PRACTICAL

ELECTRONICS

JANUARY 1977

40p

3 MICROPROCESSOR KITS TO BE WON

FREE ENTRY COMPETITION

Save fuel - Reduce pollution

CAR EXHAUST MONITOR

ALSO INSIDE...

RADIO CONTROL · MICROPHONE MIXER

Stirling Sound

QV* MODULES FOR COST-CONSCIOUS CONSTRUCTORS

SS140
40 watts r m a into 4 ohms using 45V supply such as SS345 Ideal for smal discos and P A 101 × 76 × 19mm (4 × 3 × ¾in)
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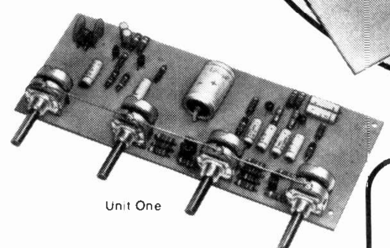


Unit One

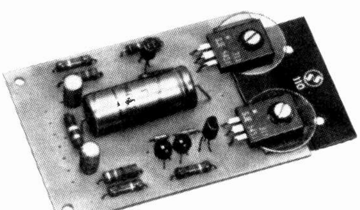
PRE-AMP/TONE CONTROL MODULE
UNIT ONE

Combined pre-amp with active tone-control circuits ±15dB at 10kHz treble and 30Hz bass Stereo Vol/balance treble bass 200mV out for 50mV in Takes 10-16V **£7·80**

SS100 Active tone control stereo ±15dB on bass and on treble **£1·60**

SS101 Pre-amp for ceramic cartridges radio, tape Stereo Passive tone control circuit shown in data supplied **£1·60**

SS102 Stereo pre-amp for low output magnetic P U s R I A A corrected Linear feedback facility **£2·65**



New style for power amps SS105 SS110 and SS120

POWER AMPLIFIERS FROM 3 TO 100 WATTS R.M.S.
THE NEW SS1100

Delivers 100 watts r.m.s. into 4 ohms using 70 volt supply. Heavy duty, ruggedly constructed module complete with output capacitor and heatsink-type mounting bracket. Size approx. 140 × 76 × 32mm. Just the job for disco or P.A. use. **9·45†**

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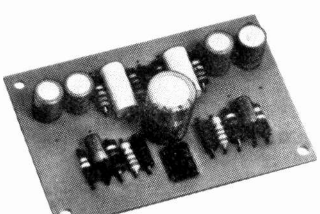
SS105 5 watts r m s into 4 ohms, using 12V (SS312 for example) **£2·25**

SS110 10 watts r m s using 24V and 4 ohm load Use SS324 as the power supply **£2·75**

SS120 20 watts r m s into 4 ohms using 34V Use SS324 for your power supply **£3·25**

Modules SS105 110/120 all measure 89 × 50 × 19mm (3½ × 2¼in) Suitable power supplies will be fouhd in the accompanying range



SS202 I F amp

FM TUNING MODULES

SS201 Front end tuner, slow geared drive, two gang A F C facility Tunes 88 108MHz **£5·00**

SS202 I F amplifier Metering and A F C facilities **£2·65**

SS203 Stereo Decoder for use with the above or other FM mono tuners A LED may be fitted **£3·85**

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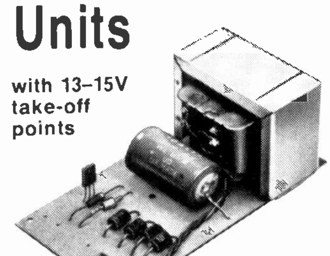
with 13–15V take-off points



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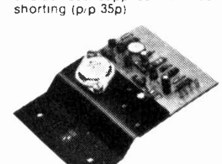
SS324	24V/1A	**£4·60†**
SS334	34V/2A	**£5·20†**
SS345	45V/2A	**£6·25†**
SS350	50V/2A	**£6·65†**

SS300 POWER STABILISING UNIT
Adjustable from 10V 2A to 50V 8A for adding to unstabilised supplies With built-in protection against shorting (p/p 35p) **£3·25†**



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PRACTICAL ELECTRONICS

VOLUME 13 No. 1 JANUARY 1977

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

FREE ENTRY MICROPROCESSOR COMPETITION

Our February issue will be on sale on Friday, January 7, 1977
(for details of contents see page 53)

SINTEL FOR KITS-CMOS-DISPLAYS-MEMORIES-BOOKS-MICROPROCESSORS

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6850 .... £17·67
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CD4020	1·28	CD4045	1·61	CD4075	0·24	CD4532	1·65
CD4021	1·16	CD4046	1·53	CD4076	1·61	CD4555	1·04
CD4022	1·11	CD4047	1·04	CD4077	0·60	CD4556	1·04
CD4023	0·24	CD4048	0·64	CD4078	0·24	MC14528	1·22
CD4024	0·89	CD4049	0·64	CD4081	0·24	MC14553	4·68
CD4025	0·24	CD4050	0·64	CD4082	0·24	IM6508	8·05
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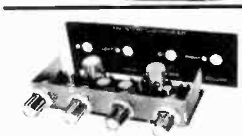

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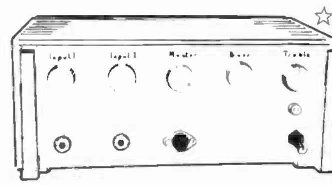

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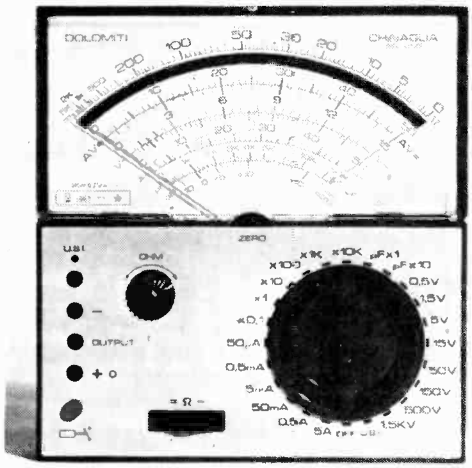

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7410	10	7476	23	74175	95
7411	16	7483	70	74176	95
7413	29	7485	80	74177	85
7416	22	7486	24	74180	80
7417	22	7489	1-50	74181	2-50
7420	11	7490	40	74182	80
7422	22	7491	71	74184	1-55
7423	22	7492	44	74185	1-30
7425	22	7493	35	74190	95
7426	23	7494	45	74191	95
7427	22	7495	49	74192	90
7430	12	7496	55	74193	85
7432	22	74100	79	74194	95
7437	25	74105	60	74195	72
7438	21	74107	27	74196	1-00
7440	11	74121	28	74197	75
7441	60	74122	50	74198	1-70
7442	55	74123	55	74199	1-70
7443	55	74125	50	74200	3-90
7444	60	74126	50		
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4006A	1-10	4022A	90	4071A	22
4007A	22	4023A	21	4072A	29
4008A	1-46	4024A	72	4073A	32
4009A	47	4025A	21	4075A	32
4010A	44	4027A	48	4078A	32
4011A	22	4028A	81	4082A	29
4012A	21	4030A	37	4518A	1-69
4013A	37	4035A	1-04	4528A	1-31
4014A	1-22	4040A	99	4585A	1-71
4015A	1-22	4042A	1-21	4901A	31
4016A	46	4049A	48		
4017A	98	4050A	48		
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		74C76	1-07	74C163	2-05
74C04	47	74C107	94	74C164	2-21
74C08	47	74C151	1-83	74C173	1-83
74C10	41	74C154	2-21	74C195	1-90
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74200	256 bit RAM tri-state	3-90

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301	21	339	1-06	562	2-23
302	49	340K	1-48	565	1-38
304	56	370	92	566	1-38
305	60	372	51	567	1-38
307	44	373	35	709	31
308	69	376	38	710	24
309K	1-25	380	93	711	51
310	75	380-8	1-02	739	75
311	67	381	1-13	741	29
319	82	382	1-13	747	54
320T	1-12	531	2-07	748	31
320K	1-32	540	1-38	75491	58
322	69	556A	1-02	75492	63

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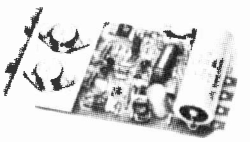
A COMPLETE SELECTION OF READY TO USE PROFESSIONAL QUALITY AUDIO & LIGHTING EQUIPMENT

POWER AMPLIFIER MODULES 30—240 WATTS



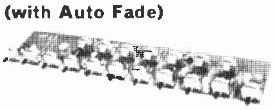
- Fully tested & guaranteed.
- Full RMS Sine Wave output.
- Distortion typically 0·2%
- 10 Transistors, 4 Diodes.
- Response 30HZ–30KHZ
- Fully short & open circuit proof
- Sensitivity suits most mixers.
- Built-in surge suppression & compensation
- Twin D.C. & output fuses.
- Top-grade components throughout.

30 Watts rms	60 Watts rms		120 Watts rms		240W rms
SA308 30W rms/ 8 ohms £9·50	SA604 60W rms/ 4 ohms £12·50	SA608 60W rms/ 8 ohms £13·50	SA1204 120W rms/ 4 ohms £14·50	SA1208 120W rms/ 18 ohms £21·00	SA2404 240W rms/ 4 ohms £25·50

POWER SUPPLIES FOR THE ABOVE MODULES—READY WIRED & FUSED ON GLASS FIBRE PCB

PM301	PM601/4	PM601/8	PM1201/4	PM1201/8	PM1202/4	PM1202/8	PM2404/1
For 1/2	For 1/2	For 1/2	For 1	For 1	For 2	For 2	For 1
SA308	SA604	SA608	SA1204	SA1208	SA1204	SA1208	SA2404
£9·90	£12·50	£12·50	£12·50	£12·50	£19·50	£19·50	£19·50

DISCO MIXER MODULES Mono or Stereo (with Auto Fade)



Printed circuit module assembled & tested with all components ready mounted.

Mono **£19·50** Stereo **£29·50**

* Front panel to suit £3·50

- Mixes two decks, tape and mic.
- Wide-range bass & treble controls on mic. & music channels.
- Variable autofade (mic. override)
- Ample headphone power.
- Needs only front panel* knobs and selector switch.
- Push-pull monitor circuit.
- 20HZ–20KHZ—Noise —77dB
- Comprehensive wiring details provided
- Perfect for incorporation in *your* system

ALL PURPOSE CUSTOM—MIXER MODULES (Mono or Stereo)

- Using these modules, mixers may be built to your specification up to 20 Channels, mono or stereo, or a combination of both. System 7000 custom-mixer modules have monitoring facilities too!

INPUT MODULES

- Accept low/high 2 mics, ceramic & magnetic cartridges, all musical instruments & line signals
- Low-noise circuitry—high grade components
- Wide-range bass & treble controls (23dB)
- 20HZ–30KHZ Noise —80dB
- Echo sound/return etc easily fitted

Mono—IM7001M
Stereo—IM7001S **£5·50**

MIXING MODULES

- Only one required per mixer track whether mono or stereo
- Feeds up to ten power modules
- Complete with ¼W monitor amplifier
- Accepts up to 20 input modules
- Will match any other make of amplifier

Mono—IM7002M
Stereo—IM7002S **£9·00**

Power supply for up to 20 modules—PPM18 £8·50

QUADRAFECT FOUR CHANNEL 4KW SEQUENCER WITH DIMMERS

NEW

A COMPLETE LIGHT SHOW!!

£29·50

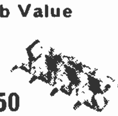
* PANEL £2·50

THE ONLY MODULAR SOUND TO LIGHT UNIT WITH:

- * Four integral dimmers.
- * Two + Two sequencer
- * Automatic audio level

- RCA 8A Triacs
- Sequence 0·5–20HZ
- I.C. circuitry
- Needs only front panel*
- Audio trigger 1–240W
- Fully suppressed
- Individual fuses
- Complete with speed Slider control

THREE CHANNEL 3KW SOUND/LITE—Low Cost—Superb Value



£16·50

* Panel £2·50

- Long-established Saxon design
- Individual level controls + master
- RCA 8A Triacs
- 1W–240W input
- Individual channel fuses
- Needs only front panel*

SYSTEM 7000 MINOTAUR 100—All Purpose Wide Range Amplifier

- 100W rms — 1dB
- Standard 8 ohm output
- Twin mixed inputs accept a wide range of signals
- 30HZ–30KHZ ±2dB
- 23dB bass/treble

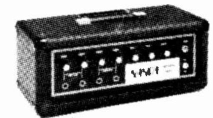
An extremely compact and versatile amplifier with full protection and a clean, attractive appearance. Ideal for all groups, disco's & clubs

£49·50

- Vynide covered case
- Fully short proof
- Superb value for money

A four input, high power amplifier which will deliver up to 150 watts output. An absolute must where multiple mixing & power are required

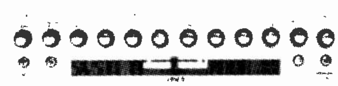
- Four individually mixed inputs
- Wide range bass/treble+master



SAXON 150 HEAVY DUTY AMPLIFIER £59·00

SYSTEM 7000 COMPLETE DISCO MIXERS (with Auto Fade)

*Ready to plug in & use
* Mono or Stereo



The choice of the professional D.J.

Controls: Mic. volume, bass, treble, A/fade depth, tape, L/deck r/deck vols., treble, bass, master, headphones vol., selector, left/right fader.

MONO 18V £37·50 MONO MAINS £43·50

- Automatic mic. override
- Mixes two decks, tape & mic
- Facilities as for modular version opposite
- Mute positions on headphone selector for ease of monitoring
- Two tone stainless steel panel
- Sockets on front & rear panels
- Left/right deck fader
- May be operated from any power supply or from mains

Stereo 18V £53·50
Stereo Mains £59·50

SYSTEM 7000 COMPLETE CUSTOM MIXERS (Mono or Stereo)

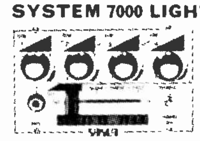
- Similar to the modules opposite these mixing modules are complete with front panels, sockets, knobs, monitor switch etc. Up to 20 channels (mono or stereo) may be incorporated in one system with any number of output tracks.

Ideal for the economical & quick assembly of a purpose built mixer with individual channel monitoring, and optional extra facilities—consult our technical dept. to discuss *your* needs.

- Stainless steel panels
- Built-in monitoring
- Will feed all amplifiers
- Professional appearance
- Accepts all types of signals
- Infinitely adaptable

Mono input module	£8·50
Stereo input module	£12·00
Mono mixing module	£8·50
Stereo mixing module	£12·00
Power supply	£8·50

SYSTEM 7000 LIGHTING CONTROL MK II



HAS YOUR SOUND TO LIGHT CONVERTER GOT:

- 4000W Handling
- Integral individual dimmers
- Automatic audio level control
- Two + Two sequence facility

NEW

OURS HAS! — PLUS:

- Stainless steel panel
- Heavy duty terminations
- Bondene case
- Matches System 7000 mixers

ALL YOUR ELECTRONIC LIGHTING NEEDS IN ONE SUPERBLY DESIGNED UNIT. **£42·50**

SAXON SOUND-LITE—An old design with improved appearance

- Scintillating performance
- Similar to Mk II lighting control in appearance
- 3KW power handling
- Individual bass, treble, middle & master controls
- 1–240W input
- Fully fused & isolated

Complete with heavy duty terminations

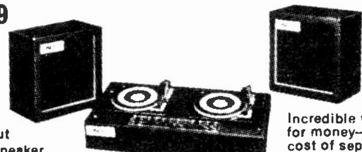
£24·75

EXPORTERS TO 17 COUNTRIES — ENQUIRIES WELCOMED — NATIONWIDE DISTRIBUTION BY NORMAN

BRANCHES AT CROYDON & WALLINGFORD

CUSTOMERS INCLUDE BBC, LONDON WEEKEND TV, SCOTTISH TELEVISION, NATIONAL TYRES, POST OFFICE, GOVT. DEPTS.

A READY-TO-USE 100W STEREO DISCO WITH BUILT-IN SOUND/LITE SEQUENCER AND LIGHTS FOR ONLY £199



THE CENTAUR

(Carr free in U.K.)

Incredible value for money—2/3 cost of separate parts!

- 100W rms stereo output
- Twin heavy duty loudspeaker
- Four channel fully automatic sound-lite with variable speed sequence
- I.C. pre-amp with tape input & X fade
- Separate mic. & music treble and bass controls
- Attractive Vynide cabinets
- Twin BSR decks with autostop & lift arm
- All connecting leads supplied—ready to plug in
- Loudspeakers have kick-proof grills
- Four colour built-in light display gives ever changing pattern with or without music

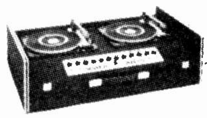
A READY-TO-USE 50W MONO DISCO COMPLETE WITH TWIN HEAVY DUTY LOUDSPEAKERS FOR ONLY £89·90

- 50W rms output
- Twin heavy duty loudspeakers
- Separate mic. input
- Wide range bass & treble controls
- Smart Vynide cases—clip together to form one neat package
- Twin BSR decks with lift & autostop
- Tremendous value—price includes leads just plug in & go!

Accessories for complete discos & other systems

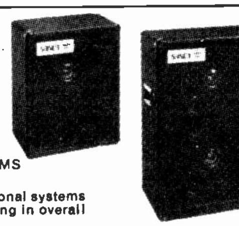
- Electret Condenser Mic ECM31 C/W windshield & clip **£12·00**
- ECM78—as above but duel impedance with removable lead **£13·00**
- Crown Stereo Headphones **£6·75**
- Heavy duty boom mic. stand **£12·50**

CUSTOM BUILT DISCOS



A full range of custom consoles are available using System 7000, from 50W mono to 500W stereo. Ask for our price list.

LOUDSPEAKER CABINETS



- Kick proof grills.
- Jointed construction
- Protective corners
- Heavy duty units.
- Black Vynide finished.
- Smart & professional

Single Twelve: Empty **£14**
With 60W unit **£33·00**
Twin Twelve: Empty **£24**
With units from **£59·00**
Folded Horn—Full range P.A. Bin 100W RMS **£120·00**

This cabinet is 3–4 times as loud as conventional systems for a given input power—thus there is a saving in overall size & cost.

- Many other cabinets available—ask for details.

EMPTY DISCO CONSOLES

£19 with plain motorboard. **£21** with cutouts.

- Black Vynide finish
- Protective corners
- With your choice of cutouts

STROBES & PROJECTORS (We stock the full Pluto range) Send for details

SUPERSTROBE £19·75

- 2–3 Joules
- 80W Tube for long life
- Compact 4" × 4" × 4"

PRO-STROBE £32·50

- 6–8 Joules
- External trigger
- Long Life tube timer circuit

150 WATT LIQUID WHEEL PROJECTOR

- Accepts all accessories
- C/w with wheel & motor plate
- Sturdy steel construction

Remarkable value—Sold elsewhere at £39·50. Our price is only: **£31·50**

Please add 8% VAT to all orders (12½% for SA308/PM301)
We accept Access & Barclaycard—simply telephone or send your card number—Do not send your card.

You may pay by cheque, crossed postal orders, cash (registered) or bank draft

To order—or for advice phone (01) 684 6385 or (01) 684 0098
Mail orders to: 327-333 Whitehorse Rd., Croydon, Surrey CR0 2HS
Shop open 9am–5pm Mon.–Sat. Mail order desk 10am–3pm Mon.–Fri.

Wallingford Branch: Flint House, High St., Wallingford, Oxon
(Callers only)
9am–5pm Mon.–Sat. Telephone (0491) 35529

ROSE ELECTRICAL TO BONA FIDE TRADE CUSTOMERS

GREENWELD

443 Millbrook Road Southampton
SO1 OHX Tel:(0703) 772501

All mail orders and callers to this address please—callers only to 21 Deptford Broadway, SE8 (Tel. 01-692 2009) and 38 Lower Addiscombe Road, Croydon

44 PAGE CATALOGUE 10P + LARGE S.A.E.

Free with orders over £2

DIGITAL I.C.s

7400	12p	7450	15p	7495	73p
7401	14p	7451	14p	7496	85p
7402	14p	7453	14p	74107	37p
7404	17p	7454	14p	74121	38p
7405	23p	7460	14p	74122	51p
7406	28p	7472	29p	74123	84p
7408	14p	7473	29p	74132	56p
7410	13p	7474	29p	74150	173p
7413	28p	7475	51p	74154	144p
7414	82p	7476	29p	74155	73p
7420	14p	7483	91p	74157	66p
7430	14p	7486	40p	74159	200p
7432	18p	7490	46p	74174	110p
7437	18p	7491	75p	74179	120p
7440	15p	7492	52p	74180	120p
7447	84p	7493	52p	74367	120p

DIL Sockets—8 pin **12p**; 14 pin **13p**; 16 pin **14p**. 100+ less 25%.

LINEAR I.C.s

741 **25p**; 555 **40p**; 723 (TO99) **50p**
Plastic Voltage Regulators:
TO126 case 5V 600mA **80p**, 12V 500mA **80p**

TRANSISTORS

AC127	15p	BC183	12p	2N2646	42p
AC128	15p	BC184	12p	2N2926G	12p
AC176	16p	BC212	14p	2N3053	18p
AC187	18p	BC213	14p	2N3054	49p
AC188	18p	BC214	14p	2N3055	38p
AD161	35p	BCY70	15p	2N3440	54p
AD162	35p	BCY71	15p	2N3442	£1·20
BC107	10p	BCY72	15p	2N3702	10p
BC108	10p	BD131	38p	2N3703	10p
BC109	10p	BD132	40p	2N3704	10p
BC109C	15p	BFY50	15p	2N3705	10p
BC147	10p	BFY51	15p	2N3708	10p
BC148	10p	BFY52	15p	2N3819	22p
BC149	10p	TIP41A	60p	2N4059	10p
BC157	10p	TIP42A	75p	2N4418	10p
BC158	10p	TIP2955	96p	2N5294	30p
BC159	10p	TIP3055	42p	40673	50p
BC161	18p	2N2219	28p		
BC182	12p	2N2369	22p		

VEROBOARD

Good size offcuts; all packs contain 100 sq. in. (About 8 pieces). All packs **£1·20**.
Pack A, all 0·1in pitch.
Pack B, all 0·15in pitch.
Pack C, mixed 0·1 and 0·15.
Pack D, all 0·1in plain.
Also available by weight 1lb **£3·45**; 10lbs **£30**.
17 × 3¾ × 0·1in sheets **£1·90**;
0·1in or 0·15in pins, single or double sided **35p**/100.

DIODES AND LEDs AND SCR's

500V 5A SCR **45p**; 400V 2A Triac **80p**; Diac BR100 **25p**; 400V 15A Triac **£1·50**; ORP12 **45p**; MRD450 **40p**; TIL209 Red LED **15p**; 0·2in LED Red **22p**; green, Yellow or amber **24p**
1N4002 **5p**; 1N4004 **6p**; 1N4007 **9p**; 1N4148 **4p**; BY127 **12p**; 100V 3A **12p**; 400V 3A **15p**; OA81 **5p**; OA91 **5p**
50V 1A bridge **22p**; 800V 1A **40p**; 250V 2½A **40p**; 200V 5A **70p**; 500V 6A **£1·60**.
50V 30A rect. + or − stud **40p**
Zeners—400mW BZY88. All voltages from 3V to 30V **10p**
1·3W plastic from 3V to 200V **20p**

RESISTORS

Carbon film 5% ¼W miniature. All values in E12 series from 1Ω to 10MΩ (over 1MΩ 10%) **1½p** each.
Metal Film 5% 1W. All values in E12 series from 27Ω to 10MΩ **2½p**.
Sub-min presets, vert. or horiz. all values from 20Ω to 4MΩ, **7p**.
Standard pots, lin or log, **22p**.
Wirewound 2½W 0·25, 0·33, 0·47 1Ω **8p**.
Wirewound 5W all values from 1Ω to 47K **10p** each.

TRANSFORMERS

6–0–6V 100mA **90p**; 9–0–9V 100mA **95p**; 12–0–12V 50mA **90p**; 12–0–12V 100mA **£1**; 12–0–12V 1A **£2·80**; 20V 55mA **90p**; 22V 100mA **£1**; 29V 50mA **85p**; 6·3V 1½A **£1·95**; 6–0–6V 1½A **£2·30**; 12V 150mA **80p**; 17V 1A **£1·80**; 25V 1½A **£2·30**; 30–0–30V 1A **£3·70**.

REEDS

1in Inserts, **5p**; 10/**40p**; 100/**£3·50**. DIL relay, 3·7–10V, **£2·20**.

WIRE

Enamelled copper wire on 2oz reels SWG/price: 16/**32p**, 18/**34p**, 20/**36p**, 22/**38p**, 24/**40p**, 26/**42p**, 28/**44p**, 30/**46p**, 32/**48p**, 34/**50p**, 36/**52p**, 38/**54p**, 40/**56p**.

RF CHOKES

0·75, 2·95, 6·8, 10, 22, 47μH, all **10p** each; 1·5, 2·5, 5·0, 7·5, 10mH, all **30p** each.

CAPACITORS

Ceramic plate, 22pF to 1,000pF **2p**; polyester 1,000 to 6,800pF **5p**; 0·01, 0·015, 0·022, 0·033, 0·047, 0·068, 0·1mF **4p**; 0·15, 0·22mF **5p**; 0·33 **6p**; 0·47 **8p**; 0·68 **10p**; 1mF **12p**; 2·2mF **18p**; 3·3mF **24p**. 1,000pF feedthrough **5p**.
1%: 1,000pF, 10,000pF **15p**; 0·1μF, 0·2μF, 0·25μF **30p**; 2·2μF **55p**.
Polystyrene 10pF to 1,000pF **4p**; 1,200pF to 10,000pF **8p**. All 2½%.
Electrolytics:
All 25V: 0·47, 1, 2·2, 4·7, 10, 22, 47mF **6p**; 100mF **7p**; 220mF **9p**; 470mF **11p**; 1,000mF **18p**; 2,200mF **27p**; 40V: 47mF **7p**; 100mF **8p**; 220mF **10p**; 470mF **18p**; 1,000mF **32p**; 2,200mF **48p**.
Tantalum bead, mF/V. 0·1/35, 0·22/35, 0·33/35; 0·47/35; 1/35; 2·2/16; 2·2/35; 3·3/35; 4·7/35; 6·8/35; 10/16, 10/25, 15/10; 22/6·3; 22/10; 22/16, 33/10; 47/6·3, 100/3. **12p** each.

BREADBOARDS

S-DEC Breadboard **£2·10**;
T-DEC Breadboard **£3·75**.
Special price to colleges etc. for quantities—ring for quote.

ALUMINIUM BOXES

Complete with base and PK Screws.

AB7	133 × 70 × 38mm	50p
AB8	102 × 102 × 38mm	50p
AB9	102 × 70 × 38mm	47p
AB10	102 × 133 × 38mm	50p
AB11	102 × 64 × 51mm	47p
AB12	76 × 51 × 25mm	44p
AB13	152 × 102 × 51mm	65p
AB14	178 × 127 × 64mm	85p
AB15	203 × 152 × 76mm	£1·50
AB16	254 × 178 × 76mm	£1·80
AB17	254 × 114 × 76mm	£1·50
AB18	307 × 128 × 76mm	£1·75
AB19	307 × 203 × 76mm	£2·00
AB23	102 × 102 × 64mm	80p
AB24	133 × 102 × 64mm	90p
AB25	152 × 102 × 76mm	£1·00

VEROBOXES AND CASES

Professional 2 part boxes made of dark and light grey high impact polystyrene.

2518	120 × 65 × 40mm	£1·90
2520	150 × 80 × 50mm	£2·15
2522	188 × 110 × 60mm	£2·85

Sloping front version, ideal for mixers

2523	220 × 174 × 100/52mm	£4·95

Cases, white plastic top and bottom, front and back aluminium panels that slot in. Type:

1410	205 × 140 × 40mm	£2·90
1411	205 × 140 × 75mm	£3·25
1412	205 × 140 × 110mm	£4·20
1237	154 × 85 × 40mm	£1·60
1238	154 × 85 × 60mm	£2·25
1239	154 × 85 × 80mm	£2·75

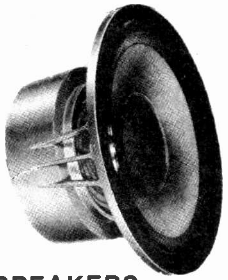
Small general purpose plastic boxes:

1413	71½ × 40 × 24½mm	32p
PB1	115 × 75 × 36mm	42p

DEVELOPMENT PACKS

Save ££££s by buying a full range of components at one go! All full spec marked devices, no rejects or old stock.
50V ceramic plate capacitors 5% 10 of each value. 22pF to 1,000pF Total 210 capacitors **£2·70**.
CR25 carbon film resistors. ⅓ watt 5% 10 of each value 10Ω to 1MΩ, total 610 **£6·00**.
Extended range. 1 ohm to 10M 850 resistors **£8·30**.
Electrolytics, wire ended 25V working 10 each of 1, 2·2, 4·7, 10, 22, 47 and 100mF 70 capacitors for **£3·20**.
Zeners. 400mW 5% BZY88 10 each 3V to 30V total 260 **£14·00**.
½ pack, 5 of each value **£8·20**.
Tantalum Bead caps, 14 values from 0·1/35 to 100/3, 10 of each total 140 caps **£12·00**.

See Practical Wireless for details of packs of components, surplus goods, etc. All prices quoted include VAT. Add 20p postage on orders under £2. Most orders despatched on day of receipt. SAE with enquiries. Send 10p for Multimeter catalogue—free on request on orders over £3. Official Orders accepted from Schools, etc. Export/wholesale enquiries welcome. Surplus components always wanted.



WILMSLOW AUDIO

THE Firm for speakers!

SPEAKERS

Baker Group 25, 3, 8 or 15 ohm	£9·00
Baker Group 35, 3, 8 or 15 ohm	£10·25
Baker Group 50/12 8 or 15 ohm	£14·00
Baker Group 50/15 8 or 15 ohm	£18·62
Baker Deluxe 124, 8 or 15 ohm	£13·38
Baker Major 3, 8 or 15 ohm	£10·69
Baker Superb 8 or 15 ohm	£16·31
Baker Regent 12in 8 or 15 ohm	£9·00
Baker Auditorium 12in 8 or 15 ohm	£14·65
Baker Auditorium 15in 8 or 15 ohm	£19·41
Castle 8RS/DD 4 or 8 ohm	£9·28
Celestion G12M 8 or 15 ohm	£12·95
Celestion G12H 8 or 15 ohm	£15·95
Celestion G12/50 8 or 15 ohm	£18·00
Celestion G12/50TC 8 or 15 ohm	£20·00
Celestion G12/50 2236 s/cone	£18·00
Celestion G12/50 2239 s/cone, alum. dome	£18·50
Celestion G15C 8 or 15 ohm	£26·95
Celestion G18C 8 or 15 ohm	£39·95
Celestion HF1300 8 or 15 ohm	£6·98
Celestion HF2000 8 ohm	£8·55
Celestion MH1000 8 or 15 ohm	£13·50
Coles 4001G	£5·90
Coles 4001K	£5·90
Decca London ribbon horn	£29·95
Decca London CO/1000/8 crossover	£6·95
Decca DK30 ribbon horn	£19·95
Decca CO/1/8 crossover (DK30)	£4·75
EMI 14 × 9in bass 8 ohms, 14A770	£11·92
EMI 8 × 5in, 10W, d/cone, roll surr.	£3·75
EMI 6½in d/cone, roll surr., 8 ohm	£3·93
EMI 8in roll surr. bass	£5·73
EMI 5in mid range	£3·15
Elac 59RM 109 (15 ohm), 59RM114 (8 ohm)	£3·38
Elac 6½in d/cone, roll surr., 8 ohm	£3·95
Elac 10in 10RM239, 8 ohm	£3·95
Eagle FR4	£5·51
Eagle FR65	£8·95
Eagle FR8	£11·95
Eagle FR10	£14·06
Eagle HT15	£3·96
Eagle HT21	£4·95
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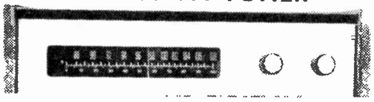

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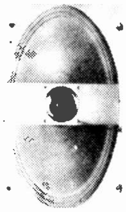

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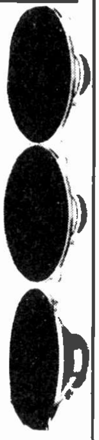

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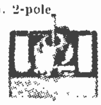

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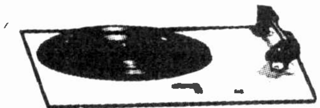

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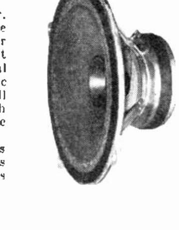

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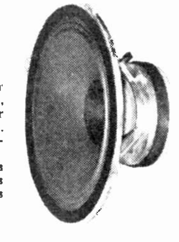

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PE

TO AID THE MOTORIST

Any device that will aid the motorist in keeping down the costs of running a car must be assured of a warm welcome as petrol prices soar skywards yet again. The Car Exhaust Monitor featured in this issue makes effective use of the solid state sensor in a simple-to-install system. With this system the driver has at all times a visual indication of the comparative efficiency of the combustion processes, as derived through the monitoring of waste products at the exhaust.

As a corrective for bad driving habits or as an early warning of the need for service attention the Exhaust Monitor will be a boon and should play a useful part in holding down motoring costs, not to mention assisting in the reduction of pollution.

On the bigger, wider scale, it is clear that electronics is becoming more and more important to the motor industry. The internal combustion engine with its dependence upon such different but interacting electrical, hydraulic, and pneumatic systems is ripe for takeover by an electronic co-ordinating master mind. A built-in computerised control system based upon a microprocessor looks like the inevitable solution, and it is known that the electronics industry is working closely with the motor industry towards such a goal. More efficient and safer driving must be the outcome of this harnessing of the newest technology. But these integrated electronic control systems will not appear overnight, not at any rate in popular family cars.

In the meanwhile, as he awaits delivery of his new Aston Martin Lagonda—that brilliant example of automobile engineering which appears to epitomise the ultimate in the use of built-in electronic systems—the electronics enthusiast has a number of immediate remedies open to him for improving the efficiency and safety of his present vehicle, in addition to this month's motoring project. Like the P.E. Scorpio Ignition System, for example.

WIN A MICROPROCESSOR

From any flights of fancy the name Lagonda may have evoked, we come right down to earth again and invite readers to think about microprocessors, instead. Recall all you have read and heard about these miniature packages of high computing power and then study the points mentioned in this month's thought stimulating competition. A microprocessor could be well within your grasp. That's a fact.

Three complete SC/MP Introkits with Keyboards, plus 25 CPU chips—these are the attractive prizes kindly donated by National Semiconductor (UK) Ltd and A. Marshall (London) Ltd. Thus manufacturer, distributor and P.E. join forces to swing the spotlight onto Microprocessors For The Constructor in this very practical way. Worth thinking about, yes indeed.

F.E.B.

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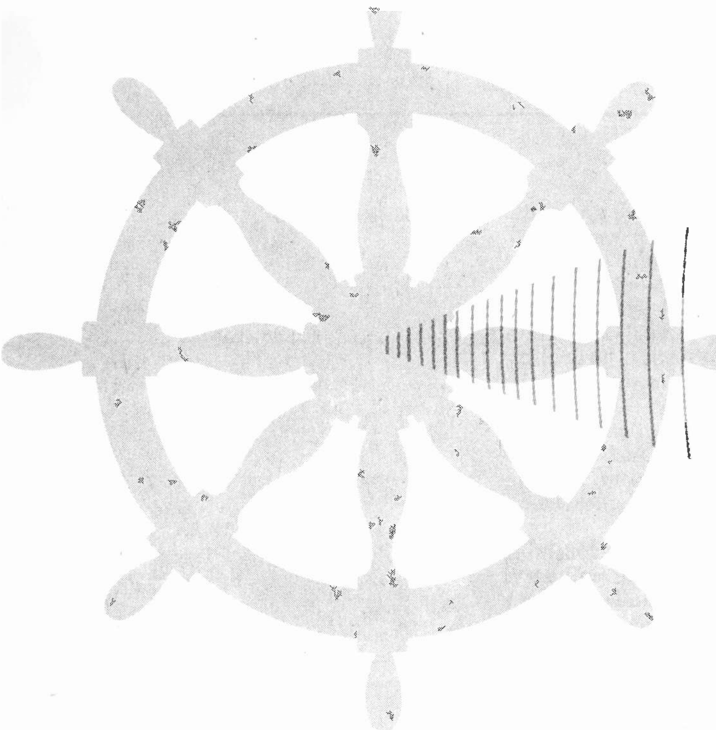


Low Cost RADIO CONTROL SYSTEM

By G.D. SOUTHERN

Part 1 – CODER

THE requirement was for a simple low cost radio control system for a model boat. Something offering a greater area of control than a single channel system was needed, without the complexity of an expensive proportional system. A multi-channel tone system was considered but for total reliability reeds had to be excluded.

The outcome was a companion coder/decoder which can be used with most transmitter/receivers.

The system is basically a four channel one but modifications are offered to extend the facility.

Standard TTL logic techniques are used to maintain the intention for high reliability at low cost.

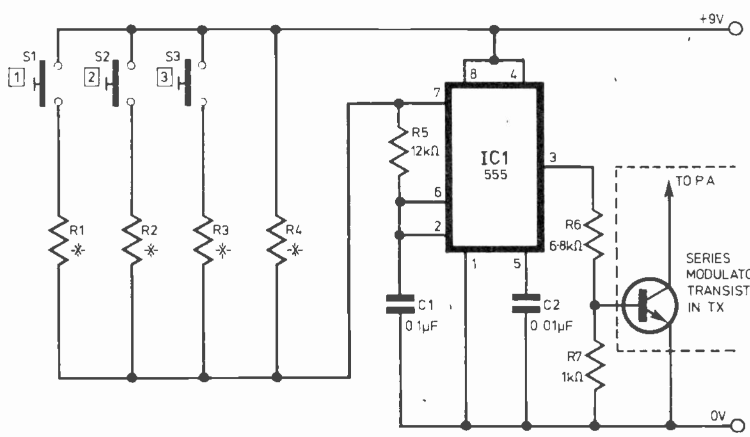
This month the alternatives of coder will be described. Next month the decoder circuitry will be given with setting up details for the system.

CODER DESCRIPTION

The coder circuit in its prototype form is shown in Fig. 1. Capacitor C1 charges through a selected resistor network from the positive supply line and discharges through resistor R5 via an internal transistor in the 555 integrated circuit. By varying these resistors, the astable duty cycle and frequency can be varied (see Tables).

This coder (Coder 1) can generate four tone frequencies. In order to radiate a continuous tone to trigger the fifth channel (O/P5) of the decoder, the circuit is arranged to oscillate at a low frequency when the three push-buttons are released (channel 4).

In this system only a single command operation can be carried out at a time. However, decoder O/P5



CODER 1

Fig. 1. The basic Coder circuit diagram

is arranged so that whenever the transmitter is modulated the model boat motor will run. This is unaffected by the frequency of modulation so long as the frequency is within the overall bandwidth of the system.

The advantage of this is that with transmitter/receiver failure or the model running out of range the motor will stop.

Resistor R4 is chosen so that the oscillator functions within the passband of the fourth channel (O/P4) of the decoder. The frequency range involved in this case is 150–317Hz and the value of the resistor is so chosen to provide a frequency of 215Hz at 9 volts. Although this means that one of the decoder channels cannot be used, it simplifies the design of the coder.

To increase the frequency of the coder for the other channels resistor R4 has to be shunted by a resistor of lower value. By pressing one of the push buttons 1, 2 or 3, channels 1, 2 or 3 of the decoder can be triggered. But as each respective tone frequency is within the overall bandwidth of the system, channel 5 output will remain high as long as the circuit is oscillating.

Coder 1 channel frequencies are shown in Table 1 together with fundamental changes expected for 6V supply lines.

Table 2 shows similar information for the modified Coder 2 which has a greater control facility.

It should be noted that the values of the charging resistors are for the prototype coders and will vary with different units. However, instructions for the selection of these, in conjunction with the decoder, will be given next month.

Table 1

Frequency (Hz)		Decoder Passband (Hz)	Decoder O/P	Charging Resistor
Vcc = 9V	Vcc = 6V			
591	598	478–631	1	R1 = 5·6kΩ
433	437	381–478	2	R2 = 22kΩ
338	342	317–381	3	R3 = 43kΩ
215	216	150–317	4	R4 = 56kΩ

Note that if one of buttons 1, 2 or 3 is pressed either resistor R1, R2 or R3 is connected in parallel with resistor R4

Table 2

Frequency (Hz)		Decoder Passband (Hz)	Decoder O/P	Charging Resistor
Vcc = 9V	Vcc = 6V			
718	724		5	15kΩ
547	551	478–631	1	22kΩ
423	435	381–478	2	22kΩ + 8·2kΩ
340	349	317–381	3	39kΩ
294	292	150–317	4	47kΩ

Note that the resistor values quoted in the above tables apply to the prototype units only and will require adjustment

MODIFICATIONS

The circuit for Coder 2 is shown in Fig. 2. The circuit of Coder 1 has been modified by the addition of a transistor TR1 and five diodes D1–D5. This modification enables the coder to oscillate at frequency slightly higher than the top limit of channel 1 (631Hz) and so allows channel 4 to be fully utilised for control purposes.

When all the push-buttons are released transistor TR1 will be saturated, because the base-emitter junction will be forward biased by the current flowing through resistor R7 and diode D5. Capacitor C1 can charge via resistors R6, R5 and the collector-emitter junction of transistor TR1. Resistor R5 is chosen so that the circuit oscillates at a frequency above 631Hz.

CODER 2

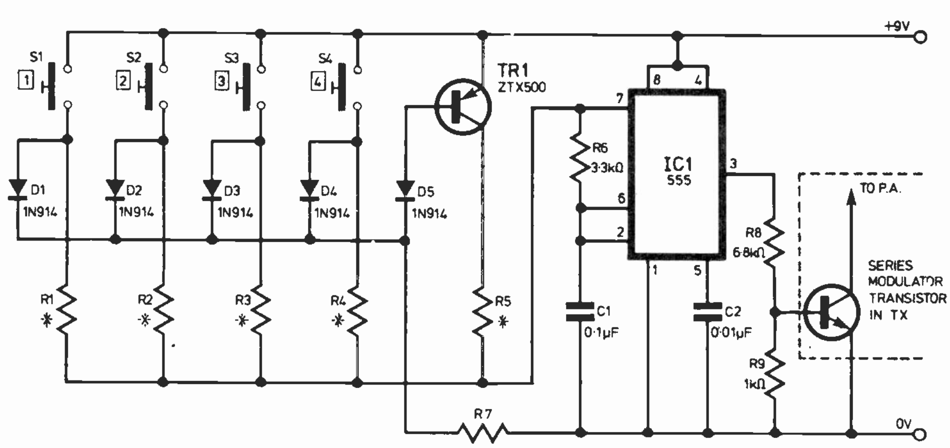
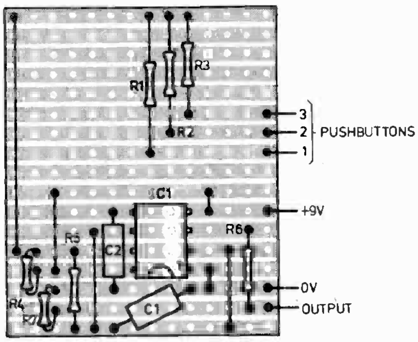


Fig. 2. Modified Coder circuit diagram allowing full control facilities on channel 4

CODER 1

CODER 2



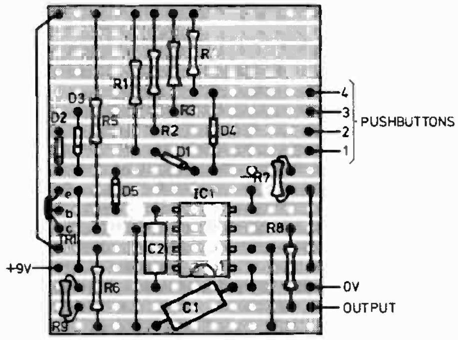


Fig. 3. Component layouts and Veroboard cutting details for Coder 1 and 2

COMPONENTS . . .

CODER 1

Resistors
R1*–R4* see text
R5 12kΩ
R6 6·8kΩ
R7 1kΩ
All ¼W high stab.

Capacitors
C1 0·1μF 250V polyester
C2 0·01μF 250V polyester

Semiconductors
IC1 555

CODER 2

Resistors
R1*–R5* see text
R6 3·3kΩ
R7 18kΩ
R8 6·8kΩ
R9 1kΩ
All ¼W high stab.

Capacitors
C1 0·1μF 250V polyester
C2 0·01μF 250V polyester

Semiconductors
D1–D5 1N914 (5 off)
TR1 ZTX500
IC1 555

When button 4 is depressed, transistor TR1 is cut off because the voltage dropped across diode D4 is less than the voltage across diode D5 and the base-emitter junction of TR1. This means the current will flow through R7 from the negative line via diode D4 and push-button 4 to the positive line.

As transistor TR1 is now cut off capacitor C1 will charge via resistors R6, R4 and push-button 4, but will of course still discharge via resistor R6 and the internal discharge transistor in the integrated circuit. Thus the frequency of oscillation is now governed by the value of resistor R4 and not by the value of two resistors in parallel as was the case with Coder 1.

When button 4 is released transistor TR1 will again saturate, bringing resistor R5 again into the charging circuit. The switching speed of TR1 can be neglected at the frequency the circuit works at. Push-buttons 1, 2 and 3 work in a similar manner to push-button 4.

TRANSMITTER MATCHING

Most radio control transmitters employ a modulation transistor in series with the power amplifier (P.A.) stage. The coder circuit is easily coupled to this type of circuit, and all that is required are two resistors.

These ensure that the modulation transistor is fully saturated when the output of the 555 is high and cut-off when the output is low. This will maintain clean modulation of the P.A. stage.

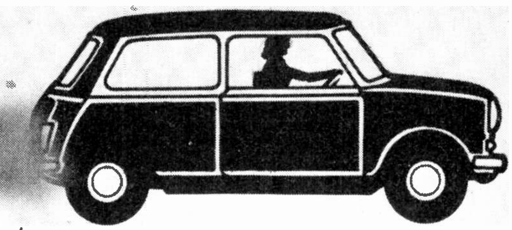
CONSTRUCTION

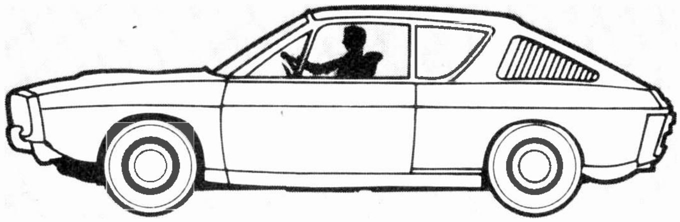
The coder units are constructed on 0·1in single-sided Veroboard. The layout is not critical and as can be seen from the board drawings, the completed unit can be assembled on a small piece of board (Fig. 3).

Care should be taken when cutting the copper strips as small slivers of copper could be left on the board, thus shorting out the section.

Next Month: The decoder will be described together with final adjustments.

CAR EXHAUST MONITOR





By E. BALL MSc & R. A. CRANE PhD

IN these days of soaring fuel costs it is of vital importance to motorists to make the most of every gallon of petrol used by their cars. The Exhaust Monitor described here enables motorists to see while they are actually driving, the efficiency of the burning process and therefore adjust their driving habits to those which most efficiently burn the fuel. The design can also be used to indicate the condition of the spark plugs, points and the condenser as the efficient burning of fuel depends on these components and any inefficiency is easily detected by the Monitor.

The use of the Monitor may be favourably compared with the inlet manifold vacuum indicators which have enjoyed popularity from time to time. The vacuum gauge uses the inlet manifold depression to indicate conditions which lead to poor burning of the fuel. The Exhaust Monitor, however, is more direct in operation as it actually measures the concentration of unburnt gas and partial combustion products in the exhaust system.

TRANSDUCER HEART

The heart of the unit is a combustible gas detector transducer type TGS308 which is mounted in an add on tube at the rear end of the exhaust system. The transducer has already been fully described in this magazine in the July and September 1973 issues.

In brief the device contains two heaters and a semiconductor resistance element. When at the normal operating temperature the resistance of this element varies with the percentage of combustible gas at the element surface.

In this design only one of the heaters is used, the other being kept as a spare in case of damage.

The exhaust gas is taken from the main exhaust stream by the gas collecting tube and diluted with air in the mixing tube. This mixing is performed in the same fashion as the bunsen burner or gas cooker. The diluted gas is then tested by the gas detector.

METER SCALING

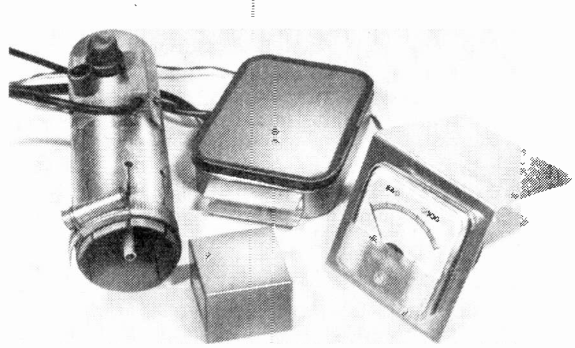
The electronics used to supply the heater and convert the change in element resistance into a signal to drive a dashboard mounted meter are contained in a small box mounted at some convenient point in the car.

The meter scale is not calibrated directly in terms of parts per million combustible gas for two reasons. First, there is a mixture of combustible gases present (petrol, carbon monoxide, alcohol) and the sensitivity of the transducer is different for each gas. Secondly, of course, the amateur constructor has no access to complex test equipment necessary to set up precisely known gas concentrations.

For these reasons the scale is left uncalibrated and arbitrarily marked as "Good" and "Bad". These bands can then be coloured green and red.

CIRCUIT

The circuit is shown in Fig. 1. It is powered from the car 12V electrical system and will work with either positive or negative earth vehicles as all the components are electrically insulated from the mounting box and car chassis.



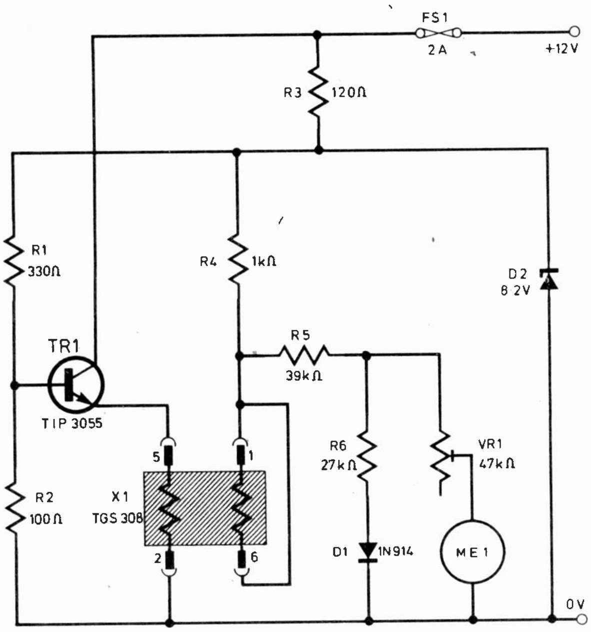


Fig. 1. Circuit of Monitor

COMPONENTS . . .

Resistors

R1	330Ω	R3	120Ω 1W	R5	39kΩ
R2	100Ω	R4	1kΩ	R6	27kΩ

All resistors ±10 per cent ¼W except R3.

Potentiometer
VR1 47k skeleton preset

Semiconductors
TR1 TIP3055 (with insulating kit)
D1 1N914
D2 8·2V ± 5 per cent 1W Zener diode

Miscellaneous
18 gauge aluminium box with lid;
X1 TGS308 combustible gas detector;
ME1 100 μA 2in meter; FS1 2A fuse;
Veroboard (0·1in matrix); B7G valve base;
1 Jubilee clip to suit exhaust pipe

The resistor R3 and the Zener diode D2 are used to derive an 8·2V reference supply, which stabilises the instrument against the variations in battery voltage usually encountered. The transducer heater supply voltage, 1·2V on pin 5, is derived from this 8·2V reference via R1, R2 and TR1. The current is approximately 0·5A so the power dissipated in TR1 is (12–1·2) 0·5 = 5·4W.

Under conditions of high battery voltage this could be higher, up to 8W at 17V so TR1 must have adequate heatsinking arrangements. In the prototype TR1 was mounted on the metal case containing the electronics (using a mica insulating washer).

If the case is clamped in close thermal contact with a car body member this will further aid the heatsinking arrangements but is not absolutely essential.

INTERPRETING THE METER

The drive to the transducer resistance element is from the 8·2V stabilised supply through the resistor R4. The voltage developed across the element is a function of the combustible gas concentration at the element surface and this voltage is applied to the 100μA indicating meter via a non-linear shaping circuit comprising R5, R6, D1 and VR1.

These are used to make the best use of the meter scale with the concentrations of gas present in the exhaust system. With no combustible gas present in the exhaust system, that is with the car engine stopped, the voltage dropped across the resistance element is a maximum and VR1 is used to set the reading on the meter to the maximum point on its scale. This corresponds to perfect combustion of the fuel and thus the right half of the scale of the meter is labelled "Good" and the left half "Bad".

CONSTRUCTION

The unit is built in three parts: tailpipe unit, electronics and meter. The exhaust tailpipe unit is mounted on the end of the exhaust pipe and holds the gas sensor. This is connected with a three core mains cable to the electronics unit mounted at some interior convenient point and fixed if possible in close thermal contact with a body member or panel.

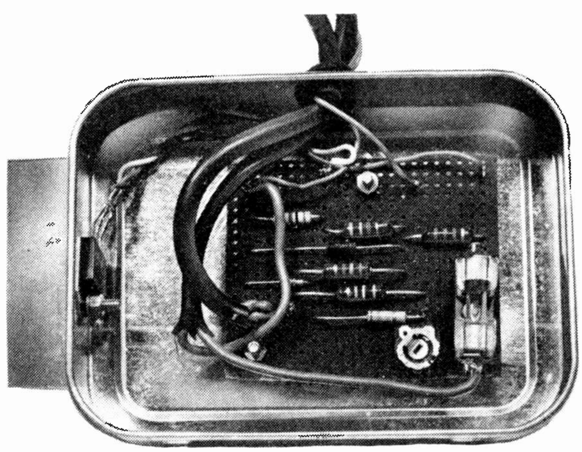
Finally the dashboard mounted meter is connected to the electronics unit with a two core cable.

ASSEMBLY

Details of the exhaust tailpipe unit are shown in Fig. 2. The transducer is plugged into a B7G valve socket which is screwed to an aluminium or steel mounting bracket with self tapping screws. The tube should be just larger than the diameter of the exhaust pipe and is clamped onto the end of the pipe using a Jubilee clip. The author's car was an Avenger 1300 estate and a 50·8mm tube was found satisfactory.

Although this size would be satisfactory for a number of other cars there are a large variety of possible exhaust sizes and the reader is advised to check before proceeding. It is possible that if difficulty is experienced in getting a suitable tube that one of the popular chromed extension tailpipes could be obtained from a car accessory shop.

The gas collecting tube is 6·35mm diameter non ferrous metal bent as shown. The end of this tube is flattened and a 2mm jet hole drilled in a flattened portion. The mixing tube is again non ferrous metal this time of 12·5mm diameter drilled with 4 × 2mm



CAR EXHAUST MONITOR

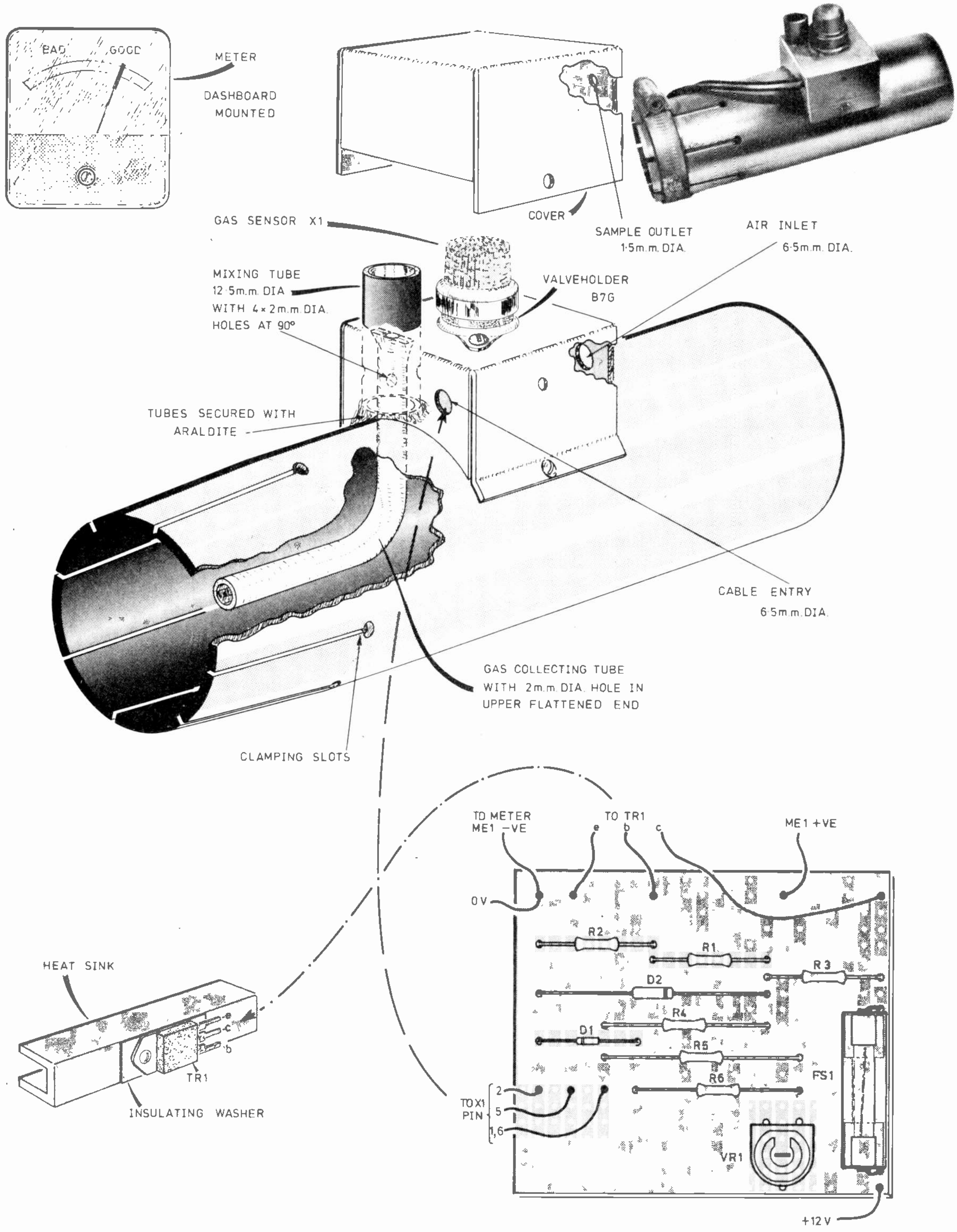
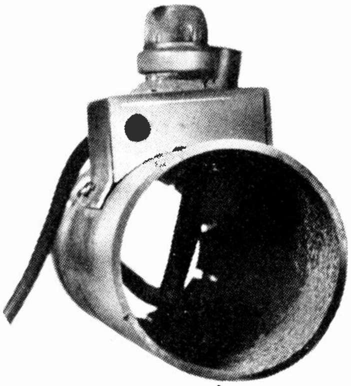


Fig. 2. The Monitor assembly consists of meter, tailpipe unit and electronics



air holes every 90 degrees as shown. These two tubes are fixed to the tailpipe extension with Araldite epoxy resin in the positions indicated.

When fixed the sensor mounting chassis complete with the valve holder is slotted over the mixing tube and held in place with self tapping screws. Finally the transducer is plugged in and the cover fitted. The case used to contain the electronics unit should be about 102 × 76 × 25mm with a lid and should preferably be made of aluminium because of its superior thermal conduction properties. TR1 is fixed to the inside of this using an insulating mica washer.

The other components are mounted on Veroboard as shown and fixed inside the case using three spacers and 6BA fixings.

The meter can be mounted on a simple bracket which is then fixed to the car dashboard. Different brackets of course may be used to suit individual tastes and requirements.

When installing the unit into the car it is important that any wiring should not come into contact with the exhaust system and careful routing of the cables is necessary, particularly the supply cable if it is taken underneath the car and via the engine compartment.

Long term testing of the unit has revealed that the aluminium parts corrode slightly and deposits of carbon and other combustibles form in the tail pipe extension and in the chamber above the mixing tube. These deposits should be removed if they build up. The period of time for the deposits to accumulate will depend very much upon the condition of the engine, whether it is in tune or burning excessive oil. However, periodic maintenance every 3 months or 3,000 miles should suffice for the average motorist.

THE GAUGE IN USE

After switching on the gas sensor requires several minutes to warm up to maximum sensitivity but nevertheless still gives useful indications during this period, easily detecting whether the choke has been left out. When both the engine and unit are warmed up, however, the needle can be moved between "Bad" and "Good" by the style of driving.

Using the engine as a brake for example produces efficient combustion and therefore a "Good" reading. On the other hand rapid depression of the accelerator pedal produces an over rich mixture and this sends the needle well into the "Bad" region. Between these extremes we have found other interesting observations, e.g. letting the car labour up hills in top gear produces less efficient combustion than changing down a gear. ★

BOOK REVIEWS

ELECTRONICS ENGINEER'S REFERENCE BOOK
(Fourth Edition)
Ed. by L. W. Turner
Published by Newnes-Butterworth
1,420 pages, 220mm × 140mm. Price £25·00

AUTOMATIC TESTING SYSTEMS and APPLICATIONS
By R. Knowles
Published by McGraw-Hill
246 pages. Price £6.30

We all need to keep up-to-date in our knowledge, but production costs of print and paper are still soaring. According to the Publishers Association the cost of text books has risen 17 per cent in the past year and the average price now works out at £1·52 per 100 pages. It is in this context that one needs to examine the "Electronics Engineer's Reference Book" published by Newnes-Butterworth with a cover price of £25. It sounds an awful lot of cash for one binding but some of the 27 sections are complete books in themselves; that on Telecommunications, for example, having 231 pages and Solid State Devices having 123 pages. Altogether there are 63 authors, all specialists, who have contributed and the complete work has been ably edited by Leslie W. Turner, now a consultant engineer but well known for many years during his time as Head of Engineerng Information with the BBC.

The last edition came out in 1967 so there was plenty of scope for an up-dated edition and this, the fourth edition, has been completely re-written. The cut-off point for editorial copy was clearly some time in 1975. Nonetheless the book is as nearly up-to-date as can be reasonably expected and includes new techniques like laser communications and plasma and liquid crystal displays but stops short of microprocessors.

The first 14 sections deal with theory, materials and circuits, the remaining 13 on applications. There are over 1,400 pages, hundreds of diagrams, tables and illustrations and comprehensive references for further reading. All in all a handsome and useful volume for both the newcomer and the old-timer who still needs to keep abreast of new developments. Nearly all the authors are industry men writing for industry as well as for students.

The fast-growing automatic test industry is dealt with in "Automatic Testing, Systems and Applications". This is a book for industry with sections on economic benefits and systems management as well as theory and practice covered in its 246 pages.

But I only realised what good value such books are when I saw "Freshwater": A comedy by Virginia Woolf with a cover price of £3·00 for its slender 75 pages.

NEXUS

SOLID STATE NOVELTY PROJECTS
By M. H. Babani
Published by Bernards (Publishers) Ltd
92 pages, 180×108mm. Price 85p

A COLLECTION of ten circuits for the electronics enthusiast, covering games, musical instruments, lighting controls, even a mosquito repeller! Most of the material has appeared previously in *Electronics Australia*.

G.C.A.

BY FRANK W. HYDE

SECOND YEAR

In completing its second year in orbit, *Ariel V* has doubled its planned life of operation. Some degradation with time has been observed but this has not detracted from the value of the real scientific performance. An interesting point that has arisen here. is that as the various subsystems are affected by age the operations control centre at the Appleton Laboratory have become more flexible in order to adjust quickly to changing conditions. This has brought a certain swift sophistication and perhaps a more close relationship between the satellite and the human interface.

The satellite gas supplies should last, in the case of the pointing of the spin axis, for a third year. After that the individual pointing for observation will cease and an all sky survey continued. Gas has been conserved beyond the design period because of the aptitude the operators have developed over time, and also the modifications that have been made to computer software to take into account the irregular changes in gas pressure.

MANOEUVRES

The gas manœuvres are restricted to times when the jet manifolds are warmer than the central propane tank to avoid the possibility of liquid propane passing through the valves. As this depends upon the time of day and the attitude of the spacecraft to the Sun, operational schedules are affected and also the scientific programme is restricted by prohibiting the viewing of certain sources at a given time of year.

There is an on-board magnetorquer which has been used regularly to minimise the attitude drift rate of the spin axis. This can also be used to a limited extent to control the manœuvres and also to conserve the gas supply.

The battery charging cycle takes power from the solar cells during the 60 minutes that the satellite is in sunlight and then supplies the power needed during the 35 minutes of darkness. This is also expected to carry on during the third year. During the two years of operation all systems have performed satisfactorily using all modes of the design.

The attitude measurements have made use of the back-up sensor system to allow for partial failure of the primary system. It has also been possible to refine the accuracy of some of the measurements by using the positions of known X-ray sources. In order to optimise calculations of spacecraft attitude, data obtained since launch have been used as a basis for making changes in the computer software.

OBSERVATIONS

Normally, the satellite is either pointed at a different source at the beginning of each day, or otherwise adjusted to a new position from which to take further observations of the same source as on the previous day. A complete sequence of observations on a source will usually take between two days and perhaps three weeks.

Since launch, the pointing axis has been scanned completely around the plane of the Milky Way once, and twice more through the region of the Milky Way in the direction of the centre of the Galaxy as this part of the sky is particularly rich in X-ray sources. In addition, the spin axis has been pointed at a large number of individual sources, many of them believed to be external galaxies.

Finally, there have been three extended periods, from 10 to 26 days each in duration, when the spin axis has been so pointed that the Sky Survey Experiment can monitor the behaviour of the Milky Way sources.

EXPERIMENTS

All of the experiments have produced outstanding results. However, one of the striking features of *Ariel V* has been the way in which the different experiments have complemented one another to produce results unrivalled elsewhere. On five occasions since launch, results from several experiments have been simultaneously published in "Nature" magazine, all dealing with different observations of the same object.

The outstanding observations of this character are those of the transient X-ray sources. These turn on rapidly and within a few days reach a peak of brightness. They then decay over a few hours, days or weeks.

X-RAY SOURCES

One of these transients (A0620-00), first observed by the Sky Survey Experiment in August 1975, became for six weeks the brightest X-ray source in the sky. Only four transients had been detected prior to the launch of *Ariel V*, and observations of these were sketchy, but *Ariel V* has observed no less than 14.

Two further transients (A1118-61 and A0535+26) were found by the Mullard Space Science Laboratory and Birmingham to be modulated with periods of 6·75min and 1·73min respectively. This caused considerable excitement, because those modulated X-ray sources which had previously been found, varied either with periods of hours, the modulation arising from the orbital motion of the X-ray star about an ordinary star, or seconds, the modulation then arising from a spinning neutron star. A periodicity of minutes might arise alternatively from an extra-ordinarily close pair of orbiting stars, or from a very slow rotator.

For some months the explanation was uncertain; then it became clear that a slowly rotating neutron star was involved. Subsequently, with their experiment on the Copernicus satellite, MSSL found no less than six slow rotators amongst the ordinary X-ray sources.

INTERCOSMOS 16

A combined effort in instrumentation was undertaken by Russia and Sweden in the form of an ultra-violet spectrometer-polarimeter. With this instrument it became possible to make measurements of the polarisation of ultra-violet radiation coming from the solar atmosphere.

The instrument was coupled with a small telescope with a focal length of 100mm. It has a mirror device which enables the unit to register the direction of the radiation from spectral regions not accessible to ground based observatories. Simultaneous observations of the solar conditions were made from a tower solar telescope at the Crimean Observatory.

MEMORIES

A TWO-PART ARTICLE BY A.BRIAR

INTRODUCTION

Due to the ever increasing demand for faster speeds and further miniaturisation in computers, the integrated circuit memory came into existence. This device has been with us for many years now and new developments are occurring almost daily; the subject has become so diverse and complex that it is a specialist field in its own right. But in an area that is growing at such a rate, especially since the advent of microprocessors, the time is perhaps ripe to stand back and take stock of some of the achievements and discoveries to date and to differentiate between the categories and specific devices currently available. Also, around this subject has grown a whole new crop of abbreviations which tend to be confusing to the newcomer but which, it is hoped, will be adequately explained in this article.

This article is intended to simplify the whole subject of binary storage memories, and by starting from the basic magnetic core store it will cover the developments with integrated circuit memories to date and show how the whole field has expanded. The article has been aimed at the reader with little or no knowledge of this subject but who it is hoped will, after reading it, possess a more than working appreciation of the modern memory systems available and their applications. It should also provide a useful "recap" for others, particularly in view of the developing interest in microprocessors.

WHAT IS A MEMORY?

For the purpose of this article a rather simple definition can be offered:

> Any device that can hold information, in whatever form, such that the information can be retrieved again can be called a *memory*.

Within this definition it is apparent that examples of memories are numerous and even include such devices as cassette tapes and gramophone records. Also, the simple bistable circuit can be considered as a form of memory and this device is perhaps the cornerstone of the modern memory system.

Since cassette tapes and gramophone records are mechanically driven systems they must, by their inherent speed limitations, be unsuitable for the fast access times required by modern computers. To be of use to these machines, stored information must be available in nanoseconds and mechanical devices (which have other advantages) are used as backing stores where access speeds are less important and where interchangeability is desirable.

The only way that fast access speeds to the memories can be achieved is by electronic methods. Until only a few years ago all computer memories relied on magnetic core stores, but with the advent of highly sophisticated integrated circuit memories these former devices are rapidly being replaced.

BINARY STORES

A computer stores the information in binary form, that is, each digit of information is stored in one of two stable states. There are two types of memory capable of storing the information in this form:

1. The READ ONLY MEMORY (ROM). With this memory the information has been previously stored (or programmed) and cannot be modified (that is to say that new information cannot be written into it).

   However, the information can be recalled at will without destroying the contents of the memory and also, the electric power to the device can be removed without any effect on the information stored such that when the power is restored the information is again readily available.

   Because of this latter characteristic the device is said to be NON VOLATILE.

2. The RANDOM ACCESS MEMORY (RAM). This type of memory can be written in to and read out from. It is the most widely used type since information can be stored, updated, modified or recalled at any time.

   However, the device cannot be physically removed from its circuit nor can it sustain a total power failure without losing the information stored within it.

   Because of this aspect the memory is said to be VOLATILE. (Although there are some RAMs which can sustain a partial shut down of the power, but these devices operate normally on at least two separate voltage levels).

Later in this article a closer look will be taken at both of these types of memory, but it is important at this stage to realise the fundamental differences between them.

HOW INFORMATION IS STORED

As mentioned in a previous section, until only a few years ago computers used magnetic core storage for the fast access memory within their central processor unit (CPU)—the heart or brain of the machine. Core stores rely on the principle of magnetism to hold the information and the results, although satisfactory, were very expensive to achieve.

We will now look at the principles behind magnetic cores and at the various types of integrated circuit memories that replaced them.

MAGNETIC CORE STORAGE TECHNIQUES

One of the characteristics of ferrous materials is that they can be magnetised; using this ability information can be stored within a piece of ferrous material.

Consider a small torroid made from magnetic material through which a loop of wire is passed (see Fig. 1). If a current is now passed through this wire in the direction A–B, then the torroid will be magnetised by the inductive effect and, since the current is in one direction only, the torroid (or core) will be magnetised in only one direction until it becomes saturated, i.e. any increase in the current in the wire will not cause any further increase in magnetism.

When the current is removed the core retains its magnetism, the amount remaining dependent upon the actual material of the torroid. The material chosen for this type of torroid is one that gives an almost square hysteresis response and a hysteresis loop for the material can be seen in Fig. 2.

The remaining magnetism corresponds to the amount of flux density held at the Retentive Point which is the point to which the core falls back to upon removal of the current (the current corresponding to the magnetising force).

Now, if a current is passed in the opposite direction, then a negative magnetising force is applied and the core saturates in the opposite direction. When this current is removed the core falls back to the retentive point in the negative sense. Since there are two stable states for the core to take up, a convention can now be assumed of positive magnetism being logical "1" and negative magnetism being logical "0".

DISTURBANCE

Having stored the information in the core, a method must be found of detecting what has been stored. By resetting the core always to the "0" state the resulting large or small change in the magnetic state of the core can be found; this change in magnetism upon resetting is called disturbance.

If a large disturbance is detected then the core had previously stored a "1"; conversely, a small disturbance indicates a "0". Note that even though the core was already in the "0" state there will still be some disturbance due to the hysteresis loop not being exactly square, and thus there will be a very small change in flux density as the core saturates with the resetting pulse.

The disturbance is detected on the sense winding which also runs through the core and a separate sense amplifier detects this disturbance pulse not by responding to changes in amplitude but by determining the width of the pulse, i.e. time taken to reset the core to "0". If the core had been in the "1" state then the time taken to reset to the "0" state will be very much longer than if the core had already been in the "0" state.

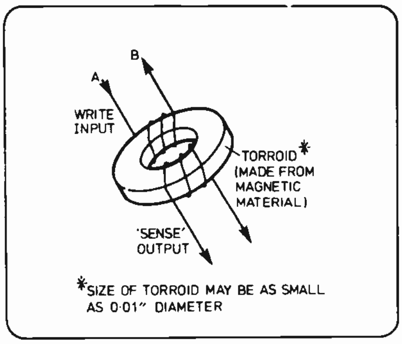


Fig. 1. Example of magnetic core store using a torroid

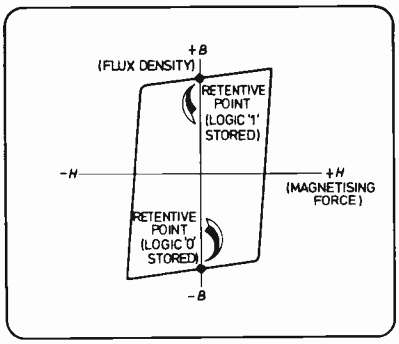


Fig. 2. Hysteresis curve for a magnetic core store

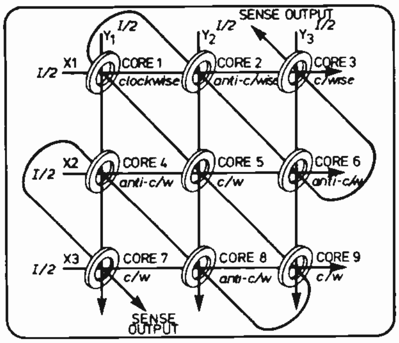


Fig. 3. Two plane ferrite core matrix array

COINCIDENT CURRENT

Large matrix stores in computers make use of these techniques and millions of identical cores are connected together to make it possible. Use is usually made of the *Coincident Current* method whereby there are two energising windings to each core, neither of which, independently, is enough to saturate the core; but when both currents are present simultaneously then saturation can take place.

This method allows the addressing of one core at a time out of the whole array by use of a grid system such as that in Fig. 3. To energise core "6", currents *X3* and *Y3* would be required. This system

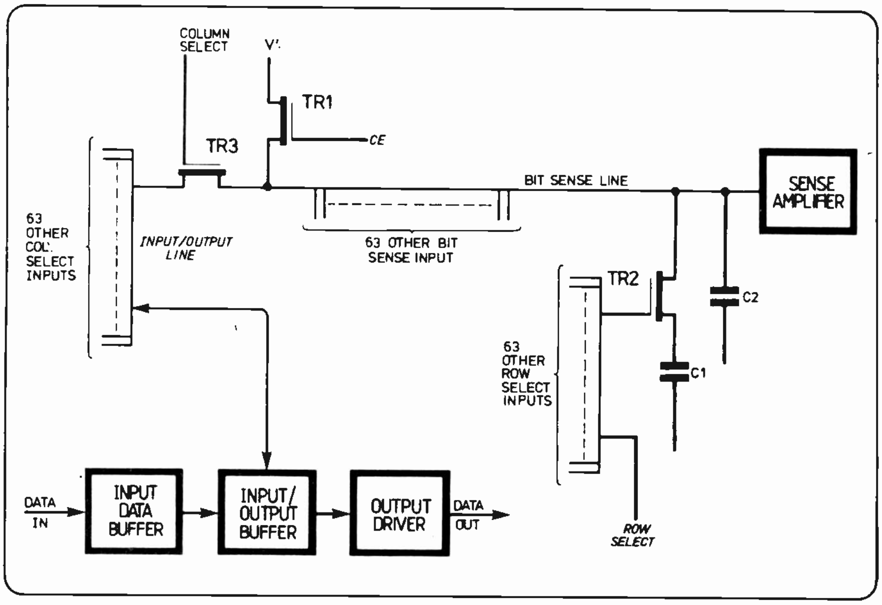


Fig. 4. Simplified memory cell of 2107B device

may be enlarged to three planes by use of a Z winding and this is usually how the large matrix core stores are operated.

The sense winding for the plane is connected as shown going alternately clockwise then anti-clockwise through the cores; the sense amplifier is unaffected by the fact that the disturbance pulses may be in either direction but just detects the duration of any pulse.

This type of storage system is very fast for accessing to any particular core, but since a large amount of the internal wiring of the matrix is done by hand during manufacture the cost per BIT (Binary Digit) of stored information is very high.

CAPACITOR STORAGE TECHNIQUES

Another method of storing information is by storing a charge on a capacitor within an integrated circuit; an example of this type of memory is the 2107B device by Intel. With this device each BIT of information is stored within a memory cell consisting of a single transistor and a storage capacitor as shown in Fig. 4.

Initially the *CE* signal is present and allows TR1 to conduct which in turn allows capacitor C_2 to charge up to a value approaching V'. After *CE* has disappeared the *Row* and *Column* inputs are presented and TR2 and TR3 both conduct (TR1 having now cut off). Now, if the storage capacitor C_1 within the memory cell had stored a logical "1" previously then C_2 will very slightly increase its charge via TR2 to a value

$$V'\left(\frac{C_2}{C_2 - C_1}\right)$$

(the value of C_2 is very much larger than the value of C_1). The sense amplifier connected to the sense line detects this small increase in the charge stored on

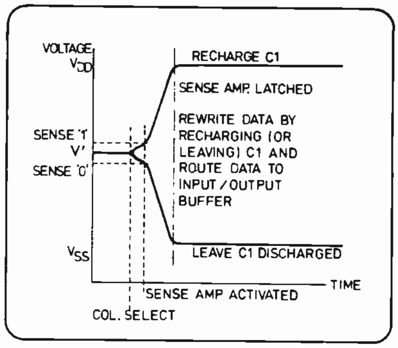


Fig. 5. Bit sense line voltage

C_2 and latches itself and therefore the sense line to the logic high state thereby recharging C_1 via TR2. If the storage cell had previously held a "0", i.e. C_1 is in the discharged state, then the sense line voltage becomes

$$V'\left(\frac{C_2}{C_2 C_1}\right)$$

The sense amplifier detects this change and latches itself to the logic "0" state (0V) thereby leaving C_1 in the discharged state.

Fig. 5 shows the latching action of the sense line. Once latched, the sense amplifier also routes the appropriate logic level to the *Input/Output* line via TR3.

If new data is to be read into the memory cell then both *Row* and *Column* addresses must be present and the input presented via the input buffer; this will override any information that is contained within the memory cell and it therefore takes up its new state.

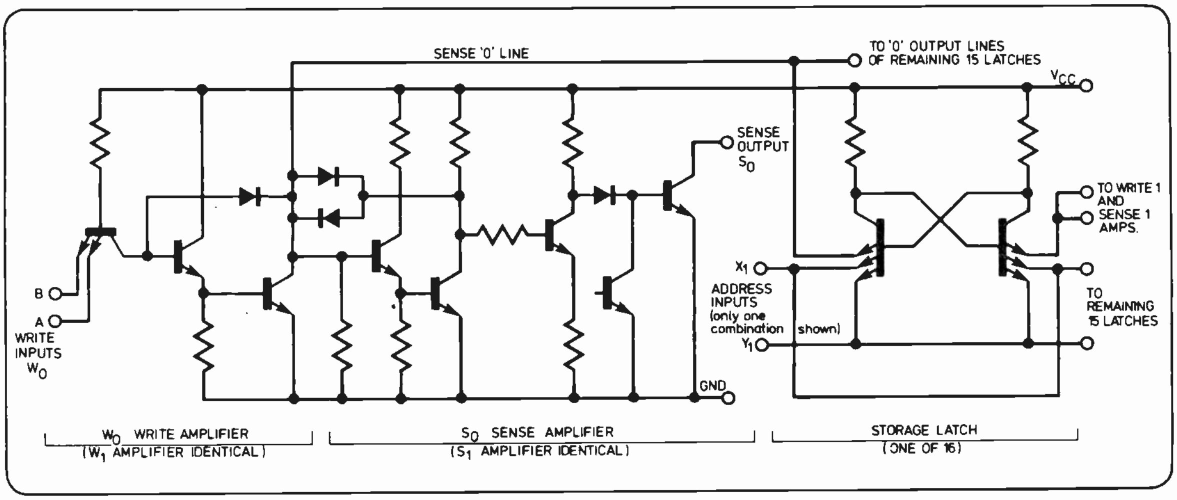


Fig. 6. Transistor latch store (part of SN7484)

LEAKAGE OF CHARGE

Unfortunately, with this type of memory the information contained within the memory cell will gradually disappear due to the leakage of the charge from the storage capacitor; for this reason each memory cell has to be "refreshed" at periodic intervals by enabling the *Row* addresses (only) in sequence. Thus the cells are read and sensed and the sense amplifiers then proceed to "top" them back up again by their latching action.

In most devices of this type (where "refresh" is needed, and called DYNAMIC) the refresh function can be carried out automatically by the device itself, if required; though this may cause problems with the internal circuitry if a refresh cycle is being carried out independently by the device at the same time that a Read or Write demand is received.

To overcome this problem the device can be refreshed at periodic intervals under the control of the external circuitry.

TRANSISTOR LATCH STORAGE TECHNIQUES

The transistor latch storage technique was the most widely used with the advent of TTL technology, and it is the natural successor to the simple bistable latch. Now, however, a large number of these transistor latches have been combined into a single i.c. package to form very large memories.

Each latch will store one BIT of information and an example of such a latch is shown in Fig. 6 where the SN7484 by Texas Instruments has been chosen.

Once again the now familiar *Row* and *Column* inputs are apparent (termed *X* and *Y* respectively here) and these are normally held at logic "0" (0V). The latch itself must have one transistor conducting and the other cut off and the former finds its current path out through the address lines. If the sense of the latch is to be determined then both of the address lines must go high to logic "1" and now the conducting transistor of the latch has to find its current path via either the "0" or "1" sense amplifiers.

Whichever of the sense amplifiers is activated then the output of that amplifier drops to logic "0" and this is presented at the output as inverted data (which fact is unimportant since the information had previously been inverted before being stored). With this type of sensing there is no destruction of the information stored.

If new information is to be written into the latch then it is addressed as before and the information is presented at the write input. If the information to be written in is the same as before then there will be no change to the latch, but if different, then the latch takes up the state of the sense "0" and sense "1" lines by finding a current path through the one which has the logic "0" thereby switching on that transistor and, since there is no current path for the other transistor down the logic "1" line, then that transistor switches off.

This type of memory will retain its information for as long as the power to the i.c. is present and does not need refreshing; it is known as a STATIC type.

RANDOM ACCESS MEMORIES (RAMs)

A very simple summary of the function of RAMs was given in an earlier section and to recap, the RAM can be written into or read out from at will and is the most widely used type of memory. There are two basic types of RAM:

(1) The DYNAMIC type in which the information needs constantly to be *refreshed* to prevent its loss.

(2) The STATIC type in which the memory retains its information for as long as the power is present and needs no refreshing.

To understand the reason for these two types it is necessary briefly to touch on the history of their development. Initially the technology which made large and cheap production of integrated circuits a viable proposition was the advent of the TTL range.

The RAMs using TTL technology stored the information in latches (as in the example given in the previous section) but an upper limit was reached in the amount of information that this type of device could contain.

With the demand for even bigger and faster memories to pacify the fast growing computer industry, the MOS technology came forward with the Dynamic RAM where memory sizes could be increased remarkably (a typical capacity of this type of device being 4096 BITS).

Because of the drawbacks of "refresh" characteristic to dynamic memories, research was carried out to find a way of increasing the capacity of static devices and again the MOS field held the answer; at present the memory capacity of MOS static memories is mainly confined to 1024 BITS but the power requirements are simpler than the MOS dynamic types.

It is now also possible to obtain static RAMs in the Schottky bipolar technology and extremely fast speeds may be obtained with these devices; as yet the maximum capacity of these devices is still limited to about 256 BITS.

The major advantage of the integrated circuit RAM is that its cost per BIT is small and the devices are so arranged that they can easily be expanded to form one vast memory incorporating many hundreds of packages. This is ideal for computers and the days of magnetic core stores are now over for new designs.

Next month: Read Only Memories, including PROMs and EPROMs, and Charge Coupled Devices.

POINTS ARISING

SIMPLE TOUCH DIMMER *(Ingenuity Unlimited, November 1976)*

In Fig. 1, the line joining the base of TR1 to the earth rail should be deleted.

Thermal Resistance & Derating of Devices

By C. Rudd

THERMAL resistance is analogous to electrical resistance in that it restricts the flow of heat while electrical resistance restricts the flow of charge as current. In fact, it is found that most of the simple equations relating to the flow of direct current have counterparts in those relating to the flow of heat.

The thermal resistance between two points is defined as the temperature difference between those points divided by the rate of flow of heat from the hotter point to the colder. The units of thermal resistance are therefore kelvin (or degrees Celsius, it makes no difference) per watt. Now, the active part of a semiconductor device will have a maximum permissible temperature (usually called the maximum junction temperature, denoted by $T_{j\,max}$) beyond which damage or incorrect operation will occur. Therefore, the total thermal resistance between the active regions of the device and the surrounding environment (ambient) should be made as small as possible so that as much heat per second as possible can be conducted away.

This total thermal resistance between the junctions of a device and ambient will usually comprise several components. First, there will be a resistance between the device's junction and its case comprised of several internal components which do not, in general, concern us since we cannot alter them. The total thermal resistance is usually denoted by θ_{jc}, which might be anywhere between three and ten kelvin per watt for a typical power transistor. Secondly, if a heat sink is fitted to the device there will be a "mounting" thermal resistance due to the insulating washers, if any, between the device and the sink and, finally, a thermal resistance between the heat sink and ambient. Generally the mounting and sink thermal resistance are lumped together and denoted by θ_{ca}.

❄ ❄ ❄ ❄ ❄ ❄ ❄

Since all the electrical power dissipated in a device must, ultimately, appear as heat, as much electrical energy as is pumped into the device per second must escape as heat energy once the device's various temperatures have settled down to steady values. Thus it is clear that if θ_{ja} is the total thermal resistance between the device's junctions and ambient, and P is the rate at which power is dissipated in the device (the rate of conversion from electrical energy to heat energy), then the junction temperature must be $\theta_{ja}.P$ above ambient temperature to maintain a sufficient flow of heat energy out of the device. Note the analogy here with the Ohm's law formula; voltage drop equals current times resistance.

Thus if T_a is the ambient temperature

$$T_j = T_a + \theta_{ja}.P$$

Since T_j must never rise above $T_{j\,max}$, the maximum tolerable dissipation must decrease as the ambient temperature rises. This is known as "derating", and the rate of change of a device's maximum power dissipation with ambient temperature is known as its "derating factor".

By rearranging the above equation to give P in terms of T_a, T_j and θ_{ja} and differentiating with respect to T_a, it is easy to show that the derating factor must be minus the reciprocal of the total thermal resistance between junctions and ambient. Therefore, the units of derating factor are watts per kelvin, typical values for power transistors being between 0·33 and $0{\cdot}1WK^{-1}$. ★

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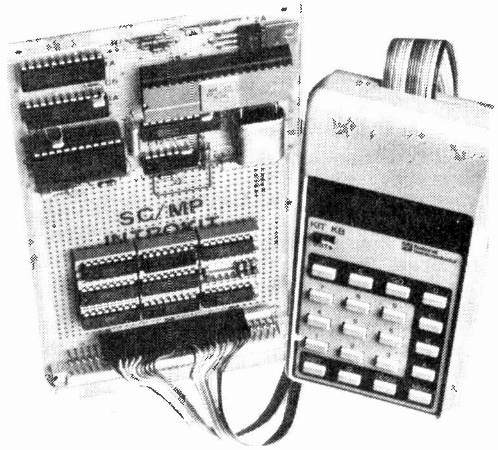

3 MAIN PRIZES

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IN ADDITION 25 Runners-up Prizes

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G CHEAPER THAN EQUIVALENT TTL
H EXTREME COMPACTNESS

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1st	
2nd	
3rd	
4th	
5th	
6th	
7th	
8th	

NAME ....
(Mr./Mrs./Miss)

ADDRESS ....
(Block letters)

....

....

Closing date for entries Monday, January 24, 1977

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In the event of a tie or ties, for any of the prizes, a further eliminating competition will be held, by post, between the tying competitors to determine such winner(s) or winning order.

Any entry which does not comply with the printed instructions or is received after the closing date will be disqualified as will any received mutilated or illegible, incomplete or bearing alterations. No responsibility will be accepted for entries lost or delayed in the post or otherwise.

The judges' decisions, and those of the Editor of PRACTICAL ELECTRONICS in all other matters affecting the competition, will be final and legally binding. No correspondence will be entered into.

The competition is open to all readers in Great Britain, Northern Ireland, the Channel Islands and Isle of Man except employees (and their families) of IPC Magazines Ltd., the printers of PRACTICAL ELECTRONICS, A. Marshall (London) Ltd. or of National Semiconductor (U.K.) Ltd.

The winners will be notified and the result announced in the earliest possible issue of the magazine.

MARKET PLACE

Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned. All quoted prices are those at the time of going to press.

CIRCUIT BOARD

A claimed new concept in prototype printed circuit boards has just been launched by **P.B. Electronics,** makers of the well-known S-DeC prototype wiring system. Known as Blob Board, it allows the user to go direct from circuit diagram to completed board.

Component layouts can be drawn direct onto the board, eliminating, it is claimed, many of the errors which can occur in transferring from circuit diagram to ordinary p.c.b.s. The component layout is simply drawn on the board pattern using an ordinary felt pen. The components are then laid over their respective drawings and "blob" soldered in position. Components can be reused and re-soldered making circuit prototype modifications and amendments fairly easy.

Initially, there are 12 different boards available in a wide variety of patterns which, between them, will accommodate most components from discretes to i.c.s.

Addresses of nearest stockists and prices of the Blob Board can be obtained from **P.B. Electronics (Scotland) Ltd. (Dept. P.E.), 57 High Street, Saffron Walden, Essex CB10 1AA.**

SERVICING PROBE

A small and lightweight signal injector probe suitable for radio and TV servicing is the latest product from **Carlo Gavazzi (UK) Ltd.**

Known as the Pantec USIJET, it can be used for fault finding in a.f., i.f., and r.f. amplifier stages, l.w., m.w., s.w., u.s.w., and f.m. wavebands for radio and v.h.f. and u.h.f. channels up to 500MHz for television.

The circuit consists of two signal generators, one at audio and the other at radio frequencies. The impulsive waveform derived from a blocking oscillator-type circuit produces a signal with a wide range of harmonic frequencies up to 500MHz.

By injecting the signal at various points in an amplifier circuit, the probe is an effective dynamic analyser for tracing breaks and component failure. The fundamental frequencies are 1kHz and 500kHz, with an output voltage of 20V peak-to-peak. Maximum permissible voltage at the probe tip is 500V d.c. Powered by a self-contained 1·5V cell, the current consumption is about 25mA.

Further details and price of the Pantec USIJET can be obtained from **Carlo Gavazzi (UK) Ltd. (Dept. P.E.), North Crawley Road, Newport Pagnell, Bucks., MK16 9HF.**

UPDATED OSCILLOSCOPE

Some four years ago, **Scopex Instruments,** was formed to manufacture and market oscilloscopes. Their first design was the 4D10, a 10MHz dual trace instrument offered at less than £100.

Now, as part of their programme of expansion and updating, Scopex have announced the 4D10A, broadly similar to the 4D10 in appearance and facilities, but incorporating a number of significant improvements.

All power supply lines are now stabilised, producing a rock steady display even with 10 per cent variations in mains voltage. Measurement accuracy is ±3 per cent for both time and voltage, maintained over the same mains input range. The vertical input attenuators are those designed for the 25MHz bandwidth 4D25, and allow the full 10MHz bandwidth to be achieved even on the 50V/cm range.

Added features in the new instrument are a TV field sync separator and a non-reflective Glarecheq screen filter. The graticule is ruled on the reverse of the latter and is actually in contact with the c.r.t. face, virtually eliminating parallax. The adoption of aluminium for the case has reduced the overall weight by 25 per cent compared with the 4D10.

Price of the 4D10A is £150 excluding VAT. Further details are available from **Scopex Instruments Limited (Dept. P.E.), Pixmore Industrial Estate, Pixmore Avenue, Letchworth, Herts SG6 1JJ.**

RECORD CLEANER

An anti-static device has been incorporated into the Mark 3 version of the Groovac vacuum record cleaner manufactured by **RI Audio.** Not only does the device discharge static on records but also the new cleaner is claimed to be considerably more effective in removing dust, both surface and microdust.

The new device consists of a small carbon fibre brush and a suction cleaning nozzle attached to the arm. The device is "earthed" via electrical connectors inside the arm. Static electricity on the record is discharged by the carbon fibres which track across the record just ahead of the suction nozzle and pick-up stylus. In addition to eliminating static, the carbon fibre brush also gathers surface dust which would otherwise collect on the suction nozzle hairs and impair tracking.

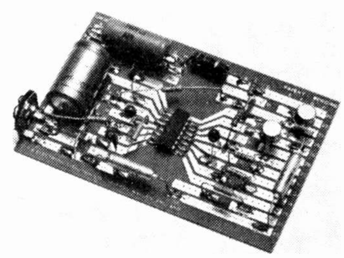
Tracking of the vacuum cleaning nozzle and carbon fibre brush across the record has been improved by replacing the plain bearing with a ball bearing, this also makes it possible to achieve a lower tracking force of 0·5 gram. The bearing housing has been redesigned to include a fluid seal which eliminates air leaks.

Anti-skating force, or bias, is provided by a hair-spring mechanism in place of the inclined face previously employed. The bias force is adjustable with the new design.

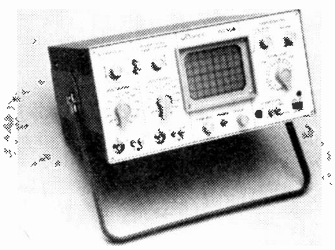
Suction is provided by a pump mounted inside an enclosure for acoustic isolation. In use the pump is suspended by springs to ensure that mechanical vibration is not transmitted to the enclosure.

Further details and price of the Groovac III vacuum record cleaner can be obtained from **RI Audio (Dept. P.E.), Kernick Road, Penryn, Cornwall.**

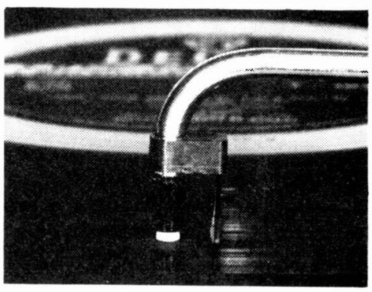
New "Blob" Printed Circuit Board from P.B. Electronics



The 4D10A Oscilloscope from Scopex Instruments



RI Audio Groovac III record cleaner



SEMICONDUCTOR UPDATE... By R.W. COLES

CA3140
LD130

THE SUCCESSOR?

Every now and again a truly great i.c. is produced which becomes an industry standard against which others are judged. Such an i.c. is the 741, and although a host of "dual 741s", "quad 741s" and, of course, "improved 741s" have appeared in recent years, up to now no-one has dared to say that their new operational amplifier chip will displace the 741 as an industry standard. Sooner or later, of course, a successor worthy of the name will come along, and RCA think they now have the necessary contender in their new **CA3140** Bi MOS operational amplifier, and after studying the data sheet, I must say they could be right.

The 741 is a popular device because it has a good "mix" of characteristics which makes it suitable for 70 per cent of op-amp applications. You can buy devices with a wider bandwidth, or higher input impedance but you generally either have to compromise other characteristics such as supply voltage range, or simply pay a higher price for the goodies you need. A 741 replacement must retain this good "mix" of characteristics while improving as many as possible so as to increase the percentage of op-amp applications it can handle, but, of course, it must also keep a low price tag!

The CA3140 has an MOS input stage which gives it a 1·5 terra-ohm input *Z*, without sacrificing input offset voltage (2mV max), or ruggedness (protection diodes built in). Slew rate is a creditable 9V/μs with full internal compensation to make application easy, and if that's not enough to sway you, perhaps the fact that it will operate on supplies of from 4V to 44V might help!

The CA3140 certainly seems a heavyweight contender, but only we, the users, can decide the eventual outcome of this title fight!

REVOLUTION

Digital voltmeters used to be large, cumbersome, expensive animals that sat on a trolley in the corner of a lab and were talked about in hushed whispers by those fortunate enough to co-exist with them. "Digital voltmeter" was synonymous with "extreme accuracy" and if you were doing anything run of the mill, the DVM stayed on its trolley and you had to use your Avo with the bent needle as usual!

Integrated circuits spoiled the DVM's hallowed position of the trolley in the corner, and soon, 3½-digit, digital multimeters were as "common-as-muck" and could be seen in the hands of all and sundry. We have now reached the position where even the humble moving coil panel meter is being overtaken by the digital revolution, mainly because the ± 2 per cent accuracy it has traditionally offered can easily be bettered by a digital unit, albeit at a higher cost.

Even the cost advantage of the moving coil meter is fast disappearing, and a new device from Siliconix, the **LD130**, must surely be another nail in its coffin. The LD130 is a low cost CMOS chip which contains nearly all the analogue and digital circuitry required to build a 3-digit, bipolar, digital voltmeter. The chip runs off plus and minus 5V supplies, is t.t.l. compatible, and lives in a tiny 18-pin d.i.p.

The 999 full scale count gives a resolution of 0·1 per cent of course, but the LD130 backs this up with a very creditable 0·1 per cent (plus or minus one count) accuracy, and an automatic zeroing system which used to appear only on the more expensive DVMs. Display outputs are multiplexed and would normally drive a 3-digit, 7-segment, l.e.d. display via an external decoder chip and three digit drive transistors. Thanks to the BCD output format it is also possible to drive all sorts of other displays such as gas-discharge or filament types, or even latch the information in a store for microprocessor interface.

On the analogue side, the high input impedance of the MOS buffer amplifiers makes possible the high accuracy and ensures the need for the minimum of external components, in fact just three capacitors and a voltage reference of about 2V. Best of all though, you don't have to keep it on a trolley in the corner, any convenient pocket will do!

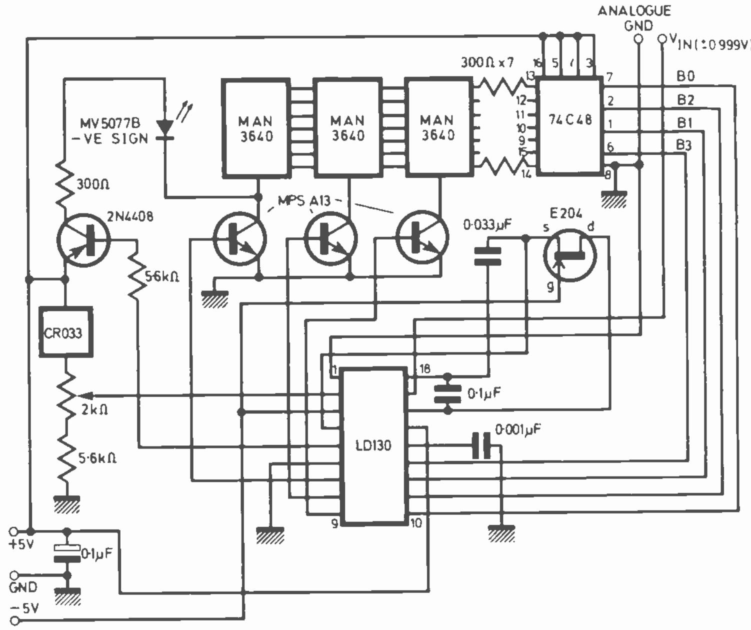
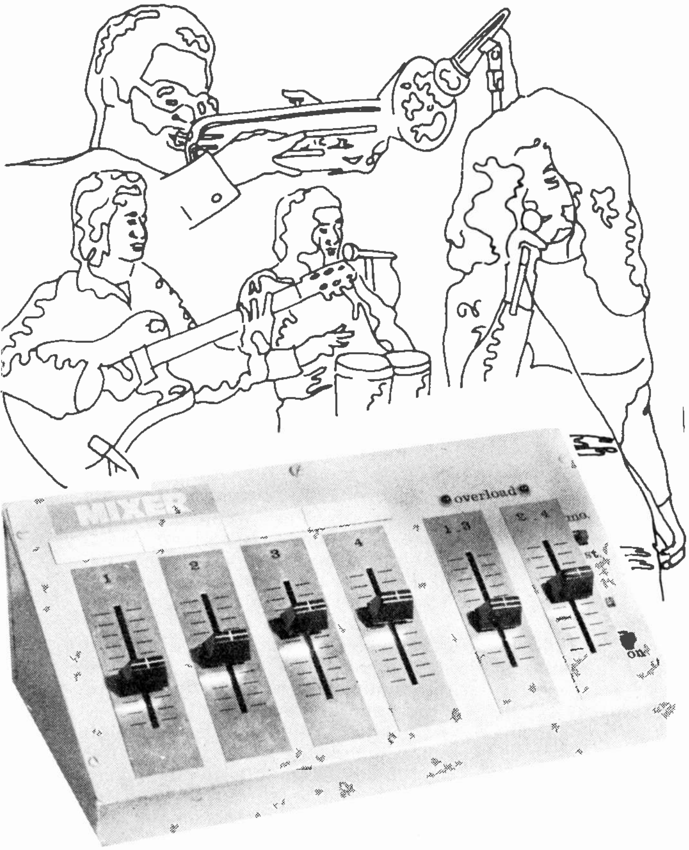


Fig. 1. Circuit diagram for a 3 digit DVM using the LD130. The CR033 is a current regulator diode



MICROPHONE MIXER

By R. S. WILSON B.Sc.

Audio mixer designs are part of the bread and butter of electronics magazines so perhaps one should not try to apologise for yet another. However, most designs do not provide for high quality low impedance microphone inputs without resorting to the use of expensive microphone matching transformers.

This design seeks to provide simple transistor matching for such microphones without the need for input transformers, and the result is a low cost but powerful and versatile unit, with many applications for recording enthusiasts, or as a mixer for a sound reinforcement system. The inputs are unbalanced but this will be found to be no disadvantage except in the most difficult recording situations. The full specifications for the mixer are listed in the table.

DESIGN AND FACILITIES

The main design point is the use of a low noise transistor connected as a common-base amplifier, for each input. The characteristics of a transistor in common-base mode are a very low input impedance, the possibility of very high voltage gain, and a high output impedance. The first two of these provide the possibility of an ideal match for a low impedance microphone input. For load resistances of 10 to 100 kilohms the input resistance is in the order of 50 ohms, exactly right for maximum power transfer from a 50 ohm microphone. We are of course more concerned with voltage gain than power gain, however for a given input current the voltage is directly proportional to the power, since $P = V \times I$.

Provided that we can make the load resistance high enough we can achieve a very high gain from a simple circuit. The present circuit does not achieve the maximum gain possible but a choice of an 18 volt supply enables the use of a 15 kilohm load resistance, which is enough for our purposes. To increase the load resistance further would depress the voltage on the collector of the transistor leading to asymmetrical cut off, and a consequent reduction in the overload point. The stage could be redesigned to utilise a smaller collector current than the 0·3mA used here, this would enable a greater load resistance to be used but would probably result in a higher noise from the stage.

For portability and to keep down the cost of construction the unit is operated from two 9 volt batteries in series (PP6 type). Current drain is about 10mA and the batteries will give many hours of use. It has also been found that the unit will operate on a much reduced voltage with only a slight loss of gain.

A block diagram of the mixer is shown in Fig. 1. There are four identical channels each comprising an r.f. filter, an impedance changer/amplifier stage, a channel fade potentiometer and a buffer stage.

SPECIFICATION . . .

Frequency Response:		
	58Hz—12kHz (−1dB)	
	40Hz—22kHz (−3dB)	
Inputs:		
	Low Impedance	Gain 64dB*
		Impedance 58Ω
		Overload point 80mV r.m.s.
	High Impedance	Gain 31dB*
		Impedance 70kΩ
	* Gain is reduced by 6dB with S1 set to MONO	
Outputs:		
	Main	Maximum level 5V r.m.s. (onset of clipping)
		Impedance 600kΩ approx.
	Optional High Impedance	Gain (1st stage only) 46dB
		Impedance 700kΩ approx.
Noise:		Maximum 1mV at output, equivalent to 74bB below maximum output
Stereo Separation:		Greater than 40dB
Power Consumption:		11mA from 18V supply

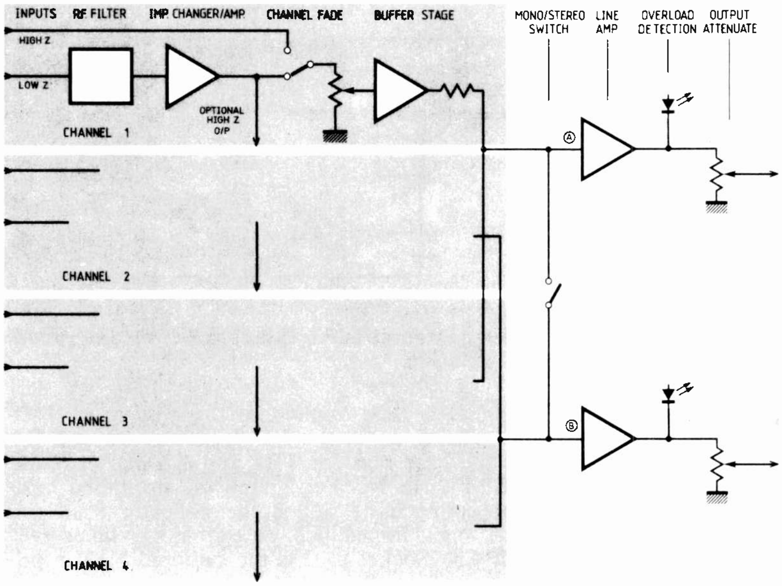


Fig. 1. Block diagram of the complete mixer

Channels one and three feed into line amplifier "A", while channels two and four feed into line amplifier "B". This arrangement enables channels one and two to be used as a stereo pair, and channels three and four as a second stereo pair.

Each channel has a less sensitive high impedance input via a breakjack which feeds directly on to the top of the channel fader control, and which breaks the connection from the output of the first stage. Each channel also has a high impedance output taken directly from the output of the first stage, and brought out at the rear of the mixer through a coaxial socket. Together, these two sockets increase the versatility of the mixer, for example the outputs could be taken to a suitable amplifier and used as a "pre-fade listen" facility. Alternatively the output could be fed to a suitable frequency shaping circuit, tone control unit, ring modulator, etc., and then back into the mixer via the breakjack to be mixed as usual with the other signals.

CHANNEL FADERS

A 500 kilohm slider potentiometer takes the output from the first stage; this is much larger than is normally used in transistor circuits, but because of the high impedance output from the first stage a high value is needed to minimise loading of the circuit. Placing the control here reduces the noise from the first stage as the signal is faded out, maintaining a good signal to noise ratio overall.

The wiper of the fader control in each channel feeds the signal to the base of a transistor connected in the common-collector (emitter follower) mode. The characteristics of the common-collector amplifier are a high input impedance, a low output impedance, a voltage gain of less than unity but a large output current. This stage is desirable as a buffer to match the high impedance output of the first stage to the relatively low impedance of the line amplifier which follows. It also serves to isolate the channel faders from each other so that operation of one of the faders does not adversely affect the signal levels of the other channels, by shorting them to earth. The outputs of the common collector stages are connected together via isolation resistors. The emitter load resistors of this stage are quite small, and to simply connect them together would result in a great loss of gain due to virtually shorting out the emitter loads. The value of these isolation resistors is necessarily a compromise between losing gain through shorting out the emitter resistors as just described and losing gain through insertion of the resistors in the signal path.

A mono/stereo switch connects all four channels to both line amplifiers when in the MONO position. Operation of this switch causes a loss of gain of about 6dB, but has no other effect on the operation of the circuits. Obviously to avoid sudden changes in signal level it should not be operated during the course of a recording.

The line amplifiers are straightforward common-emitter amplifiers with a low impedance input and a moderately high impedance output. They give additional gain to overcome the losses caused by the isolation resistors and to boost the signal to a useful level, in fact in this design the output stage will give over 5 volts r.m.s. before clipping takes place. A slide potentiometer connects the output from the line amplifiers to the output sockets, providing a means of matching the output voltage to the following equipment and a means of fading out all the channels. As with the previous faders, operation of these also reduces the noise levels. In the prototype 500 kilohm potentiometers were used.

The arrangement of the output circuits adds further to the versatility of the mixer. In the mono mode there are two separately controllable outputs which could be used for example to feed two tape recorders, or a tape recorder and a public address system.

OVERLOAD INDICATORS

Finally the outputs of the line amplifiers are also connected to l.e.d. overload indicators. The gain of the mixer is such that it is fairly easy to overload the final stages, and the l.e.d.s light up as clipping point is approached. There is a slight tendency with these simple overload circuits for the l.e.d.s to pull the output into clipping, with of course consequent distortion, and so the mixer should be operated below the point at which the l.e.d.s light up.

CIRCUIT DESCRIPTION

The complete circuit is shown in Fig. 2. Since each channel is identical it is only necessary to describe channel one and line amplifier "A".

The low impedance input is introduced via a three pin DIN socket (SK1) which is an unbalanced input. The author terminates all his screened twin cables with a three pin DIN plug, pins 1 and 3 being connected to the two cores and pin 2 to the screen. The connection between pins 2 and 3 on the mixer automatically unbalances the microphone cable so the same cable can be used for balanced connections if necessary. Capacitor C1 provides an r.f. filter function at the input. When long microphone cables are used they tend to act as aerials, picking up radio transmissions which are then amplified and detected in the high gain mixer, appearing as unwanted signals at the output. It is somewhat disconcerting to have Radios 2, 3 and 4 all appearing on your recording. Unfortunately, C1 reduces the gain of the mixer in the present design by about 2dB at 18kHz. If this is unacceptable, or the user is still troubled by breakthrough a more efficient filter is needed. Fig. 3 gives a suggested circuit.

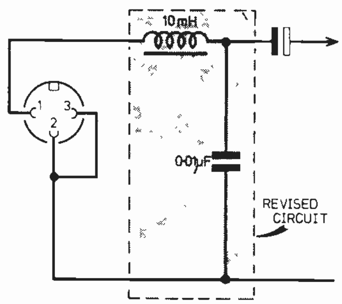


Fig. 3. Suggested circuit (replacing C1) for improved input r.f. filtering

The signal is then applied to the emitter of TR1 via the isolating capacitor C4. Resistors R1 and R4 produce the base bias for TR1 and C2 short circuits the base to earth for a.c., giving the grounded base mode of connection. R2 is the collector load for TR1, the high impedance output being taken via capacitor C3. Socket SK2 is the optional high impedance output from the channel.

The signal is transferred to the next stage by way of breakjack JK1, at which point a high impedance input can be inserted. VR1 is the channel fade control which feeds the base of TR2 via isolating capacitor C5. Resistors R3 and R6 provide base

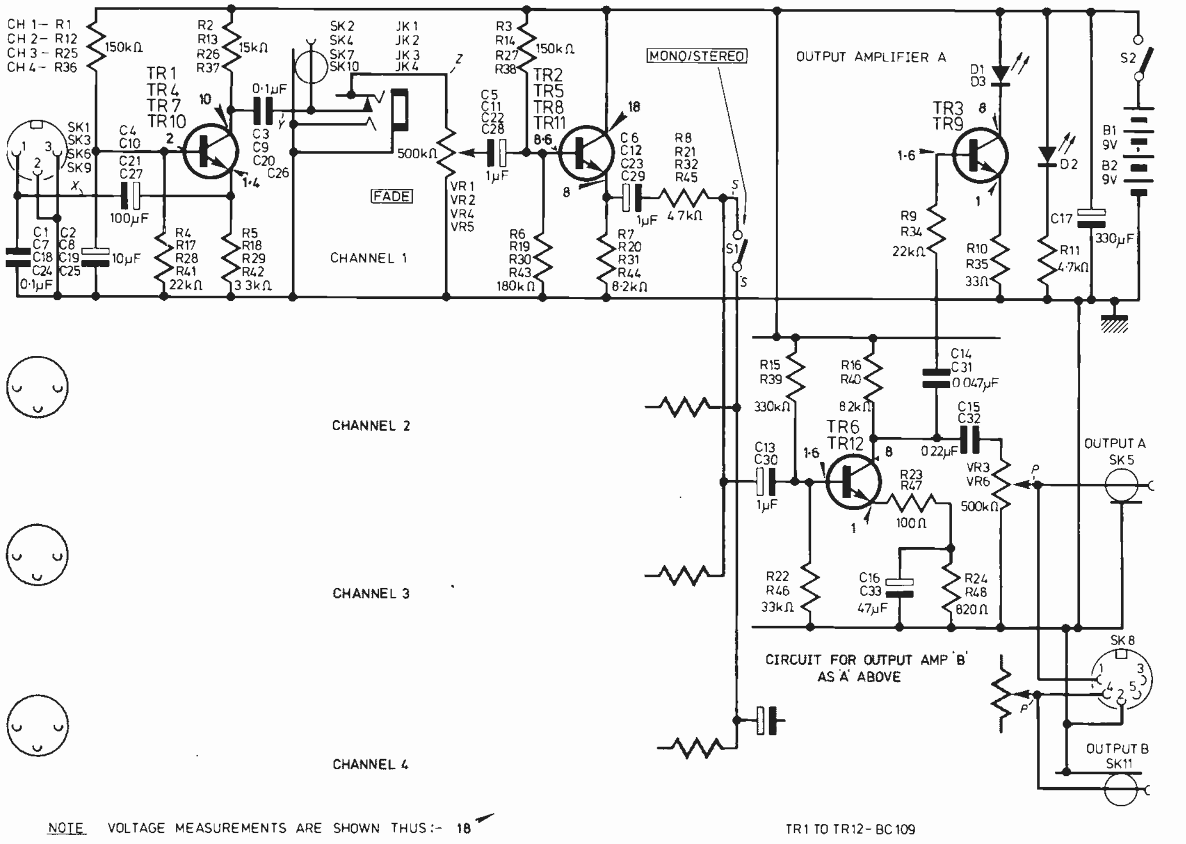
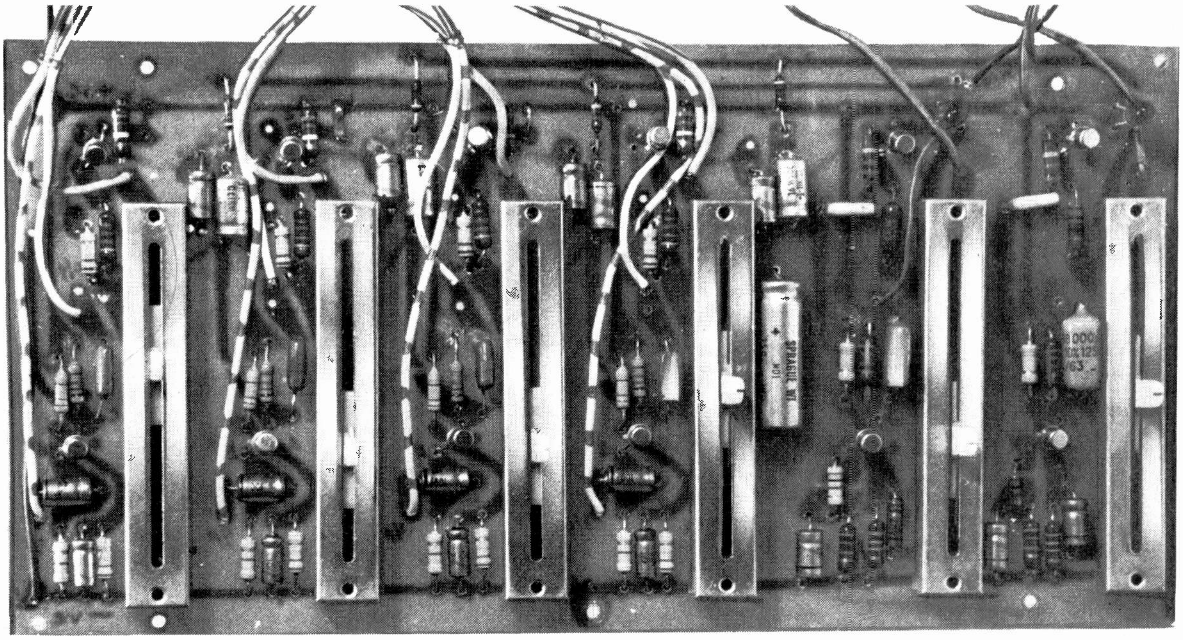


Fig. 2. Circuit diagram of the mixer. All four input channels are identical, as are the two output channels and overload indicators. Voltage readings are referenced to chassis, and were taken on a 20kΩ/V meter. The value of R11 can be reduced to make D2 brighter, but this will increase the battery drain. Italic letters indicate off-board connection points



The completed printed circuit board from the prototype mixer. There are a few minor differences in component layout from the final version shown in Fig. 5

bias for TR2, R7 is the emitter load resistor and the collector is connected directly to the positive supply. The low impedance output from TR2 is taken from the emitter via isolating capacitor C6 and resistor R8 at which point it is commoned with the other channels, either as stereo or mono depending on the setting of S1.

OUTPUT AMPLIFIER

The combination of signals is then fed to the base of TR6 through the coupling capacitor C13. R15 and R22 are the base bias resistors for TR6, and R16 is the collector load resistor. R23 and R24 in series form the emitter resistor, partially decoupled by C16. R23 being undecoupled introduces a small amount of negative feedback in this stage, but can be altered to give extra gain if needed by making it smaller and thus reducing the feedback. The output from TR6 is applied to the top of potentiometer VR3 via the coupling capacitor C15. The slider of the potentiometer is fed out of the mixer to the next equipment by way of the phono socket SK5. SK8 is an alternative output connection using a 5 pin DIN socket for both channels for ease of connecting the mixer to a stereo tape recorder.

The capacitor C14 and resistor R9 connect the output to transistor TR3. D1 connects the collector to the positive supply, and R10 is an emitter resistor. The transistor is normally biased to cut off. When a signal current is present at the collector of TR6 a small proportion is applied to the base of TR3. When this is large enough the positive peaks cause TR3 to begin to conduct, the transistor passes current and the l.e.d. begins to glow.

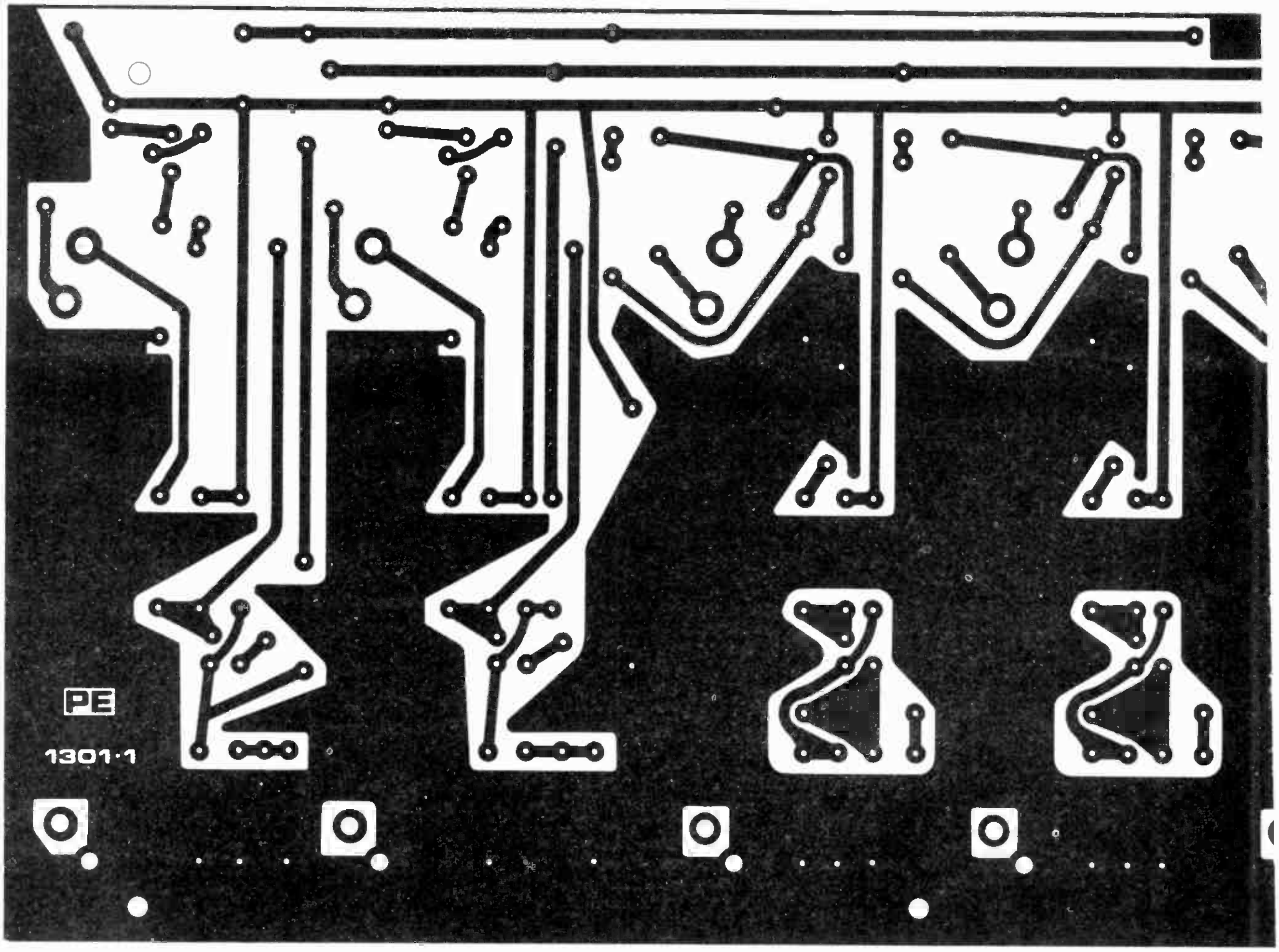
Power is supplied from two PP6, 9 volt batteries connected in series. D2 is in series with R11 across the supply, the current through the l.e.d. being about 5mA. C17 is used to decouple the supply.

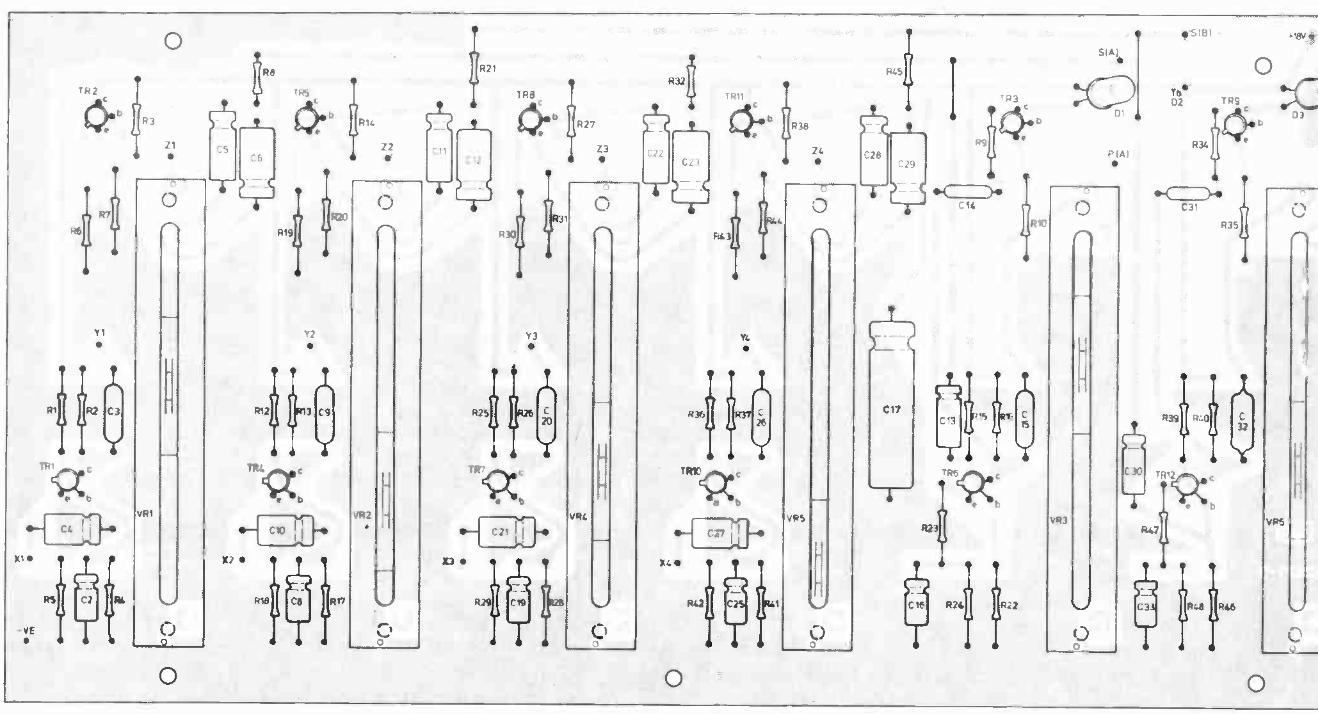
CONSTRUCTION

All of the electronics of the mixer is accommodated on a single circuit board which greatly simplifies construction. Fig. 4 is a full sized drawing of the printed circuit. When the board has been etched and cleaned up it can be drilled from the copper side. Use a fine drill (about 1mm) for the component holes, except for the four holes which are used to mount each slide potentiometer, which need to be a little larger (about 2·5mm) to take the slider terminals and allow room for physical alignment of the sliders with the panel. There are also five mounting holes which should be drilled 6BA clearance.

The six slider potentiometers can now be fitted to the circuit board. On the potentiometers as supplied there were two wiper terminals, the bottom one of each is not used. When soldering the sliders into position make sure that each one sits flush on the circuit board, and that they are all square with the bottom of the board and parallel to each other. Before proceeding any further with the circuit board it is a good idea to make the top panel and match this to the circuit board.

In the prototype the case and front panel (see photographs) were made of thin gauge sheet tinplate, which enabled the parts of the case to be soldered together. They could equally well be made from aluminium sheet, though the case would then have to be bolted or riveted together. Metal should be used to provide adequate screening. The front panel cut outs for the slider controls allow some leeway as they will be covered later with bezels, but take care not to distort the edges of the slots. Make neat holes for the switches and l.e.d.s since these will not be covered. Do not add the bezels at this time, but wait until the mixer is completely assembled to prevent damaging them.


PE
1301·1


TR2
R3
Z1
R8
TR5
R14
Z2
R21
TR8
R27
Z3
R32
TR11
R38
Z4
R45
S(A)
S(B)
+18V
TR3
D1
D2
TR9
D3
P(A)
C5
C6
C11
C12
C22
C23
C28
C29
C14
C31
R6
R7
R19
R20
R30
R31
R43
R44
R10
R34
R35
Y1
Y2
Y3
Y4
R1
R2
C3
R12
R13
C9
R25
R26
C20
R36
R37
C26
C17
C13
C15
R39
R40
C32
TR1
TR4
TR7
TR10
TR12
C4
C10
C21
C27
VR1
VR2
VR4
VR5
R23
R47
X1
X2
X3
X4
R5
C7
R4
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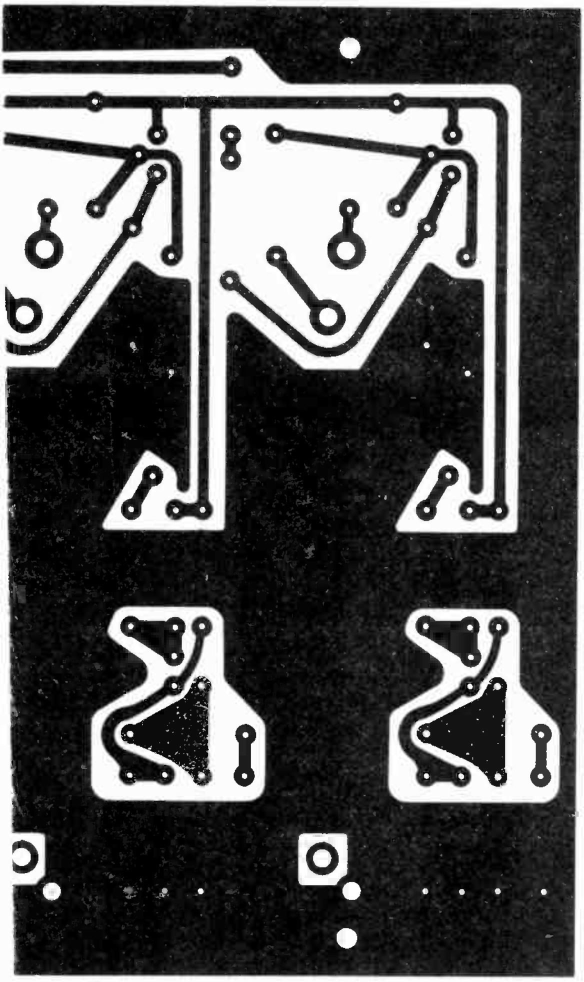
R22
R48
R46
-VE

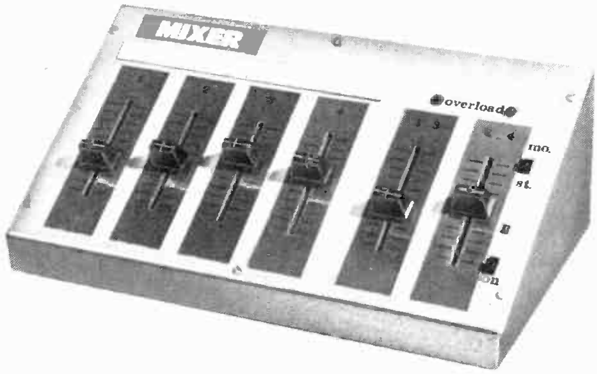


▲ **Fig. 4. Track layout for the printed circuit board, drawn full size**

◀ **Fig. 5. Printed circuit board component layout with off-board connection points identified**

The front panel and circuit board are separated by 15mm spacers drilled and tapped 6BA at one end. Mount the five spacers on the circuit board on the same side as the slider controls using short 6BA bolts. Note that one bolt contacts the negative supply rail to earth the front panel. The front panel is now supported face down on suitable pieces of wood and the circuit board laid on top of it with the spacers contacting the rear of the front panel and the slider controls protruding through it. Line the two up very carefully. If the front panel has been made from tinplate it can be soldered to the five spacers with a large hot iron. Alternatively, with an aluminium front panel, the spacers can be attached with an epoxy resin glue. When this is completed the two can be separated by removing the bolts from the spacers. The front panel can be cleaned up and painted while work continues on the circuit board.

The circuit board can now be completed by adding the resistors, capacitors and transistors. Fig. 5 shows the location of all the components. The two board mounted l.e.d.s can be placed in position but



COMPONENTS . . .

Resistors

R1, R12, R25, R36	150kΩ*
R4, R17, R28, R41	22kΩ*
R2, R13, R26, R37	15kΩ*
R5, R18, R29, R42	3·3kΩ
R3, R14, R27, R38	150kΩ
R6, R19, R30, R43	180kΩ
R7, R20, R31, R44	8·2kΩ
R8, R21, R32, R45	4·7kΩ
R15, R39	330kΩ
R22, R46	33kΩ
R16, R40	8·2kΩ
R23, R47	100Ω
R24, R48	820Ω
R10, R35	33Ω
R9, R34	22kΩ
R11	4·7kΩ

Components marked * are $\frac{1}{2}$W metal oxide, remainder are $\frac{1}{2}$W 5% carbon film type

Potentiometers

VR1–VR6 500kΩ log law sliders (Maplin Electronics, 60mm travel) with knobs and bezels

Capacitors

C1, C7, C18, C24	0·1µF disc ceramic
C2, C8, C19, C25	10µF 10V elect.
C4, C10, C21, C27	100µF 10V elect.
C3, C9, C20, C26	0·1µF polyester
C5, C11, C22, C28	1µF 25V elect.
C6, C12, C23, C29	1µF 25V elect.
C13, C30	1µF 10V elect.
C16, C33	47µF 10V elect.
C15, C32	0·22µF polyester
C14, C31	0·047µF polyester
C17	330µF 25V elect.

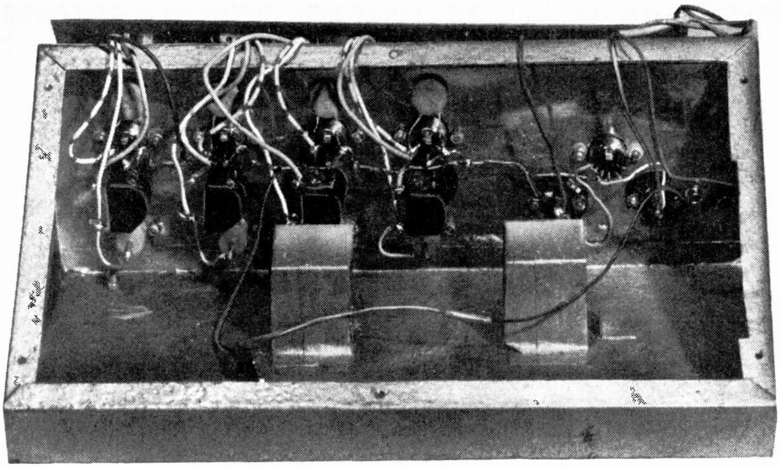
Semiconductors

TR1–TR12	BC109
D1–D3	0·2in l.e.d.s with mounting clips

Miscellaneous

SK1, SK3, SK6, SK9	3-pin DIN sockets
SK2, SK4, SK7, SK10	Coaxial sockets
JK1–JK4	$\frac{1}{4}$in Jacks with break contacts
SK5, SK11	Phono sockets
SK8	5-pin DIN socket
S1, S2	S.p.d.t. sub-min slide switch

Printed circuit board; case; PP6 batteries (2 off); spacers (15mm); battery clips.



Internal view of the case, showing battery retaining clips, etc.

should not be soldered yet since their position has to be adjusted later. The l.e.d.s must be forward biased which means that the cathode goes to the collector of the transistor. Connect pieces of flexible insulated wire to the holes *X*, *Y*, *Z*, *P* and *S* as follows: *X*, *Y*, approximately 180mm, *Z*, *P* and *S*, approximately 120mm. Wires approximately 180mm long should also be soldered to the positive and negative rails.

When the board is completed it can be checked to make sure it works correctly. Temporarily connect together wires *Y* and *Z* for each channel, and temporarily connect together the wires *S*. Connect the positive and negative wires to two nine volt batteries in series, and check the voltages on the transistors which should be more or less as shown on the circuit diagram. If you have test gear you can connect an audio signal generator to the input, between wires *X* and the negative supply, and an oscilloscope or a.c. voltmeter to the output, i.e. between wires *P* and the negative supply. If you do not have test gear you can try connecting a microphone to the input and tape recorder to the output. The mixer should meet the specification for gain, noise, etc., as detailed in the table. When all is in order proceed with construction of the case.

The front panel is completed by mounting the switches and D2 in the appropriate places and wiring them up. Reassemble the front panel to the circuit board after snapping the mounting clips for l.e.d.s D1 and D3 into their holes. Make sure that the l.e.d.s engage in their clips when the board and panel are brought together. The l.e.d.s can then be soldered into position. Connect the two wires from point *S* to switch S1, and the wire from the positive to S2.

The arrangement of the case used in the protoype can be seen from the photographs. The battery holders must be positioned carefully so as not to foul either the underneath of the circuit board nor the sockets on the rear of the case.

Wiring of the input and output sockets should commence with the earth connections. Run a single busbar of bare copper wire between the earthy (sleeve) terminals of jacks JK1–JK4, and then on to the earths of the output sockets SK5 and SK11. The earths of the input sockets SK1, SK3, SK6 and SK9, and the DIN output socket SK8 can also be wired to this busbar. Sockets SK2, SK4, SK7 and SK10 are earthed through the case if coaxial sockets are used.

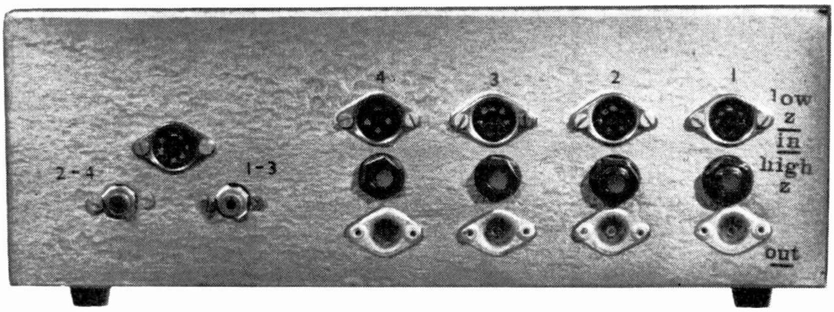
SUPPRESSION

The r.f. suppression capacitors C1, C7, C18 and C24 should be wired directly across pins 1 and 3 of the input sockets. The wires from points *X* are connected to pin 1 of the respective input sockets. The wires from points *Y* and *Z* are connected to the appropriate terminals of jacks JK1–JK4 and wires *Y* are extended to the coaxial sockets.

The wire from the negative rail on the p.c.b. should be connected to the busbar, and the two battery clips wired in series with the positive going to S2 and the negative to the busbar.

USING THE MIXER

The method of using the mixer is fairly obvious from the block diagram description given above. The warning given earlier about ensuring that the mixer is operated below the point at which the l.e.d.s light should be carefully noted. ★



Rear view of the mixer, showing arrangement of input and output connectors

INDUSTRY NOTEBOOK

By Nexus

WHY SO GLUM?

At the risk of being branded an incurable optimist I still question the forecasts of doom for British electronics put about by so many of my fellow commentators. One electronics trade journal despairingly went on record with, "What we may be seeing, therefore, is the start of the decline of a great industry which has given the world much of value in both basic technology and sound engineering."

That comment was soon after the minimum lending rate had been jacked up to 15 per cent. We can all agree that the increased rate imposed a new burden in financing further growth, a new challenge which will have to be met. But I don't see the electronics industry declining in any way. My colleague's gloomy remarks were more likely to have been influenced by his publication date (the 13th of the month), his house mortgage having gone up, and an industrial dispute in his publishing company, than a sober examination of the facts.

Of course, we could always do better but taken in relation to most other industries in Britain, electronics is doing rather well and in some product areas and in some world markets the performance is exceptional.

Who would ever have imagined that Plessey Semiconductors, not usually regarded as being in the major league of world suppliers in the most abrasive business area in electronics, would land a single order for three million i.c. devices. Or that such an order should, of all places, have come from Japan. But such is the case. The product is for Citizens' Band radio and Plessey is optimistic that more big Japanese orders are on the way.

A prime example of the simple policy of offering the right goods at the right price at the right time.

Remember the EMI-Scanner? This product is still good news and has built up EMI's medical electronics division from zero to 2,600 people and it's still growing. Latest score at my copy date was 655 systems sold worth £125 million. Not bad for an idea thought up on a country ramble and then vigorously pursued in the market place. The Scanner has helped push EMI world-wide sales up 33 per cent to £671 million and boosted profits from electronics products to 40 per cent of EMI's total.

SCRAMBLE

Remember the scramble for the aerospace "sale of the century", the successor to the ageing Starfighter? Winner was General Dynamics with the F-16 which will be built on a consortium basis in Belgium, Denmark, the Netherlands and Norway. The initial order is for 348 aircraft for the air forces of the four governments and the electronics in these aircraft are going to be worth at least 950 million U.S. dollars, say £600 million.

What a pity Britain hasn't a share. But wait a minute, Britain is still there. Marconi-Elliott head-up displays have been specified for the lot. And not only for 348 F-16's for the European consortium but also the 650 American-built F-16's on order for the United States Air Force. Altogether about £30 million worth of business although some of it will be farmed out to participating nations. There could be more business to follow because by the end of its useful life it is expected that 3,000 F-16's will have been sold. Marconi-Elliott is the world's leading suppliers of HUD's with 3,000 delivered for 25 aircraft programmes, half in the USA. which isn't bad going for a private venture development.

Remember Decca Radar? Still the world's biggest seller of shipborne marine radars and the company that has designed and installed more harbour radar schemes than the rest of the competition added together. And remember Racal Electronics Group? Still No. 1 suppliers of military manpacks and mobiles, regular purveyor to 130 different countries.

WILL TO SUCCEED

Let's go down the scale in size and into the Dorset countryside. In sleepy Wimborne you'll find a modest little company called Membrain making automatic test equipment. In a single month earlier this year Membrain pulled in another £400,000 worth of business from tough buyers like the Japanese and the Yugoslavs not to mention the toughest of all, the German Post Office, who might be expected to favour the local product but preferred the British buy.

Ever heard of Omega? It's the world-wide navigation system working on v.l.f. and it gives you a fix within one mile anywhere in the world in daylight, two miles after dark. World's largest supplier of Omega receivers is Redifon with over 800 systems sold. And Redifon is now hoping to repeat this success story with the Redifon Satellite Navigator.

Not, I should have thought, a British electronics industry in decline. Of course, there are companies doing less well and if you attend electronics exhibitions you will still find plenty of companies who are having a rough ride but few who are in a state of absolute despair.

Even in the hard-pressed consumer sector, struggling against Far East imports, there is hope of improvement. Jack Akerman, managing director of Mullard, has been conducting a vigorous campaign along with other top men in consumer electronics to warn industry of what might happen if we lose out to foreign competition. Akerman is the new chairman of the Electronic Components Board which will give him an even stronger voice. One of his themes is that the electronics industry should be regarded as a single industry instead of two industries (i.e. professional and consumer) because elimination or even further weakening of the consumer business will have a disastrous effect on the whole.

On the general economic scene I am not so optimistic. The will to succeed is evident throughout the electronics industry. I don't see the same will or the same spirit elsewhere.

CALCULATING WATCH

The U.S. company Hughes is producing a solid-state module which combines a digital wrist watch and a calculator with 8-digit l.e.d. display. The calculator keys in a standard layout, are tiny but can be operated with a pencil point.

Britain's Sinclair Radionics has moved up-market in pocket calculators with a nicely designed prestige package for the jet-set credit card user and the nouveau-riche. Satin chrome finish costs £30·00, hard gold-plate £60·00. The advertisement copy writer missed out on one point by describing the l.e.d. display as red. Perhaps ruby would have been more appropriate.

POWER OUTPUT METER

By H.T. KITCHEN

THE measurement of a.c. power developed in a load resistance requires that the voltage applied across the resistance, or the current flowing through it, is measured, the power then being computed by taking E^2/R or I^2R where E and I represent the voltage and current, R being the load resistance.

Where many power measurements are involved, the calculations can become tedious and time-consuming and errors can very easily be made. It was to circumvent such errors that the power output meter to be described was developed and built.

DESIGN REQUIREMENTS

Amplifiers with power outputs exceeding 50 watts average are as yet relatively uncommon on the domestic scene, and so a maximum power measurement capability of 50 watts was considered adequate.

The distortion levels of some class B and AB amplifiers tend to increase at lower levels, sometimes significantly, and so the capability of measuring lower power outputs accurately, in conjunction with a distortion meter, was considered essential. The lowest range is 50mW f.s.d., enabling low powers to be measured, albeit at reducing accuracy.

The bandwidth over which an amplifier should deliver its full rated output should ideally cover the full audible frequency range of 15Hz to 20kHz without significant peaks or troughs. The power output meter used for testing amplifiers to proper hi-fi standards must possess a bandwidth at least comparable to the amplifier's, but preferably much wider, with an amplitude response significantly superior to that of the amplifier under test. The amplitude response of the unit to be described is within 0·5dB from 20Hz to 50kHz, and within 0·2dB between 30Hz and 25kHz.

Loudspeaker impedances seemed to have settled down very nicely to nominal—sometimes very nominal—values of 4Ω, 8Ω and 15Ω, with 8Ω the norm for most transistor amplifiers, though there were signs that 4Ω was finding favour, particularly on the Continent. Recently, for reasons best known to themselves, some manufacturers introduced models with nominal impedances of 6Ω. For simplicity the power output meter was designed to cater for the established impedances of 4Ω, 8Ω and 15Ω, plus 600Ω usable only on the 50mW and 500mW ranges for headphones and professional 600Ω lines.

METER CIRCUIT

With so much voltage available—27·386 volts on the 15Ω/50W ranges, reducing to 447mV on the 4Ω/50mW ranges—it was tempting to explore the use of simple rectifier circuits. The diode pump, particularly, looked most promising but its extreme non-linearity proved unacceptable and so an operational amplifier was used as a simple voltage follower. The op amp adopted is the well known and highly satisfactory 741.

The complete meter circuit is shown in Fig. 1. The voltage to be measured is applied, suitably attenuated, to the non-inverting input of the op amp. A feedback loop containing the meter and rectifier diodes D1–D4 is connected from the output to the inverting input. The high level of negative feedback provides a very linear scale—voltagewise—although

when calibrated in terms of wattage the scale displays the well known square-law look. The feedback also enables the a.c. gain of the op amp to be set within precisely defined limits, and maintains that gain substantially constant over a wide bandwidth. The feedback and hence the gain is set by R8. This can be a preset resistor, or a fixed resistor if the gain required is known. On the prototype a value of 1·5kΩ gave meter f.s.d. for an input of 95mV.

The low frequency gain is dependent on the values of two capacitors, C1 and C3. The reactance of each must be very low compared to their associated resistors R7 and R8. The values shown ensure that not really warranted, besides, when measuring very low powers the isolation afforded by battery operation is invaluable in eliminating the much dreaded hum loop.

INPUT CIRCUITS

Changeover switch S1 allows either of two inputs to be selected. This greatly facilitates work on stereo amplifiers, enabling channel power balance to be quickly checked. The output from S1 goes to the load resistors and also to a coaxial socket, providing for the connection of an oscilloscope or distortion meter.

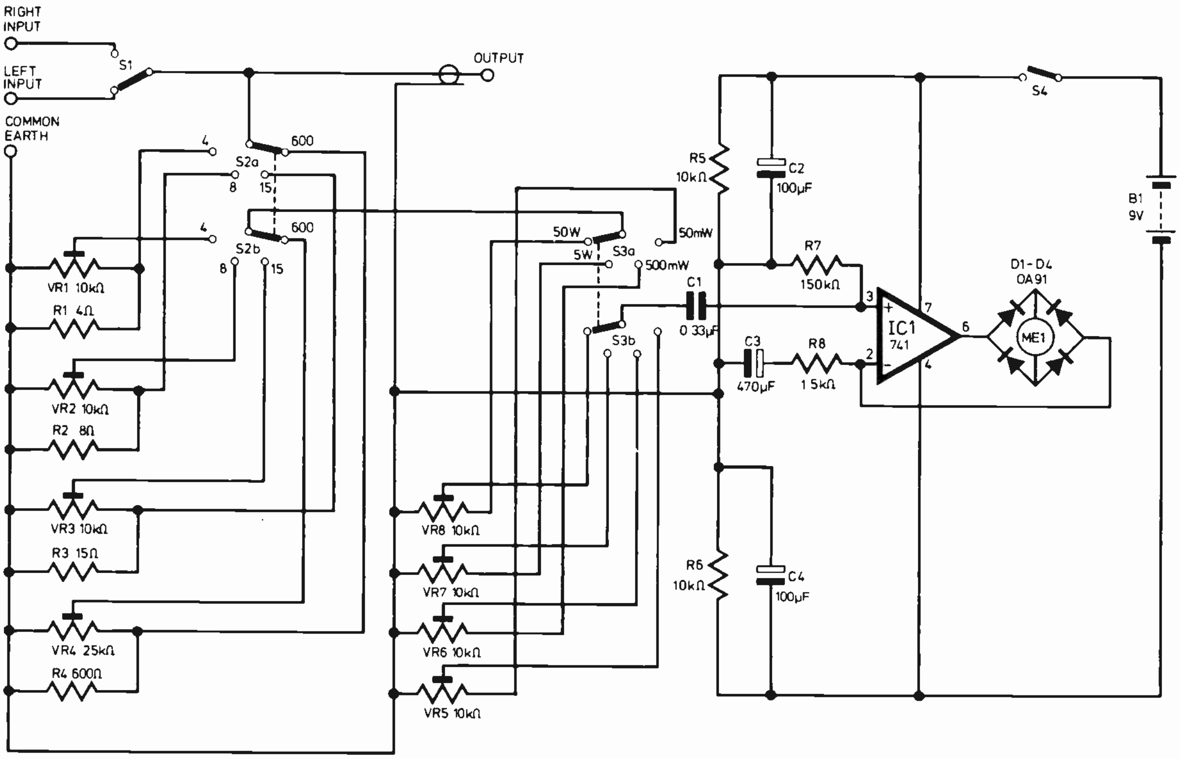


Fig. 1. Circuit diagram of the complete power output meter

the l.f. gain is well maintained with respect to that at 1kHz. The high frequency response of the amplifier is dependent on the a.c. gain; the higher the gain, the lower the frequency at which the −3dB point occurs. The a.c. gain of the prototype is very low, and the −3dB point lies at 100kHz.

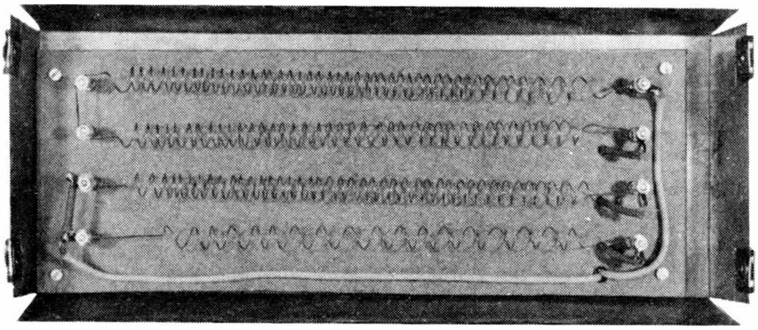
POWER SUPPLIES

The 741 is a differential amplifier and requires a dual polarity supply of up to ±18 volts. However, a satisfactory performance can be obtained by using a potential divider to provide dual-polarity supplies from a single 9 volt battery. This function is performed by R5 and R6, decoupled by C2 and C4. The inverting and non-inverting inputs of IC1 are returned to the junction of this potential divider via R8/C3 and R7 respectively.

The current consumption is very low at 1mA, and a 9 volt battery of the PP6 type should give a very useful life even if the power output meter is regularly used. A mains operated power supply is

The voltage required by the meter amplifier is only 95mV, but as mentioned previously the maximum input voltage will vary from 27·386V to 447mV. Some means of attenuating these voltages is therefore required. The original intention was to use resistive ladder attenuators using fixed resistors for the two attenuators in cascade, one for the load resistance ranges, the other for the wattage ranges. However, a little mathematical juggling soon revealed that attenuators to the required degree of accuracy could not be constructed using resistors of the easily obtained 2% E12 or E24 types. Instead, it was decided to use preset potentiometers for the attenuators. Each pot can be individually set up, so that given an accurate reference voltmeter and careful workmanship a degree of accuracy superior to that obtainable with fixed resistor ladder type attenuators should be easily obtained.

The load resistors, R1–R4, are selected by S2. The attenuator pots, VR1–VR3, are connected directly across the load resistors, the value of 10kΩ having minimal effect on the overall resistance on the 4Ω,



The load resistor assembly for the 4, 8 and 16 ohm loads

8Ω and 15Ω load ranges. On the 600Ω range, however, the parallel connection of a 10kΩ pot would reduce the total resistance to 566Ω, an error of some $5\frac{1}{2}$%. Increasing the value of the pot to 25kΩ reduces this to about $2\frac{1}{2}$%, an error acceptable for all but the most stringent applications.

The voltage change corresponding to a power change by a factor of 10 is equal to $\sqrt{10}:1$, due to the square function involved in power calculations. Therefore, each time the wattage range switch S3 is operated the input to the meter amplifier must alter by a ratio of $\sqrt{10}:1$ or 3·162 : 1.

COMPONENTS

In any measuring instrument only one type of component should be used, the best available. The 741 operational amplifier should be a new component and carry the manufacturer's markings and guarantee.

Of the static components, the preset pots and switches call for special mention. The presets used in the prototype were multi-turn types, more expensive than the normal skeleton type but giving greatly superior resolution. Switches S1 and S2 must be capable of carrying the full signal current to the loads. This will be around 3·5 amps on the 4Ω range, decreasing as the load resistance increases, to around 1·8 amps on the 15Ω range. Both values are of course at the maximum rating of 50 watts. On the prototype, S1 was a mains type double-pole changeover switch with poles connected in parallel to reduce contact resistance and also to improve reliability. Avoid the smaller type of switch, which often has non-wiping contacts unsuitable for low-power operation. S2 was a three-pole, four-way switch with two poles connected in parallel for S2a, again to reduce contact resistance and improve reliability. The importance of reliable low contact resistance in these two switches cannot be over-emphasised.

The meter used in the prototype was a BPL type S31V, but any 1mA f.s.d. movement should be suitable, providing the front can be easily removed for access to the scale for recalibration.

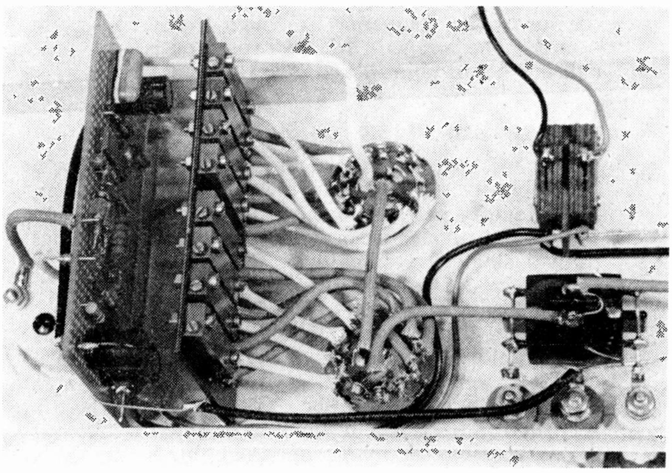
LOAD RESISTORS

The load resistors should be as accurate as possible in value, should be non-reactive, and should possess low coefficients of temperature. Proprietary components meeting these requirements are not easily obtained in small quantities; some alternative approach is therefore needed. The simplest way is to build your own from resistance wire, a ready source being replacement electric fire elements obtainable at most electrical shops. The load resistors comprise the resistance wire, recoiled and of the appropriate lengths, supported on a hardboard frame.

The element wire when unwound was found to have a resistance of approximately 6·5Ω per metre. The 15Ω resistor was constructed first, and to do this a length was cut 2·5m long. A loop was formed at one end, of the right size to be clamped between a pair of 6BA nuts on a 25mm long 6BA bolt, for the wire is not amenable to soldering by any easy and reliable means. This bolt was connected to one terminal of an accurate bridge, the other bridge terminal being slowly slid along the wire, and in firm contact with it. When precisely 15Ω was indicated, the point was marked and the wire cut just 25mm longer, another loop being formed and clamped in similar fashion. The bridge terminals were then applied to the two 6BA bolts. The resistance was, happily, just 15Ω. The 8Ω and 4Ω resistors were constructed in precisely the same way.

The ohms ranges of even the best multimeters are simply not accurate enough for this measurement, unless one is content to accept degraded accuracy. In the absence of a bridge, the ohmmeter must of necessity prevail. However, a cross check is possible by passing a known current through each resistor, the resulting volts drop being measured on

Inside view of the front panel, showing the amplifier board and board carrying the multi-turn presets on the left



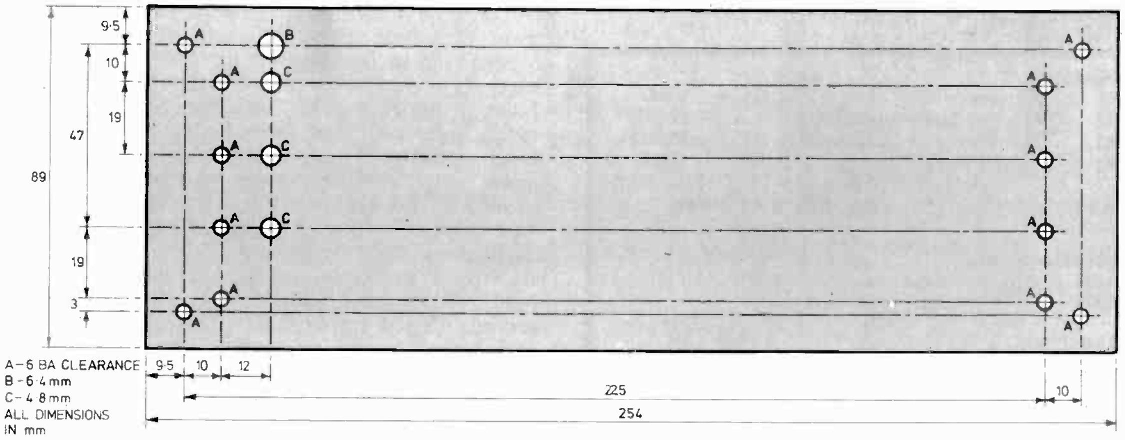


Fig. 2. Drilling details for the load resistance mounting frame

an accurate voltmeter. The voltage and current ranges of all multimeters are appreciably more accurate than the resistance measuring section.

Once the lengths are accurately determined, the individual lengths can be removed from the temporary bolts and coiled upon any suitable mandrel of about 6mm diameter, taking care that the wire is not stretched for that will increase the resistance. When released, the coils should be considerably shorter than the distance between the supporting screws, so that when they are stretched out they will be taut with adjacent turns equally spaced. The arrangement of the load resistors is shown in the photographs; drilling arrangements for the hardboard frame used in the prototype are shown in Fig. 2.

Countersunk 6BA bolts 30mm long are used to mount the load resistors, with lock-nuts to space the coils about 12mm clear of the hardboard. Washers should be fitted both sides of the resistance wire loop, plus a solder tag for the connecting wire. The nuts must be very firmly tightened down, almost to shearing point, to ensure a near-zero resistance contact between the wire and the solder tag.

CONSTRUCTION

The completed prototype power output meter was built into a West Hyde Developments size C Mod-2 instrument case. The load resistors require adequate air flow for cooling purposes and this implies open-air mounting. Consequently, the rear panel was omitted and replaced by a 22 s.w.g. aluminium panel to the dimensions shown in Fig. 3. The front panel layout is shown in the photographs, holes being drilled to suit the components that will actually be used, or to suit individual ideas.

The amplifier is built on plain 0·1in Veroboard measuring 95 × 57mm, Fig. 4. The multi-turn presets are mounted on a piece of s.r.b.p. measuring 89 × 57mm. Both boards are secured to a small U-shaped bracket, fixed to the rear of the front panel by one of the meter fastening studs.

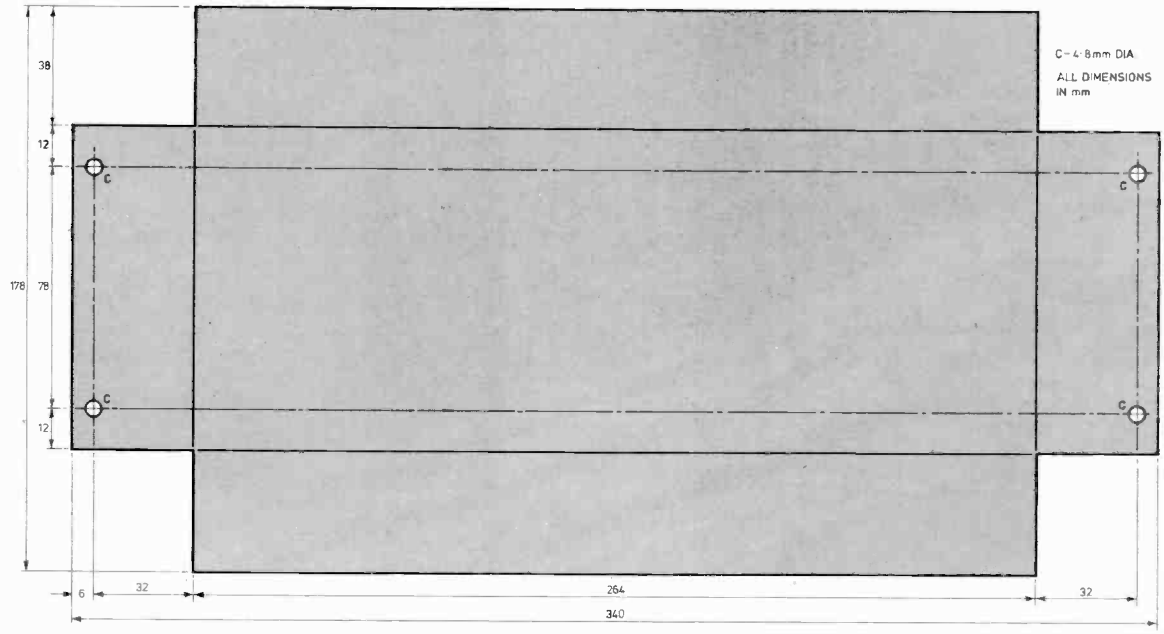


Fig. 3. Cutting and drilling dimensions for the new rear panel

COMPONENTS . . .

Resistors

R1	4Ω wire-wound (see text)	R5–6	10kΩ (2 off)
R2	8Ω wire-wound (see text)		
R3	15Ω wire-wound (see text)	R7	150kΩ
R4	600Ω 1W 1%	R8	1·5kΩ (see text)

All resistors ½W 5% unless otherwise stated

Potentiometers

VR1–3, VR5–8 10kΩ multi-turn (7 off)
VR4 25kΩ multi-turn

Capacitors

C1 0·33μF polyester
C2, 4 100μF 15V elect. (2 off)
C3 470μF 6V elect.

Semiconductors

IC1 741 8 pin d.i.l.
D1–4 OA91 or OA95 (4 off)

Switches

S1 D.P.D.T. mains toggle switch (see text)
S2, 3 3- pole, 4- way rotary switch (2 off)
S4 S.P.S.T. toggle switch

Miscellaneous

1mA moving coil meter (see text).
Instrument case, West Hyde Developments Size C Mod–2.
Battery, 9V PP6.
Plain Veroboard, 0·1in matrix, 95 × 57mm.
S.R.B.P., 89 × 57mm.
Sundry materials and hardware.

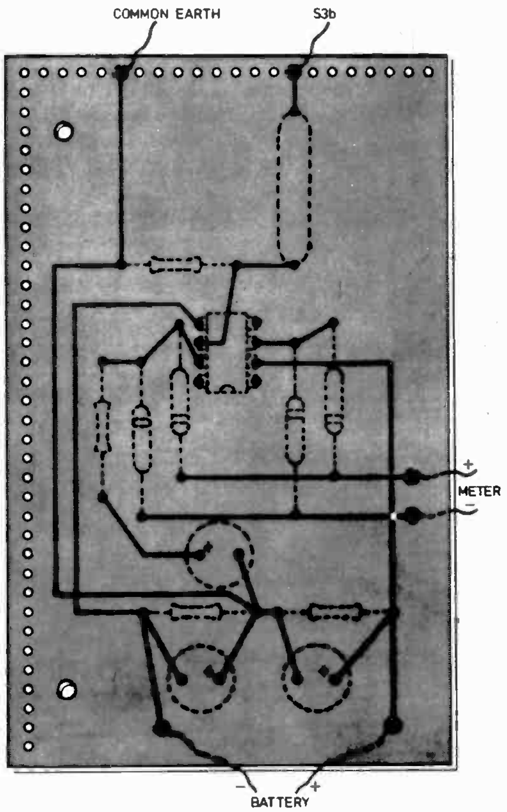
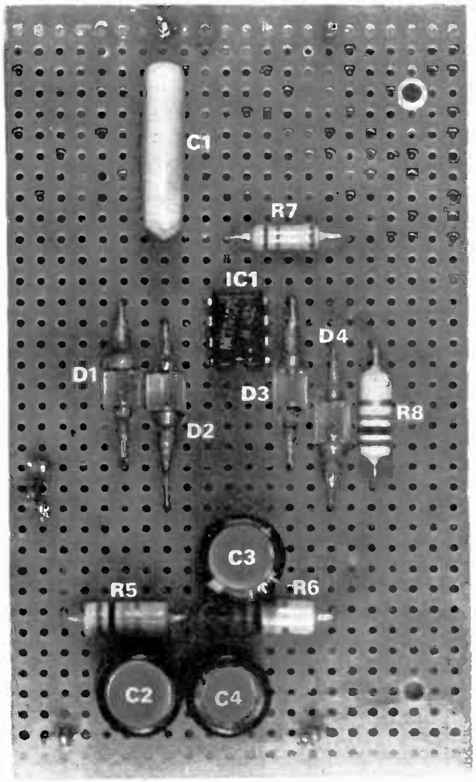


Fig. 4. Amplifier board wiring, viewed from the underside

The load panel is screwed to the new rear panel using 6BA nuts and screws, with spacers about 6mm long. Prior to building up the load panel, it can be used as a template for drilling the corresponding holes in the rear panel, ensuring accurate alignment of all holes. All lead holes in the rear panel should have grommets fitted. Connections between the load panel and the front panel switches and terminals should be of heavy gauge wire, the prototype was wired up with 16 s.w.g. The 4Ω and 8Ω resistors are earthed by means of two 16 s.w.g. wires in parallel to ensure minimum additional resistance. All the load resistor earth connections should be returned directly to the front panel earth terminal, so ensuring that all heavy circulating currents are kept out of the meter amplifier circuit.

CALIBRATION

Prior to calibration, all the attenuator presets should be set so that their wipers are at the earthy end of the tracks and the link between S2b and S3a should be broken. A variable a.c. voltage of at least 28V r.m.s. is required for calibration. A mains transformer with a good-quality wirewound potentiometer connected across its secondary is a suitable source (see Fig. 5). The value of the pot should be such that it draws an appreciable current in comparison with the calibrating voltmeter. The use of an accurate millivoltmeter is desirable for this purpose as it will enable the low wattage/low resistance ranges to be checked.



Amplifier board component layout

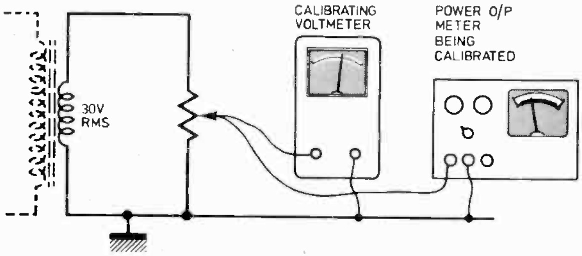


Fig. 5. Calibration source arrangements

The wattage range attenuators are set first. To do this, connect the calibrating voltage source, set to zero volts, to the wiper of S3a. Follow the procedure detailed in Table 1, line by line. If the mains voltage fluctuates considerable patience is required at this task. Accuracy depends on the care taken, so persevere. Recheck all settings of the pots until quite satisfied that all is well.

The load attenuator pots can be set next, but first of all the loads must be disconnected from circuit to prevent overloading the calibrating voltage source. Also, the link between S2b and S3a must be restored and the power level switch set to 50 watts. Then follow the procedure detailed in Table 2.

After calibration, all the ranges should be rechecked; the best way of doing this is to feed in various voltages using Table 3 as a guide, to see if meter f.s.d. is still obtained.

CALIBRATING THE METER DIAL

Dial recalibration can be a somewhat tricky task if one has not done it before, but it can be safely performed with care and patience. The completed power output meter should be placed on a clean, dust-free sheet of newspaper and the front cover removed from the meter movement. The BPL meter used in the prototype has the advantage of being supplied with a spare blank scale-plate which can be used for the new scale. With any other movement the scale-plate must be carefully removed and covered with thin white paper or plastic before being refitted.

Table 3 gives a range of voltages for each resistance range, the 600Ω range excepted, and from this one range can be selected for dial calibration purposes. The figures are quoted to three decimal places for the benefit of owners of DVMs.

Assuming the 15Ω range is chosen, an input of 27·386 volts is applied whereupon the pointer should come to rest at its normal maximum position. Being careful not to breathe on the pointer, and carefully avoiding nudging it with the pencil, a faint mark should be made as precisely under the pointer as possible. This is the 50 watt mark. Reduce the input voltage, then increase it again to the original reading and check that the meter pointer returns to the mark.

Similarly, very lightly pencil in the marks for the remaining wattages, taking very great care not to displace the pointer by heavy breathing, sneezing, or by the pencil. The latter can damage the delicate suspension so be ultra careful. Recheck by feeding in various voltages corresponding to given power levels and load impedances and seeing if the meter reading corresponds. It is worth feeding in a voltage on each range in turn, commencing with the 50mW range, such that f.s.d. is obtained. The power level switch should be set to the next range up, where the reading should be one tenth of the previous reading.

The cross checks being satisfactory, the meter dial can now be removed from the meter and firmly taped by its corners to a piece of stiff card. The centre of arc, i.e. the pointer's pivot, should be marked on the card and two arcs drawn in very lightly in pencil so that they overlap the tip of the pointer by equal amounts, say 1·5mm; i.e. the radii differ by 3mm. Using the previously established datum points for power levels, and the centre of arc, mark the final calibration lines in Indian ink using the two arcs as guide lines. When the ink is thoroughly dry the two pencil arcs can be carefully erased and the power levels marked with stencil or transfers at intervals of every five or ten watts, though the actual calibration lines can be at very much closer intervals if desired. ★

Table 1
LOAD RANGE ATTENUATOR CALIBRATION

Step	Input level to S3a	S3 range	Adjust for f.s.d.
1	10V	50W	VR8
2	3·162V	5W	VR7
3	1V	500mW	VR6
4	316mV	50mW	VR5

Table 2
WATTAGE RANGE ATTENUATOR CALIBRATION

Step	Input level to S1	S2 range	Adjust for f.s.d.
1	Set S3 to 50W		
2	27·4V	15	VR3
3	20V	8	VR2
4	14·14V	4	VR1
5	Set S3 to 500mW		
6	17·32V	600	VR4

Table 3
POWER-VOLTAGE CONVERSION

Watts	4 Ω	8 Ω	15 Ω
50	14·142	20·000	27·386
45	13·416	18·973	25·980
40	12·649	17·888	24·494
35	11·832	16·733	22·912
30	10·954	15·491	21·213
25	10·000	14·142	19·364
20	8·944	12·649	17·320
15	7·745	10·954	15·000
10	6·324	8·944	12·247
5	4·472	6·324	8·660
1	2·000	2·828	3·872
0·5	1·414	2·000	2·738
0·4	1·264	1·788	2·449
0·3	1·095	1·549	2·121
0·2	0·894	1·264	1·732
0·1	0·632	0·894	1·224
0·05	0·447	0·632	0·866
0·01	0·200	0·282	0·387

NEWS BRIEFS

The Obedient Car

PROGRAMMED to obey only his voice, Mr Neil Vickery, an electronics enthusiast in Australia, has developed a computer controlled car which responds to spoken commands.

At a cost of some ten times the value of the car, he has added about $A50,000 worth of electronic equipment to his Australian made Holden Monaro GTS and to foil would-be car thieves it is programmed to respond to only his voice.

Using a walkie talkie transmitter enables him to issue commands to his car from distances up to 19km (12 miles) away. The car will obey oral instructions such as "start", "accelerate", "slow down" and "stop". It will also obey such commands as "lights on" or "off", "sound horn", and "activate windscreen wipers". All these commands are relayed to the relevant part of the vehicle by the on-board computer, based on a microprocessor.

Infra red sensors cause the car to brake automatically as it approaches a red traffic light and a radar system monitors the distance to the car in front and adjusts the speed accordingly. Another sensor applies the brakes if it comes too close to any object, including pedestrians. There is an elaborate security system including a homing device which enables the car to be traced up to 180km (112 miles) away if stolen.

The car has a closed circuit television system using two rear mounted cameras which enables the driver to see what is behind by glancing at a small dashboard-mounted monitor screen. Also installed in the car is a radio telephone.

Mr Vickery demonstrates his car at charity functions.

Summer School

THE Department of Electrical Engineering Science at Essex University will be holding its annual Electronics Summer School for teachers during the week July 11 to 15, 1977. Two courses, *Linear Circuit Design* and *Digital Circuit Design* will be run simultaneously.

The Linear Circuit Design course is concerned with the use of transistors and operational amplifiers in analogue applications and the basic circuits of a hi-fi amplfier are investigated in detail.

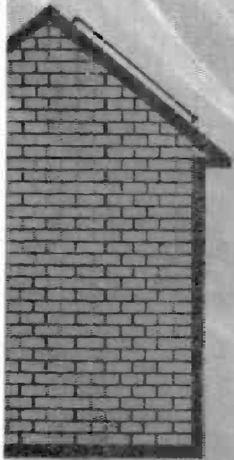
The Digital Circuit Design course concentrates on the use of the transistor as a switch and develops design using integrated logic circuits; a digital patchboard is used to introduce the concepts of combinational and sequential logic design.

Further information on the Summer School can be obtained from R. J. Mack at the Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester CO4 3SQ.

Audio Fair '77

PLANS are now ready for the 1977 International Audio Festival and Fair, to be held at Olympia from September 12 to 18. While retaining its appeal to the specialist audio and hi-fi enthusiast, the 1977 Audio Fair will take account of the greatly increased family demand for sound and visual home entertainment.

Next Month



ELECTRONIC CONTROL UNIT for SOLAR HEATING SYSTEMS

Rising fuel costs are focusing attention on natural power sources such as solar energy. Next month we describe a simple unit to control the circulating pump on a domestic solar water-heating system.

RADIO CONTROL Part 2

The decoder, plus final setting up details for the complete system.

SEVEN-SEGMENT DISPLAY

An inexpensive unit allowing the display of numerals 0-9 on an oscilloscope screen. Intensity (*Z*) modulation facilities are not required.

I.C. SNAP

An electronic version of the traditional card game, based on three 7400 integrated circuits.

PRACTICAL
ELECTRONICS

FEBRUARY ISSUE ON SALE JANUARY 7, 1977

DUAL POWER SUPPLY

One of the disadvantages of operational amplifiers is the need for a split power supply. This normally requires a mains transformer with a double secondary winding. The circuit shown in Fig. 1 overcomes this problem, allowing the use of a transformer with a single output winding.

The arrangement is that of a standard voltage doubler, but with the difference that the centre point of the output, rather than one side of it, is taken to be the 0V or earth rail. The circuit can be considered to be two half-wave rectifiers, operating on alternate half cycles of the supply. The series resistors and Zener diodes stabilise the outputs at a nominal ±15V.

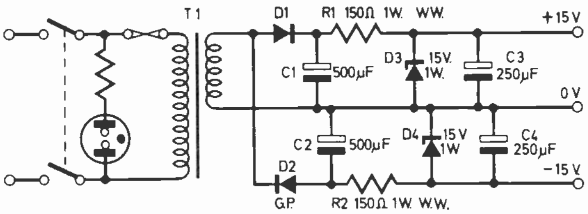
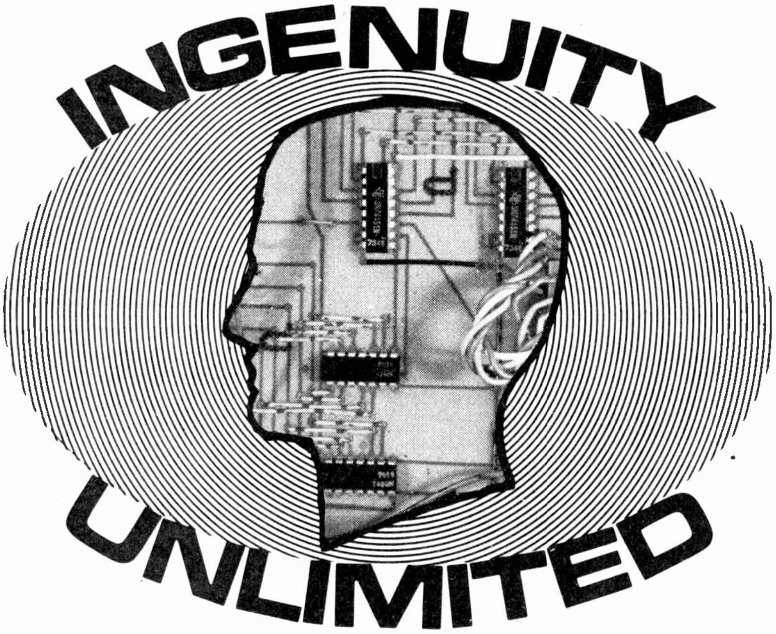


Fig. 1

Using the values shown, a maximum stabilised output of about 50mA can be obtained. A high current balanced power supply, such as is required by some direct coupled Hi-Fi power amplifiers, can be produced by omitting all components to the right of C1/C2.

N. Croucher,
Hull.



A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

Why not submit *your* idea? Any idea published will be awarded payment according to its merits.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

Each idea submitted must be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

SENSITIVE BURGLAR ALARM

This circuit (Fig. 1) monitors the level of ambient light at some position, and sounds an alarm if that level alters due, for instance, to the presence of an intruder.

Photo-transistor TR1, which is operated with its base open circuit, can be mounted at some considerable distance from the remainder of the unit. VR1 sets the sensitivity, and is adjusted so that TR4 is just cut off at normal lighting levels. When the light level falls TR2 collector current is reduced and TR3 collector current rises. Base current flows in TR4 and the fall in collector voltage triggers the SCR.

Having fired, the SCR will remain in conduction even if the intruder moves away from the vicinity of TR1, and the bell will continue to ring. VR2 ensures that enough current is bypassed to keep the SCR on when the bell trembler contacts are in the open condition. Its setting will depend upon the particular SCR used. The circuit is reset by breaking the ringing circuit momentarily with the Reset switch.

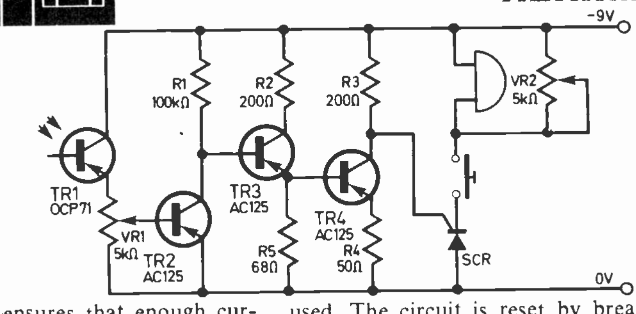
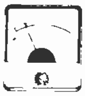


Fig. 1

I. Musa,
Lagos, Nigeria.

GRAPHIC LEVEL DISPLAY



THE following device was designed to display the relative signal levels of audio inputs to a mixer unit, in a graphical form, and thus allowing all the levels to be seen simultaneously. On a conventional audio mixer there may be at least 20 VU meters, and these need to be looked at in quick succession to judge the relative signal levels.

An arbitrary number of l.e.d. indicator lamps are mounted in a vertical line on a panel, and one column is used for each input. A low level signal will trigger the lowest lamp, a slightly higher level will trigger the next lamp, and so on, until all the lamps are triggered and all light up. The lamps could be colour coded according to the intensity.

As Fig. 1 shows, the signal levels can be seen in one glance, the higher up the bar the lamps are lit, the greater the level. This type of display could perhaps be used to greatest benefit in a sound mixer for concert work.

The audio signal is amplified and the resulting signal is rectified to produce a signal that is used as a control voltage for a CMOS switch, the quad analogue switch 4061. In this i.c. when a certain pre-fixed voltage is applied to the control input of the device, it causes an electrostatic switch to close circuit and conduct, and in this circuit, it causes the lamps to light.

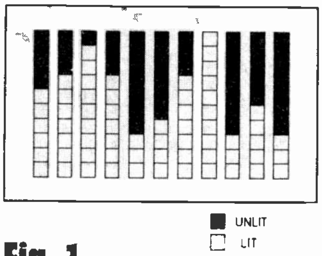
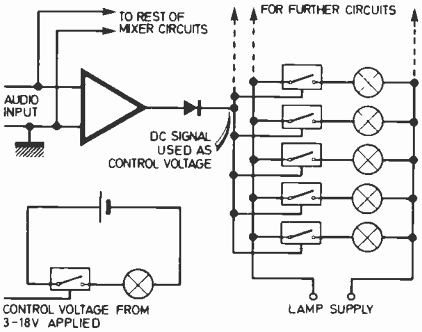


Fig. 1



A separate CMOS device is needed for each pre-set level but each i.c. can be used for three other level controls of the same magnitude on other input sections.

As an example, an amplified level of 3V (actually the lowest level that will trigger the 4061) is used as one control voltage for the i.c. This 3V level corresponds to an instrument input level of 30mV before amplifying: this is used to trigger the first lamp of the series, and using separate CMOS devices with higher trigger levels will trigger the next lamps in the series, if the instrument level increases. (Figures based on a gain of 100 for a 741.)

The power taken by each switch in the CMOS is very low, so a large number of indicator lamps could be triggered by the control voltage from the same source (i.e. high fan-out). There is no interference from the switching procedure, so there will be no pick-up on the audio signal, also the switching is very fast so no audio peaks will be missed.

PRACTICAL ELECTRONICS, February 1976 (not available), explains the 4061 and gives the layout.

Miss L. Robinson,
Wilmslow,
Cheshire.

SOUND OPERATED FLASH TRIGGER

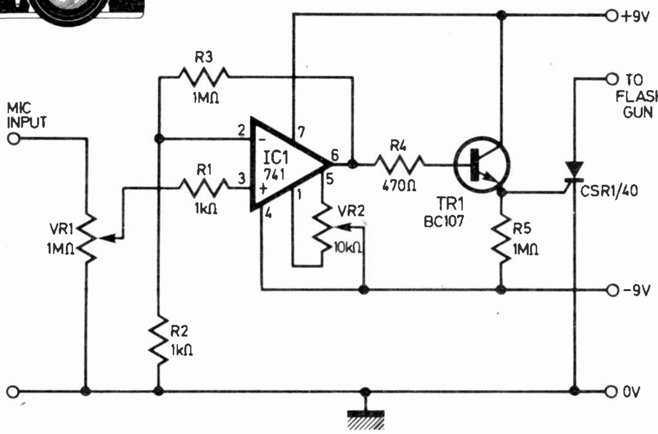


Fig. 1

THIS circuit is built around the versatile 741 operational amplifier, resistors R1, R2 and R3 are in a standard biasing pattern for a gain of approximately 10^3. A sound hitting the microphone creates an electrical signal which is developed across VR1, which provides control of the operating level. This signal is then amplified by IC1 and fed to the base of TR1. When TR1 conducts, a voltage appears on the gate of the thyristor, causing it to fire and thus discharge the flash. Resistor R5 holds the gate at or near earth potential until the trigger pulse arrives, so preventing the thyristor drifting into a random firing condition.

Preset potentiometer VR2 can be set to give an output from IC1 of about +600mV under no signal conditions, so that TR1 is on the point of conduction. Two small nine volt batteries provide an adequate power supply and allow the unit to be housed in a very small container.

R. A. Dix,
Newcastle,
Staffs.

ACTIVE CROSSOVER

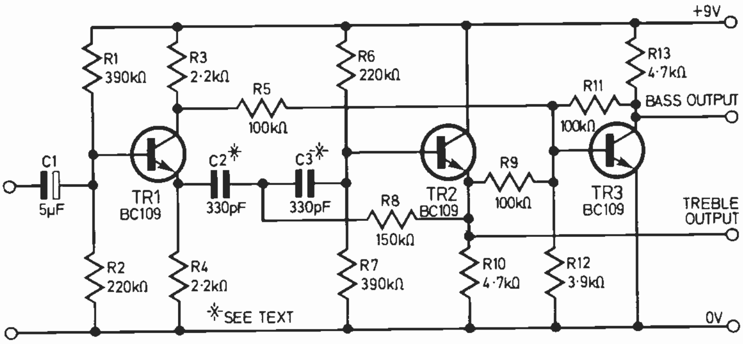


Fig. 1

THIS circuit will divide a flat audio output into bass and treble components for driving a woofer and a tweeter via separate amplifiers.

Transistor TR1 operates as a unity gain phase splitter, antiphase outputs appearing across R3 and R4. The non-inverted signal across R4 is fed to the second stage TR2. This transistor in conjunction with R8, C2 and C3 forms a second order high pass Butterworth filter with a turnover of 3kHz and a slope of 12dB per octave.

The output of the filter is the high frequency audio component. This signal is also subtracted from the flat input signal by the virtual earth amplifier formed by TR3 and its associated components. Since these signals are mixed out of phase, and their amplitudes are equal, the output at the collector of TR3 contains only the bass frequencies of the original signal.

With the values shown for C2 and C3 the crossover has a turnover frequency of 3kHz. This can easily be changed by choosing new values for these components from the formula

$$C2 = C3 = \frac{1{\cdot}06 \times 10^6}{f_0}\ \text{pF}$$

where f_0 is the required turnover frequency.

J. Macauley,
Crawley, Sussex.

LADDER OSCILLATOR WITH CMOS

THE circuit in Fig. 1 shows a ladder network oscillator constructed round one gate of a CD4011. Four oscillators can thus be constructed around the one i.c.—useful perhaps for electronic music or sound effects.

The gate output (Fig. 2) is a distinctly rounded square wave (less so at low supply voltages) whilst a good sine wave is available at input A. Input B is free for switching the oscillator on and off. Second harmonics can be induced at the gate output by R1 or R2 (dotted).

As far as values of K are concerned K values down to 1·5 are usable, but K$\geqslant$10 and/or four-stage ladders are possible with CMOS gates with their high input/output impedance ratios.

A second oscillator can be used to produce an interrupted tone. Frequencies of a few Hz are easily obtainable.

Two precautions should be noted. When using large value capacitors it would be prudent to protect the A input from switch-on damage with a 5kΩ or greater resistor. The other factor to be watched is dissipation, which should be limited to 200mW per chip (since the gate is not driven hard into high or low states). Experience has shown that at a supply voltage of 12V the overall dissipation is acceptable. According to the chip used, the minimum supply voltage for oscillation is around 3–4V.

Note: an improved waveform (but a little different in sound) is obtained by connecting input 2 of gate IC1a to gate IC1b output, if input 2 is not required for control purposes, i.e. with input 2 high an interrupted tone is obtained, and with 2 low, a continuous tone.

C. J. Collins,
Letchworth.

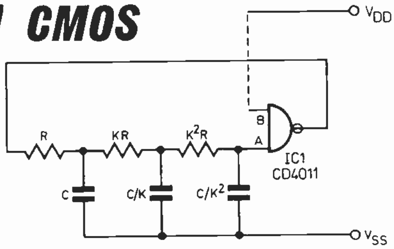


Fig. 1

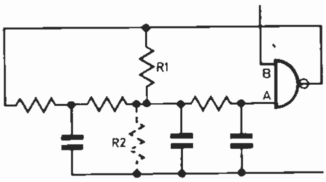


Fig. 2

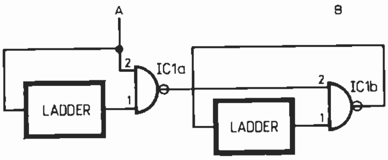


Fig. 3

GUITAR FUZZ UNIT

THIS unit is capable of producing the well known fuzz distortion sound as heard on many of today's pop records. It is basically a simple amplifier (Fig. 1) using a 741 but arranged to give a very high gain and consequently distort any high level input signals, such as those obtained from electric instruments.

The gain is determined by VR1, R3 and R4. By making VR1 variable this serves to alter the gain and so act to control the degree of fuzz. Also incorporated within the feedback loop are C3 and VR2 which tend to alter the amount of high frequency feedback and thus act as a tone control.

Although the unit uses a 741 the need for a dual supply is avoided by the biasing resistors R1, R2 enabling it to be powered from a PP3 type battery, and making it small enough to be built into an existing amplifier, or guitar. If the output level is found to be too high a volume control or small preset could be fitted as shown dotted in the diagram.

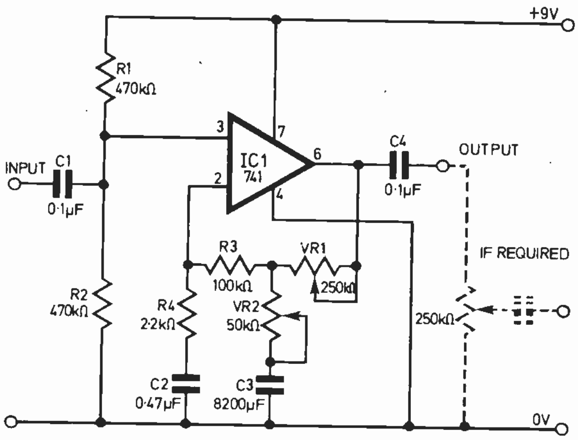


Fig. 1

J. White,
Huddersfield,
W. Yorks.

MODIFIED SQUAREWAVE OSCILLATOR

THE TTL Schmitt trigger gate plus one resistor and capacitor form a useful squarewave oscillator with many applications. The disadvantage of this simple circuit is that only a unity mark/space ratio is available, due to the single CR network.

A simple modification to this circuit, as shown in Fig. 1, allows the mark/space ratio to be set to the required value. The capacitor charges up via D1/R2 with R1 in parallel, and discharges through R1 as normal. The minimum pulse width is obtained when R2 is omitted, the charge resistance then being equal to the forward resistance of the diode.

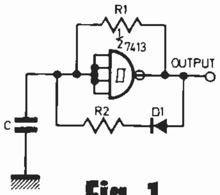
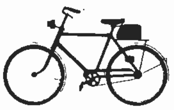


Fig. 1

A. Glover,
Braunston,
Northants.

CYCLE LIGHTING



A DYNAMO is the most economical form of cycle lighting, but is dangerous at low speed or when stationary as little or no light is produced. The circuit shown in Fig. 1 overcomes this problem.

The output from the dynamo is rectified by the rectifier bridge and fed to the lamp bulbs, originally 6V 3W at the front and 0·6W at the rear, but replaced by two standard 3·5V 0·3A lamps in series. At normal speeds the potential across the bulbs is sufficient to saturate TR1, which cuts off the Darlington pair TR2, TR3. As soon as the potential at the base of TR1 falls sufficiently it turns off, and current is fed to the lamps via TR2 and TR3, maintaining a brightness level determined by the setting of VR1. With the dynamo stationary, VR2 should be adjusted until the lights just begin to dim, so ensuring correct changeover from battery to dynamo.

One side of the dynamo was originally earthed and so had to be insulated; with a hub dynamo this would not be necessary. Two 4·5V flat batteries were used, secured in a plastics case beneath the saddle. Current drawn from the batteries drops to virtually zero at a fast walking pace, and so they should have a long life.

The circuit was built on a small piece of Veroboard and mounted in the headlamp casing. Connections to the batteries, rear lights, etc. were made via a 7-pin DIN connector, the socket bolted to the base of the headlamp unit and the pin section from the plug soldered to the Veroboard.

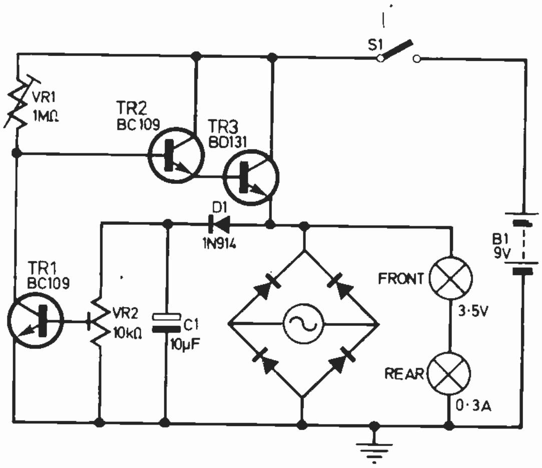


Fig. 1

A. Chadwick,
Cambridge.

PATENTS REVIEW...

IMPLANTED HEARING AID

It is clear that in the future an increasing amount of electronic gadgetry will be implanted in the human body. Already heart pacemaker implants are common, and in BP 1 440 724 John Fredrickson of Toronto, Canada, claims an electromagnetic hearing aid which is to be buried inside the human ear.

A tiny condenser microphone, amplifier and battery power source are integrated into a capsule which is a removable screw fitted into a socket permanently implanted, by surgery, into the skull of a patient, just behind the ear lobe (Fig. 1). The microphone is exposed to the air to receive sound waves but is largely invisible.

The amplifier feeds audio signals along insulated wire thread to a coil, which is secured by a rod mount at a fixed position in the middle ear space, Fig. 2. The coil surrounds, or lies close to a small powerful magnet secured to the patient's stapes; one of the three auditory ossicles of the human ear.

The audio signals from the microphone and amplifier capsule create a varying magnetic field throughout the coil, which produces an electromotor effect on the magnet and vibrates the stapes. The stapes then functions in its normal manner, like a piston, causing vibration of the inner ear fluids, to produce an inner ear vibratory sensation of the sound picked up by the external microphone.

The aid could thus be of value to any patient with a defect in the natural mechanical chain between the outer ear and stapes. Particularly valuable is the obviation of positive feedback or "howlround" risk as may be encountered with conventional acoustic aids.

STEAM TRAIN SOUND BP 1 436 814

A simple system for controlling a white noise generator on board a toy train, to simulate the puffing sound of a steam locomotive, is described by Louis Marx & Co Inc, of Connecticut, USA, in BP 1 436 814.

The noise generator, of any suitable form, is concealed in the engine chassis together with an audio amplifier and small loudspeaker. One of the engine wheels is mounted on a conductive axle and comprises two semicircular conductors separated by an insulator.

The conductors are bridged by a resistor and as the train moves under d.c. power supplies to the rails, the conductors alternately contact the live rail. In this way the white noise generator receives first unimpeded d.c., via one half of the wheel, and then impeded d.c. through the other half of the wheel and resistor.

The voltage supplied to the noise circuits thus alternately drops and rises producing the characteristic high and low hissing sounds associated with the puffing of a steam train. The sound produced is always proportional to the speed the train travels.

BP 1 440 724

Fig. 1

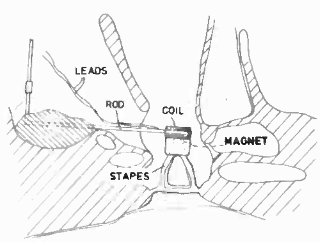


Fig. 2

OIL LEVEL ALARM BP 1 431 230

In BP 1 431 230, the British Petroleum Co. Ltd. patents a mechanical gadget that poses an interesting electronic problem. The object of the patented invention is to provide an automatic dashboard alarm when the level of oil in a car sump falls below a safety level.

The part solution to the problem as patented by BP is a dipstick, formed of plastics material (such as PTFE) with very high insulation resistance and tolerance to temperatures. This dipstick has a central core of mild steel with a spade connector at the upper end, a bared metal portion at the lower end, and a bung for securing it to any car dipstick orifice halfway along its length.

The dipstick is sold in one size and trimmed to just the right length for a specific car to locate the metal tip at the level below which the oil should not fall.

What the patent refers to simply as "an indicating means" is provided on the dashboard, to register "the very small current that is made to flow from the detecting tip of the probe into the oil" when a reference voltage is applied between the sump casing and the probe tip. Current flow, of course, indicates the presence of oil and safe conditions in the sump. However, having in mind the fact that oil is conventionally used as an insulating material, the "indicating means" claimed by BP will need to be highly sensitive to minute current flows.

No clue is given as to possible circuitry for such a means, and readers may care to consider the practicability or otherwise of adapting currently available circuitry for the task.

IN BRIEF

BP 1 446 421/2—Royce Thompson Electric Ltd: *Electrical Switching System.* A photosensitive solid-state switching circuit for a.c. power, which switches sharply from full-off to full-on and back to full-off again depending on ambient light levels and with a minimum of r.f. interference. Intended for use, for instance, in street lights as an alternative to time-switching.

Copies of Patents can be obtained from the Patent Office Sales, St. Mary Cray, Orpington, Kent Price 75p each

Readout—
A SELECTION FROM OUR POSTBAG

Readers requiring a reply to any letter must include a stamped addressed envelope. We regret that we cannot answer any technical queries on the telephone.

Time Check

Sir.—Many electronic digital watches are now advertised in PRACTICAL ELECTRONICS and elsewhere. yet none seems to offer a 24-hour display. The 12-hour display which necessitates the distinction between a.m. and p.m. is one of the main disadvantages of analogue watches which are in general easier to read and more convenient to use. The other disadvantage is that accuracy depends on high precision engineering which is costly.

The majority of digital clocks, whether mechanical or electronic, provide 24-hour displays which greatly simplify reference to virtually all public transport timetables, and it cannot be long before the BBC and P.O. adopt this format. I suspect they already use it for internal purposes and the sooner we all standardise on a single international system of weights and measures, including time, the better.

Electronic watches are often advertised with such phrases as "state of the art" or "space age technology" and it is surprising that they do not use an up-to-date display format, especially when it must be presumed that potential buyers are in favour of innovation.

I should be very grateful if any of your readers could tell me of any suppliers of 24-hour digital watches—at a reasonable price.

R. A. Porter,
Redcar.

We understand that only one digital watch with a 24-hour display is currently available in this country. This is the solar-powered Ragen Synchronar, retailing at £325·00!—Ed.

Lamp Lens

Sir.—Some of your readers may be interested in my idea for making indicator lamp lenses using a Dymo tape machine and one of the liquid plastic resins, such as Plasticraft, available from hobby shops.

The required motif is first stamped out on the tape machine. The tape is then stuck on the inside of a shallow metal tray or tin lid of the desired shape and size of the finished lens. The inside of the tray is now coated with release agent and carefully polished.

The liquid plastic resin is then mixed and poured into the tray. When set, the plastic may be removed from the tray and the tape peeled from the back of the casting. The net result is that the motif will now be cast in reverse.

The next stage is to file the lens to shape and polish it. The motif, which now looks similar to the engraving, is filled with soft wax, any excess being sanded off, and the whole of the back of the lens sprayed matt black.

When the paint is dry the wax can be carefully picked out of the motif with a pin. The result is that when the lens is illuminated from behind the motif will stand out against the black background. With a red filter behind the lens or by tinting the plastic with translucent dye the effect is similar to l.e.d.s.

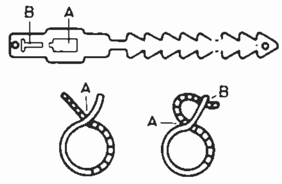
M. J. Hourican,
Portsmouth,
Hants.

Substitute Cable Clips

Sir—A project involving large amounts of interconnecting wiring between units requires cable ties or lacing cord to organise them. Purpose designed polythene ties retail at about £2·16 per 100. However, polythene "Plasti-Ties" for gardeners, for plant stems at 36p per 100, are available.

The tie consists of a serrated tail on the end of which are two slots for engaging the serrations, after encircling the plant, which, in this case, can also be used for retaining bunches of wires, see Fig. 1. One slot "A" will permit the tying of bunches of wires from 6–28mm in 2mm steps. The second alternate, slot "B", will enable wires from 10–32mm diameter to be secured.

Use of both retaining slots simultaneously will result in a figure "8" configuration, thus securing two bunches of wires alongside each other, their maximum diameter being 10 and



16mm. A hole which will accept an 8BA bolt is present at both ends of the tie and can be used for securing. The ties are reusable.

M. B. Wignall,
Portsmouth

A strong wind

Sir—I feel it hard to believe that Mr Gray has made his "Simple Anemometer" (*Ingenuity Unlimited*), October issue, work.

It would need a very strong wind to turn half "ping-pong" balls on 6in dowels unless the bearing was frictionless. I have seen half of ball valve floats used this way with three being used with arms in the region of two feet with a good bearing.

As for the use of a car, there is the very great difficulty of elevating the device above the car enough to clear currents brought about by the car moving through even still air. The speed of the airflow round a car is far higher than the road speed resulting from the displacement of the air by the car.

E. Radd,
York.

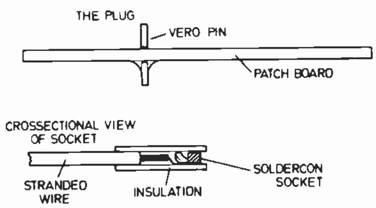
Good Connection

Sir.—Patch-board plugs and sockets, whatever their application, tend to be rather costly, particularly if a large number are required. Fig. 1 shows a way of producing a connector system which will not break the bank!

The plugs are made simply by soldering Veropins onto the patch-board. The sockets are made from Soldercon sockets, individual i.c. sockets purchased by the 100. The Soldercon socket is soldered to the end of a stranded wire lead and covered with insulation. Heat-shrink sleeving is ideal for this purpose, giving a neat and durable finish. Connections are made simply by pushing the socket onto the Veropin.

At current prices, the cost works out at about £1 per 100 plugs and sockets.

T. I. Mason,
Evington,
Leicester.



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MC1310	1·98
MC1330P	0·75
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MC1466L	3·95
MC1469R	2·50
MEO402	0·20
MEO404	0·15
MEO412	0·20
ME4102	0·10
ME4104	0·10
MJ480	1·05
MJ481	1·30
MJ490	1·05
MJ491	1·55
MJ2955	1·21
MJE340	0·58
MJE2955	1·25
MJE3055	0·75
MJE370	0·68
MJE371	0·81
MJE520	0·65
MJE521	0·75
MP8111	0·35
MP8112	0·40
MP8113	0·45
MPF102	0·30
MPSA05	0·20
MPSA06	0·20
MPSA12	0·35
MPSA55	0·20
MPSA56	0·20
MPSU05	0·40
MPSU06	0·40
MPSU55	0·45
MPSU56	0·45
NE555V	0·48
NE556	1·30
NE560D	4·48

NE561	4·48
NE565A	1·30
OC28	2·00
OC35	1·50
OC42	0·50
OC45	0·75
OC71	0·45
OC72	0·45
OC81	0·75
OC83	0·50
ORP12	0·70
R53	1·80
SL414A	2·35
SL610C	2·35
SL611C	2·35
SL612C	2·35
SL620C	3·50
SL621C	3·50
SL623C	5·75
SL640C	4·00
SL641C	4·00
SN76003N	2·36
SN76013N	1·50
SN76023N	1·45
SN76033N	2·50
ST2	0·20
TAA263	1·25
TAA300	2·67
TAA350	2·48
TAA550	0·60
TAA611C	2·25
TAA621	2·15
TAA661B	1·32
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TIL209	0·30
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TIP30A	0·60
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TIP31C	0·85
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CD4007	0·20	CD4022	0·97	CD4046	1·32
CD4008	0·97	CD4023	0·20	CD4047	1·15
CD4009	0·57	CD4024	0·79	CD4049	0·56
CD4010	0·57	CD4025	0·20	CD4050	0·56
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CD4017	1·01	CD4041	0·83		

Please enquire about CMOS not listed

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SN7400	0·21	SN7412	0·21	SN7438	0·30	SN7460	0·21	SN7484	1·00	SN74107	0·33	SN74160	1·20	SN74191	1·27
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SN7405	0·26	SN7423	0·30	SN7447	0·89	SN7475	0·46	SN7492	0·49	SN74123	0·46	SN74165	0·98	SN74198	0·90
SN7406	0·59	SN7425	0·30	SN7448	0·89	SN7476	0·39	SN7493	0·49	SN74141	0·80	SN74167	4·20	SN74199	2·28
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Rotary Pots (no 1kΩ log)	25p	75p
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Presets—Horizontal or Vertical
0·1W 9p   0·3W 11p

DIN PLUGS— 14p DIN CHASSIS SOCKETS—10p
3-pin, 4-pin, 5-pin 180°, 5-pin 240°, 6-pin, 7-pin and Speaker

LINE SOCKETS—14p each
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Red, white, black, green or pellow **10p**, Chrome **15p**

LINE PLUGS (same colour) **10p**, Chrome **15p**

PHONO CHASSIS, sockets
single **7p**, double **10p**, 3-way **12p**, 6-way **25p**, 8-way **35p**

JACK PLUGS AND SOCKETS
¼in mono plastic plug **15p**
¼in mono chrome plug **22p**
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¼in plastic switch socket **18p**
¼in stereo plastic plug **20p**
¼in stereo chrome plug **30p**
¼in stereo plastic line socket **20p**
¼in stereo chrome line socket **35p**
¼in stereo plastic switched socket **25p**
3·5mm plug **10p**; 3·5mm socket **10p**; 3·5mm line socket **10p**;
2·5mm plug **10p**; 2·5mm socket **10p**

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SWITCHES £1·55

OTHER PROJECTS

PHOTOGRAPHS in this advertisement show two of our units containing some of the P.E. projects built from our kits and PCBs. The cases were built by ourselves and are not for sale, though a small selection of other cases is available.

LIST—Send Stamped Addressed Envelope with all U.K. requests for free list giving fuller details of PCBs, kits, and other components.

OVERSEAS enquiries for list: Europe—send 20p; Other Countries—send 40p.

KEYBOARDS AND CONTACTS

Kimber-Allen Keyboards as required for many published circuits, including the **P.E. Joanna, P.E. Minisonic,** and **P.E. Synthesiser.** The manufacturers claim that these are the finest moulded plastic keyboards available. All octaves are C to C. The keys are plastic, spring-loaded and mounted on a robust aluminium frame.
3 Octave (37 notes) **£24·85.** 4 Oct (49 notes) **£29·50.** 5 Oct (61 notes) **£34·50.**
Contact Assemblies for use with above keyboards: Single-pole change-over (type SP) as for P.E. Joanna and P.E. Minisonic. Two-pole normally open-make-break (type DP) as for P.E. Synthesiser. Special contact assembly (type 4PS) having 4 poles, 3 of which are normally-open make-break contacts and the fourth is a change-over contact—this special assembly enables THE SAME KEYBOARD to be used with the P.E. Synthesiser, P.E. Minisonic and the P.E. Joanna simultaneously thus avoiding the cost of more than one keyboard.

Contact	*Each*	*3 Octave Set*	*4 Octave Set*	*5 Octave Set*
SP	**24p**	**£8·88**	**£11·76**	**£14·64**
2P	**27p**	**£9·99**	**£13·23**	**£16·47**
4PS	**53p**	**£19·61**	**£25·97**	**£32·33**

PRINTED CIRCUIT BOARDS for use with the above contacts and thus eliminating most of the inter-wiring required, are available. Details in our lists.

SOUND-TO-LIGHT (P.E. Apr./Aug. 71)

The ever-popular **Aurora**—4 or 8 channels each responding to a different sound frequency and controlling its own light. Can be used with most audio systems and lamp intensities. A MUST for any Disco, and a fascinating visual display for the home.

4 Channel Component Set (excl. thyristors)	**£14·42**
8 Channel Component Set (excl. thyristors)	**£25·75**
Power Supply Component Set	**£5·35**
PCB for 4 frequency channels	**£3·65**
PCB for power supply and 8 lamp drivers	**£1·70**
1A 400V thyristors (1 per chan. req.) each	**75p**
Panel meter (1μA) (optional)	**£4·99**

3-CHANNEL SOUND-TO-LIGHT (P.E. Apr. 76)

A simple but effective sound-to-light controller capable of operating 3 lamps each of approximately 700 watts. Includes power supply, thyristors, and by-pass switches.

Component Set incl. PCB	**£11·18**

BIOLOGICAL AMPLIFIER (P.E. Jan./Feb. 73)

Multi-function circuits that, with the use of other external equipment, can serve as lie-detector, alphaphone, cardiophone etc.

Pre-Amp Module Component Set incl. PCB	**£4·11**
Basic Output Circuits—combined component set with PCBs, for alphaphone, cardiophone, frequency meter and visual feed-back lamp-driver circuits	**£5·95**
Audio Amplifier Module Type PC7	**£6·75**

TAPE NOISE LIMITER

Very effective circuit for reducing the hiss found in most tape recordings. All kits include PCBs.

Standard Tolerance Set of Components	**£2·85**
Superior Tolerance Set of Components	**£3·30**
Regulated Power Supply (will drive 2 sets)	**£4·69**

SINE AND SQUARE WAVE GENERATOR (P.E. July 75)

Suitable for audio, digital, or general purpose. Controllable through 4 decade ranges 10Hz to 100kHz, switched attenuation through 10 ranges from 10V to 1mV peak-to-peak.

Component Set. While stocks last	**£9·83**
PCB for above components	**£1·76**
Power Supply	**£6·21**
PCB for Power Supply	**£1·06**

SEMI CONDUCTOR TESTER (P.E. Oct. 73)

Essential test equipment for the enterprising home constructor. While stocks last.

Set of resistors, capacitors, semiconductors, potentiometers, makaswitches and PCB	**£8·86**
Panel meter (500μA)	**£4·99**

P.E. MINIMIX 6 (P.E. Nov./Dec. 75)

Each of the 6 input channels has its own gain, volume and panning controls. The volume of the twin channel outputs are fully manually controllable, as are the headphone and pre-fade monitoring facilities. Twin VU meters provide visual display of channel audio levels. Ideal for use with effects and synthesiser kits.
For details see our list. While stocks last.

8-INPUT MIXER

A simple mixer having 8 inputs each of which has a preset level control and which are combined into one output channel having a preset over-all level control and a master output volume control. Designed for intercoupling our various sound effects and synthesiser kits.

Component set incl. PCB	**£3·95**

TRANSISTORS

AC128	**20p**
AC176	**20p**
BC107	**14p**
BC108	**14p**
BC109	**14p**
BC147	**12p**
BC148	**12p**
BC149	**12p**
BC157	**13p**
BC158	**13p**
BC159	**13p**
BC182L	**12p**
BC184	**12p**
BC187	**25p**
BC204	**14p**
BC209C	**14p**
BC212L	**15p**
BC213	**15p**
BC478	**28p**
BCY71	**22p**
BD131	**44p**
BD132	**54p**
BFY50	**22p**
BFY51	**22p**
BFY52	**24p**
BSY95A	**22p**
MJE2955	**110p**
OC28	**60p**
OC71	**17p**
OC72	**25p**
OC84	**25p**
ORP12	**66p**
ZTX107	**12p**
ZTX108	**9p**
ZTX501	**13p**
ZTX503	**15p**
ZTX531	**23p**
2N706	**13p**
2N914	**22p**
2N1304	**22p**
2N2219	**27p**
2N2905	**35p**
2N2905A	**36p**
2N2907	**22p**
2N3053	**18p**
2N3054	**66p**
2N3055	**48p**
2N3702	**12p**
2N3703	**12p**
2N3704	**12p**
2N3819	**35p**
2N3820	**64p**
2N3823E	**39p**
2N4060	**12p**
2N4871	**36p**
2N5245	**51p**
2N5777	**45p**

INTEGRATED CIRTS.

709	T05	**40p**
709	8-pin DIL	**40p**
723	T05	**95p**
741	8-pin DIL	**32p**
748	T05	**63p**
748	8-pin DIL	**63p**
μA7805	T0220	**165p**
μA7808	T0220	**165p**
μA7812	T0220	**165p**
μA7815	T0220	**165p**
μA7818	T0220	**165p**
AY-1-0212		**622p**
AY-1-6721/6		**188p**
CA3046		**71p**
SG3402N		**220p**

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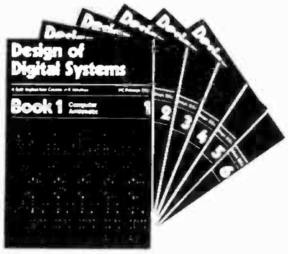

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COMPLETELY SOLDERLESS ELECTRONIC CONSTRUCTION KIT
BUILD THESE PROJECTS WITHOUT SOLDERING IRON OR SOLDER

- 4 Transistor Earpiece Radio
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- Signal Injector
- Transistor Tester NPN —PNP
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- 5 Transistor Push Pull Amplifier
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- 5 Transistor Short Wave Radio
- Electronic Metronome
- Electronic Noise Generator
- Batteryless Crystal Radio
- One Transistor Radio
- 2 Transistor Regenerative Radio
- 3 Transistor Regenerative Radio
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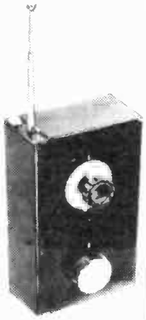
Complete kit of parts including construction plans

Total building costs £9·00 P.P. and Ins. 85p

V.H.F. AIR CONVERTER KIT



Build this converter kit and receive the aircraft band by placing it by the side of a radio tuned to medium wave or the long wave band and operating as shown in the instructions supplied free with all parts.

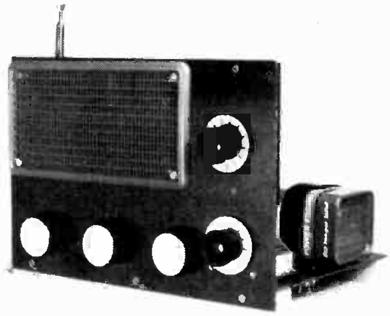
Uses a retractable chrome plated telescopic aerial, gain control, V.H.F. tuning capacitor, transistor, etc.

All parts including case and plans

£3·95 P.P. & Ins. 45p

NEW ROAMER TEN MODEL R.K. 3

MULTIBAND V.H.F. AND A.M. RECEIVER.
13 TRANSISTORS AND FIVE DIODES. QUALITY 5" 3" LOUDSPEAKERS.



WITH Multiband V.H.F. section covering Mobiles, Aircraft, T.V. Sound, Public Service Band, Local V.H.F. Stations, etc. and Multiband A.M. section with Airspaced Slow Motion Drive Tuning Capacitor for easier and accurate tuning, covering M.W.1, M.W.2, L.W. Three Short Wave Bands S.W.1, S.W.2, S.W.3 and Trawler Band. Built-in Ferrite Rod Aerial for Medium Wave, Long Wave and Trawler Band, etc., Chrome Plated 7 section Telescopic Aerial, angled and rotatable for peak Short Wave and V.H.F. reception. Push-Pull output using 600mW Transistors. Gain, Wave-Change and Tone Controls. Plus two Slider Switches. Negative Feedback circuit and SPECIAL POWER BOOSTER SOCKET AND RESISTOR, to virtually double gain if required. Powered by P.P.9—9 volt Battery.

Complete kit of parts including carrying strap. Building Instructions and operating Manuals. **£13·99** Inc. P. & P.

Case enclosure kit (if required), £1·80 inc. P. P. and Ins.

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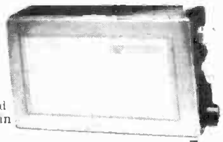


Now with 3in Loudspeaker
3 tunable wavebands. MW, LW and trawler band. 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, attractive black and gold case. Size 5½in × 1¼in × 3½ in approx.

Complete kit of parts including construction plans.

Total Building Costs: **£3·60** P.P. and Ins. 60p

NEW Everyday Series

Build this exciting new series of designs.

E.V.5. 5 Transistors and 2 diodes. MW/LW. Powered by 4½V battery. Ferrite rod aerial, tuning condenser, volume control, and now with 3in. loudspeaker. Attractive case with red speaker grille. Size 9in. × 5½in. × 2¾in. approx. All parts including Case and Plans.

Total Building costs **£4·30** P. & P. + Ins. 60p

E.V.6. Case and looks as above. 6 Transistors 3 diodes. Powered by 9V battery. Ferrite rod aerial, 3in. loudspeaker, etc. MW/LW coverage. Push/Pull output.
All parts including Case and Plans.

Total Building costs **£4·95** P. & P. + Ins. 65p

E.V.7. Case and looks as above, 7 Transistors and 3 diodes. Six wavebands, MW/LW, Trawler Band SW1, SW2, SW3, powered by 9V battery. Push pull output. Telescopic aerial for short waves. 3in. Loudspeaker. All parts including Case and Plans.

Total Building Costs **£6·95** P. & P. + Ins. 70p

ELECTRONIC CONSTRUCTION KITS

E.C.K. 2

Self Contained Multi-Band V.H.F. Receiver Kit.

8 transistors and 3 diodes. Push pull output. 3in loudspeaker, gain control, superb 9 section swivel ratchet and retractable chrome plated telescopic aerial, V.H.F. tuning capacitor, resistors, capacitors, transistors, etc. Will receive T.V. sound, public service band, aircraft, V.H.F. local stations, etc. Operates from a 9 volt P.P. 7 battery (not supplied with kit).

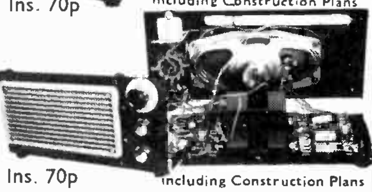
Including Construction Plans

Complete kit of parts **£7·95** P.P. and Ins. 70p

E.C.K. 4

7 Transistors, 6 tuneable wavebands, MW, LW, Trawler Band, 3 Short Wave Bands. Receiver Kit.

With 5in × 3in loudspeaker. Push pull output stage, gain control, and rotary switch. 7 transistors and 4 diodes. 6 section chrome-plated telescopic aerial. 8in sensitive ready wound ferrite rod aerial, tuning capacitor, resistors, capacitors, etc. Operates from a 9 volt P.P. 7 battery (not supplied with kit).



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Completely Solderless Electronic Construction Kit. Build these projects without Soldering Iron or Solder.

- ★ Crystal Radio Medium Wave Coverage—No Battery necessary
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- ★ 4 Transistor Medium Wave Loudspeaker Radio
- ★ Electronic Noise Generator
- ★ Electronic Metronome
- ★ 4 Transistor Push/Pull Amplifier

All parts including loudspeaker, earpiece, MW ferrite rod aerial, capacitors, resistors, transistors, etc.

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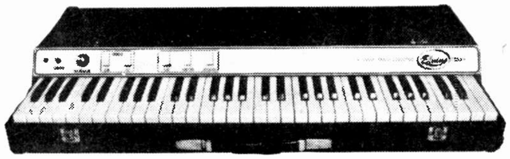

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Parts List	*Price*
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48 × resistors watt 5% (1p each)	48p
12 × terminal pins (½p each)	6p
1 × p.c. board, drilled	£1·00
2 × 0·01 (4p each)	8p
3 × 0·02 (4p each)	12p
Total Price per unit (11 units required)	£5·29
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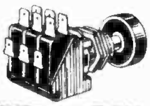

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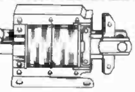

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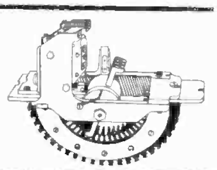

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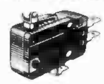

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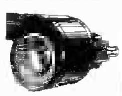

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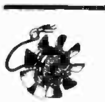

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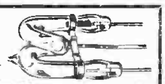

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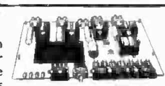

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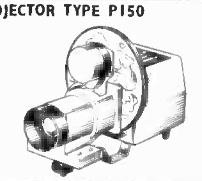

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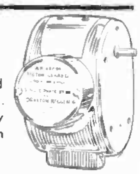

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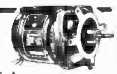

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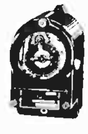

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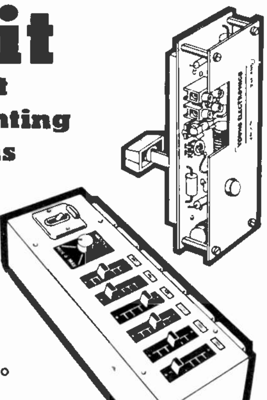

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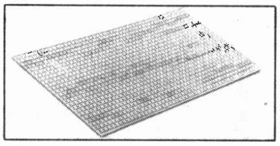

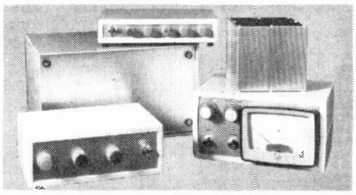

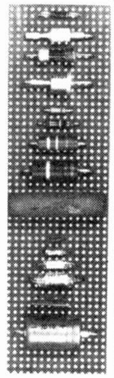

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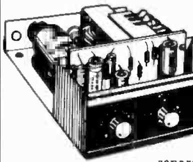

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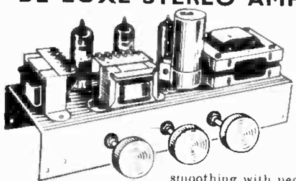

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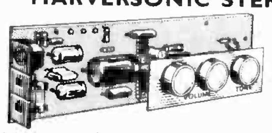

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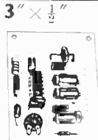

Ready built. Pre-aligned and tested. Sens. 20-560mV for 9-16V neg. earth operation. Can be fitted to almost any FM VHF radio or tuner. Stereo beacon light can be fitted if required. Full details and instructions (inclusive of hints and tips) supplied. **£5·62** plus 20p P. & P. Stereo beacon light if required 40p extra.

QUALITY RECORD PLAYER AMPLIFIER MK. II A top quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in wide × 3in deep × 6in high. Ready built and tested. PRICE **£6·20.** P. & P. 90p. ALSO AVAILABLE mounted on board with output transformer and speaker. PRICE **£7·30.** P. & P. £1·00.

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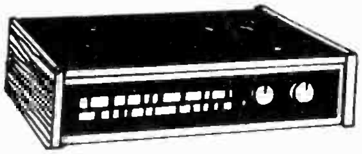
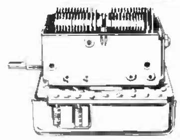


Designed and styled to match our 10 + 10 amplifier but will suit any other standard stereo amplifier. The design incorporates the very latest circuitry techniques with high-grain, low noise IF stages. Automatic frequency control to "lock on" station and prevent drift. IC stereo decoder for maximum stereo separation. L.E.D. for stereo beacon indicator. Nominal output of tuner 100mV. Approximate size 12½in wide × 8in deep by 2¾in high. Supplied ready built, fully tested and fully guaranteed. AC mains 200/240V (not available in kit form).

Special Offer £22·50 + £1·40 P. & P.

SPECIAL OFFERS

Mullard LP1159 RF-IF Double Tuned Amplifier Module for nominal 470kHz. Size approx. 2¼" × 1¼" × ½" 7·6V + earth. Brand new pre-aligned. Full specification and connection details supplied. **£2·25** + P. & P. 12p.



Pye VHF/FM Tuner Head covering 88-108M/Hz 10·7M/Hz IF output 7-8V + earth. Supplied pre-aligned, with full circuit diagram. Connection details supplied. Beautifully made with precision-geared FM Gang and 323 Pf + 323 Pf AM Tuning Gang only **£3·15** + P. & P. 35p.

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HI-FI LOUDSPEAKER SYSTEM Mk II

Beautifully made simulated teak finish enclosure now with most attractive slatted front. Size 16½" high × 10¼" wide × 9" deep (approx.). Fitted with E.M.I. Ceramic Magnet 13" × 8" bass unit, H.F. tweeter unit and crossover. AVAILABLE IN NOMINAL 4 ohm, 8 ohm or 16 ohm impedance (state which).

OUR PRICE £12·00 each. Carr. £1·90

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VYNAIR & REXINE SPEAKERS & CABINET FABRICS app. 54 in. wide. Our price **£1·50** yd. length. P. & P. 50p per yd. (min. 1 yd.). S.A.E. for samples.

"POLY PLANAR" WAFER-TYPE, WIDE RANGE ELECTRO-DYNAMIC SPEAKER
Size 11¾" × 14¼" × 1⅛" deep. Weight 19oz. Power handling 20W r.m.s. (40W peak). Impedance 8 ohm only. Response 40Hz–20kHz. Can be mounted on ceilings, walls, etc. and used with or without baffle. Send S.A.E. for details. Only **£8·40** each. P. & P. 75p for one, 90p for two.

Now also available 8"-8 ohm. 10 watts r.m.s. 20 watt peak 40 Hz-20,000 Hz. Overall depth 1". Ideal for Hi-Fi or for use in cars. **£5·10** + P. & P. (one 35p, two 65p).

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Hi-Fidelity stereo cassette tape deck transport mechanisms as used in Hi-Fi Music Centres. Electronically speed controlled motor, belt-driven flywheel capstan, three digit re-settable counter. Record/Play pre-amps. Bias oscillator. Record/Play and erase heads, etc. Power supply required 12V D.C. Circuit diagrams, etc. supplied. These units are brand new, but un-tested and are only offered to the more advanced constructor enthusiast. PRICE **£16·87** + £1·25 P. & P.
WE REGRET THAT WE ARE UNABLE TO ENTER INTO CORRESPONDENCE ON THESE UNITS.

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Overall Size 12"w × 8"d. × 2½"h.
Fully detailed 7 page construction manual and parts list free with kit or send 25p plus large S.A.E.

AMPLIFIER KIT	£13·50	P. & P. 65p
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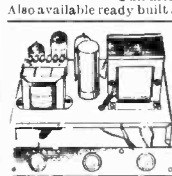
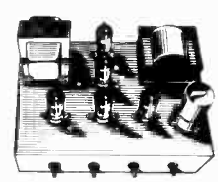


3-VALVE AUDIO AMPLIFIER HA34 MK II. Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7¾"w. × 4"d. × 4½"h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving bass and treble lift and cut. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only **£7·80.** P. & P. £1·00.

HSL "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc. **£7·00.** P. & P. £1·00

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3–15Ω speaker and 2 independent volume controls, and separate base and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 25p × SAE (Free with parts). All parts sold separately. ONLY **£11·25.** P. & P. £1·35. Also available ready built and tested **£15·20.** P. & P. £1·35.

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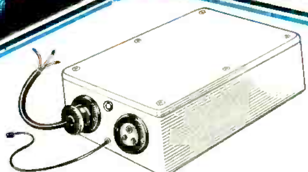

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