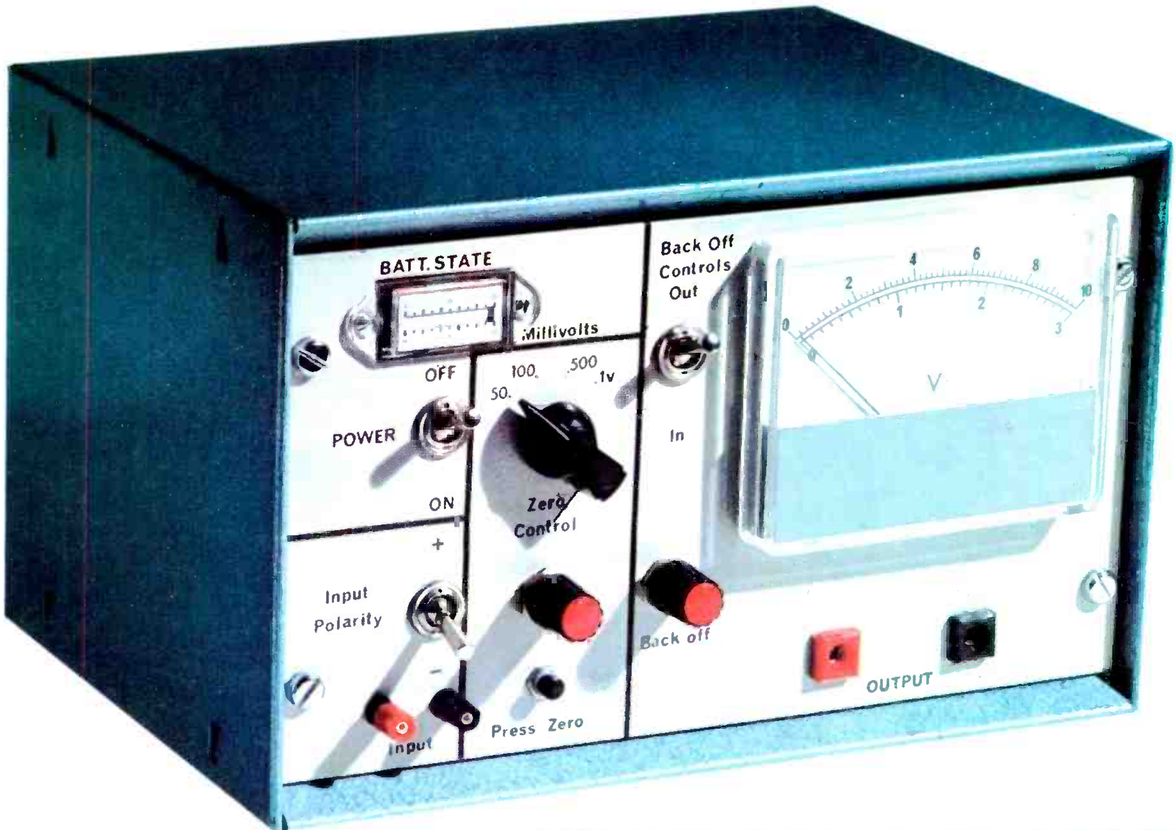
PRACTICAL

ELECTRONICS

AUGUST 1974

25p

OPEN THE DOOR TO LOW COST SCIENTIFIC EXPERIMENTS...



...WITH OUR HIGH IMPEDANCE VOLTMETER

FOR UNDERWATER PHOTOGRAPHY

SUB-AQUA COLOUR TEMPERATURE INDICATOR

PRACTICAL
ELECTRONICS
VOLUME 10 No. 8 AUGUST 1974

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our September issue will be published on Friday, August 9, 1974

Henry's

**DON'T RELY ON YOUR MEMORY
BUY NOW AT BARGAIN PRICES**
*Hi Fi and Transistors – Up to date
Brochures on request*

HENRY'S CATALOGUE
Due to rapid price changes, shortages of paper and raw materials, all prices in the existing catalogues no longer apply. Call or phone for latest prices. A new catalogue will be available for Aug/Sept. 1974.

UK's LARGEST RANGE OF KITS & GADGETS

TEST EQUIPMENT MULTIMETERS

(carr. etc. 30p)
ITI-2 20K/Volt Slimline £5·95
M210 (Case £1·25) 20K/Volt
Slimline deluxe £6·75
TLH33D 2K/Volt Robust £7·50
U4323 (+IF 8AF OSC) £7·00
AF105 (Case £1·90) 50K/Volt £12·50
U4313 20K/Volt AC current. Steel case £10·50
U4341 Plus Built-in transistor tester £10·50
Model 500 (Case £2·25). 30K/Volt £11·75

OTHER EQUIPMENT

SE250B Pocket Signal Injector 2·25 carr. 15p
TE15 Grid Dip meter 440kHz 280mHz 16·50 carr. 30p
TE40 AC Millivoltmeter 1·2mHz 19·75 carr. 35p
TE65 28 Range valve voltmeter 22·50 carr. 40p
TE20D 120kHz-500mHz RF Gen. 18·95 carr. 40p
TE22D 20Hz-200kHz Audio Gen. 19·95 carr. 40p
SE350A Deluxe Signal Tracer 12·95 carr. 20p
SE400 Volts/ohms/R-C sub./RF field/RF gen. 15·50 carr. 20p

New Revolutionary Supertester 680R

680R Multi-tester £18·50

Accessories	
Transistor tester	11·00
Electronic voltmeter	18·00
Ampclamp	11·95
Temperature probe	11·95
Gauss meter	11·95
Signal injector	5·95
Phase Sequence	5·95
EHT Probe	5·95
Shunts 25/50/100A	4·50

A SELECTION OF INTERESTING ITEMS

C3025 Compact transistor tester 6·95 p & p 15p
Q4002 Photoelectric System £13·70
E1310 Stereo mag. cart. preamp. 4·80 p & p 25p
Easiphone D1201 telephone amp 7·50 p & p 25p
D1203 Teleamp. with PU coil 4·95 p & p 20p
LL1 Door Intercomm. and chime 8·40 p & p 25p
9" Twin spring unit For 3·30 p & p 15p
16" Twin spring unit Reverbs 6·85 p & p 25p
US50 Ultrasonic Switch Trans/Rec £12·75
C3041 1-250mHz £4·25
C3043 SCH 1-300mHz £5·75
VHF 105 Aircraft Band Convertor 4·50 p & p 15p
B2005 4 Ch. mic. mixer 4·20 p & p 15p
B2004 2 ch. Stereo mixer 6·75 p & p 15p
PK3 Kit £1·95 p & p 20p

EXCLUSIVE: SPECIAL OFFERS

MW/LW CAR RADIO + or – Earth with speaker and fixings. £6·50 c/p 30p. 8 TRACK CAR STEREO (– Earth) with speakers in Pods and fixings £12·50 c/p 40p. Portable Batt/Cass Tape Player £7·25. Car Lighter Plug and adaptor for all cassette and radio 6/7½/9 V output (state width) £1·95 each. Rotel Stereophones RH630 £6·80. RH700 £10·25. RH430 £4·14. Rotel RA310 15+15 watt Stereo Amplifier (List £52·00) £34·52. Wem W500 Battery/Mains Cassette Recorder £12·75.

PORTABLE CASSETTE TAPE PLAYER—for car or carry around. £7·25 c/p. 20p. HANIMAX BC808 POCKET CALCULATOR WITH % KEY. £28·95. HANIMAX BC811M MEMORY VERSION £33·75 *BC807 √ key £22·95 *BCM850 √ key + memory £33·95. *MAINS UNIT £3·25 EXTRA. HANIMAX H101 STEREO COMPACT RECORD PLAYER 2 × 7 watts. Complete with Speakers (List £54·50) Price £39·95 Plus free pair of stereo phones.

BUILD THIS RADIO

Portable MW/LW radio kit using Mullard RF/IF module. Features MW—bandspread for extra selectivity. Slow motion tuning. Fibre glass PVC cabinet. 600MW output. All parts £7·98 (battery 22p), carr. etc. 32p.

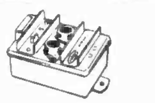
FIBRE OPTICS
0·01 diam. Mono Filament £5·50 per 100 metre reel
0·13 diam. 64 Fibres Sheathed £1·00 per metre.
SPRAYS 15mm diam. (Mare's Tail Spray £10·50.)

SPECIAL PURCHASES

UHF TV TUNERS CHANNELS 21 TO 64
Brand new transistorised geared tuners for 625 Line Receiver IF output. £2·50. Post 20p.

EASY TO BUILD KITS BY AMTRON—EVERYTHING SUPPLIED

Model No.	£ p	Model No.	£ p
310 Radio control receiver	3·29	760 Acoustic switch	12·57
300 4-channel R/C transmitter	6·61	780 Metal Detector (electronics only)	10·91
345 Superhet R/C receiver	6·61	790 Capacitive Burglar alarm	7·92
65 Simple transistor tester	1·66	835 Guitar preamp.	4·99
115 8 watt Amplifier	4·50	840 Delay car alarm	6·99
120 12 watt amplifier	4·73	875 CAP Discharge ignition (for car engine (—Ve Earth))	13·99
125 Stereo control unit	6·01	80 Scope Calibrator	2·65
130 Mono control unit	4·16	255 Level Indicator	6·98
605 Power supply for 115	5·31	525 120-160mHz VHF timer	11·31
610 Power supply for 120	5·31	715 Photo cell switch	8·97
615 Power supply for 2 × 120	6·64	795 Electronic continuity tester	4·97
230 AM/FM aerial amplifier	3·29	860 Photo timer	15·51
240 Auto packing light	6·90	235 Acoustic Alarm for driver	8·61
275 Mic. preamplifier	6·98	465 Quartz XTAL checker	9·90
5705 LF generator 10Hz-1mHz	21·45	220 Signal Injector	2·30
5755 Sq. wave generator 20Hz-20Hkz	19·77	390 VOX	15·50
590 SWR meter	9·47	432 Testakit	19·30
630 STAB Power supply 6-12V 0·25-0·1A	9·24	670 Buffer Battery Charger	6·55
690 DC motor speed Gov.	3·31	885 Capacitive Contact Alarm	6·25
700 Electronic Chaffinch	7·92	850 Electronic Keyer	18·75
		820 Electronic Digital Clock	58·50



ALL KITS OFFERED SUBJECT TO STOCK AVAILABILITY
Prices correct at time of preparation. Subject to change without notice.

BUILD THIS TUNER ML3

MW/LW Radio Tuner to use with any amplifier. Features Mullard RF/IF module Ferrite aerial, built in battery. Excellent results. Size 7" × 2¾" × 3½". All parts £5·25, carr. 15p.

MULLARD FM MODULES
LP1186 Tuning Heart Module
LP1185 IF Module complete with data
Price £9·00 pair

FM TUNER MODULE
FM 5231 12v FM Tuner £7·95
SD4912 Stereo Decoder £7·95
SF62H 6v Stereo FM Tuner £14·95

TBA800 5 WATT I.C.
Suitable alternative to SL 403D. 5/30 volt operated. 8/16 ohm 5 watt output. **With circuits and data** £1·50
Kit with printed circuit panel £2·70
All kits available from stock.

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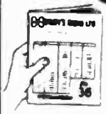
ZFT4A Suitable for Dec. '73 Pract. Electronics. £3·50
ST2 (D32) DIAC 25p
CRS1/40 SCR 45p
ZFT4 £3·50
ZFT8 £4·00

SINCLAIR SPECIAL OFFER
Stereo 60 Pre-amplifier —for use with most small amplifiers. Exclusive offer £6·75

PP9 ELIMINATOR KIT
Complete module kit 9v 100mA output £1·95 p & p 25p

All types offered subject to availability. Prices correct at time of press E & OE. 10% VAT TO BE ADDED TO ALL ORDERS. UK post, etc. 15p per order unless stated.



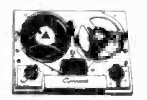
U.K.'s LARGEST RANGE OF TRANSISTORS & DEVICES

JUST A SELECTION
*TBA800 5W IC £1·50
*Sinclair IC12 6W IC £2·00
*ZN414IC Radio £1·20
*Ultrasonic Transducers £5·90 pr.
*3015F 7SEG Indicator £1·70
TIL 209 LED 24p each 22p each per 10
*With circuits/data sheet.

OVER 1,500 DIFFERENT SEMI-CONDUCTOR DEVICES IN STOCK

Free stock list—latest edition (Ref. 36) on request. Includes radio valves, I.C.'s, rectifiers, triacs, SCR's, LED's, etc. More types—better prices—discounts for quantity small or large.

GARRARD BATTERY TAPE DECK



GARRARD 2 speed 9 volt tape decks. Fitted record/play and oscillator/erase heads. Wind and rewind controls. Takes up to 4" spools. Brand new complete with head circuits. £9.50 carr. 30p.

TOP QUALITY SLIDER CONTROLS
60mm stroke high quality controls complete with knobs (post, etc. 15p any quantity).
Singles Log and Lin 5K, 10K, 22K, 50K, 100K, 250K, 500K, 1 Meg. 45p each.
Ganged Log and Lin 10K, 22K, 50K, 100K, 250K, 65p each.
(Quantity discounts available)
Complete with knobs.

MARRIOT TAPE HEADS
4 TRACK MONO or 2 TRACK STEREO
"17" High Impedance £2·50
"18" Med. Impedance £3·50
"36" Med. Impedance £5·00
R730/E73 2 track mono Record/Erase low imp. 75p pair.
Erase Heads for "17" "18" and "36" £1·00
"63" 2 track mono, High Imp. £1·75
"43" Erase Head for "63" 75p
(Post, etc. 15p any quantity).

SINCLAIR MINIATURE AMPLIFIERS & TUNER/DECODER

AMPLIFIERS (carr., etc. 20p)
4-300, 0·3 w 9 volt 1·75
104, 1 watt 9 volt 3·10
304, 3 watt 9 volt 3·95
555, 3 watt 12 volt 4·10
E1208, 5 w 12 volt 5·10
608, 10 w 24 volt 4·95
410, 10 w 28 volt 4·45
E1206, 30 w 45 volt 9·95
E1210, 2½ + 2½ watts 12 volt 8·25
RE500, 5 watt IC mains operated Amplifier with controls 6·30
SAC14, 7 + 7 watt Stereo with controls 11·75
SAC13, 15 + 15 w Stereo with controls 14·95
SP40-5 2Z40/ Stereo 80/PZ5 25·00
SP40-6 2Z40/ Stereo 80/PZ6 27·75
SP60 2Z60/ Stereo 80/PZ8 30·45
Transformer PZ8 3·95

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470C 6/7½/9 volt 300 MA (includes Multi-Adaptor for Tape Recorders, etc.) 2·25 post 20p
Car Lighter Voltage Adaptors 300mA (State voltage 6V, 7½V, 9V) 1·95 ea. post 25p
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HC244R Stabilised version 5·50 carr. 30p
P500 9 volt 500mA 3·20 post 20p
P11 24 volt 500mA (chassis) 2·90 post 20p
P15 26/28 volt 1 amp (chassis) 2·90 post 20p
P1080 12V 1 amp (chassis) 4·70 post 20p
P1081 45V 0·9 amp (chassis) 7·80 post 20p
P12 4½-12 volt 0·4-1 amp 7·15 post 30p
SE101A 3/6/9/12 volt 1 amp (Stab.) 12·75 post 25p
RP164 6/7½/9/12 1 amp (Stab.) 13·45 post 30p

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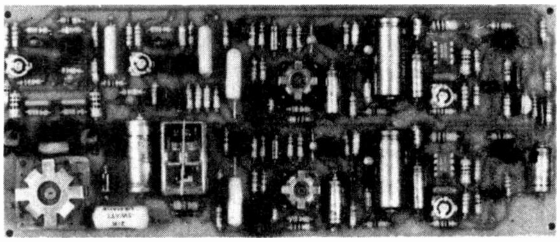


PHONOSONICS

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 ½W 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. £1·68. 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.

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.

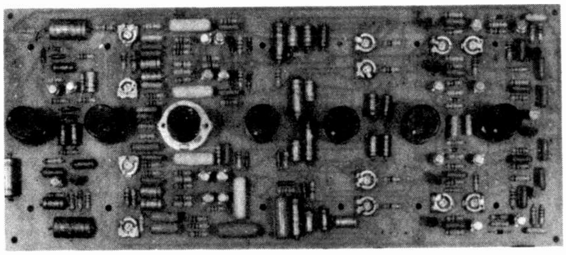
MISCELLANEOUS PCBs (While Stocks Last)
LOGICAL RADIO CONTROL (PE Dec. 71/Jan. 72) PCBs "2A", "2B", 50p each.
MODEL SERVO CONTROL (PE Feb./Mar. 72) PCBs "B", Fail-safe, 33p each.
DIGICAL PSU PCB (PE Aug. 72). 50p. OSCILLOSCOPE P/A PCB (PE Aug. 72), 33p.
GEMINI STEREO TUNER PCB (PE Apr. 72). £1·50. TRIFFID PCB (PE Feb. 73). 60p.
(The above PCBs are as published)
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.

PROJECT Q4
(PW Oct. 73/Jan. 74). Multisystem Quadraphonic Decoder. S/c's. I/c's. Rs. Cs. Pots. Makeswitches. £13·74. PSU. £3·17. Set of PCBs. £2·60.

RONDO
(PE Sept. 73/Feb. 74) Details in List.

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.

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.

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. While stocks last.

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. £11·20. PCB (3½in × 7½in) also holds pots and switch. £1·70. SCRs excluded. While stocks last.

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
¼W and ½W
CARBON FILM
MANUFACTURED BY
AEI TO DEF 6112A
E24 SERIES
¼W 5% 4E7 to 1M
½W 5% 4E7
to 2M2 then 10% to
10M
COMPREHENSIVE
STOCKS
FACILITATE RAPID
PROCESSING
AS APPOINTED
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SEMICONDUCTORS

AC126	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	6p
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	8p
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	8p
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)

0 01	3p
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

TANTALUM BEAD (µF/V)

0 1/35	12p
0 22/35	12p
0 47/35	12p
1 0/35	12p
1 5/35	16p
2 2/35	12p
4 7/35	12p
10/16	12p
10/25	16p
15/6 3	16p
22/16	16p
47/6 3	16p
100/3	16p

ADD 15p P. & P.
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SEND S.A.E. (Stamped Addressed Envelope) for Free Itemised List (and with all enquiries please).
OVERSEAS COSTS: P.&P. will be charged at cost (most kit weights and postal rates are shown in list). Send International Reply Coupon for Free List & with all enquiries. VAT does not apply to exports. EXPORT ORDERS ARE ALWAYS WELCOME.
MAILING LIST SERVICE—details with list.
COLOUR CODE identification supplied with most kits and as part of list.
PCBs are Fibreglass, Drilled, Tinned, and designed by Phonosonics unless stated "as published".
PCB Layout and Circuit Diagram supplied free with Phonosonics-designed PCBs.
POTS are rotary unless stated as slider.
PRICES correct at time of press E & OE.
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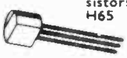

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Rondo Loudspeaker kits, Teak or sheer white pair	£37·50	LS-PR, K TEAK/WHITE
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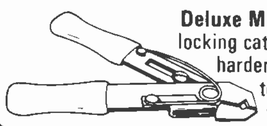

Deluxe Model 9 Automatic opening spring, locking catch, plastic-covered handles. Case hardened and precision ground. Adjusts to most wire sizes. Cuts and strips flex, splits plastic twin flex. **75p**

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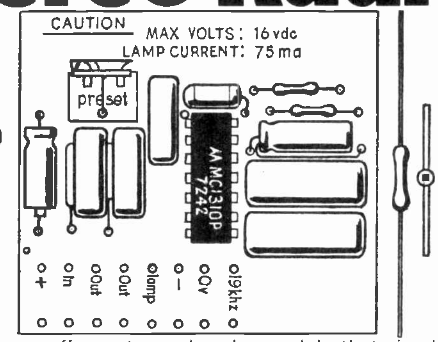

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T6	8	2G344B	OC44
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1	25	100+
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5A	TO66	0·39	0·52	0·54	0·59	0·75	0·88
5A	TO64	0·39	0·52	0·54	0·62	0·75	0·88
7A	TO48	0·52	0·55	0·62	0·67	0·84	0·99
10A	TO48	0·55	0·63	0·67	0·88	1·07	1·32
16A	TO48	0·58	0·62	0·67	0·77	0·97	1·50
30A	TO48	1·27	1·54	1·76	1·93	—	4·40

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PIV	300mA DO7	750mA SO16	1A Plastic	1·5A SO16	3A SO10	10A SO10	30A TO48
50	0·05	0·06	0·05	0·08	0·15	0·21	0·60
100	0·05	0·07	0·06	0·10	0·17	0·23	0·75
200	0·06	0·10	0·07	0·12	0·22	0·25	1·00
400	0·08	0·15	0·08	0·15	0·30	0·38	1·35
600	0·09	0·17	0·10	0·18	0·36	0·45	1·90
800	0·12	0·19	0·11	0·20	0·38	0·55	2·10
1000	0·14	0·30	0·12	0·25	0·48	0·65	2·50
1200	—	0·35	—	0·30	0·58	0·75	3·00

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UIC03	12 × 7403	0·55	UIC51	12 × 7451	0·55	UIC92	5 × 7492	0·55
UIC04	12 × 7404	0·55	UIC53	12 × 7453	0·55	UIC93	5 × 7493	0·55
UIC05	12 × 7405	0·55	UIC54	12 × 7454	0·55	UIC94	5 × 7494	0·55
UIC06	8 × 7406	0·55	UIC60	12 × 7460	0·55	UIC95	5 × 7495	0·55
UIC07	8 × 7407	0·55	UIC70	8 × 7470	0·55	UIC96	5 × 7496	0·55
UIC10	12 × 7410	0·55	UIC72	8 × 7472	0·55	UIC100	5 × 74100	0·55
UIC20	12 × 7420	0·55	UIC73	8 × 7473	0·55	UIC121	5 × 74121	0·55
UIC30	12 × 7430	0·55	UIC74	8 × 7474	0·55	UIC141	5 × 74141	0·55
UIC40	12 × 7440	0·55	UIC75	8 × 7475	0·55	UIC151	5 × 74151	0·55
UIC41	5 × 7441	0·55	UIC76	8 × 7476	0·55	UIC154	5 × 74154	0·55
UIC42	5 × 7442	0·55	UIC80	5 × 7480	0·55	UIC193	5 × 74193	0·55
UIC43	5 × 7443	0·55	UIC81	5 × 7481	0·55	UIC199	5 × 74199	0·55
UIC44	5 × 7444	0·55	UIC82	5 × 7482	0·55	UICX1	25 Assorted 74's	1·65
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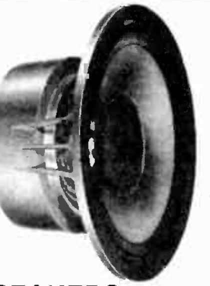

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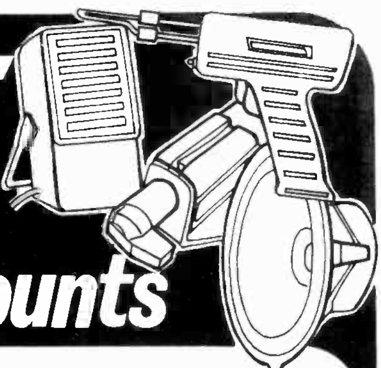

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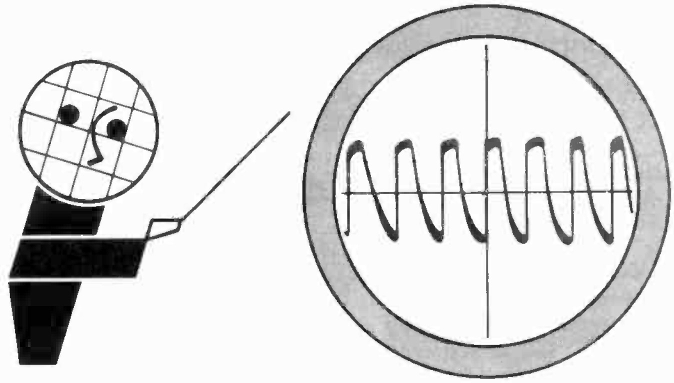

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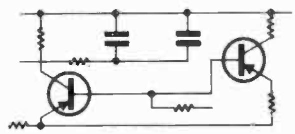

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THE CONSTRUCTOR'S LOT

A LETTER published last month must have stirred some memories. It also provokes this question: must technical progress necessarily mean an erosion of pleasure and satisfaction for the ordinary electronics constructor? For example, can a contemporary lightweight assembly on a small piece of s.r.b.p. match a robust chassis-mounted unit typical of the valve era in terms of pride in accomplishment engendered in the builder?

Nostalgia for the past is not to be derided, but it must not blind us to the very real practical advantages of modern techniques. Pride in achievement is not to be equated merely with size and mechanical complexity. A special craftmanship is required to produce a first class miniature assembly; and generally more dexterity and patience is demanded than when working on a larger scale model. The constructional business is unmistakenly different today—but it still offers its challenges and its rewards.

The fear of our correspondent H. T. Kitchen (*Readout* July) that in the next decade construction may be degraded to an operation of merely joining together modules has some basis, it is true. Yet there is a brighter compensatory side to the picture, we feel sure. To begin with, l.s.i. and circuit modules are in the main designed to meet the requirements of mass produced equipments. The private constructor is hardly likely to want to enter in competition in all such cases, but he can take advantage of the existence of particular components of the kind referred to and make use of them in less orthodox ways in circuits or systems of his own or some other's devising. In other words the private designer and constructor is better equipped to explore pastures new. And this has always been one of the reasons for amateur activity anyway. So really the only fears that one can envisage concerning the future are based upon the assumption that individual enterprise in initiating new designs and new appplications will cease to be as prolific as in the past. A couple of moments reflection will surely convince any doubting Thomas that such a proposition goes entirely against human experience.

Without doubt the physical aspect of construction will continue to change, with an appreciable reduction in the amount of traditional workshop practices like "metal bashing" called upon. But this easing of the mechanical effort is likely to be adequately balanced by the greater possibilities arising from expanding areas of application.

To speculate about the future of electronics in general is of course always tempting and maybe some of our readers would like to do some crystal ball gazing on their own account. Our correspondent expressed fears—". . . on the constructor's lot in say ten years time." Well, ten years from now brings us to that ominous date created by George Orwell. Nineteen eighty-four will also be of some (but happier, we hope) significance to this magazine, since come October of that year PRACTICAL ELECTRONICS will have completed its second decade.

Readers' own predictions concerning likely or possible developments in electronics and their effect upon the constructional field during the course of the next ten years are invited. Please refer to page 687 for details.

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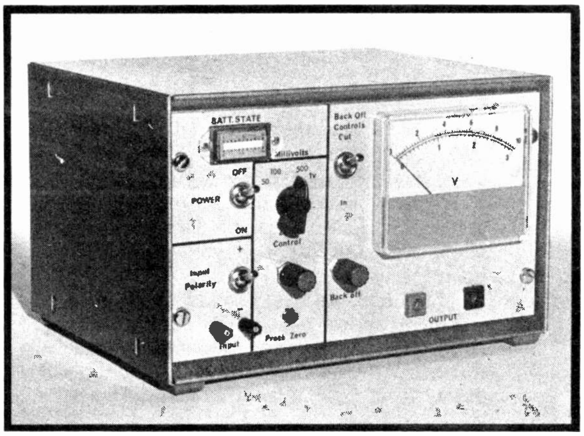
HIGH IMPEDANCE VOLTMETER

By T. P. MANNING & R. HIDER



An instrument for biophysical and other sophisticated scientific measurements

An instrument capable of measuring the output from a circuit or a device without having any effect on the circuit or device is, of course, the scientist's dream, particularly when that instrument is also sufficiently sensitive to detect variations in state of some of the transducers around today.

Typical examples of difficult-to-measure areas include thermocouples, photoelectric cells, thermistors, pH electrodes, ionisation chambers, physiological and biological investigation, and of course quite a lot of current electronic circuitry. The problem in basis is that in most cases the signal to be measured comes from a very high impedance source and/or the source is not capable of delivering sufficient current to drive an ordinary indicator such as a moving coil meter.

A number of solutions have been proposed in the past to allow measurements to be made under these circumstances including the use of very sensitive galvanometers for thermocouples and the development of the so-called electrometer valve circuitry for the high impedance sources.

Both are expensive solutions and in the case of the latter, in fact a noisy (electrically) and fairly unstable instrument is produced unless a great deal of attention and money is paid to special circuit design. Instruments have in fact been made very successfully, the EIL pH meter to mention the most famous, but low costs and, in fact true flexibility were not their hall mark.

MODERN TECHNOLOGY

The advent of solid-state technology has done much to redress the situation. The first step being the appearance of the f.e.t. (field effect transistor) with its ability to provide a circuit with very high input impedance not unlike a valve.

The second really useful item is the operational amplifier which cuts out a mass of discrete components and complex circuit design for the engineer and leaves him free to worry about the system.

The most useful device in the present context is the f.e.t.-input operational amplifier, of which several are available on the market now.

APPLICATION AREAS

Taking the availability of such devices as read, it becomes possible to consider just where they might be useful and obviously some form of replacement for the old electrometer voltmeter is feasible.

Such an instrument would be capable of indicating the condition of thermocouples, thermistors, light cells, perhaps even pH electrodes and ionisation chambers or photomultipliers. It would be possible to use such an instrument in the experiments where cell resistances, human body potentials and those in plants are measured. In fact a wide range of electronic and scientific measurements become possible without a great deal of expense.

Perhaps more important, the use of operational amplifiers facilitates the provision of an output dependent on the signal being examined but at a far higher level and power, which can be then used for chart recording, indication at remote points or even for control purposes.

Thus in the case of the plant cell measurements, a feedback potential dependent on the cell potential could be provided quite easily.

*The University of East Anglia

SPECIFICATION . . .

Input Impedance
Up to 10^{14} ohm, see text.

Accuracy
Dependent on the selection of range multiplier resistors. These should be 1% or better if possible. For best case they should be balanced on a high quality bridge used in conjunction with a d.v.m. or similarly checked out.

Ranges
Dependent on choice, see text.

Output
1V into 100 ohm with 100μA meter installed. Total 10·1mA.

Frequency Response
1kHz on lowest range rising to 1MHz on the 1V range.

Power Requirement
60mW. 8·5mA per battery.

Noise
With 10^9 ohm source measured as 50μV peak-to-peak referred to input, d.c. to 1kHz.

Input Voltage Swing
Dependent on ranges chosen. 1V on prototype but can be ± supply voltage. In fact the input i.c. can withstand 30V max. at inputs but of course this could adversely affect the meter or anything attached to the output.

Drift
The drift figures for the input i.c.s are in the μV per deg C region and in practice no drift was experienced in operation with the prototype at all. With the differential circuits and their increased sensitivity temperature drift should be expected.

A BASIC INSTRUMENT

A design of instrument which will satisfy most of the requirements for a high impedance input voltmeter can be made up from two main basic components. These are a f.e.t.-input operational amplifier used as a voltage follower, that is as a unity-gain device the output of which follows the input exactly, and a second operational amplifier to provide the necessary gain when examining small signals.

The unity gain arrangement of the f.e.t. input device allows one to extract maximum benefit from the high input impedance of the f.e.t.-input stages and in the present instance the device selected is quoted as having an input impedance in the 10^{11} to 10^{14} ohm region. In the prototype the authors used the R.S. MOPA which in fact is similar to the 741 operational amplifier with f.e.t. input stages. An electrically identical device is available under the

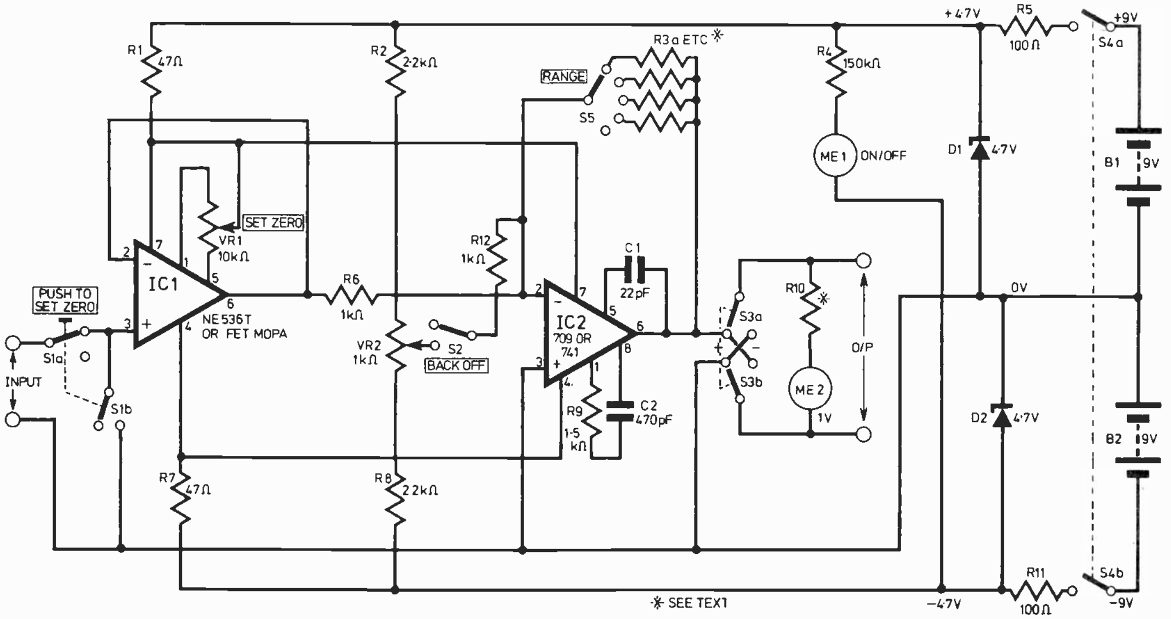
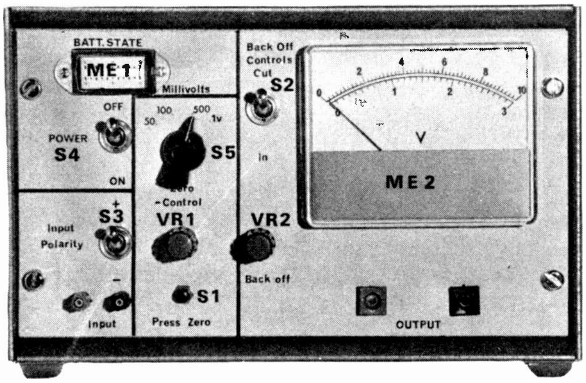


Fig. 1. The circuit diagram of a simple high-impedance voltmeter offering a performance equal to much more expensive instruments



designation NE536T from Signetics (S.D.S. Components).

The output from the input amplifier is fed to the second i.c., in this case the 709 or 741 operational amplifier, which can now amplify the signal as required to give the desired sensitivity and can, at the same time provide a "back-off" feature where the zero of the instrument can be moved, in a voltage sense, within set limits to offset input voltages, measure particular levels with a greater sensitivity and so on.

In addition, of course, the 709 is capable of providing a fairly hefty output which means that within sensible limits the instrument can drive almost any indicator and still have sufficient spare output to drive a chart recorder if this is needed.

The basic circuit of such a system is shown in Fig. 1.

IC1 is the f.e.t.-input device which acts as a non-inverting amplifier with a gain of 1 because of the feedback link from output pin 6 to inverting input pin 2.

SENSITIVITY

IC2 provides all the amplification necessary for most purposes and, as can be seen, the gain of this stage is set by selection of the feedback resistor R3 using S5. It should perhaps be added that the capacitor C1 and the capacitor and resistor combination C2 and R9 are frequency-determining components which are specific to the 709 i.c. used. If a 741 device were used these would not be necessary but can be left on the circuit.

The output of IC1 is fed to the inverting input of IC2 and switch S3 serves to again invert the output of IC2 so that the meter acts in unison with the input. This switch can be used to reverse the meter connection so as to effectively reverse the input polarity if needed. R10 is a series resistor chosen to suit the meter ME2 so as to set the f.s.d. at 1V and this latter level is chosen in the prototype because there are chart recorders with this as a standard range.

Of course, other values may be used but it is advisable to ensure that the selected value does not approach too closely to the supply rail voltage, in the present instance 4·7V. In fact ME2 is a $100\mu A$ moving coil meter in the prototype.

The effective zero point of the meter may be adjusted by means of VR2 which is a ten-turn Helipot used to give sufficient resolution to this function. Whilst this device is expensive it will none-the-less be found very useful in practice. As can be seen, this "Back-off" function can be switched out using S2.

Back-off is limited to 1·5V with the arrangement shown but experiment will show that the value may be altered if desired. However, again care should be taken not to approach right up to rail potential which can produce non-linearity. In addition, whilst a ten-turn potentiometer is used here to give good resolution, particularly at low input potentials, VR2 can be replaced by a normal potentiometer if the resolution is not needed.

VR1, the "set zero" potentiometer, is a standard component and both potentiometers are brought out to the front panel.

The indicator ME1 is in fact a so-called "roller indicator" which both indicates the ON state of the instrument and gives some idea of the condition of the batteries.

POWER SUPPLY

In this latter area it can be seen that two PP9 units are used to give a + and a − supply. Resistors R5 and R11, in conjunction with Zener diodes D1 and D2 serve to regulate the supply to 4·7V on each rail. This has proved ample in the prototype and in fact in tests carried out with a 10mA load on the output as well as the meter ME2 indicating, the instrument has been run for several hours without any ill effect.

The main reason for selecting a lower power rail potential is to extend battery life and ensure in the meantime that rail potentials do not suffer since any unbalance in these can "throw" the meter completely.

The "set zero" shorting switch S1 is of the change-over type which is a must as IC1 input must be shorted to ground when zero is being checked to remove any input voltage. At the same time, it may well be that to short the circuit an object under examination might damage it, as is the case with plant cells for example.

It is suggested that battery operation of this equipment be accepted as normal. The drain is not high and the problems involving mains-borne interference and other items associated with anchoring a very high impedance device to main supply lines are almost impossible to avoid. In addition this is particularly the case if cost is important.

In any event, the present arrangement is both simpler, makes for portability and there is always the added point that many of the measurements which this type of instrument can effect need either a screened environment into which mains supply must not be passed or, more important can involve application of electrodes to person or animal or plant, with consequent risk of dangerous shock if mains supply is used.

CONSTRUCTION

As can be seen from the illustrations (Fig. 2 is the p.c.b. master and Fig. 3 the component layout), construction of the basic printed circuit board follows normal procedure with the exception that, for convenience of mounting ranging resistors, two edge

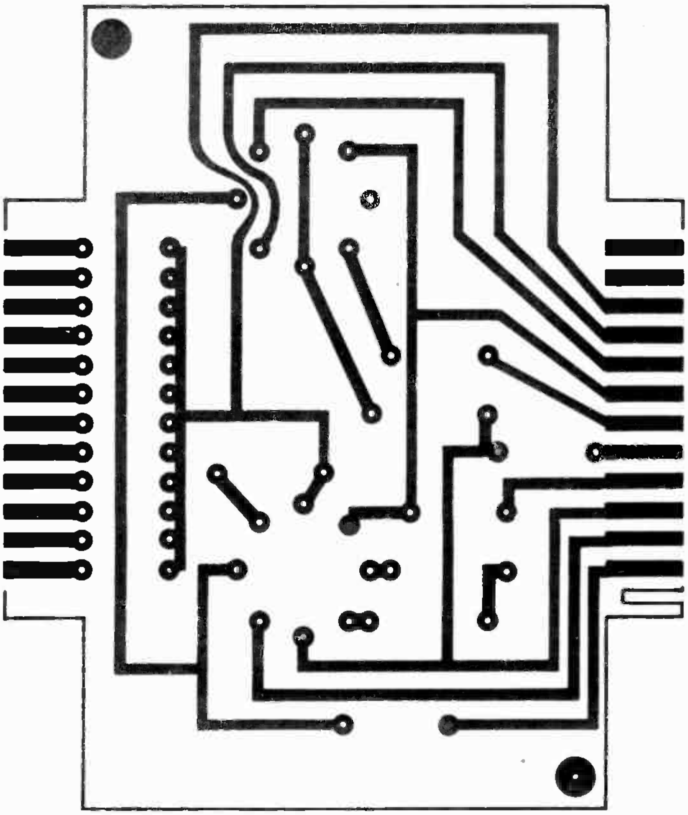


Fig. 2. A printed circuit layout for the circuit of Fig. 1 showing the use of two edge connectors so that all ranging resistors can be board mounted

COMPONENTS . . .

Resistors
- R1 47 Ω
- R2 2·2k Ω
- R3 See Text
- R4 150k Ω
- R5 100 Ω
- R6 1k Ω
- R7 47 Ω
- R8 2·2k Ω
- R9 1·5k Ω
- R10 See Text
- R11 100 Ω
- All ±2% ¼W carbon

Potentiometers
- VR1 10k Ω
- VR2 1k Ω, Ten-turn Helipot or like, see Text

Capacitors
- C1 22pF
- C2 470pF

Diodes
- D1 BZY88 4·7V Zener
- D2 BZY88 4·7V Zener

Integrated Circuits
- IC1 FET MOPA *or* NE536T
- IC2 709 operational amplifier *or* 741

Switches
- S1 2-pole changeover spring-return push button
- S2 1-pole changeover
- S3 2-pole changeover
- S4 2-pole on/off
- S5 1-pole multi-way dependent on ranges required

Miscellaneous
Battery state/on/off indicator ME1; 100μA moving coil meter ME2; glass-fibre p.c.b.; terminals; wire solder; case and matching front, etc.

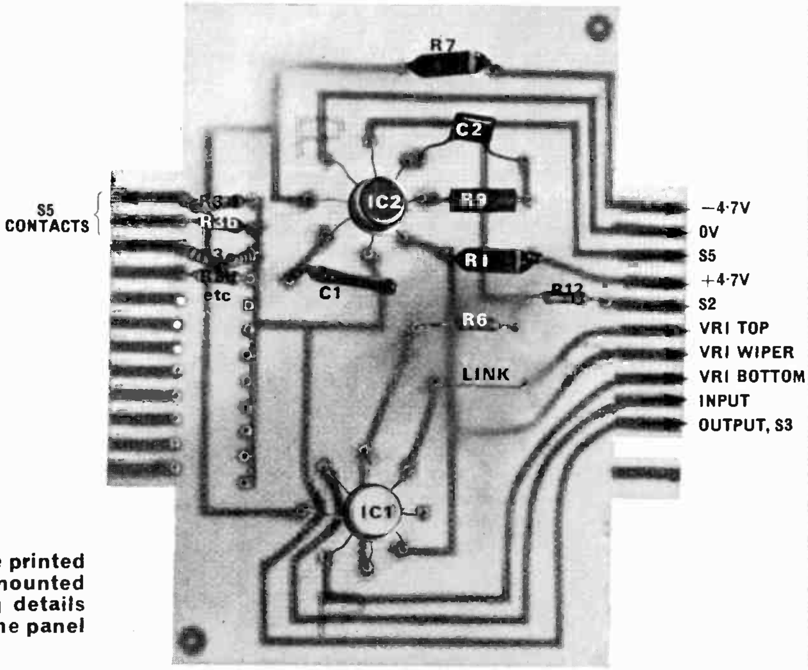


Fig. 3 (right). A photograph of the printed circuit board with components mounted and annotated, and with wiring details from the two edge connectors to the panel and case-mounted components connectors are used to interconnect the board and the various switches and other controls. The case chosen for the prototype is in fact somewhat larger than is really required and could be replaced with a smaller box. Equally, some of the components could be omitted if required.

For example there is no real need for the indicator ME1 to also be a battery state indicator, a simple lamp would suffice or, indeed the device could be omitted altogether.

There is no particular mystery to the layout of the front panel. It was selected to show each control in a "functional" manner so as to be clear to students and others not familiar with this type of device.

One point which does require some care is the assembly of the input operational amplifiers on to the p.c.b. It should be remembered that these are f.e.t.-input devices and thus have somewhat sensitive inputs, not only to the signals you wish to amplify but to such problems as static electricity.

Whilst the devices are protected it is still much less expensive in the long run to, for example, disconnect the soldering iron from the mains when working on the board during or after having mounted IC1.

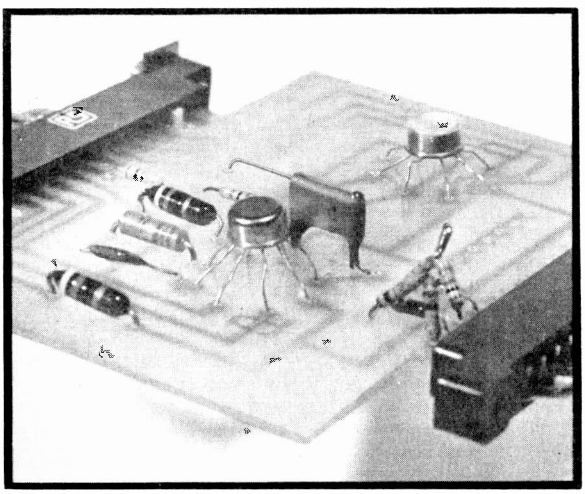
FEEDBACK SELECTION

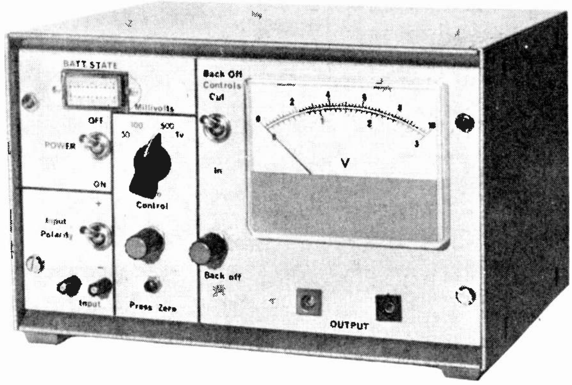
The operational amplifier in the second stage is used to provide amplification of the input signal level to give a 0–1V output for the required level of input. The gain of this stage is equal to the feedback resistor value divided by the input resistor value.

In the present case the input resistance is R6, with a value of 1kΩ. Thus if the lowest (most sensitive) range is to be 0 to 50mV, the range resistor R3 needs to have a ratio relationship with the input resistor of 1V divided by 50mV which is 20. As R6 is 1kΩ R3 must be 20kΩ.

Thus we need R3 values of 20kΩ, 10kΩ 2kΩ and 1kΩ, for ranges of 50mV, 10mV, 500mV and 1V f.s.d.

The reader is of course free to set up his own range values to suit his meter or other factors.





INPUT IMPEDANCE

Whilst the specification figures for the FET MOPA mention $10^{14}\Omega$ input impedance and $10^{11}\Omega$ to $10^{14}\Omega$ for the NE 536T, these values are only properly obtainable if some very stringent precautions are taken with the construction of the input circuitry. In the first place most printed circuit board just could not match the sorts of figures mentioned, particularly the s.r.b.p. variety which is somewhat hygroscopic and thus leaky when considering the sorts of impedance being discussed here.

In all probability the input impedance of the instrument described will end up around 1kMΩ if good glass board material is used. For most purposes this is quite sufficient but if higher figures are needed then construction becomes critical.

The input conductors of the operational amplifier IC1 would have to be attached to terminal posts in the tops of p.t.f.e. pillars and the input leads would have to be taken directly to the pillars from the input terminals.

In addition, normal terminals mounted in the body of a metal case would be out of the question. The terminals would need to be mounted in something like a sheet of acrylic (Perspex) which would give each terminal about 25mm clearance from the metalwork and each other.

The limiting factor for the input impedance under these circumstances becomes perhaps the humidity of the atmosphere around and inside the meter or perhaps the presence of any dirt or damp on the underside of the i.c. itself.

One other factor of importance. If it is required to achieve the highest possible input impedance then both the input amplifier, standoff pillars, acrylic sheet and terminals should be washed in pure alcohol or some other similar solvent to remove any traces of dirt or grease and even moisture trapped on the surface of the devices. After such a washing the parts should be handled as little as possible since each fingerprint contains all the contaminants needed to reduce the impedance by quite a large amount.

DIFFERENTIAL INPUT

The basic instrument described here is adequate for most applications but there are occasions where a differential input can be of assistance. It is not too difficult to adapt the basic circuit as is shown in Fig. 4 by the addition of a further input amplifier.

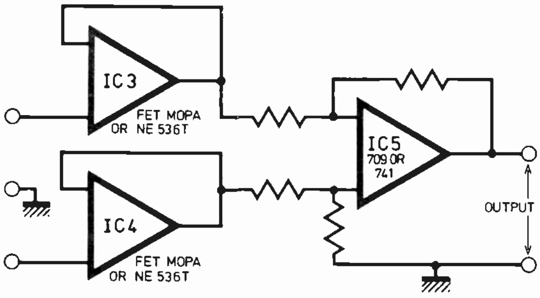


Fig. 4. Modification of the system of Fig. 1 to cope with differential measurements

DIFFERENTIAL pH METER

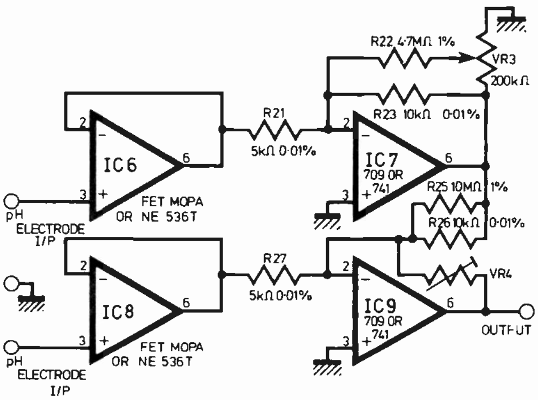


Fig. 5. A differential system with high sensitivity as suggested in a scientific paper in Analytical Biochemistry

PLANT CELL MEASUREMENTS

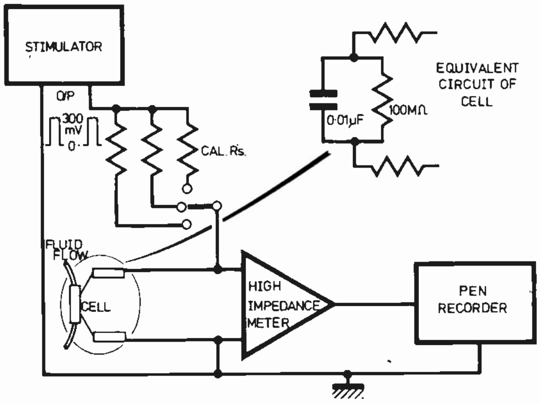


Fig. 6. Plant cell potential being measured using the basic high impedance meter

The only difference of any moment is that the upper of the two input amplifiers is set to zero using a skeleton potentiometer which is pre-set. The lower amplifier set-zero potentiometer is used on the front panel as in the basic circuit.

The output operational amplifier, the 709 or 741, is used in differential mode.

A modified form of differential instrument was the subject of a paper published in *Analytical Biochemistry* 13, 556–563 (1971) where the authors showed that it was possible to measure pH changes as low as 0·001pH using a high impedance voltmeter configuration as in Fig. 5.

Here the gain has to be adjusted to suit the scale of the recorder being used at the output and, of course, the instrument has to be kept in a very stable temperature environment if the claimed accuracy is to be achieved. Currently the authors are working on a version of this concept.

APPLICATIONS

The instrument described in detail is currently in use carrying out examination of the effects of electrical stimulation and of various materials being passed through plant cells. The general circuit is shown in Fig. 6 where it can be seen that the meter measures the output from the plant cell continuously and records the result on a pen recorder.

The plant cell is fed with various fluids which are continuously pumped through. Two micro-electrodes pierce the cell walls and the meter is connected across them.

The "High" side of the meter/cell interface is connected to a switch and a set of calibration resistors which are in turn connected to a stimulator which provides stimulus pulses as and when required.

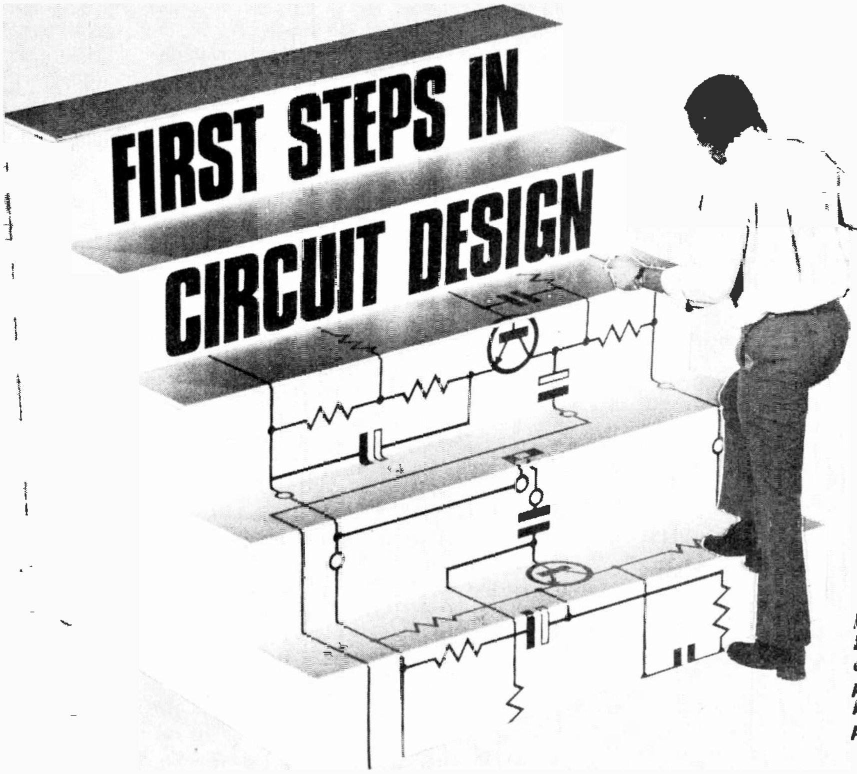
The scientist needs to know how the cell reacts and what changes occur dependent on fluid and electrical stimulation. Using the arrangement shown he can monitor the cell continuously and can also calculate the value of the cell impedance. In most cases this is equivalent to an RC parallel circuit and the impedance varies with the type of cell. Measurements have provided results from 2MΩ up to 100MΩ.

In some experiments the stimulator can be replaced with a d.c. source and then the output of the meter used to control the rate of flow of the supply fluid.

MONITORING

Other obvious applications include the monitoring of thermocouples, particularly where fairly long leads are involved since the resistance of the latter, in conjunction with any indicator which required current to drive it, would sadly effect the accuracy of the system.

Monitoring the inputs to other high impedance devices such as f.e.t.s is possible with this instrument, as are many physiological experiments involving the resistance of the human body or the ability of muscles to produce potentials detectable at the skin surface. In this context this particular form of equipment offers itself for consideration in experiments involving the provision of a feedback signal which could be used for example to control other stimuli such as lights or sounds as well as for recording purposes. ★



FIRST STEPS IN CIRCUIT DESIGN

5

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.

THE MAIN theme of this month's article is methods of achieving high input impedance in amplifiers. The Darlington amplifier is a simple but costly way of producing the desired result whilst the much more subtle "bootstrapping" technique gives excellent results with the addition of only a capacitor and resistor to the basic emitter follower.

After this we take a quick look at negative feedback techniques. We have seen an example of negative feedback in the emitter follower, but it is usual to apply negative feedback over a stage or a series of stages in order to increase stability, reduce distortion and noise, and increase impedance.

We end this description of small signal amplifiers with a look at a well-designed amplifier designed by the Mullard team which makes use of the principles covered so far.

5.1. DESIGNING FOR VERY HIGH INPUT RESISTANCE

Some signal sources (crystal microphones, photodiodes, etc.) only deliver very tiny currents because of their very high source resistance. An attempt to amplify such signals will only be successful if the input resistance of the amplifier is also very high.

Although emitter followers have this property, the possibility of achieving R_{IN} of the megohm order is still difficult.

A simple answer is the Darlington pair, the basic circuit of which is shown in Fig. 5.1.

Remembering a previous equation for a single stage emitter follower $r_{in} = h_{fe}(r_e + R_E)$ and assuming r_e is negligible in relation to R_E, we may simplify this to $r_{in} = h_{fe}R_E$.

However, this circuit uses two stages of amplification so that the formula becomes $r_{in} = (h_{fe1} \times h_{fe2})R_E$ where h_{fe1} and h_{fe2} are the respective gains for the two transistors.

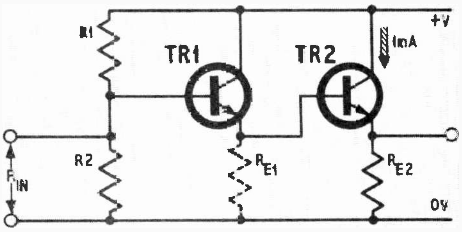


Fig. 5.1 Two transistors connected as a Darlington pair. The dotted resistor is not strictly part of the Darlington, its use is explained in the text

Assuming they are both the same, the equation becomes $r_{in} = h^2_{fe}R_E$.

For example, if R_E is 5kΩ and h_{fe} is 100, r_{in} becomes about 50MΩ which is so high in relation to the shunting of R1 and R2 that it can be ignored in the calculation of R_{IN}.

It is easy to see therefore that the R_{IN} of the stage is almost entirely determined by R1, R2 values.

The R_{E1} resistor is to complete the divider chain for the base of TR2 and also to pump a little more collector current into TR1. Without it, the base current of TR2 would be the collector current of TR1 which would reduce its h_{fe} too much. A possible set of components is shown in Fig. 5.2. This circuit gives an R_{IN} of nearly 0·7MΩ (R1 and R2 in parallel).

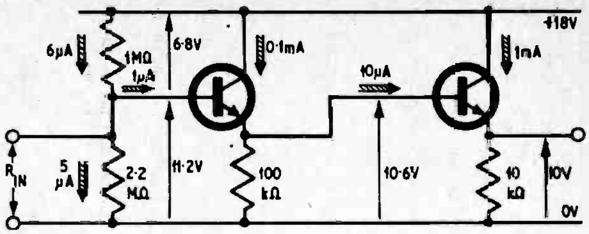


Fig. 5.2 Typical component values for a high input impedance, Darlington pair amplifier

5.2. INPUT BOOTSTRAPPING

There is a novel method of increasing the input resistance of an emitter follower stage known as "bootstrapping". The purpose is to increase R_{IN} by effectively removing the bias resistors from the signal path. Two extra components are needed as shown in Fig. 5.3.

BOOTSTRAPPING ACTION

Resistor R3 is made small enough not to interfere with the d.c. bias. Note that the signal voltage V_{IN} is at one end of R3 and the output voltage (via C1) is at the other end.

Now V_{OUT} is in phase with V_{IN} and has almost the same amplitude (voltage gain = 1).

Thus, it follows that

Both ends of R3 are at the same potential and no signal current can pass through.

This means that the signal can carry out its proper function of changing the base current without wasting half of its energy flowing down R1, R2.

Bootstrapping thus effectively removes R1 and R2 from the stage input resistance formula.

Thus $R_{IN} = r_{in}$, and r_{in} can be made very high.

CHOICE OF R3

The choice of R3 is not critical providing the base current does not produce any appreciable voltage drop (much less than 0·6V is the usual criterion).

Capacitor C1 should have a reactance (X_c) less than R3 at the lowest expected frequency. This ensures that the high input resistance is maintained at all signal frequencies.

Fig. 5.3 shows typical component values for a circuit having an input resistance of approximately 18MΩ.

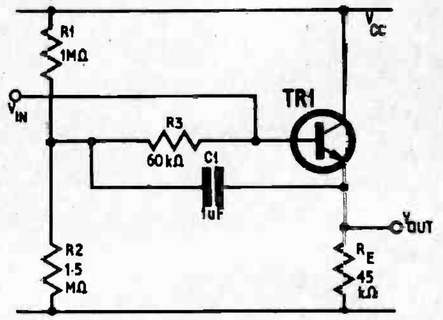


Fig. 5.3. By the addition of capacitor C1 and resistor R3 to the basic emitter follower circuit, one obtains the very high input impedance "bootstrap" configuration. The circuit shown here gives an input impedance approaching 18MΩ

5.3. COUPLING LOSSES

Suppose we have one amplifier stage which, on its own, gives a gain (A) of 100 and we feed the output into another stage having a gain $A = 50$. A miserable disappointment is in store for those hoping the overall gain would be 5,000.

The output resistance of stage 1 and the input resistance of stage 2 form a voltage divider which causes a "coupling loss" between the stages.

OVERALL GAIN

To calculate the overall gain between signal e.m.f. and final output it is customary to treat coupling losses as "gains".

For example, if we lose half the signal at some point due to coupling loss, we can say the "gain" of the coupling is 0·5.

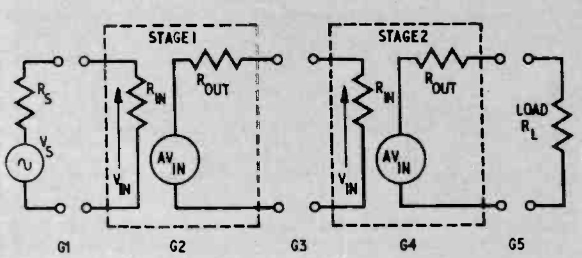


Fig. 5.4. A multistage amplifier may be envisaged as a series of blocks each having a "gain" G. The total gain is then obtained by multiplying the individual gains.

In this way we can work methodically through a multistage amplifier as if it consisted of isolated blocks, and by multiplying all the individual gains we can find the total gain.

EXAMPLE

To illustrate the procedure, consider the circuit shown in Fig. 5.4. In this example there are five "gains" in all. G1, G3, and G5 are fractional gains (losses) and G2 and G4 are actual stage gains.

Let G1 = 0·2, G2 = 100, G3 = 0·1, G4 = 100, G5 = 0·5.

Then the total gain = 0·2 × 100 × 0·1 × 100 × 0·5 = 100.

It is advisable to use this method of analysis in all multistage amplifiers.

5.4. MINIMISING COUPLING LOSSES

To illustrate the seriousness of the problem consider the following system.

A pick-up has an output e.m.f. of 5mV, a source impedance of 5kΩ and is feeding an amplifier having a gain A of 100. The R_{IN} of the amplifier is 10kΩ and R_{OUT} is 2kΩ. The final load on the amplifier is 5kΩ.

Now the coupling loss between the pick-up and amplifier is

$$G1 = \frac{10k\Omega}{10k\Omega + 5k\Omega} = 0{\cdot}67$$

The gain of the amplifier gives

$$G2 = 100$$

The coupling loss between the amplifier output and final load is

$$G3 = \frac{5k\Omega}{5k\Omega + 2k\Omega} = 0{\cdot}71$$

The total gain is G1 × G2 × G3 = 0·67 × 100 × 0·71 ≃ 48.

Thus a gain of supposedly 100 has been reduced to a mere 48.

RULES ON COUPLING

Some rules and tips on coupling designs are clearly worth memorising.

1. Keep output resistances low and input resistance high.
2. The R_{IN} tends to rise if I_c is lowered.
   The R_{OUT} tends to fall if I_c is increased.

Thus we have a conflict of requirements—to satisfy the requirement of R_{IN} or R_{OUT}.

Mathematical analysis indicates that

Total losses will be minimal if the input and output coupling losses are arranged to be equal.

There is of course an easy way out—just put an emitter follower between every stage. This is a little extremist however, and could be rather costly if adopted as a general principle.

5.5. NEGATIVE FEEDBACK

DEFINITION

Negative feedback is the feeding of part, or the whole, of the voltage or current from some later stage of an amplifier back to an earlier stage. The phasing of the voltage must tend to *reduce the gain.*

CLASSIFICATION

Series voltage feedback—the voltage fed back is in series with the input. This increases R_{IN}.

Parallel voltage feedback—voltage fed back is in parallel with the input. This reduces R_{IN}.

EQUATIONS

If A is gain before feedback, A' is gain with feedback and β = fraction of output which is fed back then

$$A' = \frac{A}{1 + \beta A}$$

If βA is large, the equation reduces to

$$\boxed{A' = 1/\beta}$$

This indicates a remarkable property—the gain of the amplifier can be made independent of the components inside it, including the transistors themselves!

In addition to this obvious advantage, negative feedback will reduce distortion and internally generated noise, and change input and output resistances *in the same ratio as the gain is reduced.*

In view of this, it is good design practice to produce a gain higher than required and reduce it by negative feedback to the desired value.

5.6. AN EXAMPLE OF GOOD DESIGN

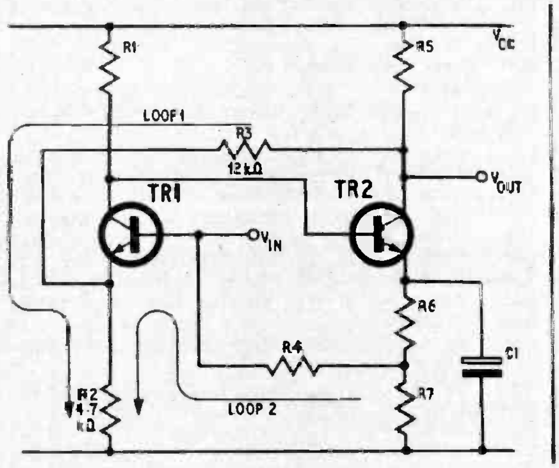


Fig. 5.5. An example of good amplifier design. The circuit shown here has two feedback loops for d.c. stability, as well as signal negative feedback

The circuit in Fig. 5.5 is from the Mullard design team and is an excellent example of the use of d.c. and signal negative feedback. By altering component values, gain can be increased to 100.

FEEDBACK LOOPS

There are two negative feedback loops, and their subtlety should be carefully studied.

Loop 1 is producing signal negative feedback, the feedback fraction being

$$\beta = \frac{R2}{R2 + R3}$$

The total closed loop gain (A') is given by

$$A' = 1/\beta = \frac{R2 + R3}{R2} = 3{\cdot}4$$

The open loop gain is of course much higher because it is basically two grounded emitter amplifiers in cascade.

Note that the feedback is *series* type because it is applied back to the emitter of TR1.

Loop 2 is not acting on the *signal* because C1 is keeping TR2 emitter at ground. Therefore this loop is stabilising d.c. conditions only.

Continued next month

NEWS BRIEFS

New Information Retrieval System

During the course of the past five years many attempts, particularly by the large American multi-national companies, have been made to produce an efficient microfilm information retrieval system to reduce the ever demanding space requirements of documentation.

Many mechanical systems have been evolved, with extreme limitations on speed, accessibility and reliability. Now, a British company, Selectro-Micro Ltd. (part of the Westminster Holding Group) has developed a fully automatic, electronically-controlled information storage and retrieval system with print-out known as Selectacopy.

This will provide, for the first time, an electronic facility for keeping over one million documents in one small room (as opposed to over 40 times the office and storage space required, and the staff costs involved) and making each document immediately available in just a few seconds.

Calling China

BRITAIN'S telephone service with the People's Republic of China, which until recently had been available for only three hours a day, became full-time with a switch over to satellite communications.

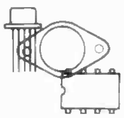
This facility is made possible by the opening in China of a satellite Earth station using the *Intelsat-IV* communications satellite positioned 22,300 miles above the Indian Ocean.

Telephone calls from Britain to China are now beamed from the Post Office satellite Earth station at Goonhilly Downs, Cornwall and received by China's new Earth station, near Peking.

Keep Moving

TRAFFIC signals in Nottingham will soon be controlled by a Ferranti data transmission and computer system as part of an integrated traffic scheme for the city centre. A dual Argus 700E system, valued at more than £250,000, ordered by Nottingham Corporation will be connected via data links to 128 outstations.

The scheme is part of Nottingham's plans to avoid costly large scale road building and widening by concentrating on optimising traffic flow over a wide city area and making more efficient use of existing roads.



THE NEXT DECADE ?

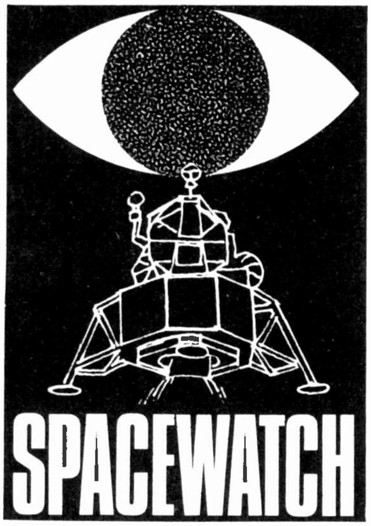
What does the future hold in store for electronics in general, and for electronics constructors in particular?

Your views and predictions concerning likely developments in the next 10 years are invited.

A selection of readers' contributions to this debate will be published in our November and December issues to mark the completion of this magazine's first 10 years of publication.

Contributions (not exceeding 300 words and entitled "The Next Decade") should be addressed to *The Editor, Practical Electronics, Fleetway House, Farringdon Street, London, E.C.4* and posted in time to reach our offices by August 21, 1974.

A payment of £5 will be made for each letter published. Selection will be based upon originality of thought, technical credibility and general presentation.



BY FRANK W. HYDE

APPLICATIONS TECHNOLOGY SATELLITE

In August, after trials are completed, the U.S. applications technology satellite will go into service. This satellite, the first of its kind, may well have far reaching effects on the shaping of future societies. Versatile and having the facilities for the transfer of command, the one and a half ton vehicle is the largest communications satellite built so far.

The facilities provide for education transmissions in the form of lessons where the students can be taught to read and write under direct supervision. The remote and developing areas, where illiteracy is still a major problem, can be covered by this one satellite. Many other uses will be made in the field of agriculture, medical service, hygiene, family planning and food preparation.

Another important application is the use of community television sets in places like India and Africa and will provide a service for the improvement of the people. In a "*Spacewatch*" report on the development of India's space projects mention was made of the cheap aerial systems to enable the signals of this powerful satellite to be received.

Under a contract with the American Government, India will not only have the use of the satellite facilities but it will be under their direct control. To bring this about, the satellite will be moved to a position near Africa and north of the equator. The only connection with operation that America will have during the year of loan, will be the loan of the satellite.

To bring all this about the satellite will first be put into a geo-stationary orbit near South America. From there the whole of the United States will be covered by the transmissions. Many uses are planned during the satellite's first run.

Medical contact with remote areas like Alaska will enable physicians to see patients direct on television screens and instruction will be given to medical assistants on the spot, as to treatments. A network will be available so that conference diagnosis can take place with a number of specialist hospitals.

Seminars will be set up by television links so that teachers in remote areas can continue their own training in advanced techniques of education. The complete facilities of instructor and student, with visual aids, are as would be available in the lecture room. Two-way voice communication will be used in a number of original experiments.

The satellite, which is 27 feet high and 30 feet in diameter, has solar panels which will provide 200 kilowatts of power. The power available is some 30 times more than any previous system. It is for this reason that extensive and continuous cover of these vast areas can be made, using the cheap receiving systems at the community centres. The transmitting aerial on the satellite is so shaped and steered that the whole of the area to which it is directed can be covered effectively.

After its period at the station in the 22,300 mile orbit above South America, the motors will be activated and the satellite will move to the new station near Africa where it can serve India. This is expected to take place in mid-May 1975. During its stay there one of the experiments will be to observe the arrival of the monsoon in various parts of India. This will help in making predictions for the future, and setting the correct period for cropping the rice and timely replanting before the beginning of the monsoon.

After its sojourn in the area of India the satellite will once more return to its first orbit where it is expected to serve the United States for several years more. This is dependent on the life of the solar cells. Thus, this venture may pave the way to a world system making the facilities available to the whole world. Not the least of the benefits is the possible and more efficient control of aircraft in flight, and world wide network of medical facilities.

DOMESTIC SATELLITE

The recent launch of the domestic satellite, somewhat similar to that set in orbit for Canada, is in a synchronous orbit such that, with the shaped aerial, signals will be received over 48 states. The satellite is named *Westar* and is the first of a series to be launched by the Western Union Telegraph Company.

The weight of *Westar* is about 1,250 lbs. This is the first commercial satellite to be put in orbit and represents the change from national funding to private enterprise. Thus, another milestone in space history is set up.

Final checkout of Westar, America's first domestic communications satellite, at Hughes Aircraft.

The satellite's ribbed antenna is capable of transmitting a signal to cover the 48 states, and also has the capacity to reach Alaska, Hawaii and Püerto Rica

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SILICON P.N.P.

Type	Voltage	Frequency	Price
BCY 71	45	200 MHz	12p
BFS 92	100	70 MHz	20p
BFS 95	40	70 MHz	17p
BFX 12	25	210 MHz	10p
2N 2906	60	200 MHz	15p
2N 3702	40	100 MHz	11p
2N 3703	50	100 MHz	12p

SILICON N.P.N.

Type	Voltage	Frequency	Price
BC 108	30	150 MHz	15p
BC 109	30	150 MHz	15p
BF 179	225	125 MHz	40p
BF 180	30	625 MHz	25p
BFW 58	80	80 MHz	15p
BFX 43	30	500 MHz	20p
BFX 86	40	50 MHz	17p
BFY 53	30	50 MHz	10p
2N 697	60	40 MHz	12p
2N 709	15	900 MHz	30p
2N 718	60	60 MHz	12p
2N 753	25	250 MHz	12p
2N 744	20	300 MHz	12p
2N 1613	75	60 MHz	17p
2N 2220	60	250 MHz	15p

SILICON N.P.N.

Type	Voltage	Frequency	Price
2N 3053	60	100 MHz	17p
2N 3707	30		12p
2N 5179	20	900 MHz	40p

GERMANIUM P.N.P.

Type	Voltage	Frequency	Price
ACY 44	50	1 MHz	10p
ADY 26	80	75 watts	£1
AF 124	20	75 MHz	20p
AFY 19	32	350 MHz	20p
ASY 32	25	5 MHz	10p
ASZ 21	15	450 MHz	20p
GET 113	32		10p
GET 120	32	2 watts	10p
OC 123	50	1 MHz	10p
OCP 70	Light-sensitive		20p
2N 1307	30	10 MHz	15p
2N 1309	30	15 MHz	15p
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BXY 35A/C	ditto	25 GHz	£1
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BXY 38C/E	ditto	120 GHz	£1
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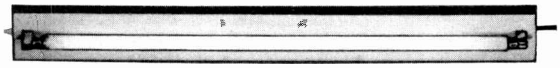

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(Note: tube only supplied if Case also ordered, to prevent postal damage)

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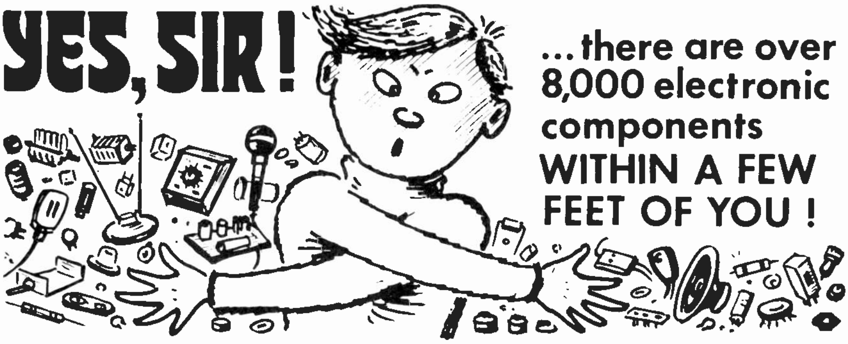

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DC/DC CONVERTER

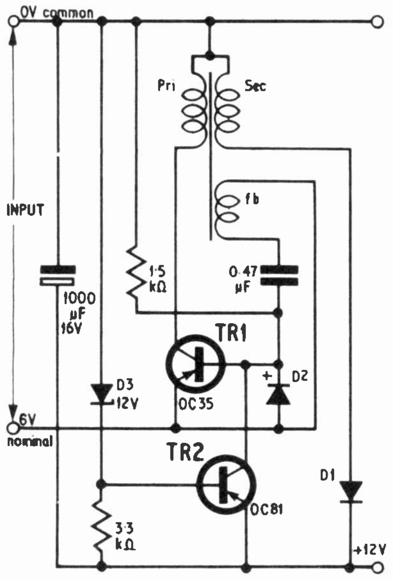


Fig. 1. Circuit diagram for a d.c./d.c. converter

The diagram of Fig. 1 is a d.c./d.c. converter designed initially to provide 12V d.c. for a car radio from a 6V supply. In fact it can operate as is to provide the 12V from any input ranging from 4 to 8·5V.

Since the voltage of a nominally 6V car system can rise to 8·5V the transformer was constructed to suit the maximum voltage. It was wound on an old output transformer core, using 45 turns 22 s.w.g. for the primary, 130 turns 22 s.w.g. for the secondary, and 25 turns 28 s.w.g. for the feedback windings.

Diode D1, which provides rectification of the output, and D2, which protects TR1 base against excess reverse bias may be any silicon type with a current rating greater than 500mA. D3 is a 12V Zener diode.

If no oscillation is obtained the connections to the feedback windings should be reversed. Also, since the output waveform is unsymmetrical it may be necessary to reverse the output windings to obtain maximum power. The quiescent current of the unit is around 125mA.

The regulation circuit is effective since, when the breakdown voltage of D3 is reached, TR2 conducts, making the base of TR1 positive with respect to its emitter and therefore turning the inverter off. When the voltage across D3 falls to below its breakdown voltage oscillation starts again and the output is thus accurately maintained.

The circuit is easily adapted to provide for other input and output voltages by winding the transformer accordingly, at five turns per volt, and choosing an appropriate Zener diode; neither the exact number of turns nor the gauge of wire used are critical.

G. Blackwell,
Stretford, Manchester.

THIRD HAND HEATSINK

When building a radio recently, I reached a situation in which an octopus would have been hard-pressed to keep hold of components, soldering iron, solder, PCB, etc., and I needed yet another hand to hold my pliers on the transistor lead as a heatsink.

To overcome this problem I turned my mind to alternative self gripping heatsinks and being a medical student I hit on the idea of using Spencer Wells forceps. These are ideal for the job being long and able to reach inaccessible places, self locking to grip the wire or wires (usually grips an artery) and they have a thermal capacity high enough to act as an efficient heatsink. The ability to grip more than one lead at once makes soldering of multi-lead components much faster.

The forceps are about 5 inches long and cost approximately 55p from medical or scientific instrument dealers.

Mr. W. R. Saywell,
Oxford.

THE times when a potential Texas millionaire could hammer a bean stick into his back garden and hit a gusher have, as we all know to our cost, long since gone. All the same, world economy is so tied to elusive "black gold" that life, without the potential energies of oil and natural gas, would be unthinkable—at least for the next few decades.

The energy shortage, increased industrial expansion, extended use of plastics and chemicals and exhorbitant prices from some exporting countries have put more emphasis on the backroom boys of the oil business—the explorers.

This article deals with the ultimate method for locating potential oil sources—Reflection Seismology—and it shows the role electronics plays in keeping our cars running, gas stoves burning and polythene bags packing!

EVOLUTION OF OIL

Oil is usually found in areas of the world that are described, by the geologist, as sedimentary basins. These are areas that once, many millions of years ago, were covered by sea. As time went by the seas dried and left thick layers of sand and silt which contained an abundance of dead organic marine life. At the same time the sand was covered by salt from the sea and as millions of years went by further deposits were laid down on top of the salt—brought there by wind, rivers, floods, or even more recent seas.

Our experience shows that the most prolific geological period when these dead sea creatures were deposited was the Tertiary Era (approximately 70 million years ago) although there were significant deposits during the Cretaceous period (150 million years ago) and as far back as Permian times (over 300 million years ago); and even before Carboniferous times, in the Ordovician period 500 million years ago.

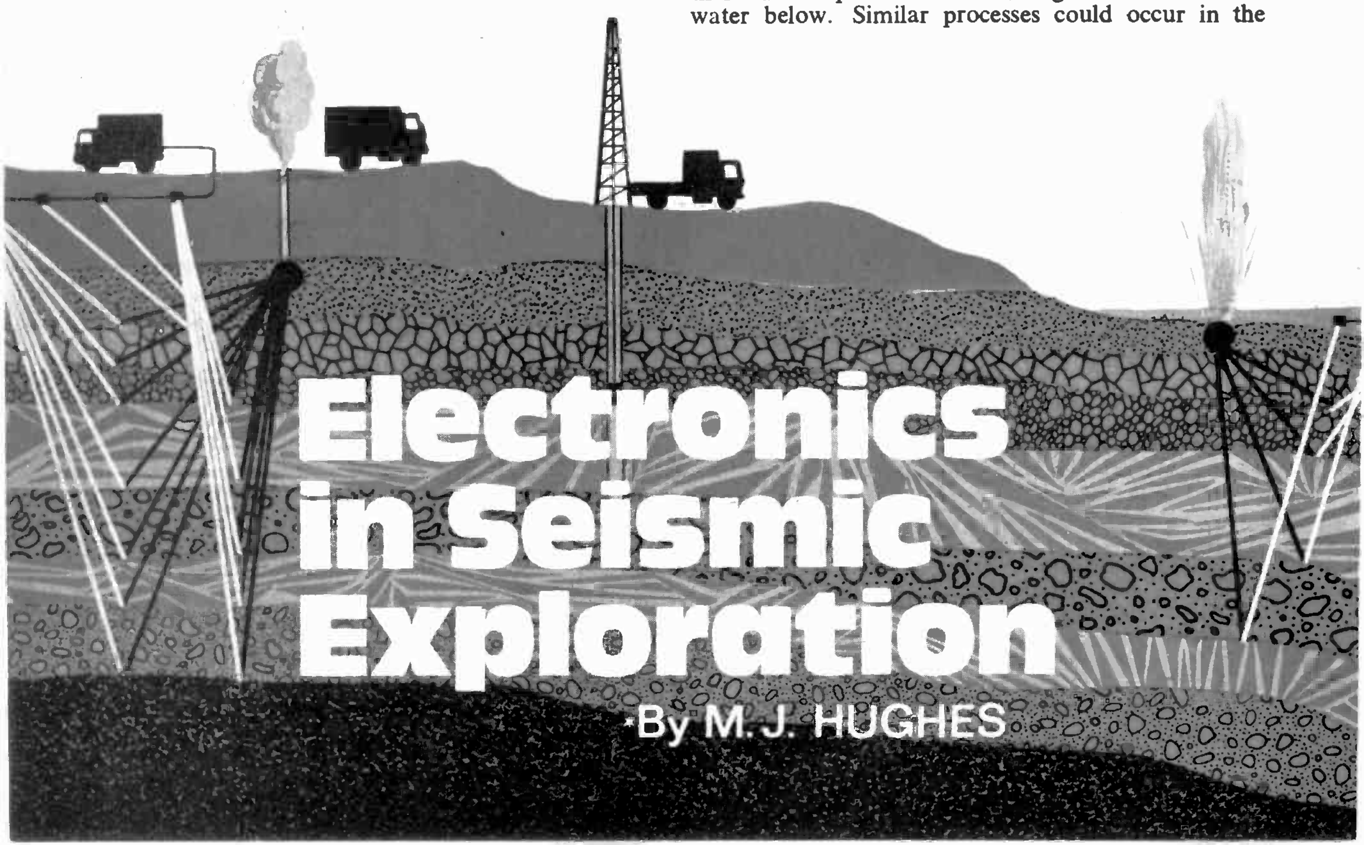
During these millions of elapsed years the dead marine organisms were subjected to terriffic pressures and temperatures, along with the sands and silts, from the shear weight of subsequent deposits. The thickness of deposits since the start of the Tertiary period alone conservatively exceed 8,000 feet in many parts of the world. These pressures and temperatures slowly compressed the sands together to form a solid, but porous rock—sandstone—and the organic matter trapped within this porous rock slowly changed in physical and chemical structure to form liquid hydrocarbons—crude oil and gas.

EARTH MOVEMENTS

As time went by the earth's crust was subjected to all sorts of deformations, as it still is today. Protracted earth movements gradually folded these "source" rocks into convolutions; more dramatic earthquakes might have sheared through rock beds giving rise to vertical displacements we know as faults and in some instances the two might have occurred together. Where we are lucky the earth might have moved to form a structure like an underground hill, we call a dome. The gas, oil and water trapped in the sandstone would percolate upwards through the pores in the rock to the top of the dome where they would meet the layer of salt—also solidified into rock.

The salt is impervious to liquids and gases and might prevent the minerals from further movement. Thus the thin layer of oil over a large region might migrate towards the top of a dome and be trapped there under pressure from the gas above and the water below. Similar processes could occur in the

*Seismograph Service (England) Ltd.



Electronics in Seismic Exploration

*By M. J. HUGHES

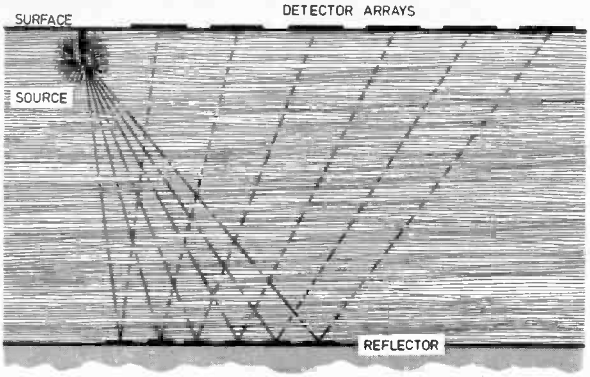


Fig. 1. Simple schematic of seismic ray paths

case of faulting or other unconformities in the laminer structures of rocks. Any structure that encourages this migration of oil into a large reservoir area is called a trap. The sediments in which oil and gas are found today are known as "reservoir" rocks.

Seismic exploration enables mapping of the substructure of the earth in precise detail and from its results the location of these traps. Provided the geological history of the area is correct and a trap structure found there just might be oil if it were drilled for. The chance of drilling into a reservoir of commercial value is still, however, ten-to-one against. A single "wild cat" oil well might well cost the best part of a million pounds so great confidence in the accuracy of a seismic survey is essential.

SEISMIC REFLECTIONS

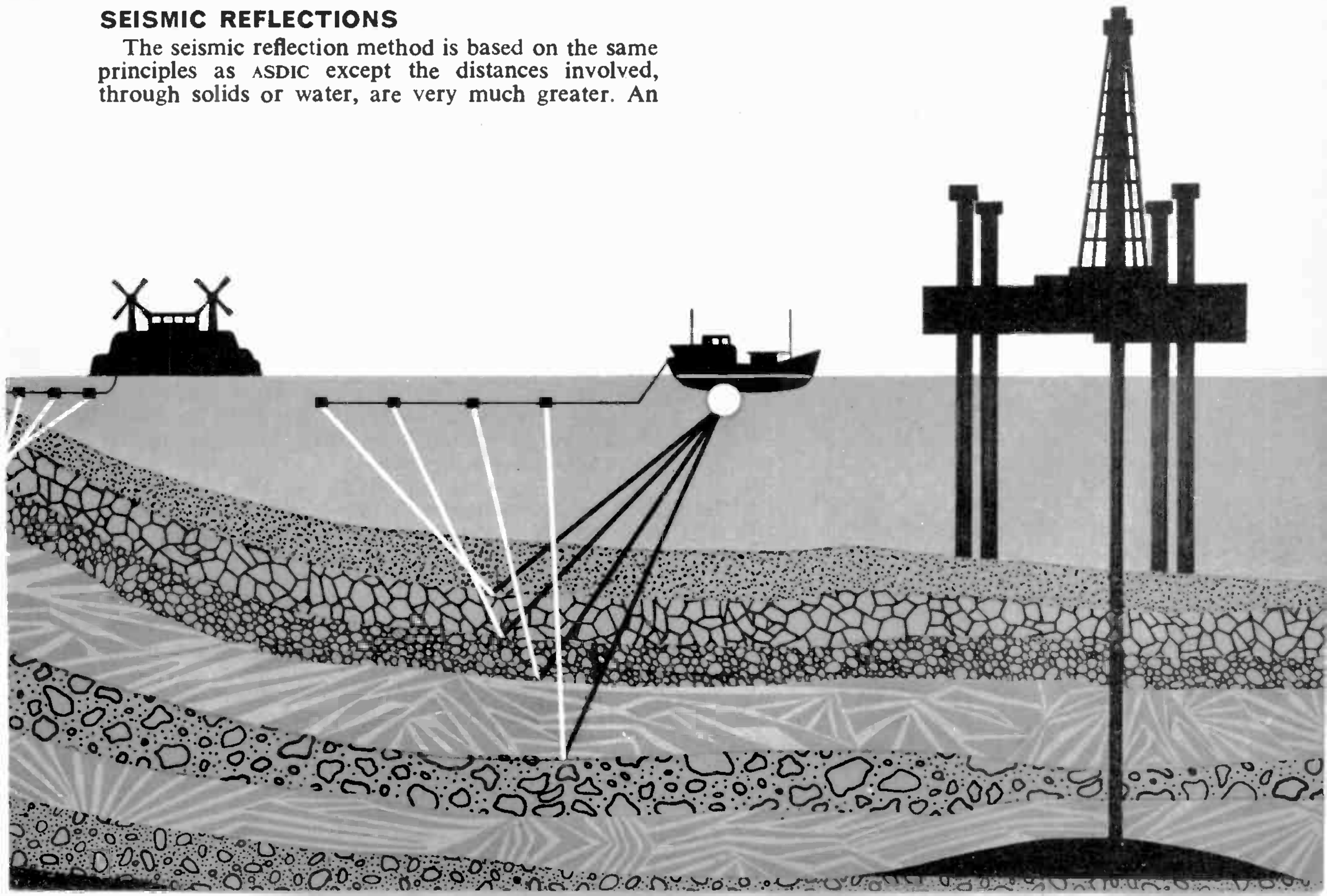
The seismic reflection method is based on the same principles as ASDIC except the distances involved, through solids or water, are very much greater. An acoustic signal is generated at the surface of the earth and this passes through the ground, downwards, as a spreading compressional wavefront (Fig. 1). As the wave passes through interfaces between rocks having dissimilar density, or velocity of propagation, a small proportion of the downward going energy is reflected (usually one or two per cent) the rest passes through to the next interface and so on.

Considerable wastage of energy occurs due to frictional losses, poor reflection coefficients, and downward reflections from horizons when a wave is on its way back to the surface. When a reflected signal does reach the surface it might, very well, have travelled over four miles.

GEOPHONES

To stand any chance, at all, of receiving a useful reflection signal there must be a lot of energy at the source. On land an explosive source is used—anything between 20 and 100lb of dynamite. This is placed at the bottom of drilled and tamped holes to try and deflect the energy downwards. In the simple case signals are received back at the surface with a geophone. This is a high sensitivity, low frequency response (down to about 8Hz) moving coil microphone—but there is a difference.

The coil of the geophone has a certain amount of inertia and it is the magnet, forming part of the case, that moves up and down around the coil, when the surface of the earth moves, that generates the electrical signal. The output signal from such a geophone can range from over 500mV for a reflection near the surface to less than 0·5μV for a signal coming from a deep horizon.



In practice there is an infinite number of ray paths, from a source, that can give rise to reflections from a given horizon so reflections can be obtained from different points along our sets of horizons if we use geophone receiving stations set apart on the earth's surface. Typically 24 or 48 such stations are used separated by about 200 feet. Thus the horizontal range of a shot might be as great as 1½–2 miles.

NOISE PROBLEMS

Most electronics engineers will appreciate the problems of handling signals as low as half a microvolt at the best of times, but add to this the problem that the signal might have to be carried down 1½ miles of wire back to the recording amplifiers. Hum pick up (from underground and overhead cables) is a problem in populated areas; this is reduced by special hum cancelling bridges at the amplifier input and we ensure our amplifier input and geophone output impedances are low.

Low impedances help (to some extent) prevent induction of signals from static sources—nearby electric storms (very prevelant in tropical jungles) or high voltage caused by moving sand particles (in the desert).

Even that is not all; frequently, while working in foul swampy conditions, simple electrical leakage to ground can sometimes arise unless the cables' insulation qualities are constantly monitored.

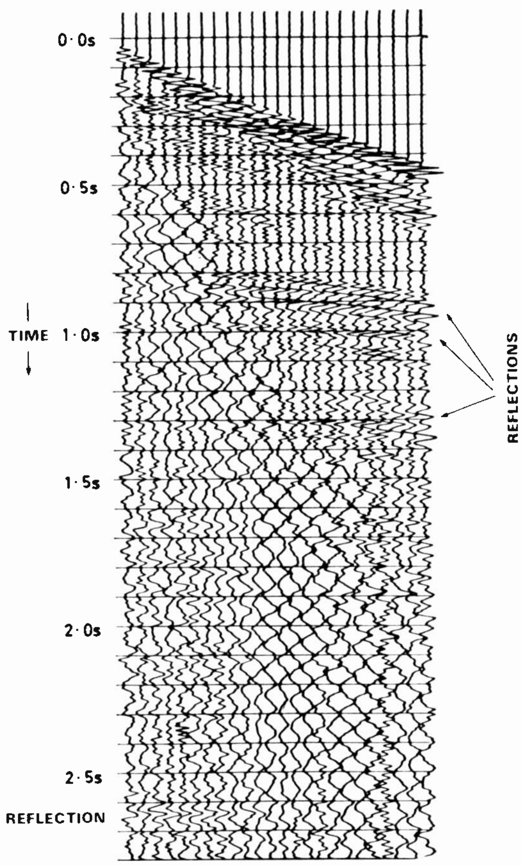


Fig. 2. A 24 trace record. The left hand trace is from a geophone station close to the shot. The right hand one is furthest away

Apart from the geophone responding to seismic reflections there is the problem of other noise sources—which can generate signals hundreds of times greater than those required. These can be man made noises—trains, trucks, people walking. They might come from the earth itself—underground rivers, microseisms, tree roots transmitting wind noise into the ground; rain, of course, is an eternal problem! Even animals do not help—a friendly elephant can devastate a seismic recording; it has even been known for a lion to chew a geophone to pieces and an unthinking grasshopper can obliterate a reflection from 3,000 feet by deciding to jump on to the geophone at the wrong moment.

To try to overcome some of these noises there might be in use as many as 60 geophones connected in a coherent series/parallel configuration at each geophone station. Hopefully they will all respond in unison to the desired signal giving an enhancement to its strength and incoherent signals should not reinforce each other!

Fortunately the range of frequencies the earth will propagate is fairly limited—in the range of 10–100Hz so electronic filtering helps remove some of the artifacts. Hum cancelling bridges—as opposed to filters—are obviously essential as 50Hz lies almost at the peak of the seismic spectrum.

AMPLIFYING THE SIGNAL

Typically, there are up to 48 geophone stations connected back to a recording centre which is ideally mounted in the back of a truck, but in the jungle all equipment might have to be portable for man handling in which case the amplifiers and recorders would be set up on the ground. In either instance accumulator power sources are used.

In the early stages of the amplifier the 48 channels are handled independently; they each enter a pre-amplifier with a pre-set gain. At that point the amplitude range considered is from 500mV down to 0·5μV, a dynamic range of 120dB (voltage ratio). The essential features to record are (a) the instant the shot went off and (b) the instances, in time, reflections arrive at the geophone station in question. The first is easily achieved but to log the latter it is necesary to record all acoustic signals in true hi-fi without clipping and distortion.

While it is possible to handle a 120dB dynamic range electronically (provided one has a low system noise) it is impossible to use conventional paper or tape recording to log such a signal unless considerable a.g.c. is used. A conventional a.m. tape recorder has a range of about 40dB while f.m. recording techniques offer up to 52dB normally which can be extended to 58dB by using special noise cancelling techniques.

Normal a.g.c. is unsuitable in this application because, depending on its rate of attack and release, it is bound to distort the wave shape—this would not be too bad if it was possible to record the actual gain of the amplifier (presumably by recording the a.g.c. level) as well as the signal. There would, at least, be a chance of recombining them later if so desired but this would require many recording tracks.

However, if one adopts the philosophy of recording both signal and system gain one must bear in mind that ultimately processing of data by computer can overcome the problem of recording in digital form from the word go.

DIGITAL RECORDING

The signal from one of the pre-amplifier channels is fed to a binary gain amplifier. This is an amplifier with electronically switchable gain; there may be 15 selectable gains operating in 6dB (factors of two) steps. The output is electronically monitored and if it appears to be going out of the top of a pre-determined amplitude window the gain is stepped down by 6dB; alternatively if the output falls, the gain is stepped up by 6dB. There being 15 possibilities we end up with a gain range of 90dB but at the same time the gain is precisely defined at every instance and can be described by a 4 bit binary number, for example:

Binary Code		Gain	Voltage Ratio
0000	=	0dB gain	Unity
0001	=	+6dB ,,	X2
0010	=	+12dB ,,	X4
0011	=	+18dB ,,	X8
etc			
1111	=	+90dB ,,	X32,768

The selected binary code defining the gain would be recorded alongside the amplitude. Firstly the residual amplitude has to be converted to digital format for recording. This is done by an A-D converter/multiplexer which samples the amplitude of each of the 48 channels in turn—going right round all of them in either 1 or 2mS—converts them to a 15 bit digital number and then records them on tape in sequential form together with their respective gain codes.

Most field recording systems have a read after write head on the digital recorder which allows instant check of signal quality and system accuracy by converting back to analogue for a compressed playback on paper together with parity checks.

The raw tapes are then sent to a Data Processing Centre where they are de-multiplexed and the data is analysed by computer to assess velocities of propagation, to remove the hyperbolic curvature from adjacent traces for a given shot, to assess the occurance of multiple reflections by a process of auto correlation of the whole signal against itself, to add coherent signals together to enhance signal to noise ratio and to ascertain the predominant frequencies.

Usually the spectrum shows frequencies predominating at around 50Hz and average velocities of propagation are about 10,000ft per second. This gives a seismic wavelength of about 200 feet; this is the limiting resolution unless high frequency response can be enhanced.

H.F. ENHANCEMENT

Techniques are available which—by judicious use—enhance the higher frequencies by re-injecting signals we predict the earth may have filtered out and at the same time we can apply filtering to any part of the spectrum that will enhance features we wish to see. The final seismic cross section is really a composite of all the geophone signal traces butting against each other, the coherent line up of reflection depicting the structures.

Although no claim is made for identifying materials by the seismic method techniques are under development whereby excessively high or low velocity beds can be identified by analysing their reflection coefficient from the amplitude of signals received.

MARINE SURVEYS

Now that offshore drilling and oil transportation problems have been solved a lot of attention has turned to exploiting potential marine oil reserves; we, in the UK, are only too familiar with the potential wealth beneath the North Sea. As far as the seismic explorer is concerned, he now has extra problems to contend with in marine surveys. To start with he may have to operate in deep or shallow water, in surf and over coral reefs or sand bars. Different vessels have to be used to contend with the various conditions.

Most deep sea surveys are conducted from modified trawlers—capable of towing 1½ miles of bouyant cable. The cable contains pressure sensitive hydrophones at set positions along its length.

The cable has automatic hydrofoils mounted on it at various intervals and when towed along at the operating speed of 6 knots this causes the cable to dive and take up a stable depth of around 35 feet—deep enough to avoid surface and boat noise but not so deep that the piezo electric or variable reluctance hydrophones response is swamped by hydrostatic pressure.

The straightness of the cable is important and this is monitored by receiving radar reflections from a passive reflector towed at the cable's trailing end.

NAVIGATION TECHNIQUES

As on land positional accuracy is most important—it may ultimately be necessary to position a drilling rig within a few feet of the right spot—so specialised navigation techniques have had to be developed. Where possible high resolution hyperbolic positioning is used; the navigator works out where he is with respect to phases of signals radiated from shore based transmitters. Although of limited range the 2MHz signals give exceedingly precise fixes to within a few feet. This technique is not practicable for mid-ocean surveys due to its comparatively short range.

A spin off from space technology is the use of navigational satellites as a technique for getting a fix anywhere in the world. By picking up the signal transmitted by a satellite, measuring its doppler shift and knowing its orbital parameters we are able to obtain a fix on ourselves to within tens of feet. The computations are vast and this is carried out by computer on board ship.

Although accurate these fixes can only be obtained while a satellite is in transit—this might be every 20 minutes or every 2 hours depending on position on the world's surface. Between satellite fixes the position is logged by dead reckoning—this could be done using an intertial platform and monitoring tidal currents and wind velocity or, as is more common, doppler sonar is used to give heading details relative to the sea bed. This assumes that the depth of the sea does not exceed 600 feet—the limit for current doppler sonar equipment.

RELATIVE SHOT FREQUENCY

One big bonus from marine exploration is that once under way a survey can be conducted very quickly and more or less automatically. On a land survey it might only be possible to get 30 shots recorded in a day's work whereas at sea we are able to use fast cycling air guns as a source and operate with a shot every 15 to 20 seconds while progressing at 6 knots. ★

Strictly

by K. Lenton-Smith

OWNERS and constructors of electronic musical instruments generally fall into two categories—those whose primary interest is in electronics and those who are principally musical. People who combine musical talent with a good knowledge of circuitry are less common, so that most have to tackle one of the aspects of electronic music from scratch.

MUSICAL SIDE

The musical side is perhaps the more difficult as, with good constructional details, anyone with sufficient energy, time and spare cash should be able to construct a successful instrument. Keyboard instruments are in the main polyphonic these days, calling for fluent reading and good basic knowledge of chord formation. Sight-reading three staves simultaneously can be recommended as an excellent way of exercising the brain! Perhaps this is why many constructors never learn to play and the task of building an instrument may well have left them feeling exhausted. But anyone with the determination to build owes it to himself to master playing technique.

TUNING

Directly an instrument is considered finished, a musical friend will be asked round to try it out and offer an opinion. Amplified acoustic instruments are no real problem: guitarists seem to find no particular difficulty in handling six strings, and can make simple tuning adjustments to accord with anything—even a NAAFI piano!

Keyboard instruments are quite another matter, where any tuning inaccuracy is emphasised by sustained chords. Electric pianos and organs usually require twelve precise tunings at least, and a free phase instrument might require a hundred or so. Adjustments usually involve taking the back off the instrument, so that it is imperative that tone sources are stable and that accurate tuning methods are used initially.

STABILITY

Long term stability of frequency generators demands the use of stabilised power supplies as a number of oscillators are sensitive to voltage changes (ignoring, of course, the v.c.o. itself). Because polyphonic instruments are major constructional projects, it is as well to soak test oscillators before going into production. The proposed keying system ought to have the same treatment, as the final result will largely depend on both departments of the instrument.

Whether building to a published plan or from one's own design, exhaustive testing is a wise precaution. For example, testing the tone sources of a recently published design with a digital frequency meter, it was found that a two volt supply deviation resulted in a rise in frequency of half a semitone. Even with a stabilised supply, this circuit would be suspect.

Each semitone is divided into 100 cents for tuning purposes and, since a trained musician will hear errors of less than 10 cents, careful choice of circuitry is essential.

OSCILLATORS

Well designed Hartley or Colpitts oscillators are extremely stable, with supply variations having little if any effect on frequency. Semiconductors used in these sources hardly affect the result as the tank circuit itself dictates frequency. Open coils should be avoided because of the danger of interaction: using screening cans will help but pot cores are better still in that they have no external magnetic fields. Although these cores are relatively expensive, only twelve will be required for many instruments.

R/C oscillators are more susceptible to changes in ambient temperature and supply voltage, even with sophisticated circuitry and high quality components. Divider stages are normally R/C circuits and, as they faithfully divide by two, their stability depends on the master oscillator.

PITCH STANDARD

The international pitch standard is A-440Hz, and the proposed oscillator could be soak tested against this standard. The BBC propagates this frequency at various times, the most convenient source being the BBC2 test card period. Each morning, the 440Hz signal is transmitted at half hour intervals between music. Tuned with this signal the A oscillator could be checked for any drift by leaving it running until the following day's test signal.

The BBC's standard frequency is an excellent starting point for tuning a completed instrument. A piano may be available, as a tuning reference; if the two are to be played together, all well and good. But, as the piano may not be at standard pitch, there could be problems. A pitch pipe is sold for tuning purposes, but wind pressure varies its pitch—so BBC2 is to be preferred.

BEATING

Sound A above middle C (which *should* be 440Hz) with the BBC2 pitch standard. In all probability, a distinct beat will be heard—the frequency difference between the two signals.

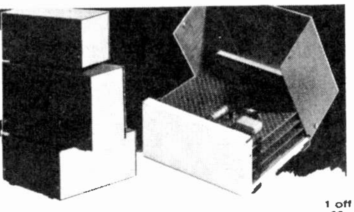
Tune the oscillator until any trace of beat disappears and, when satisfied the two are precisely in tune, turn off the television. This oscillator is now the standard for the instrument and is in no circumstances altered from this point. The remaining notes in the chromatic scale are tuned in fifths to zero beat and then flattened by a given number of beats per minute. First, play E below with the A just tuned, and adjust for zero beat: now flatten E until 90 beats per minute are counted. The rest of the scale is tuned as follows:—

B above E together, flattened by	67 b.p.m.
F # below B	100
C # below F #	76
G # above C #	57
D # below G #	85
A # above D #	64
F below A #	95
C below F	71
G above C	53
D below G	80

The next interval—A above to D—brings us the full circle and the beats should be 60 per minute. If this is not so, do not alter A but work backwards through the table and sharpen each note slightly until the error is corrected.

With a little patience, this method of tuning should preclude criticism from a musical friend. This solution will only be temporary, however, unless the tone sources are stable in themselves.

CONTIL SAMOS miniature cases



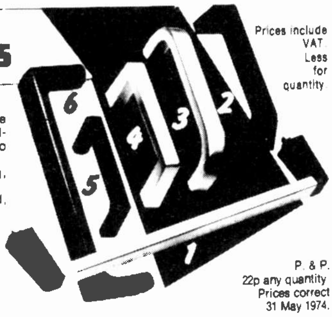
in easy-to-work blue and white PVC/steel. Assemble in the lower half; complete before springing the cover into place—4 Pozidrives, two to hinge it, two to fasten it. Carries four P.C. boards horizontally, or two vertically, four required for each case (for 1 vertical board, two each case).

		1 off
S1	100 × 50 × 50mm	89p
S2	100 × 100 × 50mm	£1·01
S3	100 × 150 × 50mm	£1·14
S4	125 × 50 × 75mm	£1·26
S5	125 × 100 × 75mm	£1·45
S6	125 × 150 × 75mm	£1·70
S7	125 × 200 × 75mm	£1·90

Much less for quantity. Prices include P & P, VAT, 4 feet and 4 plated screws. Special feet to carry printed circuit boards sold separately. Price, incl VAT, 26p for 4 P C feet. Prices correct 31 May 1974

CONTIL handles

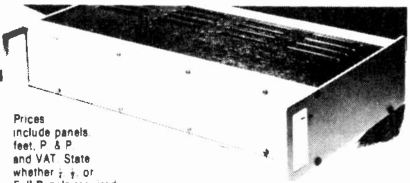
Prices include VAT. Less for quantity.



(1) No 265 Anodised aluminium centre bar. Black plastic brackets with moulded-in core. 75mm, 97p. 5 more sizes up to 154mm.
(2) No 281 1 Nylon 112mm. Load 50kg, 45p.
(3) No 277 Ali., ground, polished, anodised. 88mm, 94p., 120mm, £1·06.
(4) No 268. Satin ali 57·5mm, 94p., 102mm, £1·01, 145·5, £1·17.
(5/6) No 250 Black nylon. Very comfortable 75mm, 29p, 110mm 41p, 155mm, 67p.

P. & P. 22p any quantity. Prices correct 31 May 1974.

'Brightcase' anodised cases

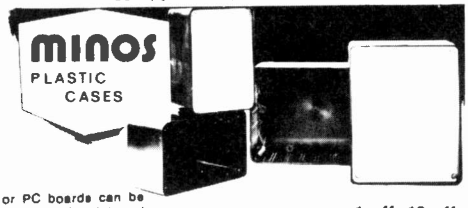


THE WEST HYDE PRESTIGE CASE
The smartest of the West Hyde cases, all anodised aluminium, with top and bottom panels only, in black PVC covered steel (plain or louvered). Free standing or 19in rack mounting with aluminium brackets. Supplied ex-stock, fully assembled with S S Pozidrive screws

Prices include panels, feet, P & P and VAT. State whether ¼, ½, or Full Panels required

Prices correct 31 May 1974	1 off	Pr brackets	Extra for louvres
BC21 (3½in whole rack)	£13·46	88p	74p
BC22 (3½in half rack)	£10·90	88p	74p
BC31 (5¼in whole rack)	£15·53	£1·24	74p
BC32 (5¼in half rack)	£12·79	£1·24	74p

MINOS PLASTIC CASES



A smart miniature case in tough, rigid, high-gloss black ABS. Front panels in either aluminium or white PVC/Steel. Built-in slots for PC cards, dividers, or screens. Chassis or PC boards can be supported on "P" clips for internal pillars. Excellent as encapsulation boxes

			1 off	10 off
M2	65mm × 100mm × 50mm	2½" × 3¾" × 2"	51p	45p
M3	100mm × 130mm × 50mm	3¾" × 5" × 2"	67p	58p

Prices include P. & P. and VAT. Less for quantities. Also available less panel and screws. Minimum order £1. Prices correct to 31 May 1974.

CONTIL MOD·2

The design of these cases permits the instrument to be built or serviced within their external panels. 48 shapes. Low cost. Blue PVC/steel with white PVC coated aluminium panels

	Width in	Height in	Depth in	1 off £		Width in	Height in	Depth in	1 off £
A	4 5	3	6 5	3·60	M	4 5	3	13	4·44
B	4 5	7	6 5	4·44	N	4 5	7	13	5·44
C	4 5	10	6 5	4·91	O	4 5	10	13	6·91
D	9	3	6 5	4·91	P	9	3	13	5·44
E	9	7	6 5	5·44	Q	9	7	13	6·91
F	9	10	6 5	6·28	R	9	10	13	8·41
G	13	3	6 5	5·44	S	13	3	13	6·91
H	13	7	6 5	6·28	T	13	7	13	8·41
I	13	10	6 5	6·91	U	13	10	13	10·20
J	18	3	6 5	6·28	V	18	3	13	8·41
K	18	7	6 5	8·41	W	18	7	13	10·20
L	18	10	6 5	10·20	X	18	10	13	12·21

Woodgrain D £5·44, E and G £6·28, H £8·91. Prices include screws rubber feet one or two chassis according to size and P & P and VAT

Prices correct to 31 May

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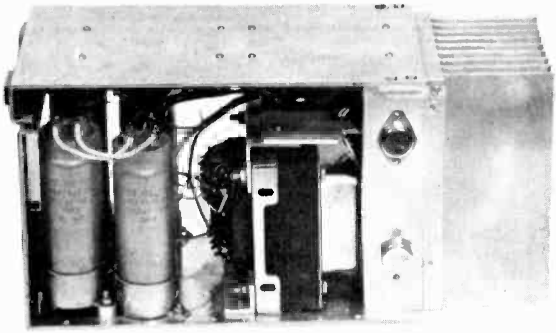


PE POWER SLAVES

BY R.B. REESON

JUST as a basic circuit configuration is given for the family of Power Slaves, similarly we can use a basic constructional method based on the 100 + 100W prototype amplifier. This means that although the printed circuit board layouts and component placements will be common to all four amplifiers, a scaling down of the chassis piece part figures given should be made for the relevant lower powered amplifiers since lower rated components such as transformers and large electrolytics will correspondingly occupy less space.

100 + 100W CHASSIS

The method of construction of the 100W chassis is fairly straight forward and comprises only four basic parts plus two side panels.

The heatsink forms the entire rear face of the chassis box and also serves to stiffen the final assembly. Base plate and sub-chassis are constructed ideally from 12 or 14 s.w.g. aluminium for rigidity, although 16 s.w.g. would be easier to work for those without access to sheet metal folding equipment. The side panels may be of lighter material such as 18 s.w.g. plastic coated aluminium, sold commercially as "Bondene" and "Lamiplate."

Fig. 3 shows the main chassis parts with drilling details but it should be emphasised that the base plate and top cover may have to be extended to accommodate differing makes of large capacitor or transformer. These items should be purchased first before chassis dimensions are fixed.

The base plate is attached to the heatsink by means of five 4 × 10mm bolts. Similarly the sub-chassis is attached to both the base plate and heatsink, a smear of thermal jointing compound being used at all three joints, so that a large composite heatsink is formed.

Due to the wide range of transformers which may be used in this design, no details are given for the cut-out in the vertical face of the sub-chassis. Thus this cut-out, and the transformer mounting holes, must be positioned to suit the particular transformer to be used.

The top cover carries the amplifier printed circuit boards, and hinges up for ease of servicing. To avoid lengthy wire-runs which might give rise to instability and hum pick-up, the input and output sockets are carried on the front face of this panel.

The heatsink used is supplied with a tongue along one side and a slot on the other, such that larger assemblies may be built up by stacking them side by side. The tongue must be carefully filed off, taking care not to score the surface which will carry the power transistors. For the sake of neatness, a strip of 10 s.w.g. aluminium 3½mm wide can then be Araldited into the slot on the opposite side and filed down flush.

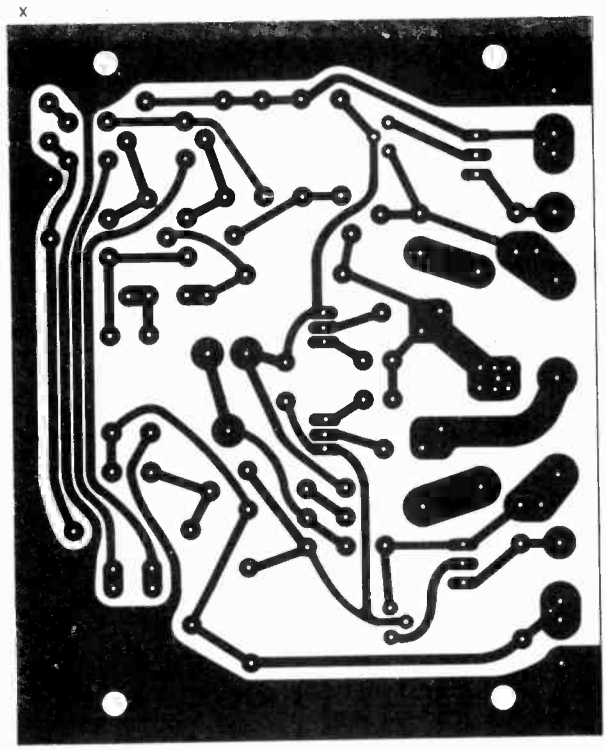


Fig. 1. Printed circuit master for amplifier boards

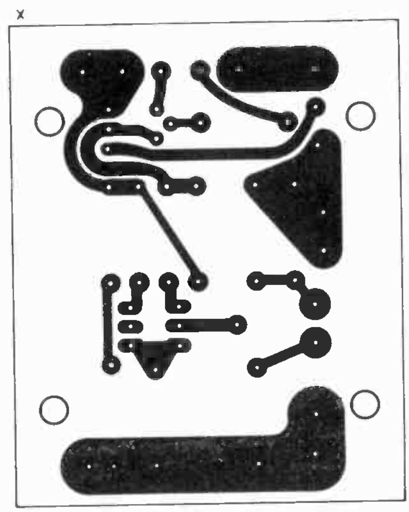


Fig. 2. Printed circuit master for p.s.u. stabiliser

CHASSIS CONSTRUCTION AND COMPONE

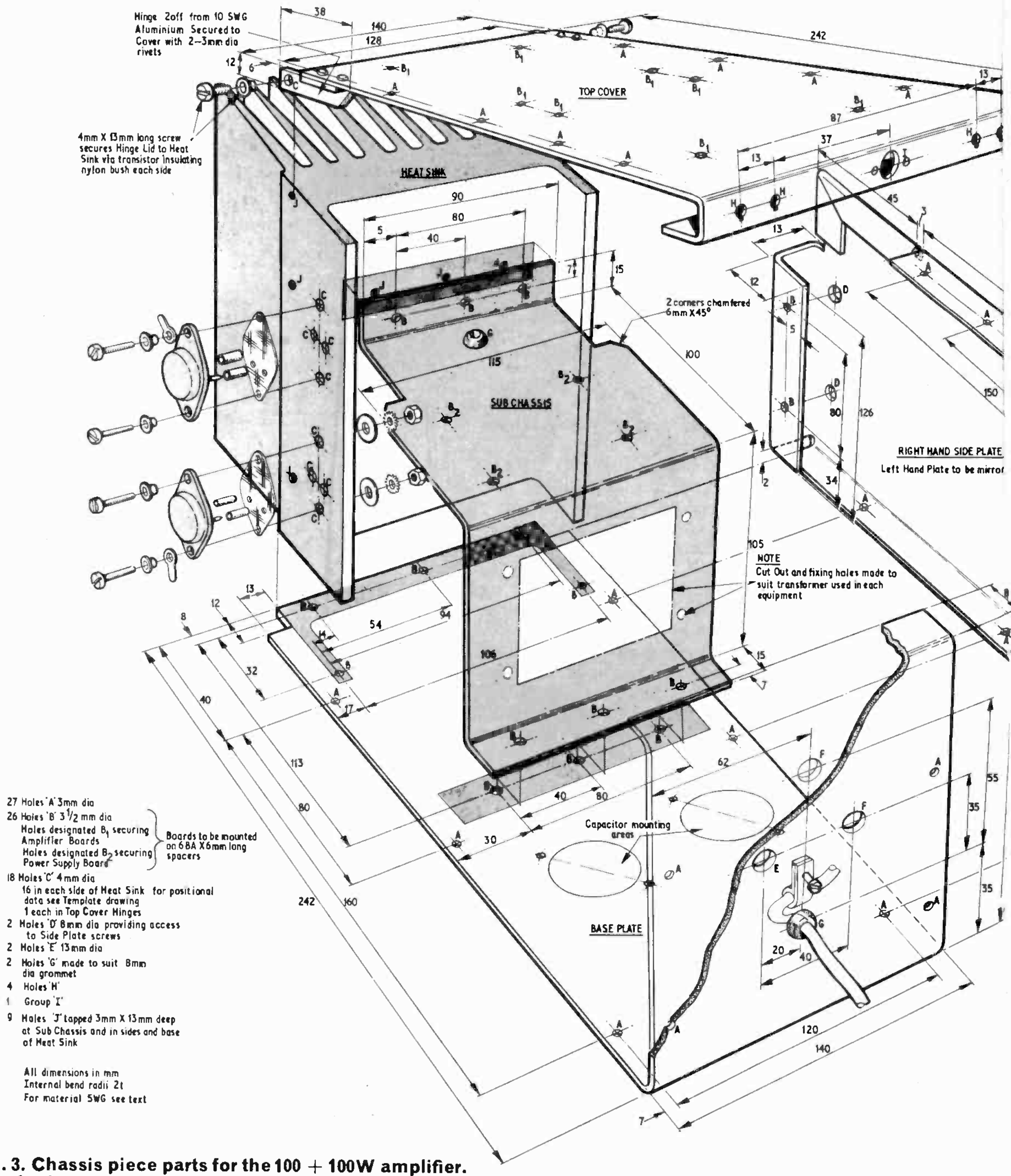
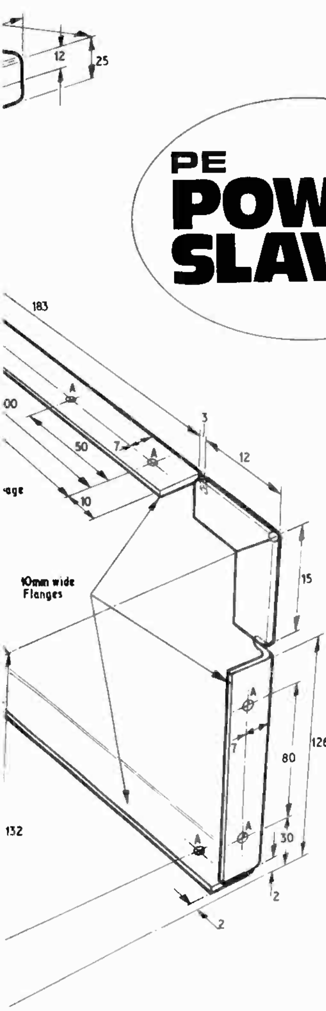


Fig. 3. Chassis piece parts for the 100 + 100W amplifier. For the lower power versions the dimensions should be sensibly scaled down

IT BOARDS



PE
POWER
SLAVES

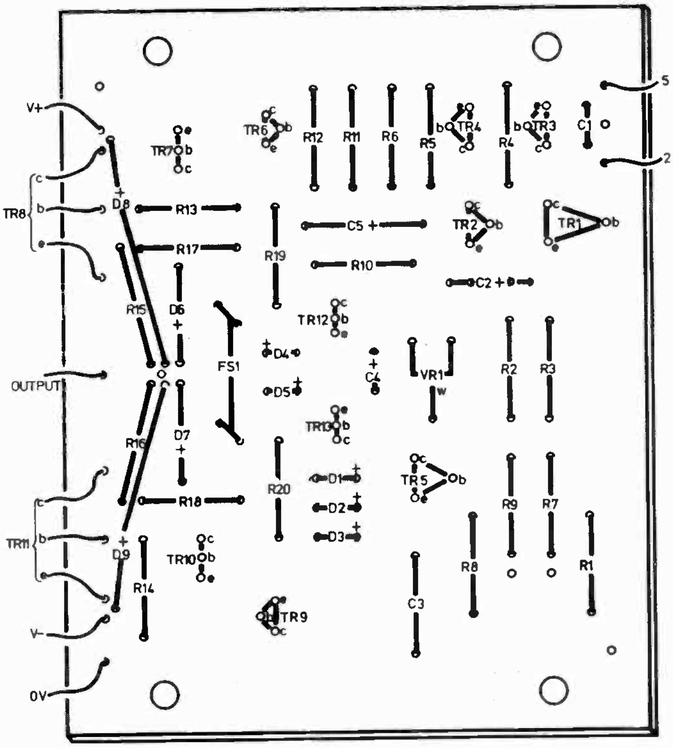


Fig. 4. Component layout for amplifier p.c.b.s

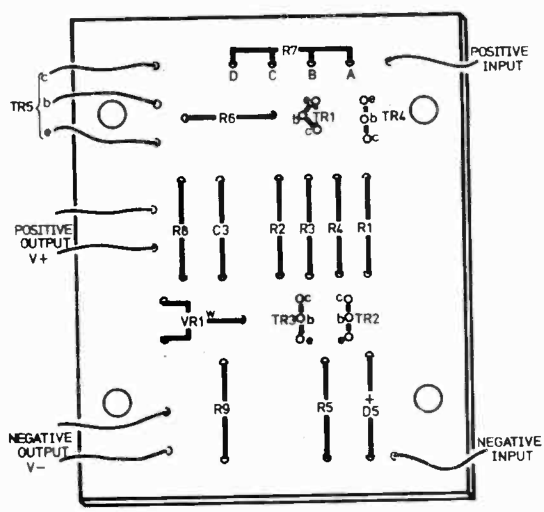


Fig. 5. Component layout for stabiliser board

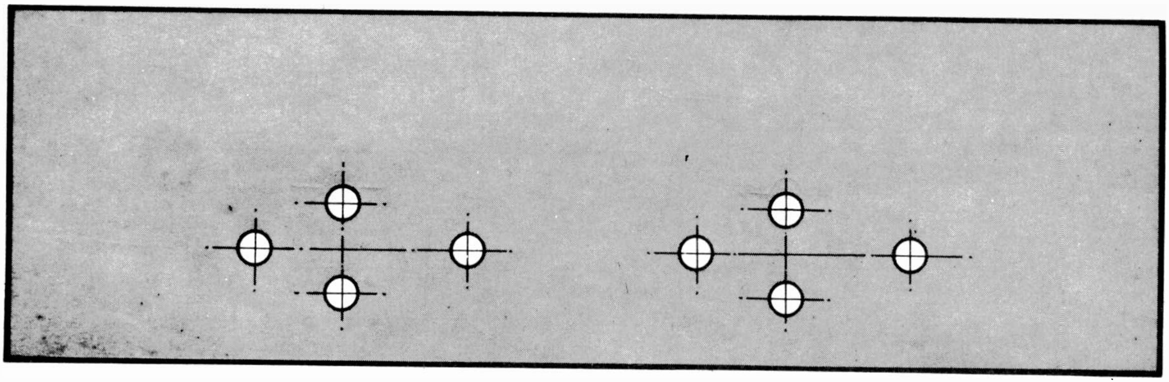


Fig. 6. Drilling template detail for power transistors

HOLE DRILLING

All holes in the heatsink, tapped 4mm, should be drilled No. 30 (⅛in) to a depth of 12mm and tapped. Any constructors not familiar with the difficulties of tapping holes in aluminium would be wise to use self-tapping screws of a similar diameter, as a broken tap in a blind hole is difficult to remove to say the very least.

The only exceptions are the holes which take the bolts forming the hinge pieces for the top cover. These should be tapped 3mm to a depth of 10mm and the top cover mounted with the aid of two bolts onto which TO3 insulating washers have been placed to provide a nylon "bearing".

The mounting holes for the power transistors are best marked out on a template, made of scrap steel or aluminium as in Fig. 6. This template can then be drilled and checked against a TO3 case transistor before it is clamped to the side of the heat sink and drilled through. The same template can then be used for the other side.

AMPLIFIER BOARD ASSEMBLY

The majority of main amplifier components are carried on a printed circuit board. Two of these are required and can be etched using the master of Fig. 1. An overlay for component positioning is provided in Fig. 4. The X at the corner of each figure should coincide for correct orientation.

When assembling semiconductors particular care should be taken that leads are correctly positioned as many versions of BC182, 184, 212 and 214 transistors are produced.

Components should be mounted flush to the p.c.b. with the exception of the transistors which should be spaced off 5 to 10mm.

Resistors R17 and R18 consist of appropriate lengths of 26 s.w.g. Constantan wire soldered directly to the circuit board. Cutting lengths and the approximate height it should clear the p.c.b. for differing powers are given below:

Power	Resistance	Length	Height
20W	0·11Ω	37mm	11mm
40W	0·08Ω	27mm	6mm
65W	0·07Ω	24mm	4·5mm
100W	0·06Ω	21mm	3mm

ADDITIONAL DIODES

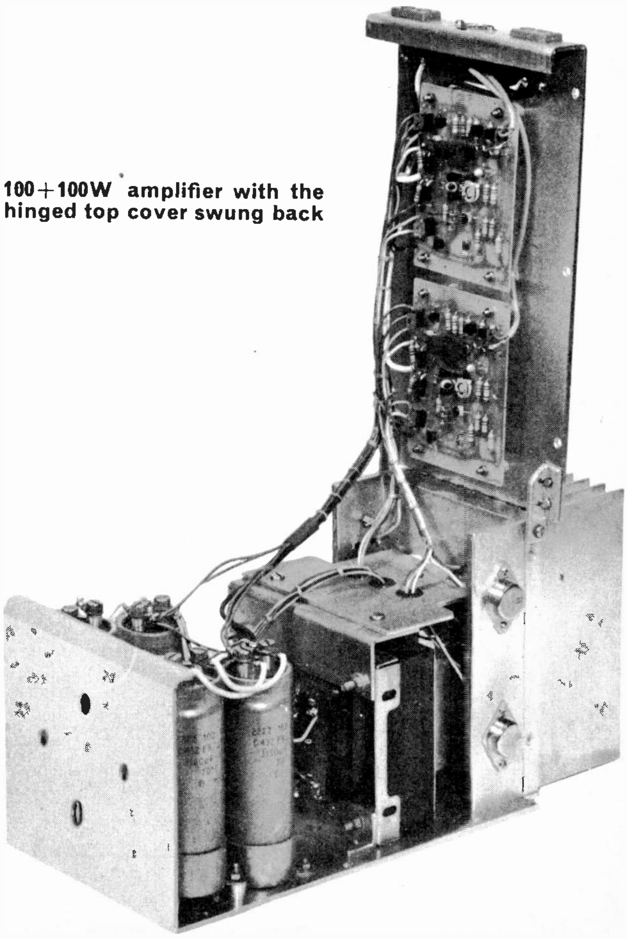
The addition of the two diodes mentioned at the end of last month's article now changes the Components List for all versions of main amplifier as follows:—

D1—D5 1N914
D6—D7 1N5401
D8—D9 BA148

OUTPUT FUSE

The purpose of the output fuse FS1 is to give protection against short circuit loads and gross overloads, as opposed to the overloads of a few dB likely

100+100W amplifier with the hinged top cover swung back



to be met when working at full power. Thus the fuse should limit operation to the safe operating area of the output transistors, and should blow at peak current in less than two seconds. A value of 1A is generally suitable, but values above 2A are not recommended. This fuse should, of course, be of the normal, quick-acting type.

Where a very low output impedance is essential, FS1 may be replaced by a wire link, but greater care will be needed in use. Full protection can be restored by fusing the two power rails to each channel separately, hence a stereo amplifier would require a further four fuses. These could be mounted on either side of the front panel.

A small heatsink may be fitted to TR7 and TR10 if sustained high power operation is anticipated, as, for example, in some musical instrument applications. This may be of 18 s.w.g. aluminium approximately 15mm by 25mm fixed to the tab of each transistor by means of a 3mm or 6B.A. bolt. Care should be taken that this does not contact any other parts of the amplifier, as the heat sink tab is not isolated.

POWER SUPPLY

The prototype 100W amplifier has a "monitoring" type of supply. If stereo use is intended there is ample room for mounting a p.c.b., including the stabiliser electronics. An etching diagram and component layout for this are shown in Figs. 2 and 5. Like the amplifier board these are full size.

R7 is made up from 26 s.w.g. Constantan wire, the tapping values of which were given last month. Links to points B and C should be made with 22 s.w.g. copper wire wrapped around a couple of times.

As Constantan does not solder easily, the wire should be scraped where connections are intended.

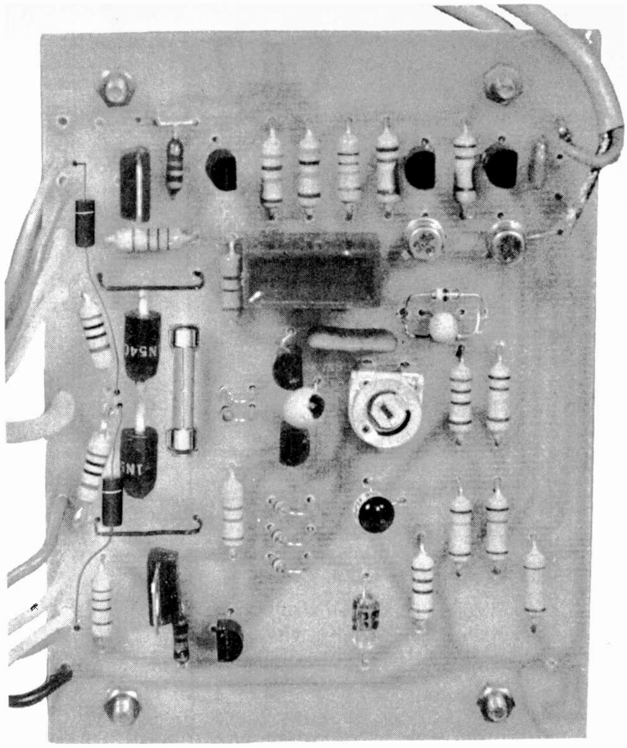
With the power supply components assembled, initial wiring can be carried out between mains input connector, mains switch and fuse and transformer. When the mains wiring is complete, the capacitors may be fixed in place and the connections from them to bridge and transformer secondary made. At this point mains should be connected, and positive and negative rails measured.

The amplifier power transistors, and that for the stabilised p.s.u., if used, should next be mounted, using thermal jointing compound on both sides of the mica insulators. Silicone grease should not be used here, as it has only a fraction of the thermal conductivity of proprietary compounds, and so allows a substantial temperature difference to develop between the device and its heat sink.

The p.s.u. circuit board is mounted in place on the horizontal section of the sub-chassis by means of 3mm bolts and short spacers or nuts. Wiring to this board is straightforward, but leads should be kept fairly short and should be of 24/0·2mm copper wire or similar, as should all the wiring so far detailed. Resistors R10 and R11 are mounted on the tags of C4 and C5, and at this time, no part of the power supply circuit should be earthed, except for the electrostatic screen in the transformer.

P.S.U. CHECK-OUT

The power supply should now be connected to the mains and turned on, with VR1 set fully anti-clockwise. VR1 may now be adjusted to give twice the nominal rail voltage between V+ and V−.



100+100W amplifier main board assembly

Bear in mind that the output capacitors on the power supply can have time constants as long as 30 seconds, so that adjustment must proceed slowly in stages.

When rail voltage has been set, the voltage drop across TR5 should be approximately 10 to 12 volts, and the voltages across C4 and C5 should be equal and within 5 per cent of nominal.

SETTING UP

The only amplifier setting up required is the adjustment of VR1 to give the desired quiescent current in the current amplifier. In general this figure should lie between 10 and 50mA. For high fidelity 30 to 40mA is recommended.

It is a wise precaution, before first turning on power, to wire a 240V 60W bulb is series with positive and negative supply leads to limit current in the event of a wiring fault. If all appears well, with the output at zero volts, and VR1 adjusted, a signal may be applied before the bulbs are removed. When connection is made directly to the positive and negative rails, a slight adjustment of VR1 will be necessary.

SERVO APPLICATION

If C2 is replaced by a shorting link, the amplifier may be used for servo applications, the input being taken directly to the base of TR1, bypassing C1. Here the gain of the amplifier may be adjusted by R2. Alternatively R10, R2 and C2 may be omitted and the base of TR2 fed from a servo potentiometer.

In this application the common-mode input voltage should be kept within ±5V of the 0V line and a resistor of 200kΩ should be included in the feedback line to the base of TR2 to maintain a low offset voltage. ★

INDUSTRY NOTEBOOK

By Nexus

END OF THE IEA?

The last ever IEA (Instruments, Electronics, Automation) show to be held at Olympia, London, opened with a whimper and finished, literally, with a bang. I exaggerate slightly because there was another day to go when one of the exhibits on demonstration exploded with a sharp crack. A pure accident (no casualties) although a few people of the meaner sort imagined it was just another of Tom Jermyn's publicity stunts. In fact it wasn't. There was no need. Jermyn Industries stand had already set a standard for elegance and comfort combined with utility which was hardly improved by a gaping hole in the roof!

As far as business was concerned the first day of the show was a disaster with very few visitors. But attendance swelled during subsequent days and by the close there were plenty of smiling exhibitors.

It's quite amazing how quickly things become "old hat". For example any company with the slightest connection with space technology used to have pictures or models of lunar modules, space rockets blasting off, communications satellites or, nearer to earth, Concorde. All these image-building themes have now been relegated to the dustbin as if they had never existed. Today's in-thing is off-shore oil rigs and all the go-ahead publicity managers saw to it that their own companies were well identified with oil exploration and exploitation. Well, that's where the money is today, and money is what business is about.

Talking point of the show was how it will make out in 1976 when it is moved to the new National Exhibition Centre at Birmingham. Clearly a brand new exhibition site matching the best that Europe can offer in comfort and convenience must be better than dreary old Olympia, but at the risk of offending readers in the Midlands I have to record that Birmingham hasn't quite the glitter of London. Few British exhibitors are attracted by the prospect of Birmingham so how will the foreigners feel? Will attendance by both exhibitors and customers be so low that IEA will die a natural death?

My own guess is that come hell or high water the Birmingham show will go on in 1976 if only because the following show, in 1978, will be the first of a three-year cycle together with Interkama (Germany) and Mesucora (France), each country having a major truly international show only once every three years. So in 1978, there will be nowhere else to go. It's Birmingham or nothing, and that could breathe new life into the show. But there is no law forcing people to Birmingham and if exhibitors and customers alike stay away then it really is curtains for Britain as a top electronics show case.

TV SLUMP

The January–April returns from the British Radio Equipment Manufacturers' Association confirmed the expected slump in TV deliveries compared with the 1973 boom. Domestically produced colour sets dropped to 600,000, ten per cent down on the corresponding period last year. Monochromes dropped to 208,000, a savage 44 per cent reduction.

This is bad news for component manufacturers but not disastrous. LCR Components, for example, is heavily geared to supplying tens of millions of polystyrene capacitors to the TV manufacturers. Kurt Balz, managing director of LCR's six factories, tells me he is still going ahead with plans to double output, the surplus being all for export. Last year LCR found itself turning down large export orders because of home demand.

OUR IMAGE OVERSEAS

At least LCR Components told overseas buyers they couldn't deliver. The damage comes when Britain takes the orders and falls behind on delivery, an unforgivable sin for which, in foreign eyes, there is no excuse—not even shortage of raw materials, strikes or three-day weeks.

Our sins in this respect were highlighted by Sammy Zilkha, the master mind behind Alphameric Keyboards and his sales director, Jim Denton, when they returned from a coast-to-coast sales trip in the United States and Canada. Overseas buyers, they say, have become evermore sceptical of delivery promises or that our prices will be held within reasonable levels on repeat orders, always a consideration when trying to get a major sub-assembly such as a solid-state keyboard designed into a new piece of equipment.

It isn't only on account of delivery and price-stability that our overseas image is suffering. Who wants to trade with a country whose government and trade unions jointly operate a selective policy of supply based on an emotional attitude to the customer country's internal politics?

Hats off, then, to Marconi on the delivery front for supplying their latest Mark VIII colour TV camera in eight days to meet an emergency requirement from French independent TV Company COFCI for coverage of the Presidential election. And let us give all support to the Radio and Electronic Component Manufacturers' Federation proposal to mount a publicity campaign to counter what is described as "derogatory and misleading reports which have appeared in overseas journals".

JAPS LOSE OUT

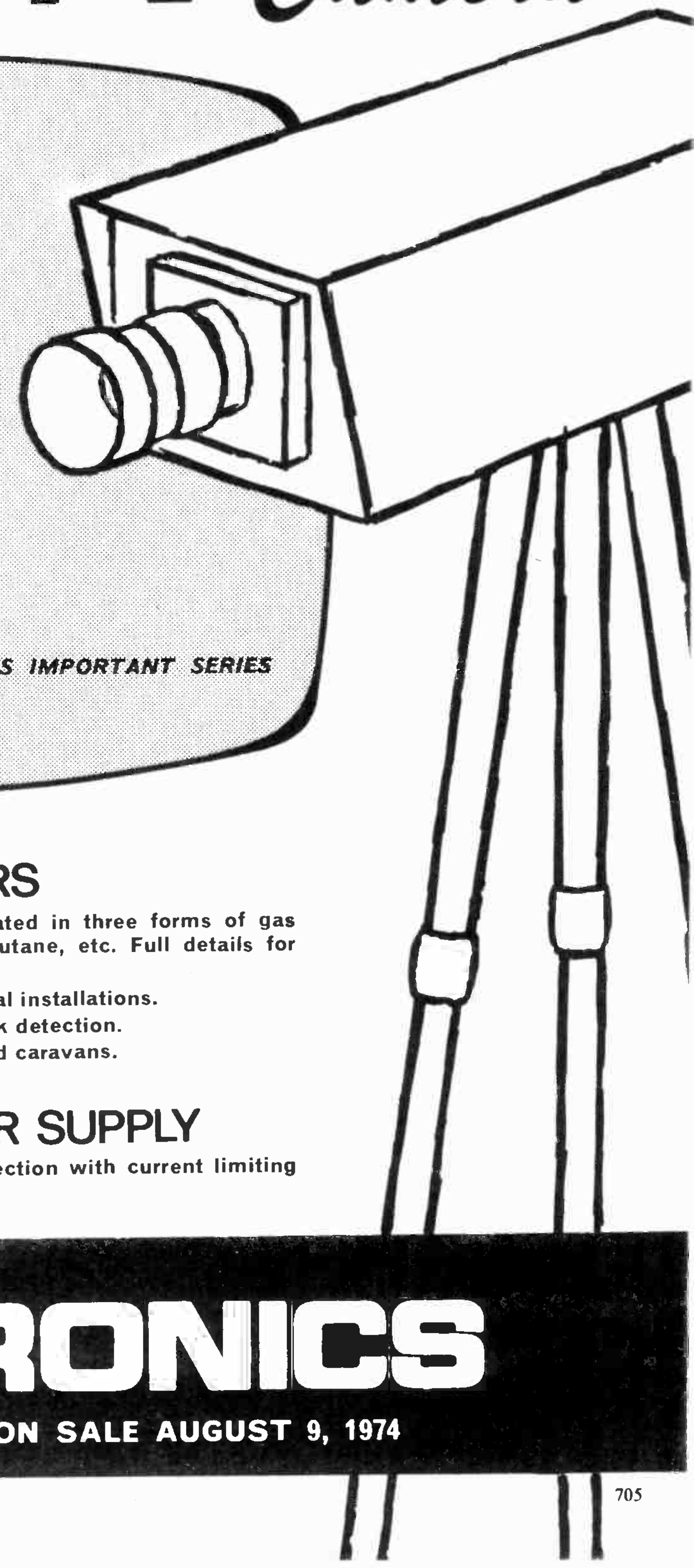
In the 20 years from 1950 to 1970 the Japanese growth in electronics has been truly phenomenal. In 1950, production was 40 million dollars (about £16 million). By 1970 it had risen to 8,800 million dollars. Japan's export performance over the same period has been even more remarkable, rising from 3 million dollars in 1950 to 2,275 million dollars in 1970. These figures were quoted by Mullard managing director Jack Akerman at a recent London conference.

The golden days seem to be over. Labour costs now are more than 30 per cent up on last year, petrochemical products are 40 per cent, other raw materials are up 20 per cent. On top of all this there is growing resistance in many countries to Japanese imports in favour of protecting their own industries. In fact overall costs are now so high at home that major Japanese companies are establishing manufacturing units in high labour cost areas like France and the United States as well as Britain.

Forecasts are that cut-backs in consumer electronics production will be more than matched by increases in industrial electronics to give an overall result about the same as last year or perhaps a very small growth. But quite clearly the days of fantastic expansion are over and what hits the Japanese even harder is that to keep a competitive pricing policy, profits may be eroded by as much as 25 per cent.

NEXT MONTH...

The PE CCTV Camera



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PRACTICAL ELECTRONICS

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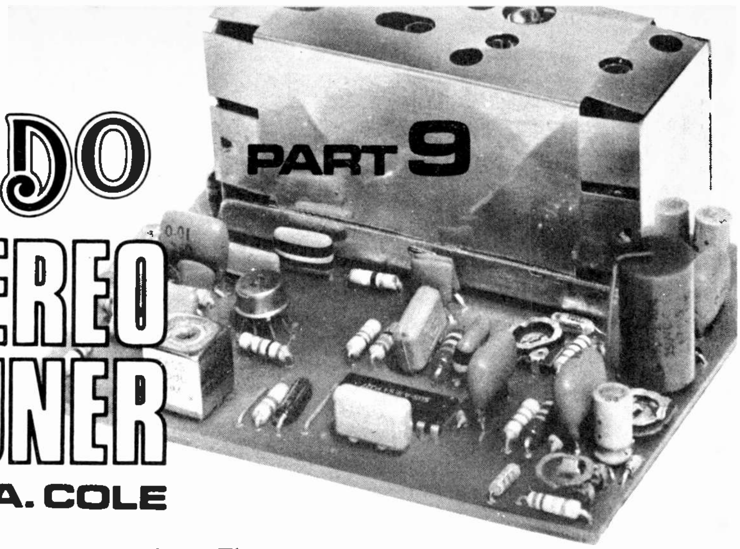


BY R.A. COLE

As described in the last part of the Rondo series, dealing with the stereo decoder and the initiation of the f.m. tuner, the tuner and decoder circuits are mounted on separate boards. Apart from providing smaller boards which can be more easily located in what is now clearly becoming a fairly crowded assembly, this does allow for flexibility of system since some constructors may desire to use their own particular tuner or decoder.

In the Rondo f.m. tuner the Larsholt head used, together with associated circuitry, give a performance which will match most other equipments and in fact even using only a rudimentary simple dipole aerial it has proved possible in North London to pull in a number of Continental stations at good signal strengths apart from all the normal U.K. broadcasts which of course come in with ample strength.

Before describing the tuner board it should be mentioned in the above context that success or failure with stereo f.m. can, in many geographical locations, be dictated by the sensible use of a good aerial system so it is as well to bear this in mind before starting construction.

F.M. TUNER BOARD

The printed circuit master negative is shown in Fig. 9.1, and the component layout in Fig. 9.2. The negative is full scale and illustrates the compactness of design which can be adopted with the Larsholt head even though the latter is a discrete component unit.

Preparation of the board follows normal p.c.b. methods though when drilling the i.c. holes do not forget that it is best to use holders here rather than mount direct on the board.

The p.c.b. is mounted in the bottom of the Rondo trough chassis in the space in front of the power supply section. It is held away from the trough bottom by stand-offs and 4 or 6 B.A. screws. Wiring to the board is loomed where necessary and, of course, signal leads are screened.

Care should be taken when locating the board to ensure that there is no risk of shorting of track or conductors on any other part of the circuitry, switches and so on when the fascia is finally re-assembled. The packing density of the Rondo system can create this danger in some circumstances.

TUNING DIAL

Assembly of the tuning dial on the left-hand side of the fascia is straightforward and follows normal procedure. The various parts, pulley wheels, large drive pulley, cord and pointer are available from a number of suppliers. Fig. 9.3 shows an exploded view of the arrangement used in the prototype.

The mechanical arrangement is self-explanatory, follows normal convention, and can be modified to suit individual requirements as they arise. Wherever possible fairly simple methods of construction have been used. Thus the tuning scale (of which more later) and tuning meter, are both held in position in the prototype using double-sided adhesive tape.

This is possible since both are light in weight and the system would not normally in any case be subject to great stresses and strains. Of course the reader is free to use any method of construction he feels is warranted but the present state-of-the-art adhesives are far stronger than is generally known.

In the Rondo, use has been made of the very latest in fascia illumination. In fact it is believed that the luminescent panel tuning scale used here, which is based on electroluminescence for its operation, is the first domestic environment application of this particular phenomena.

Fig. 9.4 is a diagrammatic section through the tuning scale which shows up the active parts of the panel. In basis the device is a capacitor with a phosphor material positioned between the electrodes. When electrical energy, in the present case 240V a.c. mains, is applied to the plates of the "capacitor" the phosphor material glows. Dependent on the frequency and voltage density applied the glow is brighter or dimmer.

As can be seen, a heavy glass sheet forms the main support member at the rear. On to this a copper electrode is evaporated to form one plate of the capacitor. A high dielectric material in a resin base is applied to the copper and the phosphor material is applied to this. The phosphor is itself carried in a resin base.

Finally, a transparent copper electrode, only a matter of microns thick, applied to a top glass sheet, forms a layer between the upper sheet and the phosphor layer.

Power to operate the device is applied to the two copper layers and consumption is in the region of 1mA per square inch.

The front glass sheet can now be suitably printed with any scale, figures or other information as required. In the present case a scale was prepared and silk-screened on in heavy black so that the scale and calibration numerals show up as illuminated figures.

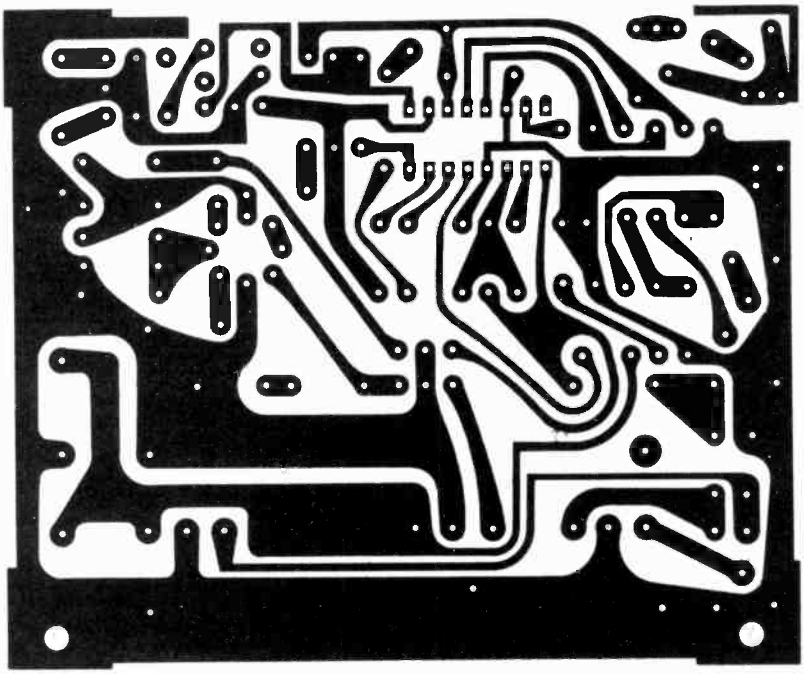


Fig. 9.1. Printed circuit master for the f.m. tuner using the Larsholt head

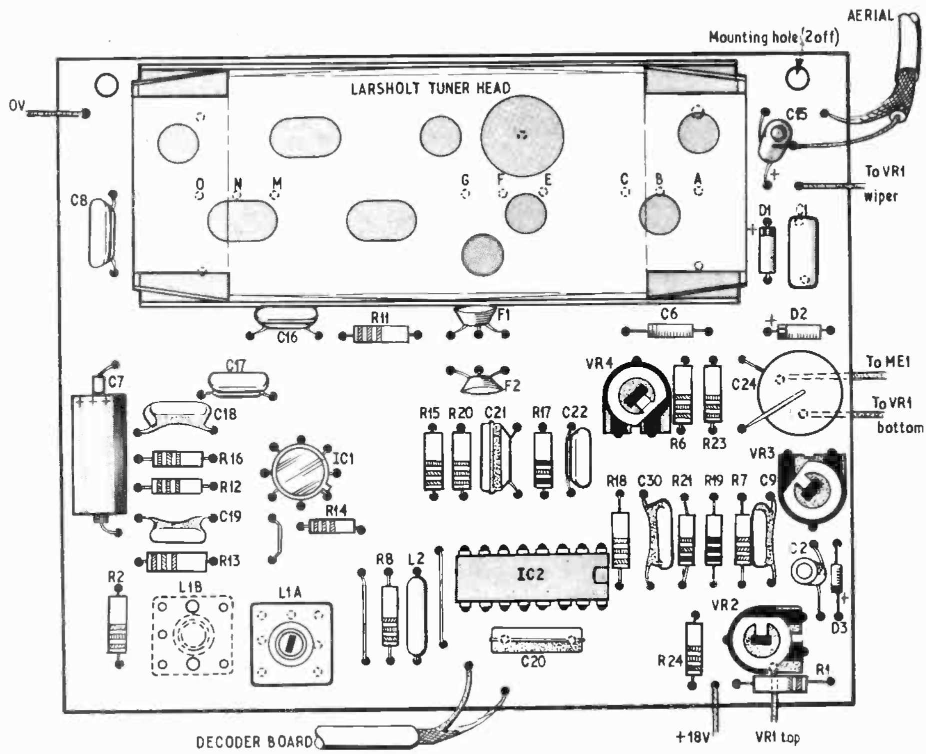


Fig. 9.2. Component layout for the tuner board. The L1B option is discussed in Part 8

PE RONDO

TUNER FASCIA

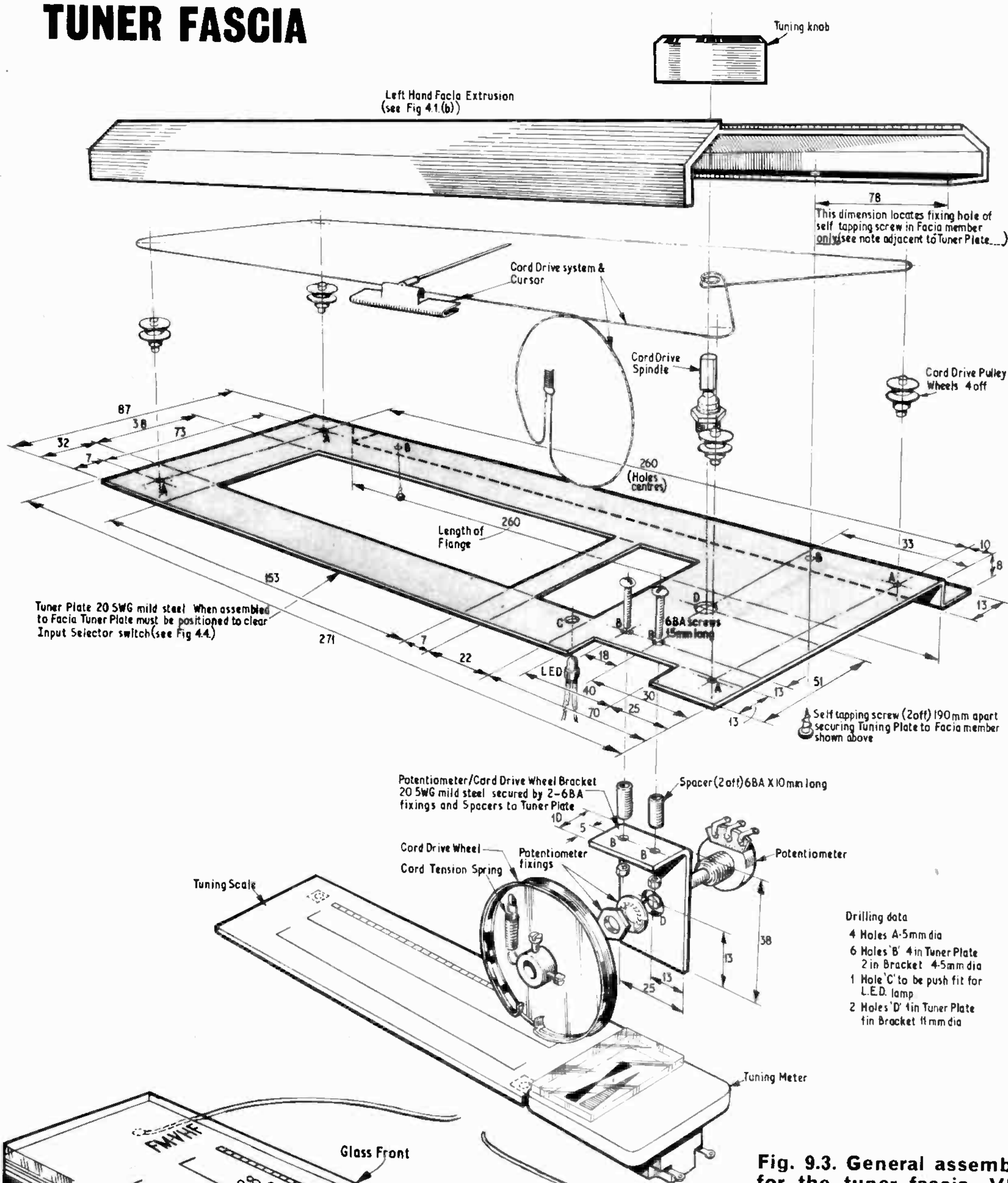


Fig. 9.3. General assembly for the tuner fascia, VR1 drive, scale and tuning meter shown exploded for clarity

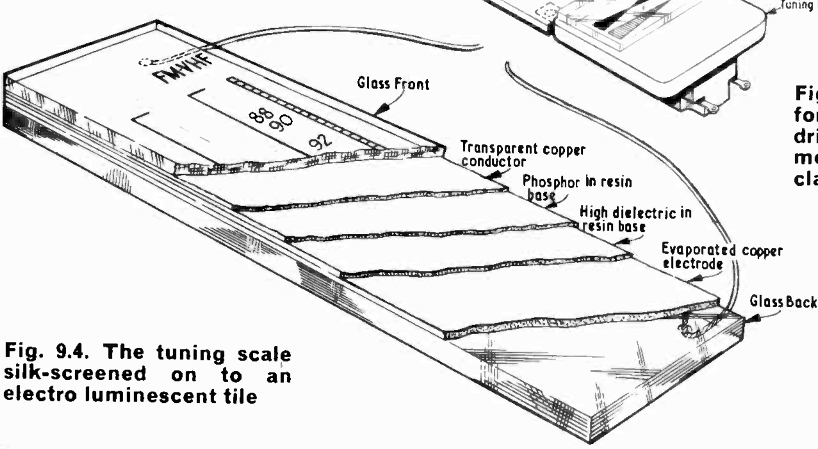
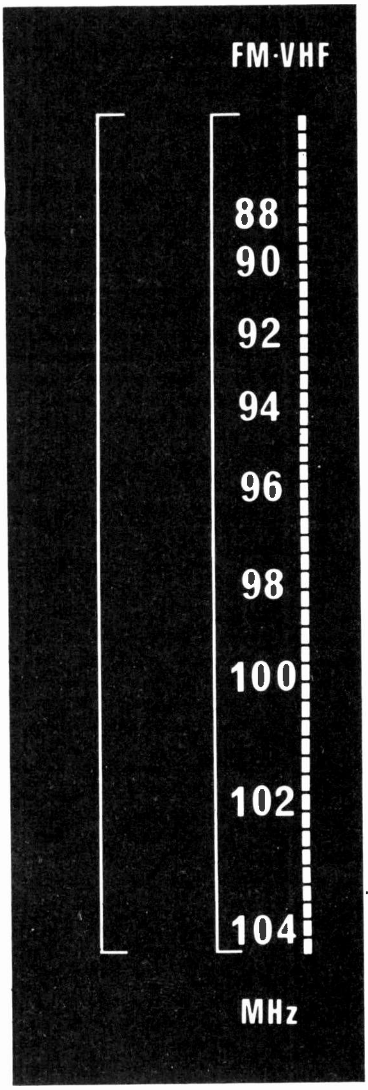


Fig. 9.4. The tuning scale silk-screened on to an electro luminescent tile



These electroluminescent devices, if fed at 400Hz, will give enough light to read by. The maximum frequency applicable is 2kHz and any increase above this or above 250V r.m.s. can considerably reduce device life.

SETTING UP

The tuner is wired up as shown and, after checking out the wiring the unit may be switched on. Selecting the appropriate f.m. button on the pre-amplifier and with the volume controls set to a moderate level a rushing sound should be heard.

The detector coil in the Larsholt head is peaked for maximum audio output. The level of muting is adjusted by selecting a weak signal for reception and turning the mute control VR4 until the station just starts to fade. In this way interstation noise will be reduced.

Any further reduction in interstation noise will of course reduce the level of the weaker station.

The stereo decoder is set up by tuning to a station known to be broadcasting stereo and then adjusting the pre-set VR5 until the LED stereo beacon lights up. As described in Part 8, a signal generator may be used for this function if desired.

MATERIALS . . .

Tuning dial—Electroluminescent panel 42×171mm (Sanders Roe Developments Ltd.).

Cord drive assembly, cursor, drive spindle, cord drive pulley wheels (4).

Drive support plate, 20 S.W.G. mild steel 262 × 120mm to be cut and bent to suit, together with 25 × 20mm and 25 × 52mm scraps for potentiometer bracket and extension piece if required. If main plate extended then latter not required.

Self-tapping screws, 4 and 6B.A. screws, nuts and washers, and spacers to suit.

TRACKING

Operation of the tuning circuit depends, since it uses Varicap tuning, on the setting of the Varicap control potentiometer VR1 in Fig. 8.2.

The end frequency at the low end of the tuned scale is set by adjustment of VR3 whilst the tracking to match the graduated scale of the tuning dial is set by adjustment of VR2. The latter sets the potential across the potentiometer VR1.

Adjustment for correct tracking can be carried out using a signal generator of known accuracy or, probably more simply, by tuning to known stations and suitably adjusting till their reception and the correct frequency agree on the tuning dial. For readers' assistance a copy of the scale used in the prototype is shown in Fig. 9.5. The tuning potentiometer VR1 is a 100kΩ linear device and the scale should be found to agree with the tuning without too much difficulty.

If required, VR3, and for that matter VR2, can be replaced with fixed value resistors once their values have been ascertained.

Whilst calibration has been going on the tuning meter will, hopefully, have been swinging up and down and it will be seen that this is a "maximum reading for tune" indicator.

If required, the tuner alignment, using the scale shown here in Fig. 9.5, can be achieved using a voltmeter rather than relying on the existence of broadcast stations. The procedure is as follows.

The main tuning potentiometer VR1 is set to mid-scale and the pointer is adjusted to align with the 100MHz calibration. After readjusting the pointer, using the tuning knob, to 88MHz measure the voltage between the wiper of VR1 and 0V. This should be done using a fairly high impedance meter preferably above 20kΩ per volt so as to avoid loading of the circuit.

Now adjust VR3 till the reading is 2·4V. Tune to 104MHz and adjust VR2 till a reading of 12·4V is obtained.

The procedure should be repeated to optimise the readings and the following will give some idea of the level of readings obtained along the scale. 88MHz, 2·4V; 90MHz, 2·7V; 92MHz, 3·2V; 94MHz, 4·0V; 96MHz, 5·0V; 98MHz, 6·5V; 100MHz, 8·0V; 102MHz, 10·2V and 104MHz is 12V.

This completes the Rondo series. We hope to publish details of further circuit modifications and additions as these become available

EXHIBITION REPORT

Just a few years ago the IEA Exhibition, held at Olympia, was heralded on each occasion as an ever-growing shop-window in which the World could look at British products. This year has seen its last occurrence at Olympia as, in future, it is to be held at the new National Exhibition Centre near Birmingham from 1976.

It is perhaps an indication of the attitude with which these large events are currently viewed by many manufacturers that the 1974 show was graced by roughly half as many exhibitors as at the previous event. Whilst this is in a way a shame, these massive circuses always add interest to the annual round, it should allow quite a saving to the industry exchequer when one remembers just how much is spent on massive events of this type.

The largest IEA held in 1970 probably cost the industry upwards of £18m including all attributable and fringe costings. To cover this the industry needs to earn at least three times the amount in turnover and clearly many of the larger manufacturers have been asking themselves if there is not a more efficient way of advertising their existence other than at this sort of cost.

Equally, it has been long admitted that centres such as Olympia and Earls Court are far from the ideal viewed in the light of other exhibition centres in Europe. Hence the choice of the new Birmingham centre which is to be a purpose-built location within easy reach of rail, road and flight links to the rest of the country and, more important, the rest of Europe.

Usually it is possible to point to a dozen or so items which catch the imagination for their novelty, sparkle or wit. But this year the feeling was very much one of soldiering on in spite of it all, against a background of hope that the components supply situation—lifeblood of the industry—would not worsen.

HEAT PIPES

Even though the show was not exactly full of sparkling new devices and equipments, there were still a few items worth noting. Many of the ideas which have come to the fore in the last few years are now being applied commercially with great effect such as is the case with heat pipes. Jermyn Manufacturing of Sevenoaks, Kent, were displaying a variety of these with capacities up to 5kW and lengths up to 10ft.

In fact they also demonstrated a hot air engine being cooled by heat pipes and it would seem that this particular invention has a future in areas across the board of industry. This perhaps illustrates the way in which one art can provide a solution to problems in other arts.

SOLID STATE

Predictably devices were not too much to the fore as the IEA is basically an equipment show but there were still some very interesting semiconductors around if one cared to look in the corners.

NEW CLOCK CHIP

Constructors who find the present state of the art in clock integrated circuits rather off-putting what with the need for two supply voltages, the physical size of the package (up to 40 pins) not to mention the cost, will no doubt welcome the introduction of a new, much simplified i.c. from General Instrument Microelectronics.

Designated the AY-5-1224 Clock Circuit, this new device features only a four digit readout as opposed to the usual six digits on the currently available chips and only a single 15V supply rail.

A single supply rail greatly simplifies the design of the power supply section of a clock which means that the whole circuit can be contained in a common 16-pin dual in line package.

The device was shown on the Semiconductor Specialists stand where it was demonstrated that the i.c. could drive a Monsanto MAN82 seven segment display directly.

Further details can be obtained from General Instrument Microelectronics, 57–61 Mortimer Street, London, W1N 7TD.

COLOURED LEDs

Light emitting diodes seem to be finding their way into more and more projects in PE but as yet the only widely available types have been red. Though the technology for producing other colours has been known for several years, it is only now that they are becoming a commercially viable proposition.

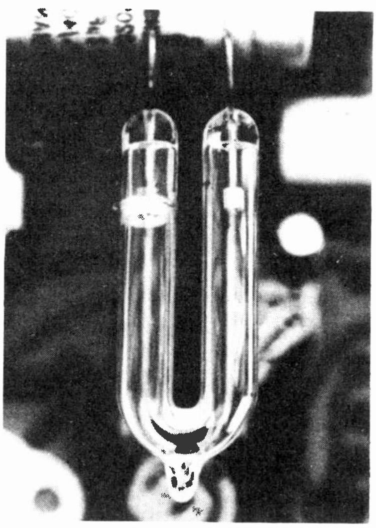
Firms such as Motorola, Hewlett-Packard and Monsanto all had l.e.d.s in various colours on their stands. The new colours available are amber, yellow and green.

At the present time the prices of the colours are about twice that of red l.e.d.s but no doubt they will soon come down.

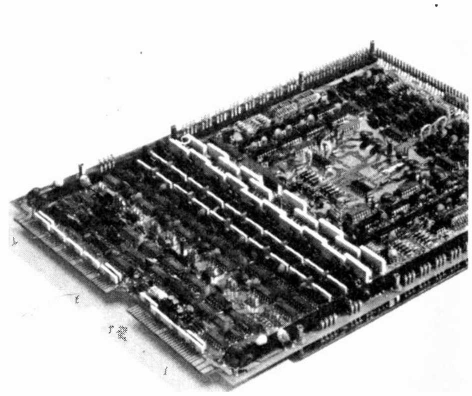
The new colours are not restricted to discrete l.e.d.s but are also appearing in alpha-numeric displays.

In this field it seems that the price barrier has already been broken for Monsanto are able to supply 0·3in

One of the new long-life Heimann U-shaped flash tubes available from AEG-Telefunken. These devices are available in various standardised forms with ratings of 4 and 8W suited for use in flash and stroboscopic applications.



Just to give some idea of the complexity and compressibility obtainable nowadays here is the latest Ampex core memory from the 1600 series which consists of a double-sided circuit board and a plug-in stack. These particular memories are available in capacities from 16·384k-word to 32·768k-word.



green, yellow or red seven segment displays all for the identical price of £2·50 (one off). For those who are interested these displays are designated MAN51, MAN81 and MAN71 respectively, and further details can be obtained from Semiconductor Specialists, Premier House, Fairfield Road, Yiewsley, West Drayton, Middlesex.

MOS LSI CIRCUITS

The new development in MOS that is destined to make quite an impact on the digital i.c. market is the production of *n*-channel circuits. This new technique makes it possible to take full advantage of the low cost and high density of MOS whilst retaining full compatibility with TTL circuitry now so cheaply available.

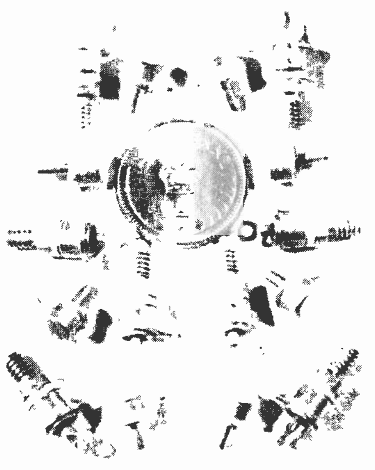
We have already seen the MOS circuit whose inputs and outputs were fully compatible with TTL in that they needed no interfacing, but they have still required a V_{ss} and a V_{gg} supply, usually +5V and −12V respectively, making it necessary to provide another supply line other than the +5V for TTL.

The *n*-channel devices only require +5V.

The new technique has also effected a reduction in price in MOS. A good example of the technique is the Intersil IM7552CPE which is a 1024 bit random access memory which uses *n*-channel silicon gate enhancement mode technology.

Power consumption is only 0·2μW per bit and access time is 1μS. The price is a mere £13·47 making a cost of less than 1½p per bit.

These tiny devices are snap-action thermal switches ideal for use in cramped locations and capable of fast switching—making them useful in overheat detection and similar applications—and they are available from Jermyn Manufacturing.



WAVEFORM GENERATOR

Another interesting i.c. from Intersil, but this time using bipolar technology, is the IM8038CCPD.

Basically this is a voltage controlled oscillator but unlike most other similar devices it is capable of producing not only square and sawtooth outputs, but also sinewave. This makes it a really useful device for all sorts of sound effects systems and at a price of only £2·85 it should be within the range of most amateurs' pockets.

Further information on both the above mentioned Intersil i.c.s is available from Celdis, 37/39 Loverock Road, Reading, Berkshire.

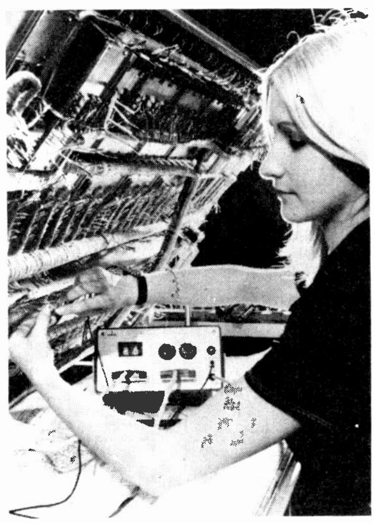
EDUCATION

Whilst most educational establishments now run some form of course in the measurement and control fields there is still a great deal of room for the development of equipment capable of demonstrating the various functions used. Feedback Instruments are specialists in this field and were showing a range of new devices.

Their electronic circuit constructor ECC 186 is a hand-case sized unit with a lift-up lid on which a circuit may be constructed using connectors and components housed in compartments formed in the other case part. The unit carries a power supply, indicating analogue meter in a multimeter circuit, and sufficient interconnections to make up many electronic circuits.

From the same source were a number of training aids in such areas as transducers. A kit TK 294 contains means for investigating variation of resistance with temperature, strain or motion, variation of capacitance with motion, proximity and level, and variation of self- and mutual-inductance with motion.

Exemplorary of the trend in multiple cable testing equipment is the VD 36 unit shown here testing a cableform in backwiring. This instrument is capable of coping with up to 100 conductors and is available from Siemens U.K.



Feedback Instruments, of Park Road, Crowborough, Sussex, also manufacture a wide range of test instrumentation suited to the educational and test markets but perhaps most interesting is their Cygnet telewriter, a desk-top equipment which can transmit and receive handwritten messages over telephone lines. Ideal for use in banks, factories and offices, this equipment offers various advantages, not the least of which is removal of ambiguity and the provision of a written copy of any message.

The use of patchboards, breadboard training aids as they used to be called, is a popular one in educational circles, as evidenced by the new products available from Limrose Electronics of 8–10 Kingsway, Altrincham, Cheshire, who showed a couple of integrated circuit patchboards. One, the PB100 system, is designed to cope with up to 40-pin d.i.l. packages and is suited to creating logic, analogue and hybrid circuitry of quite considerable complexity. For example a single patch-panel can accommodate up to 44 d.i.l. packages.

The basic unit includes power supplies, patching facilities and switched channels, and is able to accept any one of a number of patchboards which can be made up to meet the needs of the course.

A low-cost version, the Compukit 2, is designed for use with up to 16-pin d.i.l. packages or, indeed, discrete devices. Again, it includes power supplies and patching facilities but has only the one patchboard unit permanently wired in.

TEST

Of course, at the IEA a great deal of attention is paid to test and measurement, with a growing interest these days in the automation of test wherever possible. Many machines now exist to test actual equipments and these tend to follow fairly standard patterns but the area which has received least attention is the testing of cableforms or looms. These invariably present difficulty and usually require someone to spend laborious hours doing direct point-to-point tests of each conductor.

TJG Electronics, of 15 The Green, Poulshot, Devizes, Wiltshire, have developed a low cost automatic wiring tester which can be assembled in modular form to deal with various sizes of loom. It can test a wiring system with up to 2,600 connections and checks for continuity of each wire and that individual wires are not shorted together. The tests can be counted and faults can be made to arrest operation and give an indication.★

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1S131	0·13
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2G381	0·22
2G414	0·30
2G417	0·25
2N404	0·22
2N697	0·15
2N698	0·30
2N706	0·10
2N706A	0·12
2N708	0·15
2N709	0·40
2N1091	0·55
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2N1302	0·18
2N1303	0·18
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2N2219	0·25
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2N2444	1·99
2N2613	0·28
2N2646	0·50
2N2904	0·20
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2N2907	0·23
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2N3711	0·11
2N3819	0·35
2N4289	0·20
2N5027	0·53
2N5088	0·33
2S301	0·59
2S304	1·15
2S501	0·75
2S703	1·00
AA129	0·20
AAZ12	0·75
AAZ13	0·10
AC107	0·35
AC126	0·25
AC127	0·25
AC128	0·20
AC187	0·20
AC188	0·20
ACY17	0·35
ACY18	0·27
ACY19	0·27
ACY20	0·23
ACY21	0·22
ACY22	0·16
ACY27	0·25
ACY28	0·25
ACY39	0·65
ACY40	0·22
ACY41	0·23
ACY44	0·32
AD140	0·50
AD149	0·50
AD161	0·39
AD162	0·39
AF106	0·30
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·20
AF118	0·50
AF119	0·20
AF124	0·30
AF125	0·30
AF126	0·30
AF127	0·30
AF139	0·33
AF178	0·55
AF179	0·65
AF180	0·55
AF181	0·50
AF186	0·40
AFY19	1·13

	£p
FAZ11	1·15
AFZ12	2·00
ASY26	0·25
ASY27	0·30
ASY28	0·25
ASY29	0·30
ASY36	0·25
ASY50	0·20
ASY51	0·40
ASY53	0·20
ASY55	0·20
ASY62	0·25
ASY66	0·33
ASZ21	1·00
ASZ23	0·75
AU101	1·50
AUY10	1·00
BC107	0·12
BC108	0·12
BC109	0·12
BC113	0·16
BC115	0·20
BC116	0·20
BC116A	0·23
BC118	0·20
BC121	0·20
BC122	0·20
BC125	0·68
BC126	0·65
BC140	0·55
BC147	0·12
BC148	0·10
BC149	0·12
BC157	0·14
BC158	0·12
BC160	0·63
BC169	0·14
BCY31	0·45
BCY32	1·20
BCY33	0·38
BCY34	0·45
BCY38	0·55
BCY39	1·00
BCY40	0·80
BCY42	0·30
BCY70	0·15
BCY71	0·20
BCZ10	0·60
BCZ11	0·65
BD121	1·00
BD123	1·00
BD124	0·80
BDY11	1·45
BF115	0·22
BF117	0·50
BF167	0·25
BF173	0·28
BF181	0·35
BF184	0·22
BF185	0·22
BF194	0·13
BF195	0·13
BF196	0·15
BF197	0·15
BF861	0·25
BF898	0·25
BFX12	0·20
BFX13	0·25
BFX29	0·28
BFX30	0·28
BFX35	0·98
BFX63	0·50
BFX84	0·25
BFX85	0·28
BFX86	0·25
BFX87	0·25
BFX88	0·22
BFY10	1·00
BFY11	0·50
BFY17	0·40
BFY18	0·45
BFY19	0·55
BFY24	0·45
BFY44	1·00
BFY50	0·20
BFY51	0·20
BFY52	0·20
BFY53	0·17
BFY64	0·45
BFY90	0·75
BSX27	0·50
BSX60	0·98
BSX76	0·18
BSY26	0·17
BSY27	0·20
BSY51	0·50
BSY95A	0·12
BSY95	0·12
BT102/500R	0·75
BTY42	0·92
BTY79/100R	0·75
BTY79/400R	1·10
BY100	0·15
BY126	0·14
BY127	0·15
BY182	0·85

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BY213	0·25
BYZ10	0·45
BYZ11	0·40
BYZ12	0·40
BYZ13	0·35
BYZ15	1·25
BYZ16	0·60
BZY88	0·10
C111	0·55
CRS1/05	0·30
CRS1/40	0·45
CS4B	1·90
CS10B	3·50
DD000	0·15
DD003	0·15
DD006	0·25
DD007	0·40
DD008	0·38
GD3	0·33
GD4	0·10
GD5	0·33
GD8	0·25
GD12	0·10
GET102	0·50
GET103	0·40
GET113	0·35
GET114	0·30
GET115	0·75
GET116	0·85
GET120	0·50
GET872	0·30
GET875	0·40
GET880	0·55
GET881	0·25
GET882	0·35
GET885	0·40
GEX44	0·08
GEX45/1	0·45
GEX941	0·45
GJ3M	0·50
GJ4M	0·50
GJ5M	0·25
GJ7M	0·50
HG1005	0·50
HS100A	0·20
MAT100	0·20
MAT101	0·25
MAT120	0·20
MAT121	0·25
MJE520	0·65
MJE2955	1·10
MJE3055	0·75
MJE340	0·50
MPF102	0·40
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MPF105	0·46
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NKT273	0·20
NKT274	0·20
NKT275	0·25
NKT277	0·20
NKT278	0·25
NKT301	0·85
NKT304	0·75
NKT403	0·70
NKT404	0·60
NKT678	0·30
NKT713	0·30
NKT773	0·25
NKT777	0·38
O78B	0·33
OA5	0·60
OA6	0·12
OA47	0·08
OA70	0·10
OA71	0·20
OA73	0·15
OA74	0·15
OA79	0·10
OA81	0·10
OA85	0·15
OA86	0·15
OA90	0·07
OA91	0·07
OA95	0·07
OA200	0·08
OA202	0·10
OA210	0·20
OA211	0·25
OAZ200	0·50
OAZ201	0·45
OAZ202	0·45
OAZ203	0·45
OAZ204	0·45

	£p
OAZ205	0·45
OAZ206	0·45
OAZ207	0·45
OAZ208	0·40
OAZ209	0·40
OAZ210	0·40
OAZ211	0·40
OAZ222	0·45
OAZ223	0·45
OAZ224	0·45
OAZ241	0·25
OAZ242	0·15
OAZ244	0·25
OAZ246	0·15
OAZ290	0·38
OC16	1·00
OC16T	1·00
OC19	0·50
OC20	2·00
OC22	1·00
OC23	1·25
OC24	1·10
OC25	0·40
OC26	0·40
OC28	0·70
OC29	0·65
OC30	0·40
OC35	0·55
OC36	0·65
OC41	0·35
OC42	0·40
OC43	0·70
OC44	0·18
OC44M	0·17
OC45	0·18
OC45M	0·18
OC46	0·27
OC57	0·60
OC58	0·60
OC59	0·60
OC66	0·50
OC70	0·18
OC71	0·15
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OC73	0·50
OC74	0·30
OC75	0·30
OC76	0·30
OC77	0·55
OC78	0·25
OC79	0·30
OC81	0·28
OC81D	0·28
OC81M	0·20
OC81DM	0·18
OC81Z	0·45
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OC84	0·30
OC114	0·38
OC122	1·00
OC123	1·10
OC139	0·40
OC140	0·65
OC141	0·80
OC169	0·20
OC170	0·25
OC171	0·30
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OC202	0·90
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OC204	0·65
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OC206	1·10
OC207	1·00
OC460	0·20
OC470	0·30
OCP71	1·00
ORP12	0·55
ORP60	0·45
ORP61	0·48
SX68	0·20
SX631	0·45
SX635	0·55
SX640	0·75
SX641	0·75
SX642	0·60
SX644	0·85
SX645	0·85
TIC44	0·29
V15/30P	0·75
V30/201P	0·75
V30/201	0·50
V60/201P	0·75
XA101	0·10
XA102	0·18
XA151	0·15
XA152	0·15
XA161	0·25
XA162	0·25
XB101	0·43
XB102	0·30
XB103	0·35
XB113	0·30
XB121	0·43

	£p
ZS170	0·10
ZS271	0·18
ZT21	0·25
ZT43	0·25
ZTX107	0·12
ZTX108	0·10
ZTX300	0·14
ZTX304	0·24
ZTX500	0·15
ZTX503	0·16
ZTX531	0·25
INTEGRATED CIRCUITS	
7400	0·30
7401	0·20
7402	0·20
7403	0·20
7404	0·20
7405	0·20
7406	0·40
7407	0·40
7408	0·25
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7422	0·28
7423	0·40
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7441AN	0·85
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7474	0·48
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7476	0·45
7480	0·60
7482	0·87
7483	1·20
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7486	0·50
7490	0·75
7491A	1·10
7492	0·75
7493	0·75
7494	0·85
7495	0·85
7496	1·00
7497	4·32
74100	2·16
74107	0·51
74110	0·57
74111	0·86
74118	1·00
74119	1·92
74121	0·57
74122	0·80
74123	1·44
74141	1·00
74145	1·44
74150	2·30
74151	1·15
74154	2·30
74155	1·15
74156	1·15
74157	1·09
74170	2·88
74174	1·80
74175	1·29
74176	1·44
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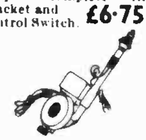

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Specification—Projector: 100W. convection cooled, at 30ft the projected image = 16ft; Motor: 1 rev per 2 min. Liquid Wheel: 6in diameter multicolour.
The Motor is fitted to the Projector and can only be purchased as a single unit. The Liquid Wheel, however, is our very popular standard model & may be purchased separately. A bargain—Projector with Motor ready for instant use, £15; 6in Liquid Wheel, £5 = £20 + 75p carr.

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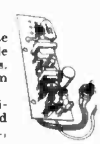

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By Brian Baily...

TIMER RESULTS AND COMMENTS

Recently I promised some preliminary readings taken using the "Random Timer" described in the June issue. At the time it was mentioned that these were expected to be interesting, as there were indications of odd happenings. I was right!

Readers will remember the suggested method of taking timings involved starting a stop-watch on a timing click, then hurriedly noting the time of the next click, resetting the watch and logging the reading during the next interval. This was the method I used initially, having first established that the timer was behaving fairly randomly. Oddly enough, during checking, when readings varied between about 3 and 20 seconds, I noticed bunches of identical timings, three 5's, three 7's and a run of 16, 14, 14, 15, 15. Was this coincidence, and if so, why should it happen to me?

⅀ ⅀ ⅀

During the tests I concentrated on slowing the timer over 10 firings, and got a total of 71 seconds, when added together. Next, concentrating on speeding the timer counts the results totalled 47. These seemed reasonable so I continued with the following results. Slow period totalled 95, fast 74; slow 81, fast 66; S 77, F 51; S 95, F 74; and finally S 81, F 66: each figure being total for 10 timer operations.

A quick glance at these figures shows a difference of about 20 seconds between fast and slow. If we assume that my thoughts had any influence they seem to be equal for fast and slow periods, this means 10 seconds per period might be presumed to be a fair assessment of the "swing of influence". Now, and here's the big snag, this works out at only half a second per reading, assuming each worked in the proper direction. Alas, with the best will in the world, a person timing himself, operating the stop-watch himself, could make an error of half a second per reading, and if he is looking for a certain result, it could easily be the case that the subconscious would delay resetting on slow timings and be a little livelier on the fast periods. This, together with errors in reading the watch with biased eyes, could explain the apparent willingness of the timer to respond to thought!

⅀ ⅀ ⅀

It was only at this stage that it occurred to me to use a better system of taking readings, obvious though it may have appeared to readers. From this time on I timed events for a fixed period each time and where an event did not coincide with the end of a period the position of the watch hand was noted prior to the end of a minute and the next firing time noted after the end of the period, so allowing a fraction of a timer count to be assessed.

Before making further readings, I had a visit from a friend, Mr Benson Herbert of the Paralab, Downton, Wilts, and he asked to check its randomness after I had showed him one or two successful results. I noticed his logged readings were a list of six counts per minute which continued for some time. I apologised and said the timer was obviously going berserk (or had gone) and that I would fix it before doing a series of trials at his laboratory.

It's a strange fact, you only have my word, but when Mr Herbert left the timer behaved normally from that time to this. When I say normally perhaps I should say "paranormally", the constant timings had completely gone and we were back to normal paranormality once more. I admit to one interference with the timer: I did adjust the preset setting since, but as explained in the timer description this sets only the longest timing duration, unless adjustment is overdone, which it was not. Mr Herbert assures me that he made no conscious effort to influence the timer during his visit.—Strange indeed!

OVERSEAS NEWS

Brazil . . . The design and construction of an "Electromagnetic Space Tensioner" has just been completed by Prof. H. G. Andrade, Director of Research Dept., of the Brazilian Institute for Psychobiophysical Research. It took five years to complete the machine.

The machine operates on a theory based on compressing empty space by magnetic forces, such that the tension so created would propagate into hyperspace, causing a secondary reaction in space as we know it, simulating a "biomagnetic" field. The biomagnetic field is presumed to surround and permeate living organisms.

Experiments using bacteria indicate increase in reproductive rates of some 12 per cent at maximum field strength. One wonders if this is the result of the elaborate system or simply the effect of any magnetic field, as reports from experimenters in plant biology indicate that certain levels of magnetic field above that of the earth's natural field, can increase plant growth. It is claimed that fields up to 2,000 gauss are used in experiments.

USA . . . According to one report, when chicks are placed close to a random timing device the timings tend to speed up. Fertilised eggs are reported to have a similar effect.

U.S.S.R. . . . Information transfer between living cells. Two colonies of cells were placed in adjacent compartments, separated by a quartz glass divider. One colony was deliberately killed by poisoning or by virus infection and each time the other colony was affected by the same sickness as the first colony.

Over 5,000 experiments were performed and it was found that if the divider was of ordinary glass, no transfer of "infection" occurred. Apparently, cells emit light in minute measures, and in sickness the light seems to be modulated into pulses. Transmission through quartz glass suggests that the radiation may be in the ultra violet spectrum and carries photo-communication information.

Madam Kulagina, Russia's answer to Uri Geller, has been demonstrating remarkable talents in psycho kinesis (P.K.).

Having seen films of her feats which included the spinning of a compass needle with a simple pass of her hand over or around it. Hidden magnets was the first reaction until she turned the compass casing and moved it in a zig-zag with the needle only just moving as a result of disturbing its pivot. All objects to be moved were placed on a transparent box-like table of glass or clear plastic.

⅀ ⅀ ⅀

In April 1973, Benson Herbert of Paralab investigated and witnessed many such experiments and results seem to rule out electrostatic or electromagnetic effects, at least, so far as d.c. fields are concerned, as special equipment was used to detect these and other side-effects. But an interesting point to note is that Kulagina was able to create burn-marks on people's arms by a simple touch of the finger. It leaves one wondering if she is capable of producing radio-frequency radiation in concentrated form, which the apparatus present at the time would not be expected to respond to.

Another feat of this lady was to split the bubble of a spirit-level.

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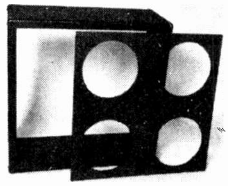
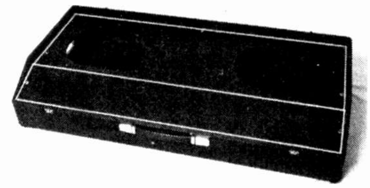


4' x 12" Cabinet



Disco Console (includes lid not shown)
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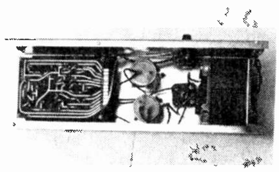
Please ask for quotation on any other type or size of cabinet you may require.



* 100 w RMS slave amp for Disco
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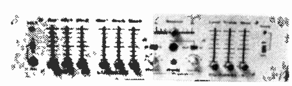

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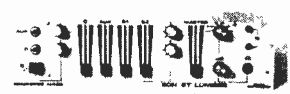

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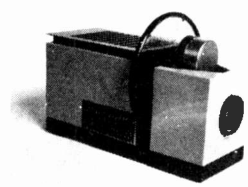

Disco imp projector 150 watt tungsten
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Normally £24–£27.50

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PATENTS REVIEW...

MOTOR CONTROL CIRCUIT

In BP 1 335 182 Smiths Industries describe circuitry for energising motors for short periods of time, a few milliseconds in every couple of seconds or minutes. Although the invention is concerned mainly with automatic aerosol operation (e.g. for kitchens, toilets, etc.), the invention principles have possibilities for much wider applications.

A charging circuit, Fig. 1, comprising fixed resistors and a variable resistor VR1 is connected between one side of a capacitor C1 and a 6 V positive supply. The capacitor is also connected via a resistor to the emitter of a *pnp* transistor TR1.

When the power supply is switched on, C1 charges via the resistors and potentiometer at a rate dependent on the setting of VR1. When the voltage across the capacitor rises above the base voltage of TR1 the latter switches on, causing the *npn* transistor TR2 to switch on which in turn holds TR1 hard on.

Whilst TR1 and TR2 are held on this provides a discharge path for C1 into the base of TR4, which allows the motor to run for as long as the charge on the capacitor holds TR1, TR2 on. Simultaneously TR3 is turned on so that C1 receives no charging current.

LIGHT OPERATED CLOCK

BP 1 334 640

As a rule this column does not report curious inventions. But there should be an exception to every rule. Arthur Pedrick of Selsey, Sussex, is by now well known for his numerous patents for odd inventions because usually his patents have more than a grain of sound sense behind them.

Pedrick describes, in BP 1 334 640, a clock which is supposedly regulated by the speed of light. According to the inventor, a light photon exerts a small but measurable pressure on whatever it strikes in a regular cycle of pulses. He believes that such pulses may be created by an electric spark produced between two electrodes located at the focus of a parabolic mirror so that a highly concentrated beam is projected.

The light pulses are received on a delicate, small, magnetically mounted target member. A small plate is secured to the opposite face of the target and has a tiny hole in it which acts as a light shutter.

Each time the target plate is moved, allegedly when struck by a light pulse, a minute quantity of light from a lamp is allowed to fall on a photocell through the small hole. The photocell output is amplified to operate a solenoid which releases a trigger to allow a tooth wheel to rotate through one tooth angle to regulate a clock mechanism, driven in the conventional manner by a spring or weight.

Thus, the theory is that the minute movements of the target plate caused by the impingement of light pulses will result in accurate control of the mechanical member.

Even discounting physical theory doubts it seems highly unlikely that any target plate could be so delicately mounted as to move under the impact of light alone. But the idea behind the invention is sound for other applications.

A perforated target plate could be made which will respond to other stimuli (as, for instance, a Crookes windmill or radiometer responds to radiated heat) or could be coupled to a diaphragm sensitive to sound signals, or air disturbances. The latter application might well be relevant to audio visual displays or a solenoid (or solid state equivalent) triggering light or sound generators for alarm purposes.

BP 1 335 182

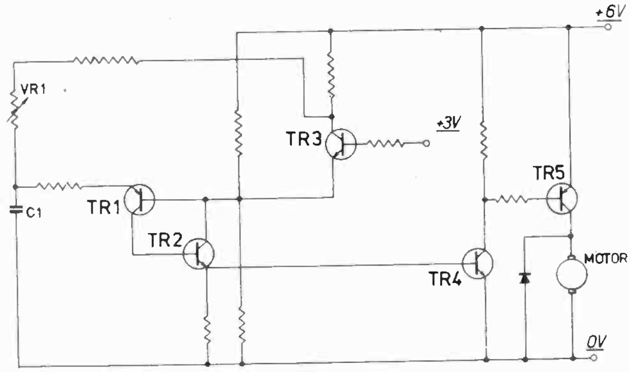


Fig. 1

FALSE START DETECTION

BP 1 330 569

According to BP 1 330 569 from Michael Weidacher, of Munich, previous attempts at electronically detecting false starts in athletic events have been unsatisfactory.

Some devices have worked on the principle that the first thing a runner does on hearing the starting pistol is to take his feet off the starting blocks. In reality the exact opposite is the case; the runner exerts a force back on to the starting blocks. Make and break contacts have been operated by this force but a switch travel of only 2mm can produce a switching lag of 1/1000th of a second, which is a distance of 10cm in sprint athletics.

The invention seeks to overcome these problems and has two main aspects in which an inertia switch and starting block design, with false start lamp, is suggested. The arrangement also incorporates a pistol cocking catch to prevent firing of the pistol in the event of false starts.

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

Sub-Aqua Colour Temperature Indicator

By O. N. BISHOP

SNORKELLING and scuba-diving have increased in popularity in recent years and, following this trend, the camera makers have produced a new range of underwater cameras. Many of these are relatively cheap and simple to operate, so the underwater photographer is by no means the rare fish that he was. But waterproofing the camera is not the only problem of sub-aqua photography.

Water absorbs some of the light passing through it, especially if it contains suspended material, and usually it absorbs more light from the red end of the spectrum. So, the deeper we go, the bluer the ambient light becomes. This blue cast spoils many underwater colour shots.

Unfortunately the human eye automatically compensates for variations in the colour temperature of ambient light, but colour film does not. The photographer is commonly unaware of the colour cast—until he views the processed slides, prints or movies!

The colour temperature of the ambient light varies with depth, suspended matter and other factors, and even at the same site may change from day to day. So the sub-aqua photographer needs some way of telling if the light is suited to the colour film he is using and, if not, what colour correcting filter he should use.

DESIGN FEATURES

The colour temperature indicator described here was designed especially for underwater use, though there is nothing to prevent its use for normal dry-land photography. Its main design features are:

1. **Small size**—achieved by compact layout and by avoiding the use of a milliammeter (which also makes it cheaper to build).

2. **Low power consumption**—power is provided by a small 9 volt radio battery (PP6).

3. **No external controls**—it is very awkward to provide waterproof seals for switches and the spindles of potentiometers, so this circuit was designed for use while completely sealed in a watertight container. For use at shallow depths it could be enclosed in a sealed glass preserving jar, or a Perspex box, but this gives the diver just one more item to handle under water.

It is preferable to put the indicator inside the camera housing, as described below. This is why its small size is so important.

CIRCUIT DESCRIPTION

As shown in Fig. 1, the circuit employs two photo-conductive cells PCC1, PCC2, connected in series between the positive (+9V) and negative (0V) rails. These are balanced (as described later) so that under all intensities of illumination their resistances are equal. The potential at point A thus remains at approximately 4·5V.

One photocell has a red gelatine filter covering it, the other has a blue filter. If the ambient light is of low colour temperature (relatively too much red light and too little blue), PCC1 will receive relatively more light than PCC2.

The resistance of PCC1 will fall and that of PCC2 will rise. This will cause the potential at point A to increase. So although the potential at A is not affected by changes in the *intensity* of illumination, it is affected by changes in the colour temperature.

Similarly, when colour temperature is high (too much blue, too little red) the potential at A will fall.

REFERENCE POTENTIAL

To detect the changes of potential at A we set up a reference potential at B, using the potentiometer VR1. This is set so that the potential at B is 4·5V.

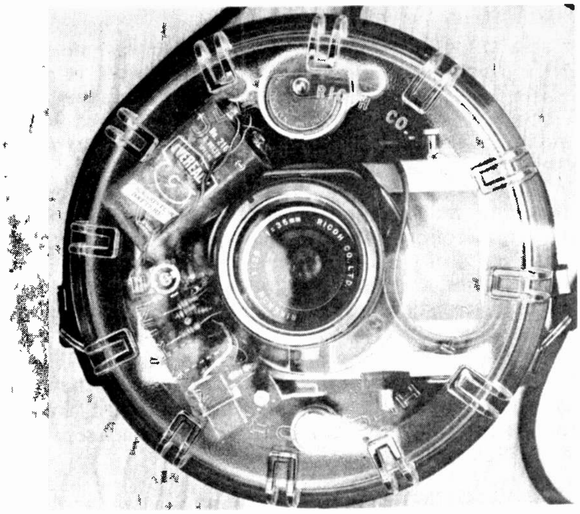
The operational amplifier IC1 is connected as a differential amplifier. Its output relative to the 4·5V line, (wiper of VR2) depends on the differential between its two inputs, the potentials of points A and B.

The integrated circuit amplifies potential swings, so that a small change of potential at A produces a large swing in the potential of the amplifier output. This large swing is used to operate the indicator lamps, D1, D2, which are light-emitting diodes.

If the output rises towards the 9V line a potential difference of up to 9 volts develops across R8 and D2 which glows brightly. The potential across D1 is correspondingly reduced and the lamp is almost extinguished.

Thus lack of balance due to low colour temperature causes the TOO RED lamp (D2) to be brightly lit. Conversely, as the output of the amplifier falls towards 0V, D2 no longer conducts and is extinguished, while the increasing potential difference between the output and the positive rail causes D1 to glow brightly—indicating TOO BLUE.

In operation VR1 is adjusted so that when the cells are illuminated by light of the correct colour temperature for the film being used, both lamps glow equally brightly. Then a departure from correct colour temperature will cause one lamp to glow more brightly than the other—indicating either TOO RED or TOO BLUE.



Photograph of the colour temperature indicator mounted inside the waterproof housing

POWER CONSUMPTION

The use of light-emitting diodes helps to keep the device small and ensures low power consumption. The indicator uses about 30mA, rising to 70mA in full sunshine. The battery may be drained after an hour or so of use, and its output voltage will fall.

This does not affect the operation of the circuit, since the important potentials (at A, and at the wiper of VR1) are all obtained by potential-dividing between the positive and negative lines. They maintain their *relative* values independently of the actual voltage of the supply.

Even with a flat battery, delivering only 7 volts, the circuit still works perfectly, though the light output from the lamp begins to weaken at this stage.

CONSTRUCTION

Cut a rectangle of 0·1in matrix Veroboard, measuring 21 holes long and 9 strips wide. Bore

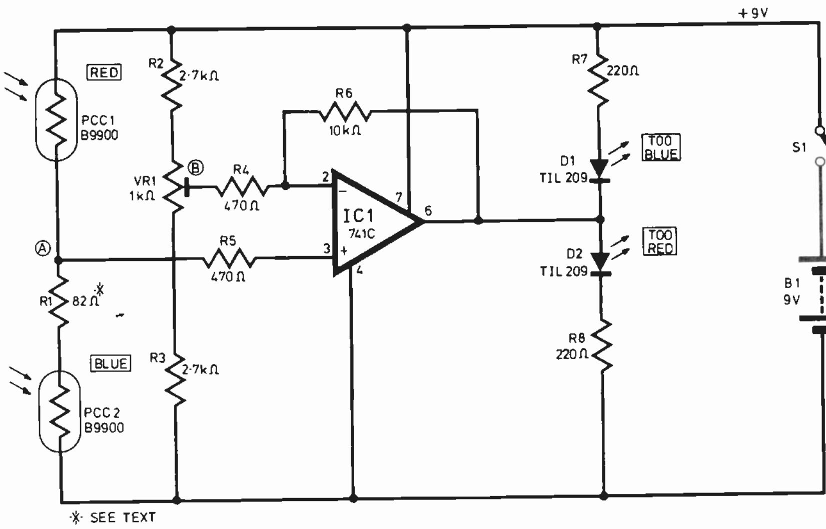


Fig. 1. Complete circuit diagram of the Sub-aqua Colour Temperature Indicator

mounting holes if these are required. The photograph shows that the author's model was mounted on a bracket made of aluminium which fits into the accessory shoe of the camera. This happened to be a convenient way of securing the circuit board where the cells could receive ambient light through the transparent front half of the housing.

With other camera housings, other means of attaching the circuit board may be devised. Construction follows the normal sequence of cutting away parts of the copper strips (Fig. 2) soldering on the resistors, and then the larger components. When working on such a small scale, with components crowded together, it is essential to prevent odd blobs of solder causing unintended shorts.

The metal ends of the photocells project beyond the body of the cell, so a small piece of card, folded and stuck to the circuit board, is used to separate the two cells to prevent short circuits.

LAMP MOUNTING

Some thought should be given to the mounting of the lamps, and this depends on the nature of the housing. If there is a viewfinder port it might be possible to mount the lamps to one side of this, so that they could be seen when using the viewfinder.

The lamps are very small and would easily fit in some kinds of housing. Leads would then be soldered to the circuit board, running to the lamps. This scheme was not possible with the author's housing, and it was decided that with the housing pointing upward to receive light from above, it would be easy to view the lamps through the side of the transparent front half of the housing (even though this has a slightly frosted surface).

Accordingly the lamps were positioned so as to face out from the axis of the housing. They were at one end of the i.c., and in bright light they are shaded by a piece of rubber tubing, about one inch long pushed over both lamps. For permanency this could be stuck lengthways along the top of the i.c. To enable the lamps to be put in contact, the rim of each l.e.d. was gently filed away on one side.

Twin wires run from the Veropins to the battery. The battery can be fitted in any convenient space in the housing, and secured if necessary to prevent it fouling the camera mechanism. Since the indicator is to be operating continuously there is no point in providing the switch S1 in the sub-aqua version. However, if this is being constructed on a larger scale as a terrestrial version (see photograph of the prototype), a push-button is ideal, and the PP6 will last for months.

The prototype was built to test the circuit design, and afterwards housed in a spare plastic food container. The circuit board was bolted just below the translucent white plastic lid.

The cells are just beneath the circular area covered with 70% Letratone, placed there partly

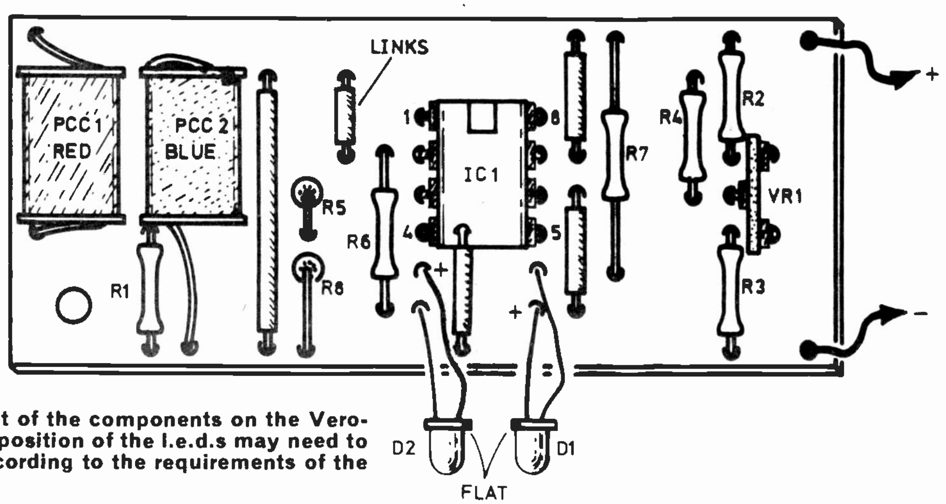


Fig. 2. Layout of the components on the Veroboard. The position of the l.e.d.s may need to be varied according to the requirements of the user

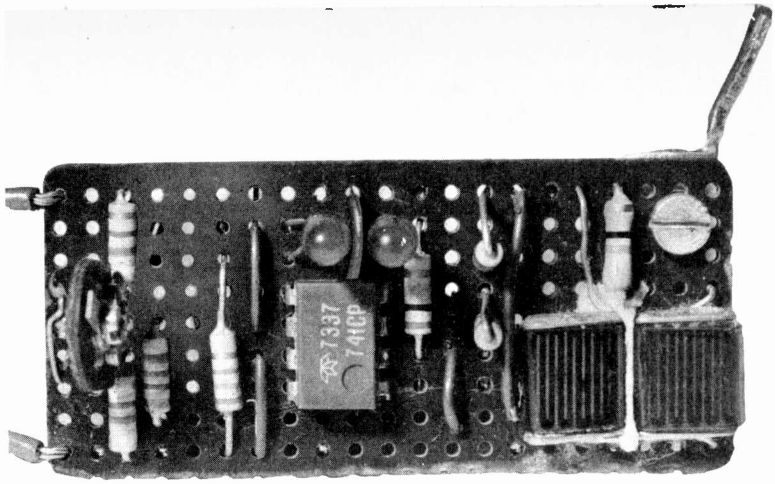
COMPONENTS . . .

Resistors
R1 68Ω to 120Ω (see text)
R2, R3 2·7kΩ (2 off)
R4, R5 470Ω (2 off)
R6 10kΩ
R7, R8 220Ω (2 off)
All $\frac{1}{8}$W or $\frac{1}{4}$W ±5% sub-miniature

Potentiometers
VR1 1kΩ linear sub-miniature skeleton preset (or potentiometer, see text)

Semiconductors
IC1 741C 8-pin DIL
D1, D2 Light emitting diode TIL209 (2 off)
PCC1, PCC2 B9900 photocells (2 off)

Miscellaneous
S1 On/off switch (optional see text)
0·1in matrix Veroboard, 21 × 9 holes
Veropins
Photographic gelatine colour filters—tricolour red and blue



Photograph of the prototype unit fitted with a small aluminium bracket for attachment to the camera accessory socket

to shade the cells and partly to indicate the location of the cells so that colour filters could be accurately placed over the cells when required.

The l.e.d.s were mounted on a piece of tag strip bolted to the rear wall of the box, and a light-proof plastic tube was placed across the box, making a sort of tunnel opening at the front of the box. This gave very effective shade, making it easy to see the lamps even in the brightest sunlight.

The control knob operates VR1, determining the potential of point B, with which the potential of point A is to be compared. There is no space for a potentiometer and knob in the sub-aqua version, its place being taken by the preset potentiometer.

SETTING UP THE CIRCUIT

Before colour filters are placed over the photocells, these must be balanced so they respond identically to variations in light *intensity*. This can be done when the connections to the positive and negative rails have been soldered, but the other connections are still loose.

Connect the battery to the circuit, and connect the negative probe of a test-meter to the negative terminal of the battery. Twist the lower (loose) leads of the photocells together and connect this joint to the positive probe of the meter. This should read 4·5 volts when the photocells are illuminated by indoor daylight or low power artificial light (e.g. 1ft from a 100W lamp).

If the meter reads other than 4·5 volts try putting a finger over one or other of the photocells and see what happens to the voltage. By this means it is easy to find out which of the photocells has too low a resistance. Part of this cell is blacked out by painting black ink on it, until the meter reads 4·5 volts.

In fact it is not necessary in this circuit to adjust exactly to 4·5 volts—somewhere between 4 and 5 volts is near enough, though the nearer the better.

Next take the circuit outdoors, still connected to the battery and voltmeter—place it in bright midday sunshine. There will probably be a change of meter reading. In bright light the resistance of both photocells falls markedly and probably not equally, so the voltage changes. One of the photocells now has too low a resistance, and this needs increasing by wiring a resistor (R1) in series with that photocell.

In Fig. 1 the resistor is in series with PCC2 (as in the model in the photograph) but it may be necessary to wire R1 in series with PCC1 instead. The exact value for R1 must be found by experiment. Try various resistors of low value in series with PCC1 (or PCC2). The correct value is found when the circuit is carried from bright sunlight to deep shade (indoors) and the voltage changes by less than about 0·1 volts. The resistor may then be soldered in place.

PHOTOCELL FILTERS

The photocells may then be covered with coloured gelatine—using one, two, or three layers, depending on the depth of colour of the material available. Cadmium sulphide cells are especially sensitive to red light, so the red filter should be strongly red. The sharper the cut-off of the filters, the more sensitive will the indicator be to changes of colour temperature.

To calibrate the indicator, take it outdoors on a sunny day, between 10 a.m. and 2 p.m. and place it in direct sunlight. Adjust VR1 until the lamps both glow equally brightly. Now take the indicator in the shade and point it towards a bright blue sky—the TOO BLUE lamp should be bright and the other lamp dim. Take it indoors and expose it to artificial light (filament lamps — *not* fluorescent lamps)—the TOO RED lamp should be bright now and the TOO BLUE lamp dim.

By balancing the lamps in direct sunlight the indicator has been set for daylight colour film. Since the colour temperature of sunlight is modified by the presence of clouds in the sky it is worthwhile repeating this calibration on several occasions to find the mean setting for daylight. This can then be marked with a dot of paint on the preset. If you intend only to use daylight film (which is likely for sub-aqua work) calibration is now complete, and there is no further need to alter the preset. The indicator will always tell you if the light is correct for colour film (lamps equal) or TOO RED or TOO BLUE. In sub-aqua photography the latter is more likely.

UNDERWATER WORK

Colour correcting filters are available for compensating for incorrect colour temperature. For underwater work a set of pinkish filters of various strengths are useful for filtering out some of the excess blue light. To find out which filter to use, hold it over *both* cells of the indicator. If the lamps now glow equally, this filter is the correct one to

continued on page 723

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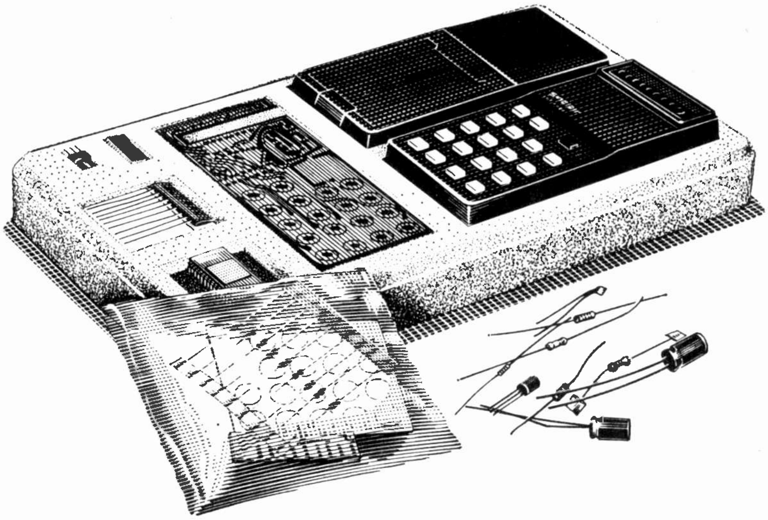

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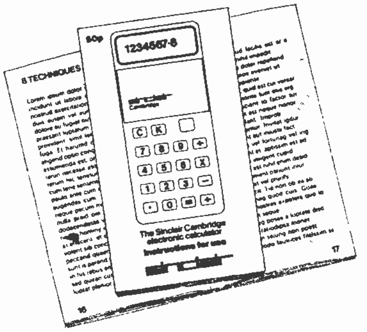

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Readout—

A SELECTION FROM OUR POSTBAG

Congratulations

Sir,—I would like to congratulate you on an extremely readable and very good magazine. In particular I liked the series "First Steps in Circuit Design."

I have followed many such series, but this is the first one that has really helped in getting down to actually building one's own circuits. I thank all concerned for publishing such a superb magazine.

Mr. E. Barton,
Craigellachie,
Banffshire.

Diode pump

Sir,—May I comment on Mr. Jones' "M.P.G. Meter" in your June issue, as I designed a meter on a related principle some time ago.

A meter of this type cannot respond accurately to, say, the increase in fuel consumption during sudden acceleration: it shows consumption correctly only after conditions have been steady for several seconds. Thus its main use is in comparing consumption during steady travel at various speeds or in different gears.

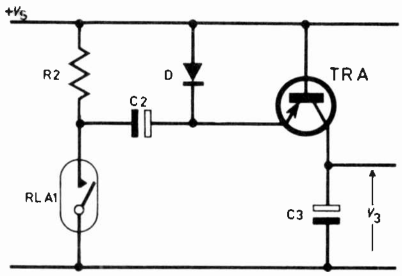
Before the meter can settle after a change in conditions, the pump must operate and C3 discharge, C3 charge again to the new peak value, the voltage on C4 follow this and the meter needle move. This will take around 5 seconds.

The meter scale is non-linear because of the behaviour of the diode pump C2, C3, D2, D3. For each operation of RLA, the voltage on C3 increases by

$$(V_s - V_3)\ C2/(C2+C3)$$

where V_s is the supply voltage and V_3 the output voltage on C3 before the operation. Linearity is only obtained if V_3 always remains small compared with V_s.

The diode-transistor pump shown below is hardly more complex, but remains linear until V_3 rises to within 1V of V_s. In this circuit, when RLA1 closes, C2 charges via the diode. When RLA1 opens, the right-hand plate of C2 rises to above the supply potential, and discharges into TRA, with time constant RC × C2. The current flowing from TRA collector is almost equal



Mr. Bradfield's transistor diode pump circuit

to the emitter current, irrespective of V_3, so the increase in output voltage is V_s C2/C3 and operation is linear.

In the original circuit TR1/C4 is described as an emitter follower, but the circuit can only follow an increase in voltage above that already on C4, Fig. 2 shows the circuit functioning as a peak-value rectifier, which I would expect to be used. This operation is hampered by an excessive charging time constant R4 × C4 = 2·2sec. Reducing R4 to 100Ω improves this time constant while limiting peak collector currents to a safe value.

With linear operation obtained, the maximum voltage on C3 could be increased, but above 6V, reverse breakdown of TR1 emitter-base junction would upset operation when C3 discharges but C4 remains charged.

C. D. Bradfield
Kingston upon Hull

I find the points raised by Mr. Bradfield's letter very interesting.

With regard to the problem of linearity, it would seem to me that it is important to know whether one is doing 10 or 15 m.p.g. and relatively unimportant to know whether one is doing 75 or 80 m.p.g. This may not be so with a very small engined car, but the diode pump which produces this non linear scale has, in my opinion, the advantage of increasing accuracy at the high consumption end of the scale.

Readers may wish to try Mr. Bradfield's modification, but to judge from the last paragraph, it would seem that some careful designing is necessary.

The response time may be a little slower than Mr. Bradfield would like, but with less than 20 components in the circuit, I am myself surprised that the Meter works as well as it does. It is not so many years since another magazine published a m.p.g. meter with over 50 transistors and a scale for each gear.

The response time of the m.p.g. meter depends on three factors. Firstly, the time between pump strokes—this will be the absolute minimum response time and with this type of pump is from 0·3sec. upwards, the average being perhaps 1·5secs. The other two factors are the charge and discharge times for C4. I agree that the charge time for C4 can be decreased by reducing R4, but in order to supply the increased current would it not be necessary to transistorise the stabilised power supply?

The discharge time of C4 depends on the resistance of ME1/VR1; more complexity would be needed to reduce this and could only result in the wild fluctuations C4 was put there to prevent. It is clearly explained in the text that C4 is something of a compromise and readers can reduce its value or that of R4 to obtain a response which suits them best.

TR1/C4 is not described as an emitter follower—the purposes of TR1 and C4 form two distinct paragraphs.

I hope that this satisfactorily clarifies the matter.—SJ

Telebell improvement

Sir,—I have read with interest the article "Telebell" in your June 1974 issue, a device for providing remote telephone bells wherever required without physical connection to the Post Office system.

It occurred to me that some signal other than a bell might be of greater use, either for the benefit of the deaf or in circumstances where an audible signal would be undesirable and I accordingly fitted a low voltage lamp in place of the bell. Obviously, this switches on and stays on until the supply is disconnected, due to the action of the CSR1, but this is no great disadvantage and works well.

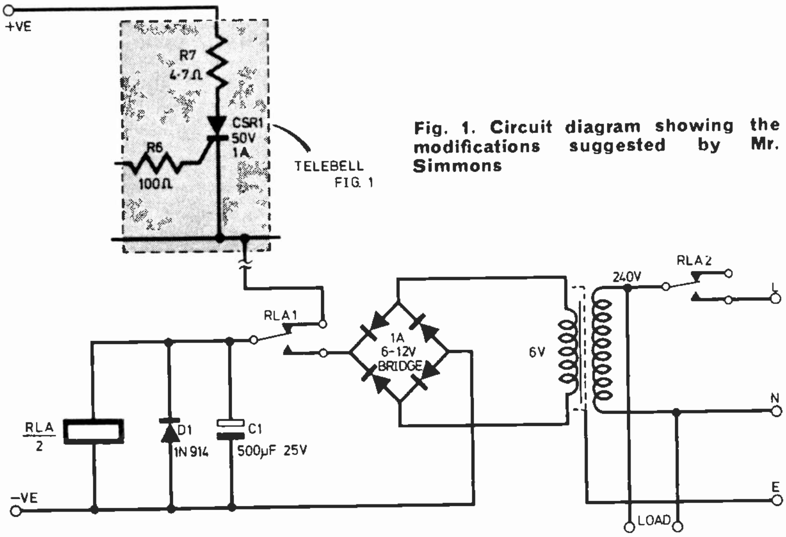


Fig. 1. Circuit diagram showing the modifications suggested by Mr. Simmons

A further thought then occurred and I replaced the bell/lamp by a 6V direct-current relay which has heavy-duty contacts, capable of handling several amperes, see Fig. 1. By making use of the various contacts as shown, I have produced a device which has the advantage of working from a battery on negligible current in the stand-by condition, but which switches itself to mains operation when activated and disconnects the battery supply through the thyristor CSR1. Moreover, the relay is capable of handling enough current to switch on a load of several hundred watts or, if greater capacity switching is required, of operating a further heavy-duty contactor.

The possibilities for use are endless; a toot on the horn as one drives up to the garage doors, with a suitably placed microphone, can activate lamps in the garage, the porch, switch on the fire and the TV, etc, etc.

Reverting to the original intention of the telephone bell providing the necessary activation, one might ring one's empty home while on a journey and bring about the same results as a security measure, though I am uncertain of the views of the local Telephone Manager on this use of the public equipment—it might constitute illegal use of his electricity! A deterrent from this sort of use, apart from any possible legal infringement, is that some other person may ring up during one's absence and bring about the same result at the wrong time of day!

C. H. Simmons,
Wallingford.

SUB-AQUA COLOUR TEMPERATURE INDICATOR

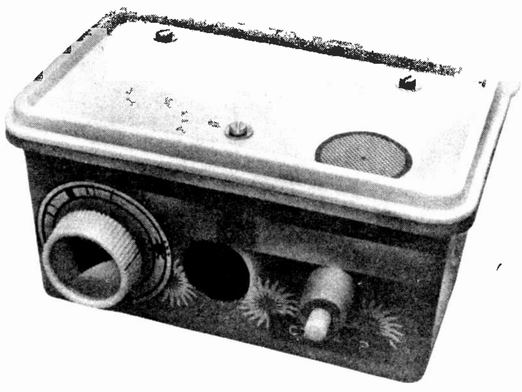
continued from page 719

use under the prevailing lighting conditions. This procedure requires that you have filters which can be fitted over the lens port of the camera housing while under water, so it is possible to change filters while diving. Alternatively one can fit a filter to the camera before sealing it in its housing and place an identical filter over the photocells; the indicator will then show whether or not correct colour rendering will be obtained with this filter in use.

TERRESTRIAL CALIBRATION

For terrestrial use the indicator can also be calibrated for use in artificial light. Most "type A" colour films are balanced for the light from a photoflood lamp, so to calibrate the indicator, expose it to a photoflood and adjust VR1 until the l.e.d.s are balanced. Mark the position with a spot of paint.

If by any chance the lamps will not balance, even when the VR1 is at one end of its track, this is because the balance-point lies beyond the end of the track—somewhere along R2 or R3. With the values given, this should not happen, but if it does then R2 or R3 may be replaced with a resistor of greater or lesser value. Alternatively a 2·2kΩ preset could be used in place of VR1, though this would make it harder to adjust to exactly the correct balance point.



Photograph of a suggested box so that the colour temperature indicator can be used on dry land

PRECAUTIONS

When the circuit has been adjusted and tested it is worth while to cover the underside of the board with a strip of self-adhesive tape. This will prevent the possibility of short-circuits through the metal parts of the camera and also protect the camera from scratching by the sharp cut ends of the component wires.

One final word of warning—the indicator is very sensitive to *all* coloured light reaching it—not just that from the intended source of illumination. When calibrating, turn off any lamps other than the one against which the indicator is being tested.

A fluorescent strip-light in the same room will throw calibration badly out. When the prototype was being calibrated some very inconsistent results were obtained, until it was realized that behind one of the lamps was a large blue window-curtain. So when calibrating, and when using the instrument, watch out for strongly coloured surfaces nearby; keep test sources away from walls and curtains—and don't wear a bright red shirt! ★

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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.

SPECIAL OFFER!

LIMITED NUMBER OF BRAND NEW ELAC 10in TWIN CONE LOUDSPEAKERS. With large ceramic magnet and plasticised cone surround. 8 ohm impedance. **£3·70**, P. & P. 35p.

HARVERSONIC 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.

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Made by Evershed and Vignoles, Ltd. Measures from 0·1 ohm to 200,000 ohms in 2 switched ranges. Used, but in perfect condition. Complete with test probes, Leather carrying case and 4½V standard battery. Only **£7**, P. & P. 40p.

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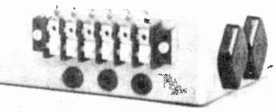

Following the phenomenally successful Scorpio Capacitor-Discharge Electronic Ignition system introduced in 1972 and proved by many thousands of satisfied motorists, we are happy to announce availability of all parts for the PE SCORPIO Mk. 2—

* Now with added R.F.I. suppression.
* Fully machined and painted die-cast case with AMP termination connector block.
* Custom wound transformer.
* NOW AVAILABLE IN 6V. and 12V.
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* Improves acceleration, gives better high speed performance and quicker engine warm up.
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* PROMOTES FUEL ECONOMY.

Construction of the unit can easily be completed in an evening—installation should take about half an hour. A complete complement of components is supplied with each kit together with ready drilled, roller tinned professional quality fibreglass printed circuit board. —Uses original plugs, points, and coil.—No special parts or extras required.
(Case size 7½in 4½in 2in)

* All components available separately.—S.A.E. with enquiries.
* Construction manual available separately 25p.

Cost **£12·95** incl. carr., ins. and VAT. (Carriage at cost outside U.K. —Export enquiries welcome.)

CONVERSION KIT FROM Mk. I to Mk. 2. FOR CONSTRUCTORS ALREADY POSSESSING Mk. I KITS.—Miniature P.C. assembly **£1·10** incl. Carr., Ins. and VAT with full conversion instructions.

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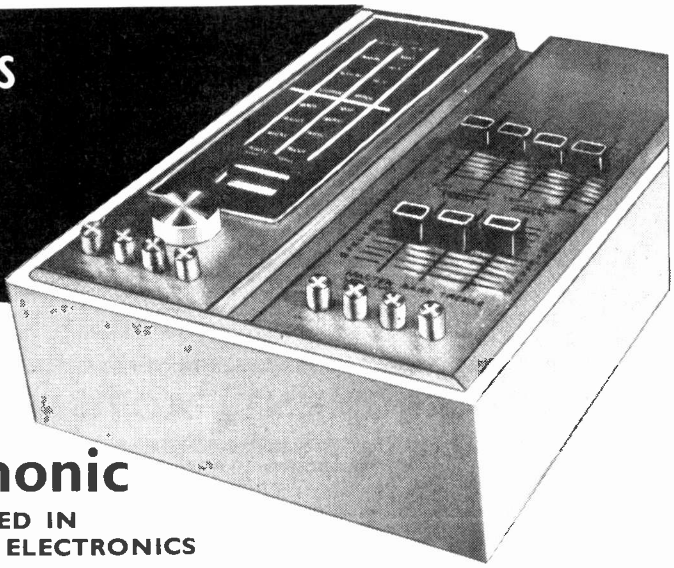

PE RONDO

complete quadraphonic Hi-Fi System

AS FEATURED IN PRACTICAL ELECTRONICS

There's never been an offer like it! Construct this 80 watt RMS Quadraphonic System with 4 matched high performance speakers. *All* finishes including polishing of cabinets and brushing and anodising of metal work are already completed. You can achieve the finest production finish and the styling will do justice to any room setting.

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- **GOLDRING G101/2 TURNTABLE Less Cartridge** £23·90 ☐ — Post Free. + VAT £2·39
- **DEUTSCHE ELAC STS 144/17 CARTRIDGE** £7·90 ☐ — Post Free. + VAT 79p

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- **COMPLETE SET OF 4 EDGE-CONNECTORS** £1·44 ☐ — Post Free. + VAT 14p
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- **TUNING DIAL ASSEMBLY Complete with Meter and Calibrated Electro-luminescent Dial** £10·42 ☐ — Post Free. + VAT £1·04

SPEAKER KITS

All components parts for "Rondo" loudspeaker assemblies are available, including special precision machined wrapround cabinets for very easy construction and perfect professional finish—as shown in fig. 7.9 of January 1974 issue.

COMPLETE SPEAKER KIT WITH 4 DRIVE UNITS, CROSSOVER WADDING, ETC. INCLUDING CABINETS Price Per Pair £34·50 ☐ — Post £1. + VAT £3·55

SPECIAL OFFER - SAVE £7

4 Speaker kits (as required for Rondo) £62·00 ☐ — Post £2. + VAT £6·40

Comprising 16 loudspeaker drive units, FOUR 5 element crossover networks including 12 prewound coils, four fully machined and polished wrap-round cabinets, four routered front and four routered back panels. 72 feet of coded coloured wire, four recess panels containing din and 4mm sockets, 24 lengths of 2" thick special acoustic wadding and latest acoustically transparent Declon fronts to complete the finish.

- **BASS DRIVE UNITS (2 per cabinet)** £4·25 EACH ☐ — Post Free. + VAT 42p
- **TWEETERS (2 per cabinet)** £1·20 EACH ☐ — Post Free. + VAT 12p
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DETAILS OF ANCILLARY KITS ☐

We apologize to our customers for any inconvenience caused by delay in delivery. This is due to tremendous demand for our products and we are endeavouring to clear back-log with all possible speed.

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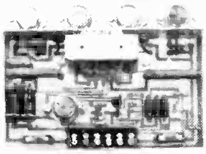
TUAC

NEW TUAC POWER MODULES. Now in their third successful year offering more power and quality than ever before.



TP125

Illustrated
£17·25

- ★ 125 Watts RMS continuous sine wave output
- ★ 4 RCA 150 Watt 15 Amp output transistors
- ★ Special layer wound driver transformer
- ★ Short, open, and thermal overload protection
- ★ Compact size: 7 x 6½ x 3 in.

TL30 £9·50

- ★ 30 Watts RMS sine wave
- ★ Full thermal overload protection
- ★ Short and open circuit proof
- ★ Rugged transformer driver

TL100

Illustrated
£13·50

- ★ 100 Watts RMS sine wave
- ★ 2 RCA 15 Amp output transistors
- ★ Rugged transformer driver
- ★ Full thermal overload protection
- ★ Compact size: 5 x 5 x 3 in.

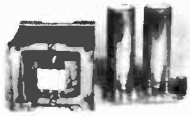
TL60 £11·75

- ★ 60 Watts RMS sine wave
- ★ RCA 115 Watt output transistors
- ★ Only six connections to make
- ★ Same size as TL100

Specification on all 4 power modules:
All output power ratings ±0·5dB. Output impedance 8–15 Ohms. THD at full power 1% typically 0·5%
Input sensitivity 60mV into 10 kΩ. Frequency response 25Hz–25kHz ±2dB. Hum and noise better than —70dB.

Power supplies vacuum impregnated Transformers with supply board incorporating pre-amp supply:

PS 125 ±50 volts for one TP100	£11·75
PS 100 ±45 volts for one TL100	£10·75
PS 60 ±40 volts for one TL60	£9·50
PS 30 ±50 volts for one TL30	£7·00
PSU 2 for supplying Disco Mixer	£4·75



NEW FROM TUAC ! ! !

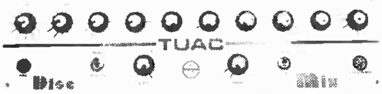
100W 2 × 12 Disco Group cabs, fitted 2 50W RMS super heavy duty speakers **£66·00** (carr. £1·00)
100W 4 × 8 P.A. Cols, fitted 4 75W heavy duty speakers. **£75·00 pair** (carr. £2·00).

Rotary Flashing Beacons

- ★ 240V mains operation
- ★ Choice 5 colours, red, amber, blue, green and clear
- ★ Light source is from standard SBC filament bulb
- ★ Flash rate 140 per minute. Only **£22·00**

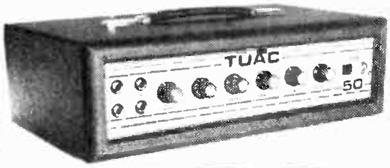
ALL PRICES INCLUDE V.A.T. AND POSTAGE AND PACKING

ACCESS & BARCLAY CARDS ACCEPTED, JUST SEND US YOUR NUMBER. H.P. ARRANGED THROUGH PAYBONDS.

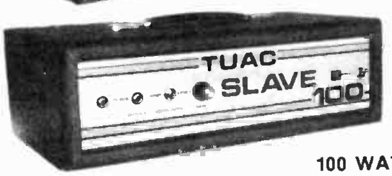


TUAC DISCOTHEQUE MIXER WITH AUTO FADE **£27·00**
Designed for the discerning D.J. of professional standard.
Offering a vast variety of functions
Controls: Mic Vol. Tone. Over-ride depth. Auto Manual Sw. Tape Vol. L & R Deck Faders. Deck Volume. Treb. and Bass. H. Phon Vol. Selector. Master Vol. on off sw. Max. output 1V RMS. Specification as VA06.
PANEL SIZE 18" x 4½" DEPTH 3"

TUAC HIGH POWER AMPLIFICATION—built to high standards, and built to last



50 WATT RMS SINE WAVE ALL PURPOSE AMPLIFIER
Suitable for Disco, PA, Guitar. 4 inputs. 2 volume controls. Master volume, treble, middle and bass controls. Rugged circuit, rugged leathercloth covered case, short and open circuit protection. Tone control specification as VA08 pre-amp. FULLY FUSED.



50 WATT	**£44·00**
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100 WATT SLAVE	**£49·50**

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PUSH BUTTON CAR RADIO KIT

The Tourist II

NO SOLDERING REQUIRED!

NOW BUILD YOUR OWN PUSH BUTTON CAR RADIO

Easy to assemble construction kit comprising fully completed and tested printed circuit board on which no soldering is required. All connections are simple push fit type making for easy assembly.
Fine tuning push button mechanism is fully built and tested to mate with printed circuit board.
Technical specification:

(1) **Output** 4 watts R.M.S. output. For 12 volt operation on negative or positive earth.
(2) **Integrated circuit** output stage, pre-built three stage IF Module.

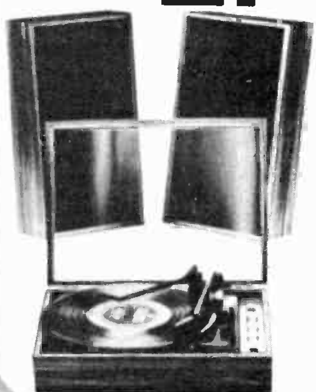
Controls volume manual tuning and five push buttons for station selection, illuminated tuning scale covering full, medium and long wave bands.
Size chassis 7″ wide, 2″ high and $4\frac{5}{16}$″ deep approx

Car Radio Kit £7.70 + 55p post. & pack.

Speaker including baffle and fixing strip
£1.65 + 23p postage & packing

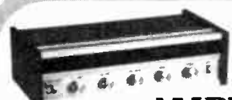
Car Aerial Recommended – fully retractable and locking
£1.35 post paid

STEREO 21



QUALITY SOUND(*) FOR LESS THAN £19·00

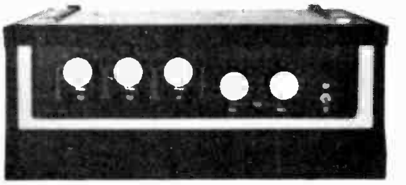
Stereo 21 easy to assemble audio system kit, – no soldering required. Includes:–
BSR 3 speed deck, automatic, manual facilities together with ceramic cartridge.
Two speakers with cabinets.
Amplifier module. Ready built with control panel, speaker leads and full, easy to follow assembly instructions.
For the technically minded:–
Specifications:
Input sensitivity 600mV; Aux. input sensitivity 120mV: Power output 2.7 watts per channel: Output impedance 8–15 ohms. Stereo headphone socket with automatic speaker cutout. Provision for auxiliary inputs – radio, tape, etc., and outputs for taping discs. **Overall Dimensions.** Speakers approx. $15\frac{1}{2}$″ × 8″ × 4″. Complete deck and cover in closed position approx. $15\frac{1}{2}$″ × 12″ × 6″. Complete only **£18.95** + £1.60 p & p.
Extras if required.
Optional Diamond Styli **£1.37**
Specially selected pair of stereo headphones with individual level controls and padded earpieces to give optimum performance. **£3.85.**



DISCO AMPLIFIER

Reliant Mk IV Mono Amplifier, ideal for the small disco or house parties.
Outputs 20 watts R.M.S. into 8 ohms (suitable for 15 ohms).
Inputs * 4 Electrically Mixed Inputs *3 Individual Mixing controls. *Separate bass and treble controls common to all 4 inputs *Mixer employing F.E.T. (Field Effect Transistors). *Solid State Circuitry. *Attractive Styling.
INPUT SENSITIVITIES
–Input–1.) Crystal mic. guitar or moving coil mic, 2, and 10 mV. (selector switch for desired sensitivity.–Inputs–2), 3), 4, Medium output equipment–ceramic cartridge, tuner, tape recorder, organs etc.
– all 250mV sensitivity.
AC Mains 240V. operation.
Size approx. $12\frac{1}{2}$ ins × 6 ins × $3\frac{1}{2}$ ins
£15.00 + 60p. post & pack

DISCO 50

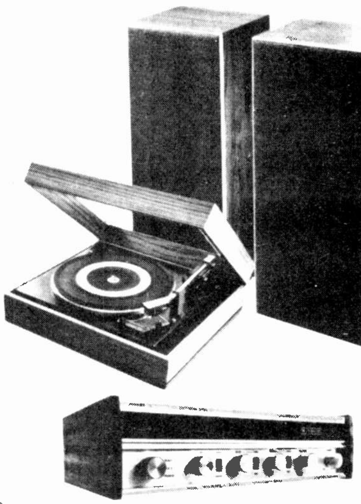


45 WATT R.M.S. MONO DISCOTHEQUE AMPLIFIER

Ideal for Disco Work. Output Power: 45 watts R.M.S. Frequency Response 3dB points 30Hz and 18KHz. Total Distortion: less than 2% at rated output. Signal to noise ratio: better than 60dB. Bass Control Range: 13dB at 60Hz. Treble Control Range: 12dB at 10KHz. Inputs: 4 inputs at 5mV into 470K. Each pair of inputs controlled by separate volume control. 2 inputs at 200mV into 470K. Size: $19\frac{1}{4} \times 10\frac{1}{2} \times 8$ins. approx. Amplifier **£27.50 + £1.50 p. & p**

Special Offer: Disco 50 plus two 15″ E.M.I. speakers type 14A/780 (as illustrated on opposite page). **Complete £57.00 + £4.00 p&p.**

COMPLETE(*) STEREO SYSTEM



£51·00

40 Watt Amplifier.
Viscount III – R102 now 20 watts per channel.
System I includes,
Viscount III amplifier – volume, bass, treble and balance controls, plus switches for mono/stereo on/off function and bass and treble filters. Plus headphone socket.
Specification
20 watts per channel into 8 ohms.
Total distortion @ 10W @ 1kHz 0·1%. *P.U.1* (for ceramic cartridges) 150mV into 3 Meg. *P.U.2* (for magnetic cartridges) 4mV @ 1kHz into 47K. equalised within 1dB R.I.A.A. *Radio* 150mV into 220K. (Sensitivities given at full power). Tape out facilities: headphone socket, power out 250mW per channel. *Tone controls and filter characteristics*. Bass: +12dB to −17dB @ 60Hz. Bass filter: 6dB per octave cut. Treble control: treble −12dB to −12dB @ 15kHz. Treble filter: 12dB per octave. *Signal to noise ratio:* (all controls at max.) −58dB. Crosstalk better than 35dB on all inputs. Overload characteristics better than 26dB on all inputs. Size approx. 13¾"×9"×3¾".
Garrard SP25 deck, with magnetic cartridge, de luxe plinth and hinged cover.
Two Duo Type II matched speakers – Enclosure size approx. 17½" · 10¾"×6" in simulated teak. Drive unit 13"×8" with parasitic tweeter 10 watts handling

Complete System £51.00

£69·00

System II
Viscount III amplifier (As System I)
Garrard SP. 25 (As System I)
Two Duo Type IIIA matched speakers—
Enclosure size approx. 31" × 13" × 11½". Finished in teak veneer. Drive units approx. 13½" × 8½" with 3½" HF speaker. Max. power 20 watts, 8 ohms. Freq. range 20Hz to 20kHz.

Complete System £69.00

PRICES: SYSTEM 1

Viscount III R 102 amplifier	£24·20 + £1 p & p
2 Duo Type II speakers	£14·00 + £2·20 p & p
Garrard SP25 with MAG. cartridge de luxe plinth and hinged cover	£21.00 + £1.75 p & p.
total	£59.20

Available complete for only £51.00 + £3·50 p. & p.

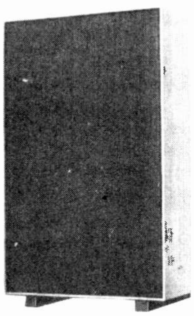
PRICES: SYSTEM 2

Viscount R102 amplifier	£24·20	£1·00 p. & p.
2 Duo Type IIIA speakers	£39·00	£4·00 p. & p.
Garrard SP25 with MAG cartridge de luxe plinth and hinged cover	£21·00	£1·75 p. & p.
total	£84·20	

Available complete for only £69.00 + £4 p & p.

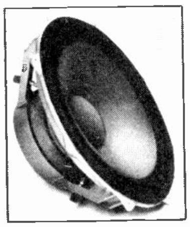
EMI SPEAKERS AT FANTASTIC REDUCTIONS

THE ULTIMATE COMPLETE SPEAKER SYSTEM
EMI LE 315 List Price £86.00



A professional standard five way speaker system with enclosure giving top quality performance
Enclosure Dimensions
approx. (3ft. · 2ft. · 1ft.).
Drive Units
Hand built – 15" diameter bass with 3" voice coil, – two 5" diameter Mid Range units, – two 3½" HF. units, plus matching crossover panel with two variable potentiometers for mid and high frequency adjustment.
Power Handling
Continuous rating 35 W rms., Peak power rating 70 W.
Frequency Response
20 Hz 20,000 Hz. Imp. 8 ohms.

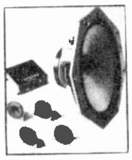
Our price £45·00 + £3·50 p. & p.



15" 14A/780 BASS UNIT

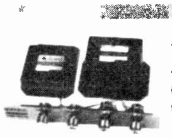
Bass unit on a rigid diecast chassis. Superior cone material handles up to 50 watts RMS, and is treated to give a smooth frequency response. Resonance 30 Hz. flux density 360,000 Maxwells. Impedance at 1 kHz is 8 ohms. 3" voice coil.

Recommended retail price £40·80.
OUR PRICE £18·70 + £1·50 p & p



950 KIT

Five matched speakers and crossover unit for handling up to 45 watts, frequency response from 20 to 20,000 Hz.
Huge 19" × 14" (approx.) high efficiency Bass-Speaker with 16,500-gauss magnet built on a heavy diecast frame.
The four 10,000 gauss tweeters, each 3¼" dia approx., are fed by the crossover which critically adjusts signal for maximum fidelity. Impedance at 1 kHz is 8 ohms. Bass coil 2", others 0·5". Recommended list price £44·00. **OUR PRICE £19.50 + £1·50 p & p Special Offer**



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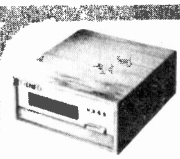

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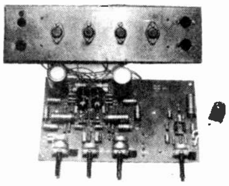

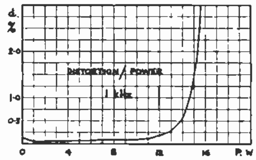

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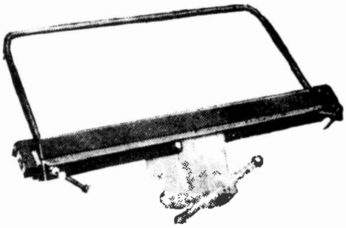

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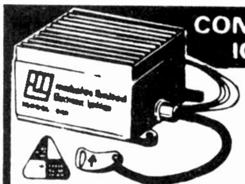

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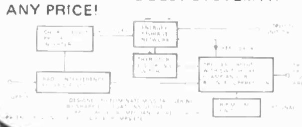

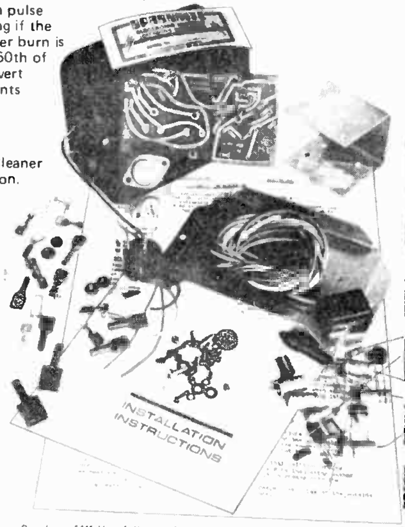

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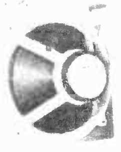

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2N1307	0·22	2N4036	0·63	BC108	0·15	BD123	0·32	LM741	
2N1308	0·40	2N4037	0·42	BC109	0·19	BD124	0·67	TO99	0·40
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2N2904A	0·45	40407	0·33	BC168B	0·13	BF181	0·34	NE565A	4·48
2N2905	0·48	40408	0·50	BC168C	0·11	BF182	0·40	OC23	0·56
2N2905A	0·50	40409	0·52	BC169B	0·13	BF183	0·40	OC28	0·76
2N2906	0·31	40410	0·52	BC169C	0·13	BF184	0·30	OC35	0·60
2N2906A	0·37	40411	2·00	BC170A	0·11	BF185	0·17	OC42	0·35
2N2907	0·40	40414	3·55	BC171	0·13	BF194	0·16	OC45	0·32
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	0·11	40669	1·00	BC186	0·25	BF237	0·22	SC40D	1·89
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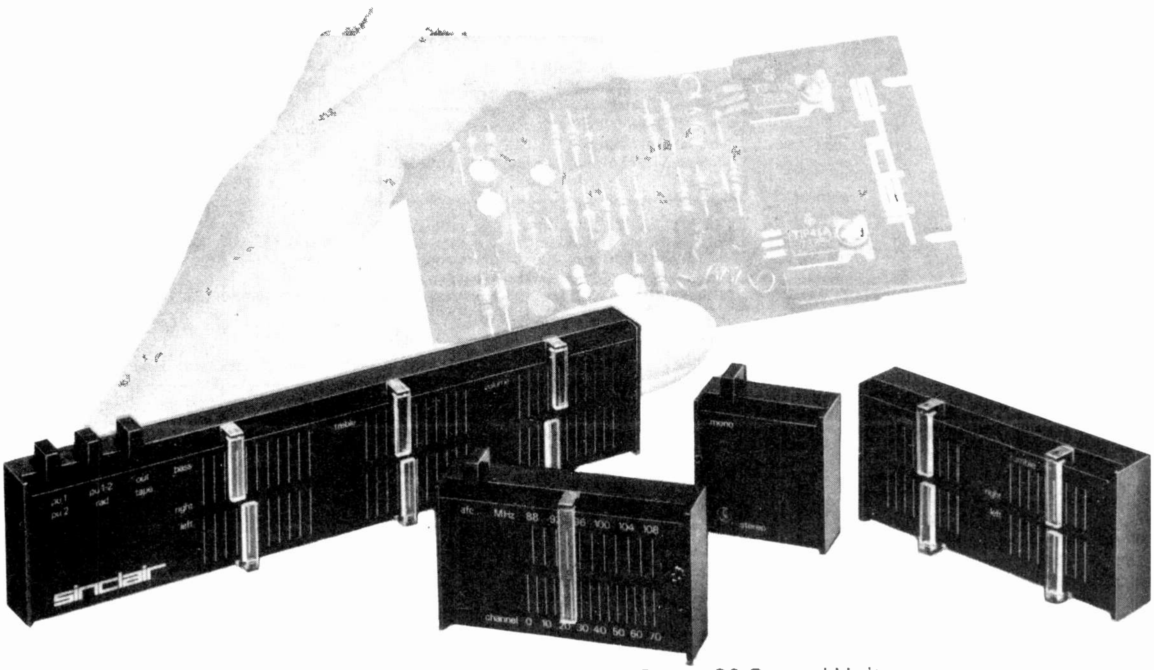

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Stereo 80 Control Unit Size – 260 · 50 · 20mm ($10\frac{1}{4} \cdot 2 \cdot \frac{3}{4}$ins) Finish – Black with white indicators and transparent sliders Inputs – Magnetic pick up 3mV RIAA corrected Ceramic pick up 350mV Radio 100mV. Tape 30mV Signal/noise 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 tape radio and P U Sliders on each channel for volume bass treble R R P (add £1 19 V A T) **£11.95**

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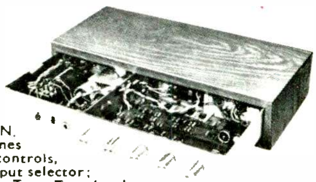

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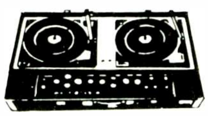

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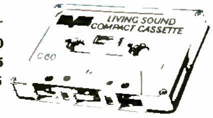

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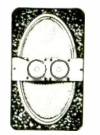

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