basic system is as follows (See Fig. 1). A light beam is directed along the Motorway verge in the direction of oncoming traffic to an optical receiver 300m away. While the beam is maintained a relay controls another signal lamp directed to a receiver a further 300m along the Motorway verge and so on. Such a chain is optically possible since Motorways are practically straight and level and there are no obstructions along the verges.

If the beam is interrupted by fog, heavy rain, snow or smoke the receiver causes the relay to change over and transfer power from the following signal lamp to multivibrator controlled warning lamps. The net result is that all lamps in the chain are cancelled and warning lamps are left to flash warning of danger.

The optical receiver consists of a long collimator tube, matt black inside, which directs the light beam from the lamp to a 4½in concave mirror and light dependent resistor which almost forms the focus. Similarly the transmitter has a 4½in concave mirror fed from a 10V, 1A bulb. This supply is obtained from a tapped car battery (older kind) which also sources two groups of six 3·5V, 0·3A bulbs in a series parallel arrangement making up the collector loads to a multivibrator circuit.

A modification to the system is the inclusion of a lamp pulser (multivibrator). This permits the system to be used over long distances. If, say, fog were were only affecting a section of the Motorway the closing of the relay would operate the warning lamps and the pulser. For that transmitter path where there was no fog the pulser would cause the lamp to flash, this would restore the "all-clear" to the other units along the Motorway.

By carefully timing the pulses and adding a suitable delay to each receiver it is possbile to have two fog affected units showing a warning and the rest of the chain showing "all-clear."

From the circuits devised, field trials have been encouraging. Some further experiments have been conducted using modulated light, but it is a matter for further study as to which of these ideas is the most suitable, but the writer believes that it should not be beyond the abilities of, say, students working for A level physics to devise a practical solution, working on these lines, to a national problem.

G. Cozens,
Bartley,
Southampton

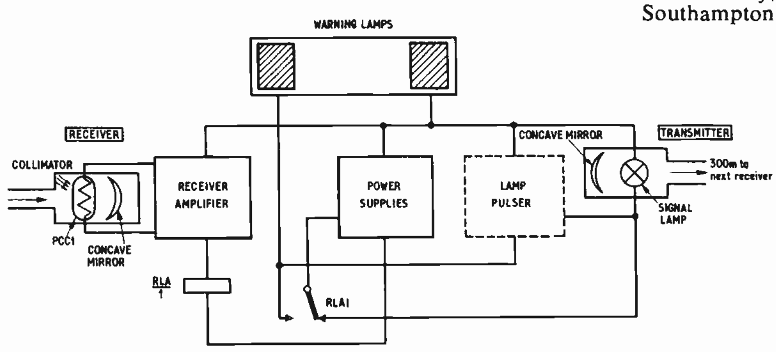


Fig. 1. Basic receiver/transmitter unit for controlling fog warning lamps on the Motorway

Psycho-sensitive semiconductors?

Sir—With reference to Mr. Brian Baily's article in P.E. April '74 about *ESP* I should like to propose the following explanation of the results he obtained from his experiments on plants. I wish to point out that this is merely a hypothesis and that I have no evidence other than that which I state:

In one of the programmes in the recent BBC T.V. series "Young Scientist of the Year!" the results of a group of boys' experiments on growing plants in magnetic fields, were presented. They found that plants grown in a magnetic field bent and grew along the lines of force. Could this not be something to do with the fact that there is an atom of iron at the core of the chlorophyll molecule, which may render it magnetically sensitive?

It is possible that the molecules align themselves along the lines of force, presenting a coherent chain of electrically resistive molecules, whereas normally they would be in an amorphous distribution. This migration of the vital chlorophyll towards one point would explain the tropic response of the plants in the magnetic fields.

Is it not possible then, that if a large, strong field is enough to cause the plant to change its direction of growth, the weak field surrounding an electrically active brain would be sufficient to align one or two chains of molecules and thus cause a change in the cells' resistance?

The shrimps' nervous system on contact with the boiling water would radiate a field of far greater strength than normal, this would be selected by the plant and the appropriate change in resistance would occur. I propose that a concentrating mind, regardless of the subject of that concentration, produces a field strong enough for the plant to detect.

Assuming this theory to be correct, there must be other chemicals possessing the same property, in which case it is not hard to imagine, in the not-too-distant future, the invention of a psycho-sensitive semiconductor device. This would be a boon for handicapped people who would be able to turn on equipment merely by thinking about it, no physical help required.

P. Watson,
Bedfordshire.

Hot line

Sir—A short while ago, my wife and I decided to change the position of the furniture in our lounge. The arrangement we chose meant that the colour television would not plug directly into the socket, so I decided to use an extension cable. The only one which was available was a 150ft cable which I use with the electric lawn mower.

Being the cautious type I checked that the television would not overload the cable and as the cable was rated at 5A and the television consumption 245W, which is just over 1A at 240V, I decided that it would be safe. As you can imagine, 150ft of cable across a lounge leaves quite a lot to spare so I coiled it neatly and put it behind the television.

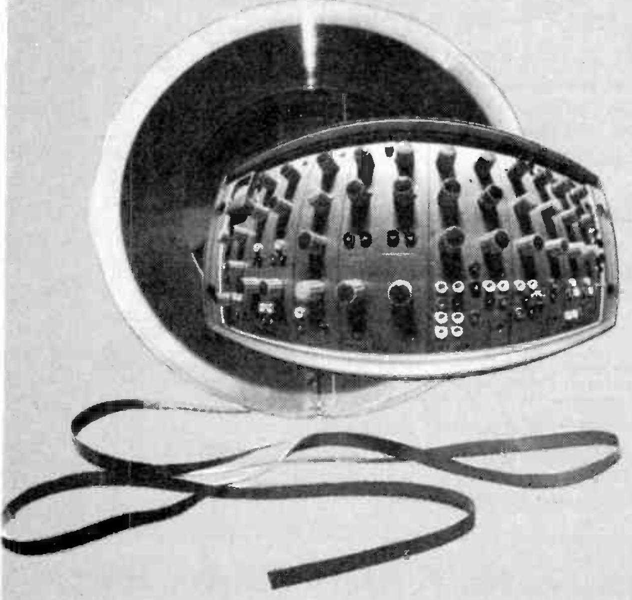
I offered a neighbour of mine the use of my lawn mower as he was having trouble coping with a thick growth. As the cable on the machine was not long enough I also offered the extension cable, this was when I found to my horror that the neatly coiled cable had welded itself together, it had apparently acted as a heating coil with 1A being sufficient to create enough heat to ruin all but 15ft of the cable. During this time the cable has not short circuited or failed but it has left a nasty burn mark on the carpet.

I had wondered why the cat had taken to sleeping under the television, she usually finds the warmest position to curl up.

R. F. Burgin,
Witham,
Essex.

According to I.E.E. regulations current ratings for cable are based on a fixed ambient air temperature. Any heat arising from the cable caused through coiling must derate this figure. The combination of heat generated in a long cable magnified by coiling and the cat probably contributed to the thermoplastic insulation deteriorating.—Ed

SOUND SYNTHESIS FOR THE AMATEUR



Due to the unprecedented number of letters we have received from readers stating their disappointment at not being able to attend the P.E. Audio Fair lectures, and more recently the lecture given at Essex University, we have decided to make available (at a small fee) to Clubs, Schools and Universities a taped recording and colour slides of the lecture.

Entitled "SOUND SYNTHESIS FOR THE AMATEUR" the tape runs for approximately 45 minutes at 7½ i.p.s. and was recorded on a Philips N4450 domestic recorder. The colour slides contain waveforms, block diagrams and circuits on the various sections of the P.E. Synthesiser. Only two sets of tapes and slides are available and requests will be dealt with in strict rotation of receipt.

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44p ?

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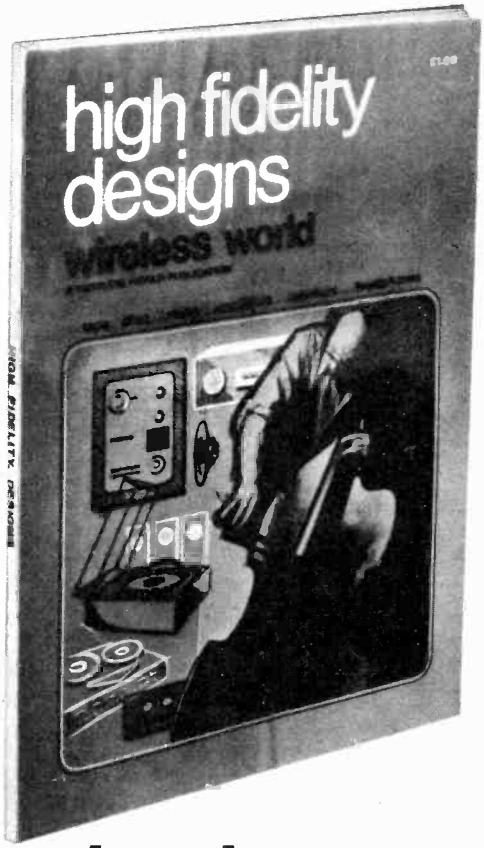

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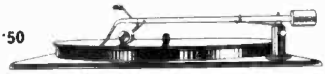

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R3	50 Mixed 10K ohms-82K ohms	40p
R4	50 Mixed 100K ohms-1 Meg. ohms	40p

THESE ARE UNBEATABLE PRICES—LESS THAN 1p EACH INCL. V.A.T.

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C60, **32p**; C90, **41p**; C120, **52p**

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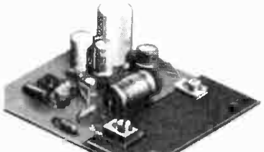
BI-PAK *QUALITY* COMES TO AUDIO!

AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po = 3 WATTS f = 1KHz	0·25%
LOAD IMPEDANCE	—	8–16 Ω
INPUT IMPEDANCE	f = 1KHz	100 k Ω
FREQUENCY RESPONSE —3dB	Po = 2 WATTS	50 Hz–25KHz
SENSITIVITY for RATED O/P	Vs=25V. Rl=8Ω f=1KHz	75mV. RMS
DIMENSIONS	—	3" × 2½" = 1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power out for 2% T.H.D. (RL = 8Ω f = 1KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.

AUDIO AMPLIFIER MODULES

AL 10. 3 watts £2·19
AL 20. 5 watts £2·59
AL 30. 10 watts £3·01

PRE-AMPLIFIERS

PA 12. (Use with AL10 & AL20) £4·35
PA 100. (Use with AL30 & AL50) £13·15

POWER SUPPLIES

PS 12. (Use with AL10 & AL20) 88p
SPM 80. (Use with also AL30 & AL50) £3·25
FRONT PANELS PA 12 with Knobs £1·00

TRANSFORMERS

T461 (Use with AL10) £1·38 P & P 15p
T538 (Use with AL20) £1·93 P & P 15p
BMT80 (Use with AL30 & AL50) £2·15 P & P 25p

PA12 PRE-AMPLIFIER SPECIFICATION

The PA12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridges while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm.

Frequency response— 20Hz–50KHz (−3dD)
Bass control— ± 12dB at 60Hz
Treble control— ± 14dB at 14KHz
*Input 1. Impedance 1 Meg. ohm, Sensitivity 300mV
†Input 2. Impedance 30 K ohms, Sensitivity 4mV

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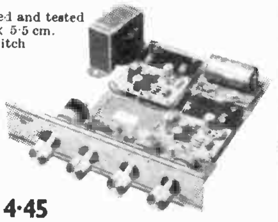
ALL PRICES INCLUDE VAT

The STEREO 20



The "Stereo 20" amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The "Stereo 20" has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ± 12dB at 60Hz typically 0·25% at 1 watt. Treble con. ± 14dB at 14kHz.

£14·45

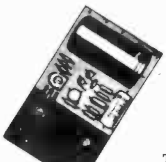
NOW WE GIVE YOU 50w PEAK (25w R.M.S.) *PLUS* THERMAL PROTECTION! The *NEW* AL60 Hi-Fi Audio Amplifier FOR ONLY £3·95

- Max Heat Sink temp 90°C.
- Frequency Response 20Hz to 100KHz
- 0·1% Distortion
- Distortion better than 1% at 1KHz
- Supply voltage 10–35 volts
- Thermal Feedback
- Latest Design Improvements
- Load — 3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm × 105mm × 13mm

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

FULLY BUILT — TESTED and GUARANTEED

STABILISED POWER MODULE SPM80

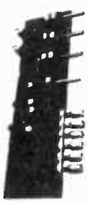


AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63mm × 105mm × 30mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disco Systems, Public Address, Intercom Units, etc. Handbook available 10p **PRICE £3·25**

TRANSFORMER BMT80 £2·15 p. & p. 28p

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.



SPECIFICATION

Frequency Response	20Hz—20KHz ± 1dB
Harmonic Distortion	better than 0·1%
Inputs: 1. Tape Head	1·25 mV into 50K Ω
2. Radio, Tuner	35 mV into 50K Ω
3. Magnetic P.U.	1·5 mV into 50K Ω

All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ± 1dB. from 20Hz to 20KHz.

Bass Control	± 15dB at 20Hz
Treble Control	± 15dB at 20KHz
Filters: Rumble (High Pass)	100Hz
Scratch (Low Pass)	8KHz
Signal/Noise Ratio	better than −65dB
Input overload	+26dB
Supply	+35 volts at 20mA
Dimensions	292mm × 82mm × 35mm

ONLY £13·15

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £25·30 FREE p. & p.

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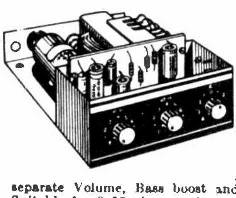
PRICES INCLUDE VAT

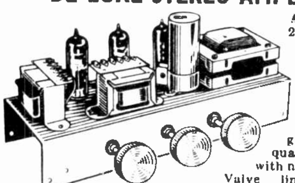
SUPERSOUND 13 HI-FI MONO AMPLIFIER



A superb solid state audio amplifier. Brand new components throughout. 5 silicon transistors plus 2 power output transistors in push-pull. Full wave rectification. Output approx. 13W r.m.s. into 8 ohm. Frequency response 12Hz—30KHz ± 3db. Fully integrated pre-amplifier stage with separate Volume, Bass boost and Treble cut controls. Suitable for 8-15 ohm speakers. Input for ceramic or crystal cartridge. Sensitivity approx. 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3in high × 6in wide × 7½in deep. A.C. 200/250V.

PRICE £12·00 P. & P. 50p.

DE LUXE STEREO AMPLIFIER



A.c. mains 200–240 volts. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line up:—2 × ECL86 Triode Pentodes. 1 × EZ80 as rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble boost and cut. A dual volume control is used. Balance of the left and right hand channels can be adjusted by means of a separate "balance" control fitted at the rear of the chassis. Input sensitivity is approximately 300m/v for full peak output of 4 watts per channel (8 watts mono), into 3 ohm speakers. Full negative feedback in a carefully calculated circuit, allows high volume levels to be used with negligible distortion. Supplied complete with knobs, chassis size 11in. w × 4in. x. Overall height including valves 5in. Ready built and tested to a high standard. **Price £10·40.** P. & P. 50p.

NEW! POWER SUPPLY UNIT

200/240V A.C. input. Four switched fully smoothed D.C. outputs giving 6V and 7½V and 9V and 12V at 1 amp on load.
Fitted insulated output terminals and pilot lamp indicator. Hammer finish metal case, overall size 6" × 3¼" × 2¼". Suitable for Transistor Radios, Tape Recorders, Amplifiers, etc., etc. Ready built and tested.

PRICE £5 P. & P. 35p.

HI-GRADE COPPER LAMINATE BOARDS. 8" × 6". Five for 60p plus 30p P. & P.

BRAND NEW MULTI-RATIO MAINS TRANSFORMERS. Giving 13 alternatives. Primary: 0-210-240V. Secondary combinations: 0-5-10-15-20-25-30-35-40-60V half wave at 1 amp or 10-0-10, 20-0-20, 30-0-30V, at 2 amps full wave. Size 3inL × 3½inW × 3inD. Price £2·31. P.& P. 40p

FEW ONLY. High grade mains transformers with grain orientated lamination. Primary 200/240 secondary 18·5 volts at 0·6 amps and 4·6 volts at 0·3 amps. Size 2"H × 2¼"W, × 2"D overall. £1·25 plus 25p P. & P.

MAINS TRANSFORMER. For transistor power supplies. Pri. 200/240V Sec. 9-0-9 at 500mA. £1·10 P. & P. 25p. Pri. 200/240V Sec. 12-0-12 at 1 amp. £1·21 P. & P. 26p. Pri. 200/240V Sec. 10-0-10 at 2 amp. £1·82 P. & P. 35p.

GENERAL PURPOSE HIGH STABILITY TRANSISTOR PRE-AMPLIFIER. For P.U. Tape, Mike, Guitar, etc., and suitable for use with valve or transistor equipment. 9–18V. Battery or from H.T. line 200/300V. Frequency response 15Hz-25KHz. Gain 26dB. Solid encapsulation size 1¾ × 1¼ × ⅝in. Brand new — complete with instructions. Price £1. P. & P. 15p.

3 REFERENCE ENCYCLOPEDIAS FOR ELECTRONIC ENGINEERS AND DESIGNERS, covering between them, transistor characteristics, diode and transistor equivalents. Many thousands of up-to-date European types listed.

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HANDBOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES
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FOR PERSONAL CALLERS ONLY! Limited number of Stereo Radiogram chassis covering LW/MW/FM bands. Mono radio and stereo gram. Overall size approx. 16½"W, 6½"H, 8"D. 4 Watts per channel output. ONLY £16·50.

SPECIAL BARGAIN OFFER!

Limited number of BSR C123 Auto Changer De Luxe with lightweight tubular arm and stereo cartridge. Brand new. **ONLY £8.00** plus P. & P. 60p.

PRECISION ENGINEERED PLINTHS

Beautifully constructed in heavy gauge "Colorcoat" plastic coated steel. Resonance free. Designed to take Garrard 1025, 2000, 2025TC, 2500, 3000, 3500, 5100, SP25 II and III, SL65B, AT60, etc., or B.S.R. C123, C109, C129, A21, etc. Black leatherette finish. Size 12½in × 14¼in × 3¼in high (approx. 7¼in high, including rigid smoked acrylic cover). P. & P. 70p. **Now only £4·95**

8 pole 3 way 2 bank low loss Yaxley type switches 1½" sections. Standard spindle. 2 switches 66p + 10p P. & P.

LATEST ACOS GP91/1SC Mono Compatible Cartridge with t/o stylus for LP/EP/78. Universal mounting bracket. £1·50, P. & P. 15p.
SONOTONE 9TAHC COMPATIBLE STEREO CARTRIDGE T/O stylus. Diamond Stereo LP and Sapphire 78. ONLY £2·30. P. & P. 10p. Also available fitted with twin Diamond T/O stylus for Stereo LP. £2·80. P. & P. 15p.
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LATEST RONETTE T/O Mono Compatible Cartridge for EP/LP/78 mono/stereo records on mono equipment £1·50, P. & P. 15p.

QUALITY RECORD PLAYER AMPLIFIER MK II
A top-quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3 d. × 6 h. Ready built and tested. PRICE £5·00. P. & P. 50p. ALSO AVAILABLE mounted on board with output transformer and speaker. PRICE £6·30. P. & P. 60p.

SPECIAL OFFER!!
HI-FI LOUDSPEAKER SYSTEM

Beautifully made teak finish enclosure with most attractive Tygan-Vynair front. Size 16in high × 10½in wide × 6in deep. Fitted with E.M.I. Ceramic Magnet 13in × 8in bass unit, two H.F. tweeter units and crossover. Max. power handling 10W. Available 3, 8 or 15 ohm impedance.

Our Price £9·25 Carr. 75p.

CABINET AVAIL. SEPARATELY £4·95. Carr. 65p. Also available in 8 ohm with EMI 13in × 8in. bass speaker with parasitic tweeter. £7·15. Carr. 75p.

HARVERSON'S SUPER MONO AMPLIFIER

A super quality gram amplifier using a double wound fully isolated mains transformer, rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3·5 watts. Volume and tone controls. Chassis size only 7in. wide × 3in. deep × 6in. high overall. AC mains 200/240V. Supplied absolutely Brand New, completely wired and tested with good quality output transformer.

OUR ROCK BOTTOM BARGAIN PRICE £3·85 P. & P. 40p

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5in 3 ohm £1·25, P. & P. 15p. 7 × 4in 3 ohm £1·40, P. & P. 20p. 10 × 6in 3 or 15 ohm £2·10, P. & P. 30p. E.M.I. 8 × 5in 3 ohm with high flux magnet £1·70, P. & P. 20p. E.M.I. 13½ × 8in with high flux ceramic magnet with parasitic tweeter 3, 8, or 15 ohm £3·50. P. & P. 30p. E.M.I. 13 × 8in, 3 or 8 or 15 ohm with two inbuilt tweeters and crossover network £4·65. P. & P. 30p.

EMI CERAMIC MAGNET HEAVY DUTY TWEETER. pprox. 3½in. Av. 3 or 8 or 15 ohms. £1·25 plus 20p p. & p.
BRAND NEW. 12in 15w H/D Speakers, 3, 8 or 15 ohm (state which). Current production by well-known British maker. Now with Hiflux ceramic ferrobar magnet assembly £9·90. Guitar models: 25w £9·90. 35w £11·00. P. & P. 45p each.

SPECIAL OFFER!

LIMITED NUMBER OF BRAND NEW ELAC 10" TWIN CONE LOUDSPEAKERS. With large ceramic magnet and plasticised cone surround. 8 ohm impedance.

£3·70. P. & P. 35p.

Also available specification as above but size 10" × 6" £2·70 P. & P. 35p.

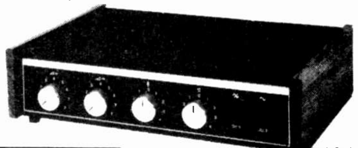
12in "RA" TWIN CONE LOUDSPEAKER
10 watts peak handling, 3 or 8 or 15 ohm (state which), £2·95, P. & P. 36p.

"POLY PLANAR" WAFER-TYPE, WIDE RANGE ELECTRO-DYNAMIC SPEAKER
Size 11¾in × 14⁵⁄₁₆in × 1³⁄₁₆in deep. Weight 19oz. Power handling 20W r.m.s. (40W peak). Impedance 8 ohm only. Response 40Hz-20kHz. Can be mounted on ceilings, walls, doors, under tables, etc., and used with or without baffle. Send S.A.E. for full details. Only £6·55 each. P. & P. 34p.

HI-FI STEREO HEADPHONES

Adjustable headband with comfortable flexifoam ear-muffs. Wired and fitted with standard stereo ¼in jack plug. Frequency response 30–15,000Hz. Matching impedance 8–16 ohms. Easily converted for mono. PRICE £3·30. P. & P. 25p.

HAVERSONIC SUPER SOUND 10 + 10 STEREO AMPLIFIER KIT



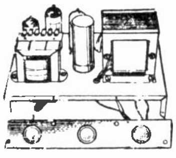
NEW FURTHER IMPROVED MODEL WITH HIGHER OUTPUT AND INCORPORATING HIGH QUALITY READY DRILLED PRINTED CIRCUIT BOARD WITH COMPONENT IDENTIFICATION CLEARLY MARKED FOR EASIER CONSTRUCTION

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integrated pre-amp with Bass, Treble and two Volume Controls. Suitable for use with Ceramic or Crystal cartridges. (Very simple to modify to suit magnetic cartridge—instructions included). Output stage for any speakers from 5 to 15 ohms. Compact design, all parts supplied including drilled metal work, high quality ready drilled printed circuit board, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification: Power output 14W r.m.s. per channel into 5 ohms. Frequency response ± 3dB 12–30,000Hz. Sensitivity better than 80mV into 1MΩ. Full power bandwidth ± 3dB 12-15,000Hz. Bass boost approx. to ± 12dB. Treble cut approx. to −16dB. Negative feedback 18dB over main amp. Power requirements 35V at 1·0 amp. Overall size—12" wide × 8" deep × 2½" high.
Fully detailed 7-page construction manual and parts list free with kit or send 18p plus large S.A.E.

PRICES AMPLIFIER KIT, £11·55 P. & P. 25p.
(Magnetic input components 33p extra)
POWER PACK KIT, £3.50 P. & P. 35p.
CABINET, £3·50 P. & P 35p.

(Post Free if all units purchased at same time). Full after sales service. Also available ready built and tested, £25·10. Post Free.
Note: The above amplifier is suitable for feeding two mono sources into inputs (e.g. mike, radio, twin record decks, etc.) and will then provide mixing and fading facilities for medium powered Hi-Fi Discotheque use, etc.

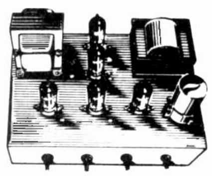
3-VALVE AUDIO AMP. HA34 MK II



Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in w. × 4in. d. × 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving bass and treble lift and cut. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only £6·00. P. & P. 45p.

HSL "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc. £5·00. P. & P. 45p.

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3–15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 15p plus S.A.E. (Free with parts). **All parts sold separately. ONLY £9·00.** P. & P. 60p. Also available ready built and tested £13·00. P. & P. 70p.

VYNAIR & REXINE SPEAKERS & CABINET FABRICS app. 54 in. wide. Our price £1·10 yd. length. P. & P. 15p per yd. (min. 1 yd.). S.A.E. for samples.

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VARIABLE VOLTAGE TRANSFORMERS

INPUT 230/240V a.c. 50/60 OUTPUT VARIABLE 0–260V
All Types

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0·5 KVA (2½ amp) (MAX) £10·00
1 KVA (5 amp) (MAX) £14·70
2 KVA (10 amp) (MAX) £28·10
3 KVA (15 amp) (MAX) £31·25
4 KVA (20 amp) (MAX) £72·50
37·5 amp (MAX) £102·50
CARRIAGE AND PACKING EXTRA

L.T. TRANSFORMERS

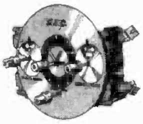
All primaries 220–240V

Type No.	Sec. Taps	Price Post
1	30, 32, 34, 36V at 5A	£6·90+45p
2	30, 40, 50V at 5A	£9·15+60p
3	10, 17, 18V at 10A	£7·20+50p
4	6, 12V at 20A	£8·60+60p
5	17, 18, 20V at 20A	£9·15+60p
6	6, 12, 20V at 20A	£8·65+60p
7	12, 20, 24V at 10A	£6·75+50p
8	4, 6, 24, 32V at 12A	£8·60+60p
9	6 and 12V at 10A	£4·30+40p

VOLTAGE CHANGING TRANSFORMER
M.f.g. to highest W.D. spec. Auto wound, and tapped 0–130–160–200–250 at least 2kVA. Can also be used as 230–240V input, 115V out for U.S.A. equipment, or reverse to obtain 240V from 115V. The ideal transformer for making up solid state constant voltage unit, by use of taps the following voltages may be obtained 30–40–50–70–90V at 10 amps. Weight 40lb, length, 260mm, height 190mm, width 230mm. In original maker's wooden case, £8. Carr. £1.

300 VA ISOLATING TRANSFORMER
115/230-230/230 volts. Screened. Primary two separate 0-115V for 115 or 230 volt. Secondary two 115V at 150 VA each for 115 or 230 volt output. Can be used in series or parallel connections. Fully tropicalised. Length 13·5 cm. Width 11 cm. Height 13·5 cm. Weight 15 lb.
SPECIAL OFFER PRICE £5. Carr. 80p.

A.C. MAINS TIMER UNIT



Based on an electric clock, with 25 amp. single pole switch, which can be preset for any period up to 12 hrs. ahead to switch on for any length of time, from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets, etc. Attractive satin copper finish. Size 135 mm × 130 mm × 60 mm. Price £2. Post 20p. (Total incl. VAT and Post £2·42).

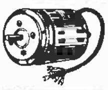
VENNER TIME SWITCH TYPE MSQP

200/250 Volt 2-ON/2-OFF every 24 hours at any manually pre-set time. 20 amp contacts. Fitted diecast case. Tested and in perfect condition £4·75. Post 25p.

FOOT SWITCH

Suitable for Motors, Drills, etc., etc. 5 amp. 250 volt. Price 75p. Post 15p.

A.C. MOTOR 'Mfg. by AEI.'



Smooth running, powerful, continuously rated, reversible motor. 230/250V a.c., 50 cycle 1/50 H.P., RPM 900, 0·25A. £3·50 post 50p.

METERS NEW! 2¼in. Flush round. Available in D.C. Amps 1, 5, 10, 15, 20 or A.C. Amps 1, 5, 10, 15, 20, Voltmeter 0-300V A.C. All types £2. Post 15p.

230/240 VOLT A.C. EXTRACTOR FAN KIT

Comprising of impeller, continuously rated motor, motor housing and fixings as illustrated. Price £1·75. Post 25p. (Total incl. VAT and Post £2·20).

MINIATURE UNISELECTOR SWITCHES

2 Bank, 12 position, 24 volt D.C. operation, full wiper with ancillary contacts. NEW Price £2·50. Post 20p. As above but with 5 Bank, 12 position. Price £3·50. Post 20p.

All Mail Orders—Callers—Ample Parking
Dept. PE7, 57 BRIDGMAN ROAD CHISWICK, LONDON W4 5BB
Phone 01-995 1560
Showroom open Mon.-Fri.

STROBE! STROBE! STROBE!

Build a Strobe Unit, using the latest type Xenon white light flash tube. Solid state timing and triggering circuit. 230/250V a.c. operation.

EXPERIMENTERS' ECONOMY KIT
Speed adjustable 1 to 30 flash per sec. All electronic components including Xenon Tube and instructions £6·30. Post 30p.

INDUSTRIAL KIT
Ideally suitable for schools, laboratories, etc. Speed adjustable 1-80 f.p.s.
Approx. ½ output of Hy-Lyght. Price £12·00. Post 50p.

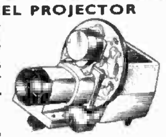
HY-LYGHT STROBE MK III
For use in large rooms, halls and utilises a silica tube, printed circuit. Speed adjustable 0-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. £12. Post 50p.

THE 'SUPER' HY-LYGHT KIT
Approx. four times the light output of our well proven Hy-Lyght strobe.
- Variable speed from 1-13 flash per sec.
- Reactor control circuit producing an intense white light. ONLY £20. Post 75p.

ROBUST, FULLY VENTILATED METAL CASE. For Hy-Lyght Kit including reflector £5·75. Post 25p.
Super Hy-Lyght case including reflector £8. Post 60p.

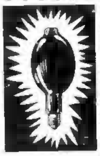
7-inch POLISHED REFLECTOR
Ideally suited for above Strobe kits. Price 55p. Post 15p.

COLOUR WHEEL PROJECTOR



Complete with oil-filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. £18·50. Post 50p.
6 INCH COLOUR WHEEL As used for Disco lighting effects, etc. Price £4·50. Post 30p.

BIG BLACK LIGHT



400Watt. Mercury vaoour ultra violet lamp. Powerful source of u.v. Innumerable industrial applications also ideal for stage, display, discos, etc. P.F. ballast is essential with these bulbs. Price of matched ballast and bulb £16. Post £1.
Spare bulb £7. Post 40p.

BLACK LIGHT FLUORESCENT U.V. TUBES
4ft 40 watt. Price £5·50. Post 30p. **2ft 20 watt, £4·25.** Post 25p. (For use in standard bi-pin fittings.)
MINI. **12in 8 watt, £1·60.** Post 15p. **9in 6 watt, £1·30.** Post 15p. Complete ballast unit and holders for 9in and 12in tube, £1·70. Post 25p. (9in and 12in measures approx.)

AUTO FADE COLOUR BLEND MODULE
Will control up to 750W. of lighting. Automatic fade-up, fade-down at a manually pre-selected timing, which may be varied between 1 second to 1 minute. Based on 10 amp triac for maximum reliability. Ready built with switch and Time Control, on 4½" × 5" glass P.C. board. Three modules or more can be sequenced to obtain fantastic colour blending effects. Price £12·50. Post 30p per module.

PROGRAMME TIMERS

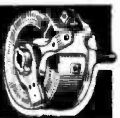
230/240V a.c. 15 r.p.m. Motors. Each cam operates a c/o micro switch. Ideal for lighting effects, animated displays, etc. Ex equipment tested.
4 cam model. £2·50 post 30p.
6 cam model. £3·25 post 30p.
12 cam model. £4·00 post 35p.
6 cam model. 3 r.p.m. £3·25 post 30p.

TRIACS
GENERAL ELECTRIC POWER-GLAS TRIACS
10 amp. Glass passivated plastic triac. Latest device from U.S.A. Long term reliability. Type SC146D 10 amp, 400 PIV, £1. Post 5p. Type SC146E 10 amp, 500 PIV, £1·30. Post 5p. (Inclusive of data and application sheet.) Suitable Diac 18p.

All prices are subject to **10% VAT.** (10p in the £)
To all orders add 10% VAT to total value of goods including carriage/packaging.

SERVICE TRADING CO

Superior Quality Precision Made NEW POWER RHEOSTATS



New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10/25/50/100/250/300/500/1k/ohm £1·15. Post 10p.
50 WATT 1/5/10/25/50/100/250/500/1k/1·5k/ohm £1·60. Post 10p.
100 WATT 1/5/10/25/50/100/250/500/1k/1·5k/2·5k/3·5k/5k ohm £2·35. Post 15p.
Black Silver, Skirted knob calibrated in Nos. 1-9. 1½in. dia. brass bush. Ideal for above Rheostats, 22p each.

RELAYS SIEMENS, PLESSEY, Etc. MINIATURE RELAYS

Col.(1) Coil ohms
Col. (2) Working d.c. volts
Col. 3 Contracts
Col. (4) Price
HD = Heavy duty
*Incl. Base
All prices incl. P. & P.

1	2	3	4
52	4-6	6M	60p*
58	5-9	6 c/o	80p
150	4-9	2 c/o	70p*
185	8-12	6M	60p*
308	9-14	4 c/o	75p*
700	16-24	4M 2B	60p*
700	16-24	4 c/o	80p*
700	6-12	1 c/o HD	70p*
700	20-30	6 c/o	50p*
2,500	31-43	2 c/o HD	60p*
2,500	36-45	6M	60p*
2,400	30-48	4 c/o	60p
5,800	24-26	2 c/o	60p*
9,000	40-70	2 c/o	60p*
15k	85-110	6M	60p*

6 VOLT D.C. 1 make contacts **35p.** Post 5p.
6 VOLT D.C. 2 make contacts **75p.** Post 5p.
9 VOLT D.C. RELAY
3 c/o 5 amp contacts. 70 ohm coil. **75p.** Post 5p.
12 VOLT D.C. RELAY
3 c/o 5 amp contacts. 120 ohm coil. **75p.** Post 5p.
24 VOLT D.C. 3 c/o **75p.** Post 5p.

ITT LOW PROFILE RELAY

500 ohm coil, 12-24 volts D.C., 4 c/o. Price **85p.** Post 5p each.

CLARE-ELLIOTT TYPE RP7641 G8
Miniature relay. 675 ohm coil. 24 Volt D.C. 2 c/o. **70p** post paid.
100 VOLT A.C. 2 c/o sealed type, octal base **£1.** Post 10p.
24 VOLT A.C. Mfg. by ITT.2 h.d. c/o contacts. **55p.** Post 5p.
240 VOLT A.C. RELAY. Mfg. by ITT. 240V A.C. 10 amp h.d. c/o contacts. Octal plug in base. (Similar to illustration below). Price **75p.** Post 5p.

HEAVY DUTY A.C. SEALED RELAYS

230/240 V. 2 c/o. 20 amp contacts. 110 Volt. 2 c/o 20 amp contacts. Either type **£1·25.** Post 10p.

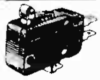
DRY REED RELAYS
Mfg. by ERG, 12 volt d.c. encapsulated.
Single c/o **65p,** post paid. Two c/o **85p,** post paid.
STC 280 ohm coil 6/12V d.c. **3** make metal shrouded. **60p** post paid.
Other types available, state your requirement.

"HONEYWELL" PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY

Each bank comprises a c/o rated at 10 amps 240V. A.C. Black knob 1 in. Fixing hole ⅜ in. ONE bank **30p;** TWO bank **40p;** THREE bank **50p.** Quote for quantity.

HIGH VISIBILITY PANEL MOUNTING LED's. 0·25 inch mounting, 0·16 inch lens. Typical parameters 2V, 20M amps all type. Supplied complete with snap in mountings and data. Red 4 for **£1,** Green 3 for **£1,** Yellow 3 for **£1.** Post 5p. (in order) **(£1).**

VERY SPECIAL OFFER
MINIATURE ROLLER MICRO SWITCH.



5 amp. c/o contacts. Mfg. BONNELLA. NEW. Price 10 for **£1·50.** Post 10p. (Min. order 10).

INSULATION TESTERS ***NEW!***

Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L.8in, W.4in, H.6in, weight 6lb. **1,000V,** 1,000 megohms, **£34.** Post 60p. **500V,** 500 megohms, **£28.** Post 60p.

24 VOLT DC SOLENOIDS
UNIT containing 1 heavy duty solenoid approx. 25lb pull 1 inch travel. Two × approx. 1lb pull ½ inch travel. 6 × approx. 4oz. pull ½ inch travel. One 24 volt d.c., 1 heavy duty single make relay. Price **£2·50 P+p 60p.**
ABSOLUTE BARGAIN.

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SWR METER Model SWR3
Handy SWR meter for transmitter antenna alignment, with built-in field strength meter. Accuracy 5%, Impedence 52' Indicator 100uA DC. Full scale 5 section collapsible antenna. Size 145 x 50 x 60mm.
OUR PRICE £4.25 P&P 25p

AT201 Decade ATTENUATOR
Frequency range 0–200kHz. Attenuator 0–111dB, 0.1dB steps. Impedence 600 ohms. Input power maximum 30dBm. Size: 180 x 90 x 55mm.
OUR PRICE £12.50 P&P 37p

TRANSISTORISED L.C.R. A.C. BR/8 MEASURING BRIDGE
A new portable bridge offering excellent range and accuracy at low cost. Resistance: 6 ranges: 0.1 ohm-11.1 megohm ± 1% Inductance: 6 ranges: 1 microhenry-111 henries ± 2% Capacity: 6 ranges 10pf-1110 mfd ± 2% Turns Ratio: 6 ranges 1:1/1000-1 11100 ± 1% Bridge Voltage at 1,000cps. Operated from 9-volt battery. 100 micro-amp meter indication. Size 7¼" x 5" x 2"
OUR PRICE £25.00 P&P 25p

TE16A TRANSISTORISED SIGNAL GENERATOR
5 ranges, 400kHz to 30 MHz. An inexpensive instrument for the handy-man. Operates on 9V battery. Wide easy to read scale. 800kHz modulation. Size: 149 x 149 x 92mm. Complete with instructions and leads.
OUR PRICE £8.97 P&P 25p

MODEL TE20 RF SIGNAL GENERATOR
Six bands. 120kHz–260MHz. Dual output RF terminals. Separate variable audio output. Accuracy ± 2%. Audio output to 8V. Power requirements: 105–125V, 220–240V AC. Size: 193 x 265 x 150mm. Complete with test leads etc.
OUR PRICE £17.50 P&P 40p

TE-200 RF SIGNAL GENERATOR
Accurate wide range signal generator covering 120 kHz-500 MHz on 6 bands. Directly calibrated. Variable R.F. attenuator audio output. Xtal socket for calibration. 220/240V a.c. Brand new with instructions. Size 140mm x 215mm x 170mm.
OUR PRICE £17.50 P&P 30p

TE22 SINE SQUARE WAVE AUDIO GENERATOR
Sine 20cps to 200kHz on 4 bands. Square 20 cps to 30 kHz. Output Impedence 5000 Ohms. 200/250V AC operation. Supplied brand new guaranteed, with instruction manual and leads.
OUR PRICE £24.95 P&P 37p

ARF 300 AF/RF SIGNAL GENERATOR
All transistorised compact fully portable. AF sine wave 18Hz to 220 kHz. AF square wave 18Hz to 100k Hz. Output Square/Sine wave 10V. P-P RF 100kHz to 200MHz. Output 1V maximum. 220/240V AC operation. Complete with instructions and leads.
OUR PRICE £37.50 P&P 50p

Also see previous page

MODEL MG100 SINE SQUARE WAVE AUDIO GENERATOR
Range 19–220,000Hz Sine Wave 19–100,000 Hz Square Wave Output Sine or Square wave 10v P to P Size 180 x 90 x 90mm Operation 220/240v A.C.
OUR PRICE £19.95 P&P 37p

PS200 Regulated POWER SUPPLY UNIT
Solid state. Variable output 5–20V DC up to 2 Amp. Independent meters to monitor voltage and current. Output 220/240V AC. Size: 190 x 136 x 98mm.
OUR PRICE £19.95 P&P25p

POWER RHEOSTATS
High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing. ¼" diameter shafts. Bulk quantities available.

25 WATT 10/50/100/250/500/1000 Ohms £1.15 P&P 10p

50 WATT 10/25/50/250/500/1000/2500/5000 Ohms. £1.62 P&P 10p

100 WATT 1/10/25/50/100/250/500/1000/2500 Ohms £2.34 P&P 15p

YAMABISHI VARIABLE VOLTAGE TRANSFORMERS
Excellent quality at low cost. Input: 230V 50/60Hz. Output 0–260V.

MODEL S260 BENCH MOUNTING

		P&P
1A	£10.50	30p
2.5A	£12.00	35p
5A	£17.50	37p
8A	£30.35	50p
10A	£33.75	75p
12A	£29.50	75p
20A	£85.00	125p
25A	£95.00	130p
40A	£120.00	150p

MODEL S260B PANEL MOUNTING

1A	£10.00	30p
2.5A	£12.00	35p

BVD5 Vernier TUNING DIAL
App. 7:1 ratio planetary drive vernier dial. Log scale 0–180 degrees. Blank scales 1–5. Dial size 128 x 76mm. Overall size 190 x 117 x 41mm. deep including knob and coupling. ¼" diam. shaft
OUR PRICE £1.62 P&P 15p

240° Wide Angle 1mA METERS
MW 1–6 60x60mm £6.50 P&P 15p
MW 1–8 80x80mm £6.90 P&P 15p

CP110 CHASSIS PUNCH SET
Carefully machined top grade steel. Contains 1/2", 5/8", 3/4", 1" and 1 1/8" punches complete with gripper and accessories.
OUR PRICE £3.00 P&P 40p

HITACHI FLUORESCENT LANTERN L1901
A portable battery operated lantern ideal for home, motoring, camping etc. Approx. 10" tall. Provides brilliant light from 9 1.5v batteries (not supplied)
OUR PRICE £7.19 P&P 25p

KE630 3 Station INTERCOM
Master and two sub-stations. Can be used on desk or wall mounted. Complete with cable and batteries
OUR PRICE £5.25 P&P 50p

WALKIE TALKIES
LIMITED STOCKS

SKYFON 100mW
OUR PRICE £24.95 per pair
P302 Two Channel 300mW
OUR PRICE £52.50 per pair
P1003 Three Channel 1 Watt
OUR PRICE £71.25 per pair
P&P 50p per pair
N.B. Unlicenceable in U.K.

DT55G DIGITAL CLOCK MECHANISM
Features 24 hour alarm setting, on/off and auto alarm 'sleep' switch. Illuminated rotary dial with hours, minutes and seconds. Automatically turns off radio, TV, light etc. and with auto-switching will turn on again when required. 240V AC operation. Switch rating 250V–3 Amp.
OUR PRICE £5.95 P&P 30p

SINCLAIR IC12 INTEGRATED CIRCUIT AMPLIFIER
complete with printed circuit mounting board.
OUR PRICE £2.35 P & P 15p

LH02S STEREO HEADPHONES
Light weight headphones with padded ear pieces. 4/16 ohms 20–20,000Hz. Complete with 6' lead and plug.
OUR PRICE £1.97 P&P 30p

TE1018 Deluxe Mono High Impedence Headset.
Sensitive magnetic headset with soft ear pads. Impedence 2,600 ohms (600 ohms DC). Frequency response: 200–4,000Hz.
OUR PRICE £2.25 P&P 30p

TE1035 Stereo HEADPHONES
Low cost with excellent response. Foam rubber earcups. Adjustable headband. 8 ohms impedence. Frequency response 25Hz–18kHz. Complete with cable and stereo jack plug.
OUR PRICE £2.60 P&P 30p

SH8DV MONO/STEREO HEADPHONES
Volume control for each channel. 4/16 ohms impedence. Frequency response 20Hz–18kHz. Complete with 10ft. coiled lead and jack plug.
OUR PRICE £4.97 P&P 30p

BH001 HEADSET and Boom Microphone
Moving coil. Ideal for language teaching, communications etc. Headphone impedence 16 ohms. Microphone impedence 200 ohms.
OUR PRICE £5.95 P&P 30p

EMI LOUDSPEAKERS
Model 350 13 x 8" with single tweeter/crossover. 20–20,000Hz. 15 watts RMS. Available 8 or 15 ohms.
OUR PRICE £7.50 each P&P 37p
Model 450 13 x 8" with twin tweeter/crossover. 55–13,000Hz. 8 watts RMS. Available 8 or 15 ohms
OUR PRICE £3.62 each P&P 25p

SPECIAL PURCHASE LIMITED QUANTITY! Tannoy 12" DR/8 Bass Speakers
8 ohms. 30 watt Heavy duty, ideal for Hi-Fi P.A. Group
OUR PRICE £12.50
P&P 50p

SPECIAL BARGAIN! FERGUSON 3406 HI-FI SPEAKERS
High quality 2 way speaker systems. 25 Watts. 4–8 ohms. 40Hz–18kHz. Size: 560 x 340 x 255mm. approx. Wood grain finish with black fronts.
OUR PRICE £26.95 PR. P&P £1

SPECIAL BARGAIN !! STEREOSOUND SPEAKERS
Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size: 368 x 229 x 190mm. 8 ohms. 8 watts RMS, 16 watts peak. Complete with Din lead.
OUR PRICE £12.95 P&P 50p

FM TUNER CHASSIS
6 transistor high quality tuner. Size only 153 x 101 x 63mm 3 IF stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Covers 88–108MHz. Ready built, ready for use. Fantastic value for money.
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Stereo Multiplex Adaptor £5.95 extra

Model A1018 FM TUNER
6 transistor high quality unit—3 IF stages and double tuned discriminator. For use with most amplifiers. Covers 88–108MHz. Powered by 9V battery.
OUR PRICE £13.50 P&P 30p
Stereo multiplex adapter £5.95 extra.

SINCLAIR "SCIENTIFIC" CALCULATOR
8 digit display. Four functions plus logarithms to base 10, antilog, sine, cosine, tangent, arcSine, arcCosine and arcTangent. Complete with instructions, case and batteries. Rec. Price £49.00
OUR PRICE £44.50
P & P 25p plus VAT

SINCLAIR SYSTEM 2000 STEREO AMPLIFIER AND TUNER

AMPLIFIER
Amplifier output 8 watts per channel RMS. Distortion less than 0.06%. Silicon transistors. Two pick-up plus radio and tape inputs, tape output and scratch filter. Excellent Value.
OUR PRICE £28.50 P & P 60p

FM TUNER
Excellent selectivity and sensitivity. Twin dual-varicap tuning. 4 pole ceramic filter. 19 transistor stereo demodulator giving 40 dB separation. Distortion 0.2% output. Fantastic Value.
OUR PRICE £28.50 P & P 60p.

SINCLAIR Project 80 Modules

Z40 Power Amplifier	£5.45
Z60 Power Amplifier	£6.95
Stereo 80 Pre-Amplifier	£11.95
Active Filter Unit	£6.95
Project 805	£26.95
PZ5 Power Supply	£4.98
PZ6 Power Supply	£7.98
PZ8 Power Supply	£7.98
Transformer for PZ8	£4.05

SINCLAIR Project 80 Packages

2 x Z40/Stereo 80/PZ5	£25.00
2 x Z40/Stereo 80/PZ6	£27.75
2 x Z60/Stereo 80/PZ8	£30.45

POST & PACKING 35p each.

MP7 MIXER-PREAMPLIFIER
5 Microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. Size: 235 x 127 x 76mm. Inputs: Mics. 3 x 3mV 50k; 2 x 3mV 600 ohms. Phono. Mag. 4mV 50k; Phono Ceramic 100mV 1 Meg. Output 250mV 100k.
OUR PRICE £8.97 P&P 20p

JOSTY KIT HIGH QUALITY CONSTRUCTION KITS
WE ARE APPOINTED STOCKISTS AT ALL BRANCHES

All kits are complete with comprehensive easy to follow instructions and covered by full guarantee.

Post and Packing 15p per kit.

AF20 Mono amplifier	£4.80
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AF30 Mono pre-amplifier	£2.61
AF35 Emitter amplifier	£2.27
AF80 0.5W mic. amplifier	£4.22
AF305 Intercom	£9.52
AF310 Mono amplifier	£5.91
AT5 Automatic light control	£2.58
AT25 Window wiper robot	£5.82
AT30 Photo cell switch unit	£5.70
AT50 400W triac light dimmer/speed control	£4.80
AT56 2,200W triac light dimmer/speed control	£6.90
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GP304 Circuit board	£4.94
GP310 Stereo pre-amplifier for use with 2 x AF310	£21.27
GP312 Circuit board	£11.45
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HF65 FM transmitter	£2.70
HF75 FM receiver	£2.87
HF310 FM tuner	£15.81
HF325 Deluxe FM tuner	£24.12
HF330 Decoder (HF310/325)	£9.96
HF380 lw/vhf aerial amplifier	£4.94
HF395 broadband aerial amp.	£1.77
LF380 Quadraphonic device	£11.36
M160 Multi-vibrator	£1.71
M191 VU Meter	£4.55
M192 Stereo balance meter	£4.97
M1302 Transistor tester	£8.45
NT10 Stabilised power supply 100mA, 9V	£6.15
NT300 Stabilised p. supply	£12.51
NT305 Voltage converter	£4.50
NT315 Power supply 240V AC to 4,5/15V DC, 500mA	£9.57

Amateur Electronics by Josty-Kit, the professional book for the amateur—covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10 listed below.
OUR PRICE £3.30 (No VAT)
P&P 25p plus VAT.

AE1 100mW output stage	£1.50
AE2 Pre-amplifier	£1.15
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AE4 Flasher	99p
AE5 Astable multi-vibrator	95p
AE6 Monostable multi-vibrator	93p
AE7 RC generator	97p
AE8 Bass filter	90p
AE9 Treble filter	90p
AE10 CCIR filter	90p

1021 Stereo Listening Station
For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. Two gain controls, speakers on–off slide switch, stereo headphone socket.
OUR PRICE £2.25 P&P 15p

AUDIOTRONIC LOW NOISE CASSETTES

TYPE	5	10	25
C60	£1.57	£3.00	£7.08
C90	£2.24	£4.25	£10.00
C120	£2.73	£5.17	£12.24

AUDIOTRONIC CrO2 CASSETTES

TYPE	5	10	25
CR60	£3.92	£7.72	£19.12
CR90	£5.32	£10.46	£25.22

AUDIOTRONIC 8 TRACK CARTRIDGES

TYPE	Each	5	10
40M	85p	£4.00	£7.50
80M	£1.15	£5.40	£10.25

P&P Cassettes 3p, Cartridges 5p each OVER 10 of either POST FREE!

AUDIOTRONIC AHA101 Stereo Headphone Amplifier
All silicon, transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery. INPUTS: 5mV and 100mV. OUTPUT: 50mV per channel.
OUR PRICE £8.50 P&P 20p

EA41 REVERBERATION AMPLIFIER
Self contained, transistorised, battery operated. Simply plug in microphone, guitar etc. and output to your amplifier. Volume control and depth of reverberation control. Beau-walnut cabinet. 184 x 77 x 108mm.
OUR PRICE £7.50 P&P 20p

ALL PRICES EXCLUDE VAT

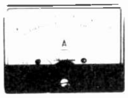
SEW CLEAR PLASTIC PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVERNMENT DEPARTMENTS, EDUCATIONAL AUTHORITIES ETC.

Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

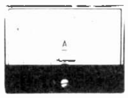
*Items with asterisk are Moving Iron type, all others are Moving Coil

CLEAR PLASTIC MODEL SD640
Size: 85 x 64mm



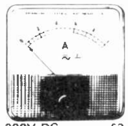
50uA	£3 80		
100uA	£3 75		
200uA	£3 70		
500uA	£3 65		
50-0-50uA	£3 75		
100-0-100uA	£3 70		
1mA	£3 65		
5mA	£3 65		
10mA	£3.65		
50mA	£3.65	10V DC	£3 65
100mA	£3.65	20V DC	£3 65
500mA	£3.65	50V DC	£3 65
1A DC	£3 65	300V DC	£3 65
5A DC	£3 65	15V AC	£3 75
10A DC	£3 65	300V AC	£3 75
5V DC	£3 65	VU Meter	£3 90

CLEAR PLASTIC MODEL SD830
Size: 110 x 83mm



50uA	£4 30		
100uA	£4 25		
200uA	£4 20		
500uA	£4 15		
50-0-50uA	£4 25		
100-0-100uA	£4 20		
1mA	£4 10		
5mA	£4 10		
10mA	£4 10		
50mA	£4 10	10V DC	£4 10
100mA	£4 10	20V DC	£4 10
500mA	£4 10	50V DC	£4 10
1A DC	£4 10	300V DC	£4 10
5A DC	£4 10	15V AC	£4 20
10A DC	£4 10	300V AC	£4 20
5V DC	£4 10	VU Meter	£4 40

CLEAR PLASTIC MODEL MR 65P
Size: 86 x 78mm

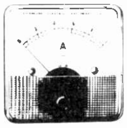


50uA	£3 95		
100uA	£3 85		
200uA	£3 80		
500uA	£3 75		
50-0-50uA	£3 85		
100-0-100uA	£3 80		
500-0-500uA	£3 70		
1mA	£3 70		
1-0-1mA	£3 70		
5mA	£3 70		
10mA	£3 70	300V DC	£3 70
50mA	£3 70	15V AC	£3 80
100mA	£3 70	50V AC	£3 80
500mA	£3 70	150V AC	£3 80
1A DC	£3 70	300V AC	£3 90
5A DC	£3 70	500V AC	£3 80
10A DC	£3 70	S Meter 1mA	£4 10
15A DC	£3 70	VU Meter	£3 70
20A DC	£3 80	1A AC	* £3 70
30A DC	£3 85	5A AC	* £3 70
50A DC	£4 05	10A AC	* £3 70
5V DC	£3 70	20A AC	* £3 70
10V DC	£3 70	30A AC	* £3 70
15V DC	£3 70	50mA AC	* £3 70
20V DC	£3 70	100mA AC	* £3 70
50V DC	£3 70	200mA AC	* £3 70
150V DC	£3 70	500mA AC	* £3 70

CLEAR PLASTIC MODEL SW100
Size: 100 x 80mm

50uA	£4 60		
100uA	£4.50		
500uA	£4 30		
50-0-50uA	£4.50		
100-0-100uA	£4.45		
1mA	£4 30		
1A DC	£4 30		
5A DC	£4 30		
20V DC	£4 30	150V AC	£4 45
50V DC	£4 30	300V AC	£4 45
300V DC	£4 30	VU Meter	£4 90

CLEAR PLASTIC MODEL MR 45P
Size: 50 x 50mm

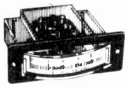


50uA	£3 20		
100uA	£3 15		
200uA	£3 10		
500uA	£3 00		
50-0-50uA	£3 15		
100 0 100uA	£3 10		
500-0-500uA	£2 95		
1mA	£2 95		
5mA	£2 95		
10mA	£2 95		
50mA	£2 95		
100mA	£2 95		
500mA	£2 95	300V AC	£3 05
1A DC	£2 95	S Meter 1mA	£2 95
5A DC	£2 95	VU Meter	£3 40
10V DC	£2 95	1A AC	* £2 95
20V DC	£2 95	5A AC	* £2 95
50V DC	£2 95	10A AC	* £2 95
300V DC	£2 95	20A AC	* £2 95
15V AC	£3 05	30A AC	* £2 95

BAKELITE MODEL S80 Enlarged Window
Size: 80 x 80mm

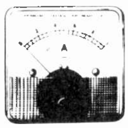
50uA	£4 50
100uA	£4 45
500uA	£4 20
50-0-50uA	£4 45
100-0-100uA	£4 40
1mA	£4 20
1A DC	£4 20
5A DC	£4 20
20V DC	£4 20
50V DC	£4 20
300V DC	£4 20
300V AC	£4 30
VU Meter	£4 70

EDGWISE MODEL PE70
Size: 90 x 34mm



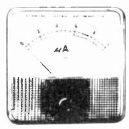
50uA	£4 15
100uA	£4 10
200uA	£4 05
500uA	£3 90
50-0-50uA	£4 10
100-0-100uA	£4 05
1mA	£3 85
300V AC	£3 95
VU Meter	£4.30

CLEAR PLASTIC MODEL MR 38P
Size: 42 x 42mm



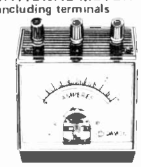
50uA	£3 10		
100uA	£3 05		
200uA	£3 00		
500uA	£2 85		
50 0-50uA	£3 05		
100-0-100uA	£3 00		
500-0-500uA	£2 80		
1mA	£2 80		
1 0-1mA	£2 80		
2mA	£2 80		
5mA	£2 80		
10mA	£2 80		
20mA	£2 80		
50mA	£2 80	20V DC	£2 80
100mA	£2 80	50V DC	£2 80
150mA	£2 80	100V DC	£2 80
200mA	£2 80	150V DC	£2 80
300mA	£2 80	300V DC	£2 85
500mA	£2 80	500V DC	£2 85
750mA	£2 80	750V DC	£2 90
1A DC	£2 80	15V AC	£2 90
2A DC	£2 80	50V AC	£2 90
5A DC	£2 80	150V AC	£2 90
10A DC	£2 80	300V AC	£2 90
3V DC	£2 80	500V AC	£3 00
10V DC	£2 80	S Meter 1mA	£2 80
15V DC	£2 80	VU Meter	£3 20

CLEAR PLASTIC MODEL MR 52P
Size: 60 x 60mm



50uA	£3 70		
100uA	£3 50		
500uA	£3 35		
50-0-50uA	£3 50		
100 0-100uA	£3 45		
1mA	£3 30		
5mA	£3 30		
10mA	£3 30		
50mA	£3 30		
100mA	£3 30		
500mA	£3 30		
1A DC	£3 30		
5A DC	£3 30	S Meter 1mA	£3 30
10V DC	£3 30	VU Meter	£3 80
20V DC	£3 30	1A AC	* £3 30
50V DC	£3 30	5A AC	* £3 30
300V DC	£3 30	10A AC	* £3 30
15V AC	£3 40	20A AC	* £3 30
300V AC	£3 40	30A AC	* £3 30

MODEL ED107 EDUCATIONAL METER
Size: 100 x 90 x 150mm including terminals



A range of high quality moving coil instruments ideal for school experiments and other bench applications. 3" mirror scale. The meter movement is easily accessible to demonstrate internal working.

50uA	£8 50		
100uA	£7 90		
50-0-50uA	£7 90	20V DC	£7 60
1mA	£7.60	50V DC	£7 60
1-0-1mA	£7 60	300V DC	£7 60
1A DC	£7 60	500mA/5A DC	£8 60
5A DC	£7 60	5V/50V DC	£8 60
5V DC	£7.60	5V/15V DC	£8 60
10V DC	£7 60	1/5A DC	£8 60
15V DC	£7 60	1A/15A DC	£8 60

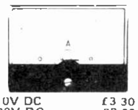
BAKELITE MODEL MR 65
Size: 80 x 80mm

25uA	£5 25		
50uA	£4 00		
100uA	£3 95		
500uA	£3 65		
50 0-50uA	£3 95		
100-0-100uA	£3 90		
500-0-500uA	£3 60		
1mA	£3 60		
1-0-1mA	£3 60		
5mA	£3 60		
10mA	£3 60		
50mA	£3 60	300V DC	£3 60
100mA	£3 60	30V AC	* £3 60
500mA	£3 60	50V AC	* £3 60
1A DC	£3 60	150V AC	* £3 60
2A DC	£3 60	300V AC	* £3 60
5A DC	£3 60	500V AC	* £3 60
10A DC	£3 60	VU Meter	£4 10
15A DC	£3 60	1A AC	* £3 60
30A DC	£3 60	5A AC	* £3 60
50A DC	£3 80	10A AC	* £3 60
5V DC	£3 60	20A AC	* £3 60
10V DC	£3 60	30A AC	* £3 60
15V DC	£3 60	50A AC	* £3 60
20V DC	£3 60	500mA AC	* £3 60
50V DC	£3 60	50mV DC	£3 75
150V DC	£3 60	100mV DC	£3 75

CLEAR PLASTIC MODEL MR 85P
Size: 120 x 110mm

50uA	£5 45		
100uA	£5 40		
200uA	£5 35		
500uA	£5 25		
50-0-50uA	£5 40		
100-0-100uA	£5 35		
500-0-500uA	£5 20		
1mA	£5 20		
1-0-1mA	£5 20		
5mA	£5 20		
10mA	£5 20		
50mA	£5 20		
100mA	£5 20	300V DC	£5 20
500mA	£5 20	15V AC	£5 30
1A DC	£5 20	300V AC	£5 30
5A DC	£5 20	S Meter 1mA	£5 20
15A DC	£5 20	VU Meter	£5 55
30A DC	£5 40	1A AC	* £5 20
10V DC	£5 20	5A AC	* £5 20
20V DC	£5 20	10A AC	* £5 20
50V DC	£5 20	20A AC	* £5 20
150V DC	£5 20	30A AC	* £5 20

CLEAR PLASTIC MODEL SD460
Size: 59 x 46mm



50uA	£3 50		
100uA	£3 45		
200uA	£3 40		
500uA	£3 35		
50-0-50uA	£3 45		
100-0 100uA	£3 40		
1mA	£3 30		
5mA	£3 30		
10mA	£3 30		
50mA	£3 30	10V DC	£3 30
100mA	£3 30	20V DC	£3 30
500mA	£3 30	50V DC	£3 30
1A DC	£3 30	300V DC	£3 30
5A DC	£3 30	15V AC	£3 45
10A DC	£3 30	300V AC	£3 45
5V DC	£3 30	VU Meter	£3 65

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87 TOTTENHAM CT. RD.	01-580 3739
257/8 TOTTENHAM CT. RD.	01-580 0670
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193 EDGWARE RD. W2	01-723 6211
207 EDGWARE RD. W2	01-723 3271
311 EDGWARE RD. W2	01-262 0387
346 EDGWARE RD. W2	01-723 4453
382 EDGWARE RD. W2	01-723 4194
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Signature

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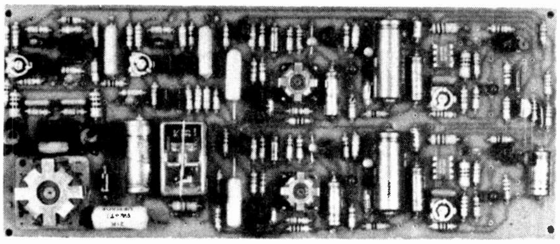


PHONOSONICS

PCB's AND KITS

HI-FI TAPE LINK
(PE Mar./Apr. 73) S/c's. i c's. Rs. Cs. Relay and pc-base. Pot Cores and pc-bases. Sw's. Pots. Panel Lamp—Mono. £12·78; Stereo. £20·41. PSU. £3·58. Main Circuit PCB (3½in × 9in) Stereo (also holds relay and cores). £2·10. Sub-assembly PCB (2½in × 6½in). Stereo 80p.

BIOLOGICAL AMPLIFIER
(PE Jan./Feb 73) P/A Set—S/c's. i.c's. Rs. Cs. Pots. PCB. £3·46. Output Stages—S/c's. Rs. Cs. Pots. Rotary Sw's and PCBs for Alphaphone. Cardio. Freq-Meter. Vis-Feed. £4·96. Audio Amps: PC7. £5·20; EA1000. £3·30.

ENLARGER EXPOSURE METER AND THERMOMETER
(PE Sept 73) S/c's. Thermistor. LDR Rs. Pots. PCB. £3·90.

ELECTRONIC PIANO
(PE Sept. 72/Jan. 73) Details in lists

GEMINI STEREO AMPLIFIER
(PE Nov 70/Mar 71) Stereo Sets and PCBs Pre-amp—Rs. Cs. Pots. Sw s—with ½W MO Rs £14·18—with ¼W CF Rs. £10·40. PCB as published. £2·20. Main Amp—Rs. Cs. Pots. £5·88. PCB (3½in × 5in). £1·28. Power supply—Rs. Cs. Pot. £4·56. PCB (2in × 4in). 65p.

AUDIO MILLIVOLTMETER
(PE Feb 74). S/c's. Rs. Cs. Pots. Sw's PCBs. £4·95.

MICROPHONE MIXER
(PE Apr. 69). S/c's. Rs. Cs. Pots. PCB (also holds pots). £4·12. While Stocks Last

8 WATT AMPLIFIER
(PW Nov./Dec. 72) Pre-amp—S/c s Rs Cs Pots. Sw—Mono. £2·50; Stereo. £6·03. PCB (3½in × 7½in) (Stereo) also holds rotary or slider pots and Sw. £1·66. Main Amp—S/c s. Rs. Cs. Pot—Mono. £4·18. Stereo. £8·36. PCB (2½in × 3in) (Mono). 72p. PSU. £3·90.

SOUND SYNTHESISER
(PE Feb. 73/Feb. 74)
RHYTHM GENERATOR
(PE Mar./June 74)
SOUND BENDER
(PE May 74)
Details of all these in List

REVERBERATION UNIT
(PW Nov./Dec. 72) S/c s. Rs. Cs T/former—with Rotary Pots. £6·44 PCB (2in × 11½in). £1·40. 9in Spring Unit. £4·50.

LOUDHAILER AND SIREN
(PW Dec 72) Pre-amp and Siren Generator—S/c's. Rs. Cs. Pot. PCB (2½in × 2½in). £2·20. While Stocks Last Main Amp Module PC5. £6·25.

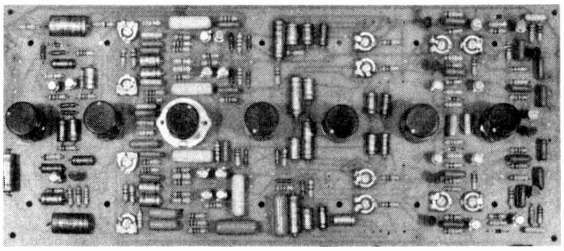
MISCELLANEOUS PCBs (While Stocks Last)
LOGICAL RADIO CONTROL (PE Dec 71/Jan. 72) PCBs "2A", "2B", 50p each
MODEL SERVO CONTROL (PE Feb./Mar. 72) PCBs "B", Fail-safe. 33p each
DIGICAL PSU PCB (PE Aug 72). 50p. OSCILLOSCOPE P/A PCB (PE Aug 72) 33p.
GEMINI STEREO TUNER PCB (PE Apr 72), £1·50. TRIFFID PCB (PE Feb 73) 60p.
(The above PCBs are as published)
DIGITRONIC (PW Mar. 73) Read-out PCB (1½in × 3½in). 50p. CALLERCORD (PE Jul 72) Main Control PCB (4in × 7½in)

PHOTOPRINT PROCESS CONTROL
(PE Jan./Feb. 72) For Colour and B & W—finds exposure, controls timing, stabilises mains voltage. S/c's. SCR. LDR. Rs. Cs. Pots. Relay. Keyswitch. T/fmr. £7·98. PCB (3½in × 5½in) also holds pots. Sw. relay. £1·60.

RONDO
(PE Sept 73/Feb 74) Details in List

PROJECT Q4
(PW Oct 73/Jan 74) Multisystem Quadraphonic Decoder. S/c's. I/c's. Rs. Cs. Pots. Makeswitches. £12 48 PSU. £3·17. Set of PCBs. £2·60.

PHASING UNIT
(PE Sept 73) S/c's. Rs. Cs. Pots. PCB (1½in × 2½in). £2·20.



AURORA
(PE Apr./Aug 71) Multichannel Sound Controlled Light S/c s (Excl SCRs). Rs. Cs. Pots. Cores—Pre-amp. Sync Generator and 4 Chans. £10·97; 4 extra chans. £8·35. Reg PSU. £4·32. PCB (4½in × 10½in) for Pre-amp and 4 Chans (also holds pots). £2·50. PCB (4½in × 5in) for Sync. Gen PSU. 8 cores. 8 SCRs. £1·25.

AURORA AUXILIARY CONTROL UNIT
2 Variable Frequency Strobe Generators and 4 Variable Amplitude Frequency Generators S/c s. Rs. Cs. Pots. PCB (3½in × 5½in). £4·87.

SEMICONDUCTOR TESTER
(PE Oct 73) S/c's. Rs. Cs. Pots. Makeswitches. Sub-assembly PCB. £5·30.

ULTRASONIC TRANSMITTER-RECEIVER
(PE May 72) S/c s. Rs. Cs. Pot. Relay. Dual PCB (2in × 5½in). £4·40. Transducers excluded.

VIBRASONIC GUITAR PRE-AMP
(PW Sept 70) Incl. Mic P/A. 2-Guitar P/A. Trem and Tone Controls. Master Volume S/c's. Rs. Cs. LDR. Rotary Pots. Lamps. Coupling T/fmr. £7·64. PCB (3½in × 10½in) also holds pots. £1·92. Power Supply. £3·90.

TAPE NOISE LIMITER
(PE Feb 72) S/c's. Rs. Cs. Pot. Sw. PCB (1½in × 3in). £2·30. Reg PSU and PCB (1½in × 2½in). £3·40.

VERSATILE LIGHT EFFECTS UNIT
Single Channel Sound Controlled Light with built-in variable strobe. (PE Jun 72). S/c's. Rs. Cs. Pots. T/fmrs. Keyswitch. £11·28. PCB (3½in × 7½in) also holds pots and switch. £1·70. SCRs excluded

VOICE OPERATED FADER
(PE Dec 73) S/c's. Rs. Cs. Pot. PCB (1½in × 3½in). £2·95.

WIND AND RAIN EFFECTS
(PE Oct 73) S/c's (incl special noise diode). Rs. Cs. Pots. £1·95.

RESISTORS
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½W 5% 4E7
to 2M2 then 10% to
10M
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STOCKS
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SEMICONDUCTORS

AC128	20p	2N2905	27p
AC176	20p	2N2907	22p
AD161	40p	2N3702	12p
BC107	13p	2N3703	12p
BC108	13p	2N3704	12p
BC109	13p	2N3819	35p
BC147	12p	2N3823E	39p
BC148	12p	2N4871	36p
BC149	12p		
BC157	12p		
BC158	12p		
BC159	12p		
BC182L	12p		
BC204	14p		
BC209c	14p		
BC212L	15p		
BCY71	22p		
BFY50	22p		
BFY52	23p		
BSY95A	12p		
MJE2955	110p		
MJE3055	75p		
NKT0033	112p		
OC28	65p		
OC71	14p		
OC84	25p		
ORP12	55p		
TIS43	30p		
2N706	13p		
2N914	22p		
2N1304	22p		
2N2219	27p		

DIODES

1N916	4p
1N4001	6p
1N4002	7p
1N4004	8p
1N4005	8p
BA145	23p
OA91	7p
OA200	8p
1GP7	12p
1SJ50	11p

INTEGRATED CIRCUITS

709 TO5	40p	7447	175p
723 TO5	95p	7473	44p
741 8P DIL	40p	7489	432p
747 14P DIL	115p	7815 TO220	220p
748 TO5	63p	CA3046	69p
7400	20p	PA263	168p
7402	20p	SG3402N	169p
7420	20p		

ELECTROLYTIC (µF/V)

0 47 63	6p	100 10	6p
1 0.63	6p	100/25	6p
2 2/63	6p	100 40	7p
4 7 35	6p	100 63	12p
4 7 63	6p	150 16	6p
6 8 40	6p	150 63	12p
10 25	6p	220 10	6p
10 63	6p	220/16	6p
15 40	6p	220 25	10p
22/10	6p	220 40	14p
22/25	6p	220 63	21p
33 6 3	6p	330 10	6p
33 16	6p	470 6 3	6p
33 40	6p	470 10	10p
33 50	6p	470 25	14p
47 25	6p	470 40	20p
47 40	6p	500 64	46p
47 63	7p	680/6 3	10p
50/6 4	6p	680 25	20p
		680 40	25p
		1000 10	14p
		1000 16	25p
		1000 25	25p
		1000 40	40p
		2200 25	45p
		2200 40	50p
		2800 100	350p
		3300 63	133p
		3300 100	350p
		4700 16	60p
		4700 25	75p
		4700 40	93p

POLYESTER (µF)

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0 015	3p
0 022	3p
0 033	3½p
0 047	3½p
0 068	3½p
0 1	4p
0 15	5p
0 22	5p
0 33	7p
0 47	9p
0 68	11p
1 0	14p

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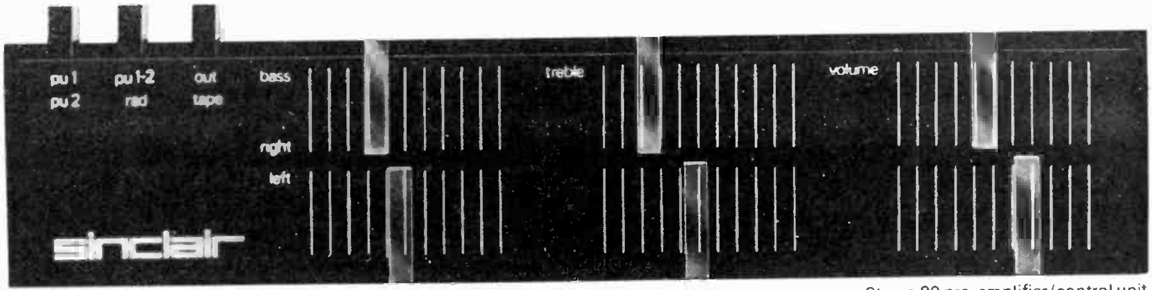
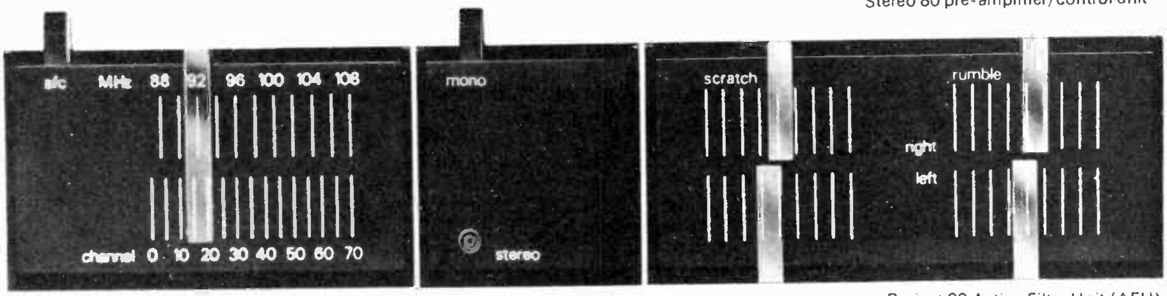


Stereo 80 pre-amplifier/control unit



Project 80 tuner — Stereo decoder — Project 80 Active Filter Unit (AFU)

only $\frac{3}{4}$" deep x 2" high

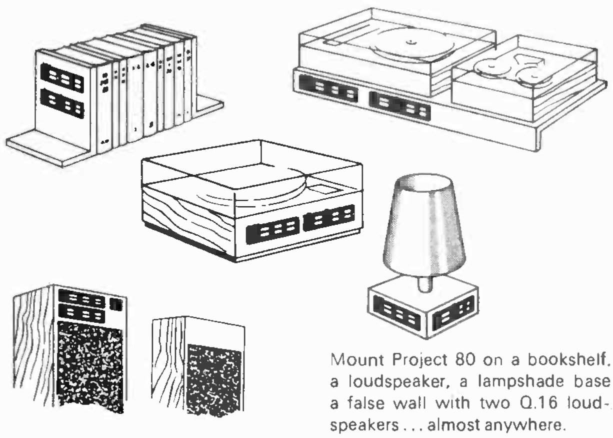
Living with hi-fi takes on new meaning with Sinclair Project 80. The electronics of these revolutionary new modules are all contained within elegantly designed matching cases no more than three-quarters of an inch deep. They are designed for mounting on any appropriate flat surface by means of 6BA bolts extending from the rear of each module and which pass through suitably drilled holes. Connections are taken away out of sight in a similar manner. The possibilities opened up by Project 80 are endless – superb hi-fi systems can be installed in ways hitherto only dreamed about and never before made practical. No more cutting out and shaping to put modules in position. A few holes drilled with the aid of templates supplied and the job is done. Now you need never again be faced with problems of keeping the hi-fi from clashing with carefully thought-out furnishing schemes. (That will surely please wives!) Slider controls have been introduced in place of knobs and all modules in the range incorporate new up-dated circuitry with emphasis on performance standards and built-in protection against overload and shorting. The aim was to re-think modular construction completely – to make it infinitely more versatile, even simpler and more reliable – the result – Project 80 – another triumph for Sinclair, and the most exciting construction modules ever.

the slimmest, most elegant hi-fi modules ever made

Typical Project 80 applications

System	The Units to use	Units cost
Simple battery record player	Z.40	£5·45 +54p V.A.T.
Mains powered record player	Z.40, PZ.5	£10·43 +£1.04 V.A.T.
30W. RMS continuous sine wave stereo amp.	2 × Z.40s, Stereo 80; PZ.6	£30·83 +£3.08 V.A.T.
50W (8 Ω) RMS continuous sine wave de luxe stereo amp.	2 × Z.60s, Stereo 80; PZ.8	£33·83 +£3.38 V.A.T.
Indoor P.A.	Z.60, PZ.8	£14·93 +£1.49 V.A.T.

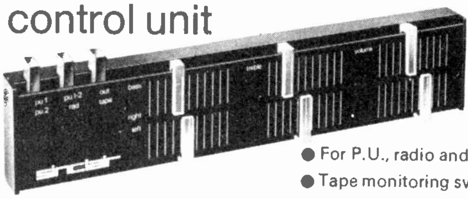
Project 80 FM tuner, decoder, and A.F.U. may be added as required



Mount Project 80 on a bookshelf, a loudspeaker, a lampshade base a false wall with two Q.16 loudspeakers . . . almost anywhere.

new thinking in modular hi-fi

Stereo 80 pre-amplifier and control unit



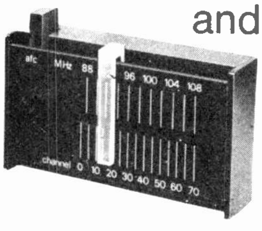
- For P.U., radio and tape
- Tape monitoring switch
- Simplest ever fixing

Each channel has its own separate tone and volume controls operated by sliders, enabling ideal environmental matching to be obtained. A virtual earth input stage forms part of the up-dated circuitry that ensures the finest possible quality from all signal sources. Generous overload margins are allowed on all inputs. Clear instructions with template are supplied.

TECHNICAL SPECIFICATIONS
Size – 260 × 50 × 20mm (10¼ × 2 × ¾ins)
Finish – Black with white indicators and transparent Sliders
Inputs – Magnetic pick-up 3mV RIAA corrected; Ceramic pick-up 300mV
Radio 300mV; Tape 30mV
Signal/noise ratio – 60dB
Frequency range – 20Hz to 15KHz ± 1dB. 10Hz to 25KHz ± 3dB
Power requirements – 20 to 35 volts
Outputs – 100mV + AB monitoring for tape
Controls – Press button for tape radio and P.U. Sliders for volume, bass (+ 12dB to – 14dB at 100Hz) treble (+ 11dB to – 12dB at 10KHz)

R.R.P. **£11.95** +£1·19 V.A.T.

Project 80 FM tuner and stereo decoder



- Twin dual varicap tuning: 4 pole ceramic filter: switchable A.F.C.
- On the decoder, solid state stereo indicating beacon.

Making the Project 80 F.M. tuner and decoder available separately gives a wider choice of systems and saves money where stereo reception may not be required. The tuner is a triumph of electronic design and assures excellent performance. The decoder gives a 40dB channel separation with 150mV output per channel. Both units may be used with other than Project 80 systems.

TECHNICAL SPECIFICATIONS OF TUNER
Size – 85 × 50 × 20mm (3½ × 2 × ¾ins)
Tuning range – 87·5 to 108 MHz
Detector – I.C balanced coincidence for good A.M. rejection
One I.C. equal to 26 transistors
Distortion – 0·2% at 1KHz for 30% modulation
4 pole ceramic filter in I.F. section
Aerial impedance – 75 Ω or 240-300 Ω
Sensitivity – 4 microvolts for 30dB quieting
Output – 300 mV for 30% modulation
Power requirements – 23 to 33 volts

R.R.P. **£11.95** +£1·19 V.A.T.

DECODER
Size – 47 × 50 × 20mm (1⅞ × 2 × ¾ins)
One 19 transistor I.C.

R.R.P. **£7.45** +0·74 V.A.T.

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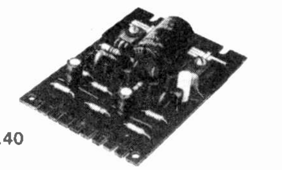
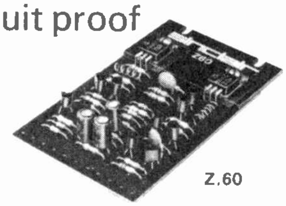


Z.40



Z.60

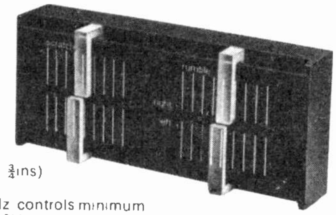
Intended for use in Project 80 installations, these modules readily adapt to an even wider range of applications. Both incorporate built-in protection against short circuiting and risk of damage from mis-use is greatly reduced.

Z.40 TECHNICAL SPECIFICATIONS
Size – 55 × 80 × 20mm (2¼ × 3¼ × ¾ins) 9 transistors
Input sensitivity – 100mV
Output – 15 watts RMS continuous into 8 Ω (35v)
Frequency response – 10Hz – 100KHz ± 1dB
Signal/noise ratio – 64dB
Distortion – at 10 watts into 8 Ω less than 0 1%
Power requirements – 12 to 35 volts

Z.60 TECHNICAL SPECIFICATIONS
Size – 55 × 98 × 15mm (2¼ × 3¾ × ¾ins) 12 transistors
Input sensitivity – 100-250mV
Output – 25 watts RMS continuous into 8 Ω (45V).
Distortion – typically 0·03%
Frequency response – 10Hz to more than 200KHz ± 1dB
Signal/noise ratio – better than 70dB
Built-in protection against transient overload and short circuiting
Load impedance – 4 Ω min. max safe on open circuit

Z.40 R.R.P. **£5.45** + 0·54 V.A.T., **Z.60** R.R.P. **£6.95** + 0·69p V.A.T.

Project 80 active filter unit



Makes a highly desirable part of any worthwhile system where inputs may be from record, radio or tape. As with Stereo 80, separate controls applied to each channel make it easier to obtain ideal stereo balance.

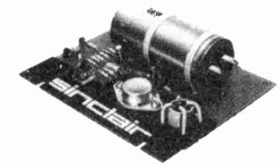
TECHNICAL SPECIFICATIONS
Size – 108 × 50 × 20mm (4¼ × 2 × ¾ins)
Voltage gain – minus 0·2dB
Frequency response – 36Hz to 22KHz controls minimum
Distortion – at 1KHz – 0·03% using 30V supply
HF cut off (scratch) – 22KHz to 5·5KHz, 12dB/oct. slope
L.F. cut off (rumble) – 28dB at 20Hz, 9dB/oct slope

- For scratch and rumble control
- Transistorised active circuitry

R.R.P. **£6.95** +0·69 V.A.T.

Power supply units

PZ.8



Stabilised. Re-entrant current limiting makes damage from overload or even direct shorting impossible. Normal working voltage (adjustable) 45V.

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PZ.6 35V. stabilised
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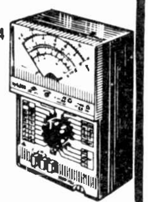

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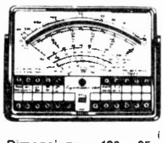

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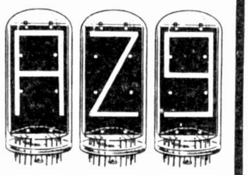

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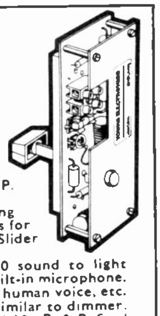

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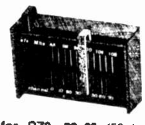

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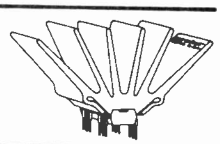

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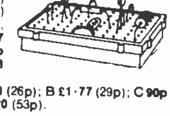

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