

electronics today

FEBRUARY 1979

INTERNATIONAL

50p

LOW COST, HIGH QUALITY

100W_{RMS} DISCO MIXER AMPLIFIER



**Inside:
computing
today no 4**

TWONKY - A SCAMP Of A Composer!

Computer Speech Lessons

Tape Slide Synchroniser

Noise Reduction

CHROMATHEQUE 5000

5 CHANNEL LIGHTING EFFECTS SYSTEM

All kits also available as separate packs (e.g. P.C.B. component sets, hardware sets, etc.)
Prices in FREE CATALOGUE



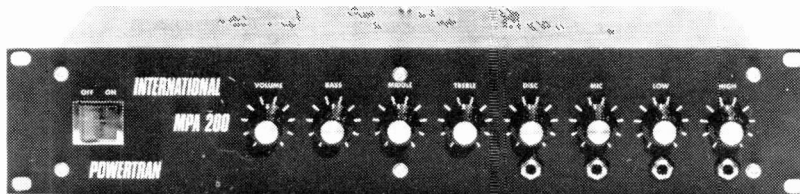
**COMPLETE KIT
ONLY
£49.50 + VAT!**

This versatile system featured as a constructional article in *ELECTRONICS TODAY INTERNATIONAL* has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound to light or have it strobe all the lights at a speed dependent upon music level or front panel control or use the internal digital circuitry which produces some superb random and sequencing effects. Each channel handles up to 500W and as the kit is a single board design wiring is minimal and construction very straightforward.

Kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. — Complete right down to the last nut and bolt!

THIS MONTH'S FRONT COVER FEATURE!

100 WATT (rms into 852) MIXER/AMPLIFIER



**COMPLETE KIT
ONLY
£49.90 + VAT!**

Parts to build power amp module only. (PCB, res, caps, s/cs)

£10.60 + VAT

Custom designed toroidal transformer with mounting clamp

£10.50 + VAT

Parts for power supply only (caps, rects, fuses, F. holders)

£3.40 + VAT

Kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. Complete right down to the last nut and bolt!

TRANSCENDENT 2000

SINGLE BOARD SYNTHESIZER

LIVE PERFORMANCE SYNTHESIZER DESIGNED BY CONSULTANT TIM ORR (FORMERLY SYNTHESIZER DESIGNER FOR EMS LIMITED) AND FEATURED AS A CONSTRUCTIONAL ARTICLE IN *ELECTRONICS TODAY INTERNATIONAL*.

The TRANSCENDENT 2000 is a 3 octave instrument transposable 2 octaves up or down giving an effective 7 octave range. There is portamento, pitch bending, a VCO with shape and pitch modulation, a VCF with both low and high pass outputs and a separate dynamic sweep control, a noise generator and an ADSR envelope shaper. There is also a slow oscillator, a new pitch detector, ADSR repeat, sample and hold, and special circuitry with precision components to ensure tuning stability amongst its many features.

The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or 1/2W metal trim) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibreglass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £700!

**COMPLETE KIT
ONLY
£172.00 + VAT!**

Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more elaborate than a multi-meter and a pair of ears!

POWERTRAN



Cabinet size 24.6" x 15.7" x 4.8" (rear) 3.4" (front)

**ORDERING INFORMATION
AND MORE KITS ON PAGE 6**

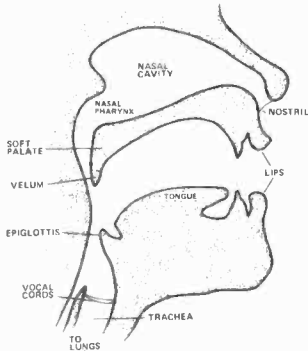
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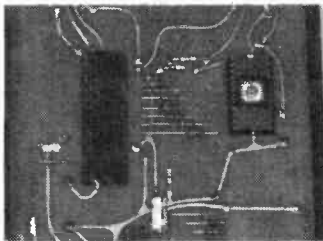
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FEATURES

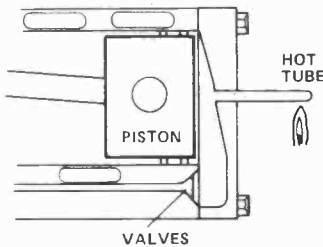
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TAPE NOISE LIMITER	41	Less hiss, more shhh!
LIGHT ACTIVATED TACHO	50	No contact, 10 RPM resolution.
100W DISCO AMPLIFIER	64	Hi-fi quality amp, versatile mixer.
TWONKY	79	Eat your heart out Bach!

DUE TO CONTINUING DEVELOPMENT WORK, AND SOME PROBLEMS ON THE PROTOTYPE WE HAVE HAD TO POSTPONE PART TWO OF THE CLICK ELIMINATOR. OUR APOLOGIES TO READERS

INFORMATION

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Publisher
Les Bell
Acting Editor

Holland Anton Kriegsman
Editor-in-Chief

CANADA Steve Braidwood
Editor
Graham Wideman
Assistant Editor

GERMANY Udo Wittig
Editor



ABC

EDITORIAL AND ADVERTISEMENT OFFICE
25-27 Oxford Street, London W1R 1RF. Telephone 01-434 1781/2. Telex 8811896

Halvor W. Moorshead	Editor
Ron Harris B.Sc	Assistant Editor
Gary Evans	Project Editor
Pete Howells	Production Editor
Paul Edwards	Technical Illustrator
Steve Ramsahadeo	Project Development
Margaret Hewitt	Administration
Kim Hamlin, Brenda Goodwin	Reader Services
Tim Salmon, Val Tregidgo	Advertising Manager
Mark Strathen	Provincial Advertising Manager
David Sinfield	Advertising Assistant
Joy Cheshire	

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It's W-W-WINTER S-S-

74 SERIES TTL IC's

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
7400	£0.07	7427	£0.21	7472	£0.19	7410	£0.22	7485	£0.05
7401	£0.09	7428	£0.25	7473	£0.22	7411	£0.55	7486	£0.35
7402	£0.09	7430	£0.25	7474	£0.22	7412	£0.55	7487	£2.80
7403	£0.09	7432	£0.20	7475	£0.27	7413	£0.75	7488	£0.80
7404	£0.09	7433	£0.28	7476	£0.22	7414	£1.10	7489	£0.80
7405	£0.09	7437	£0.20	7480	£0.40	7415	£0.22	7490	£0.85
7406	£0.22	7438	£0.20	7481	£0.80	7416	£0.35	7491	£0.85
7407	£0.22	7440	£0.10	7482	£0.65	7417	£0.38	7492	£0.80
7408	£0.12	7441	£0.45	7483	£0.55	7418	£0.50	7493	£1.25
7409	£0.12	7442	£0.38	7484	£0.82	7419	£0.50	7494	£0.55
7410	£0.09	7443	£0.68	7485	£0.65	7420	£0.54	7495	£1.00
7411	£0.15	7444	£0.68	7486	£0.22	7421	£0.65	7496	£0.68
7412	£0.14	7445	£0.64	7489	£0.60	7422	£0.45	7497	£0.64
7413	£0.22	7446	£0.60	7490	£0.30	7423	£0.45	7498	£0.55
7414	£0.05	7447	£0.45	7491	£0.60	7424	£0.80	7499	£0.80
7416	£0.22	7448	£0.52	7492	£0.32	7425	£0.48	7494	£0.55
7417	£0.22	7450	£0.09	7493	£0.28	7426	£0.48	7495	£0.55
7420	£0.09	7452	£0.09	7494	£0.70	7427	£0.48	7496	£0.60
7421	£0.39	7453	£0.09	7495	£0.45	7428	£0.55	7497	£0.58
7422	£0.15	7454	£0.09	7496	£0.48	7429	£0.60	7498	£1.00
7423	£0.20	7455	£0.09	7497	£0.80	7430	£0.60	7499	£1.00
7425	£0.18	7460	£0.09	7498	£0.35	7431	£0.60	7427	£1.00
7426	£0.11	7470	£0.24	7499	£0.35	7432	£0.65		

THYRISTORS

No. THY1A/50	1 Amp	50 volt	T05	18p
No. THY1A/400	1 Amp	400 volt	T05	32p
No. THY3A/50	3 amp	50 volt	T06	25p
No. THY3A/200	3 amp	200 volt	T06	32p
No. THY3A/400	3 amp	400 volt	T06	40p
No. THY5A/50	5 amp	50 volt	T06	25p
No. THY5A/400	5 amp	400 volt	T06	40p
No. THY5A/600	5 amp	600 volt	T06	50p
No. C106/4	6 Amp	400 volt	T0220	52p

TRIAC

S84	8 Amp	400 volt	T0220 Plastic	80p
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DIACS

ITT	V413	equivalent		12p
8R100	D37			12p

CAPACITOR PAKS

16201	18 Electrolytics	4.7µF — 10µF		
16202	18 Electrolytics	10µF — 100µF		
16203	18 Electrolytics	100µF — 680µF		

All 3 at SPECIAL PRICE of £1.20

16160	24 Ceramic Caps	22pF — 82pF		
16161	24 Ceramic Caps	100pF — 390pF		
16162	24 Ceramic Caps	470pF — 3300		
16168	24 Ceramic Caps	4700pF — 0.047µF		

All 4 at SPECIAL PRICE of £1.60

RESISTOR PAKS

Order No.	16213	60½W	100 ohm — 820 ohm	
	16214	60½W	1K — 8.2K	
	16215	60½W	10K — 82K	
	16216	60½W	100K — 820K	

All 4 at SPECIAL PRICE of £1.60

16217	40½W	100 ohm — 820 ohm		
16218	40½W	1W — 8.2K		
16219	40½W	1K — 8.2K		
16220	40½W	100K — 820K		

All 4 at SPECIAL PRICE of £1.60

VOLTAGE REGULATORS

Positive				
No. MVR7805	µA7805	T0220		55p
No. MVR7812	µA7812	T0220		55p
No. MVR7815	µA7815	T0220		55p
No. MVR7818	µA7818	T0220		55p
No. MVR7824	µA7824	T0220		55p

Negative				
No. MVR7905	µA7905	T0220		75p
No. MVR7912	µA7912	T0220		75p
No. MVR7915	µA7915	T0220		75p
No. MVR7918	µA7918	T0220		75p
No. MVR7924	µA7924	T0220		75p

µA723C	T099	38p	72723	14 pin Dil	38p
LM309K	T03	£1.20			

SWITCHES

No. 16178	5 x Mains Slide Switches	40p's
No. S17	5 x Miniature Slide Switches	40p's
No. S18	4 x Standard Slide Switches	40p's
No. S19	4 x Miniature Push to Make single hole mounting	40p's
No. S20	3 x Miniature Push to Break single hole mounting	40p's
No. S21	Push button Switch Pak 4 x Assorted types multi bank and singles latching and non-latching	£1.00's

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Order No.	127	Audio lead 5 pin DIN plug to 4 phono plugs	90p's
	29	Audio lead 5 pin plug to 5 pin DIN plug — Mirror Image	70p's
	130	5-metre lead 2 pin DIN plug to 2 pin DIN inline socket	45p's

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Order No.	S1	5 x 3.5 mm Plastic Jack Plugs	40p's
	S2	5 x 2.5 mm Plastic Jack Plus	40p's
	S3	4 x Sid Plastic Jack Plugs	50p's
	S4	2 x Stereo Jack Plugs	30p's
	S5	5 x 5 Pin 180° DIN Plugs	50p's
	S6	4 x 2 Pin Loudspeaker Plugs	50p's
	S7	6 x Phono Plugs Plastic	25p's
	S8	5 x 3.5 mm Chassis Sockets (Switched)	25p's
	S9	5 x 2.5 mm Chassis Sockets (Switched)	25p's
	S11	2 x Stereo Jack Sockets with instruction leaflet for Hi-Phone connection	50p's
	S12	5 x 5 Pin 180° DIN Chassis Sockets	40p's
	S13	8 x 2 Pin DIN Chassis Sockets	50p's
	S14	6 x Single Phono Sockets	40p's

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S110	Mixed Bundle P.C.B. Fibre-glass/paper single and double-sided Fantastic value	75p
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SPECIAL OFFER!

UNTESTED SEMICONDUCTOR PAKS

Code No's shown below are given as a guide to the type of device. The devices themselves are normally unmarked.

No. 16130	100 Germ. Gold bonded diodes like OA47	40p
No. 16131	150 Germ. Point contact diodes like OA70/81	40p
No. 16132	100 200mA Sil. diodes like OA200	40p
No. 16133	150 75mA Sil. Fast switching diodes like IN4148	40p
No. 16134	50 750mA Sil. top hat Rects.	40p
No. 16135	20 3 amp Sil. stud Rect.	40p
No. 16136	50 400mw Zeners D.O.7 case	40p
No. 16137	30 NPN Plastic trans. like 8C107/8	40p's
No. 16138	30 PNP Plastic trans. like 8C177/8	40p's
No. 16139	25 NPN trans. like 2N697/2N1711 T039	40p
No. 16140	25 PNP trans. like 2N2905 T039	40p
No. 16141	30 NPN trans. like 2N706 T018	40p
No. 16143	30 NPN Plastic trans. like 2N3906	40p's
No. 16144	30 PNP Plastic trans. like 2N3905	40p's
No. 16145	30 PNP Germ. trans. like OC71	40p
No. 16147	10 NPN T03 Power trans. like 2N3055	80p

I.C. SOCKET PAKS

No. S66	11 x 8 pin DIL Sockets	£1.00
No. S67	10 x 14 pin DIL Sockets	£1.00
No. S68	9 x 16 pin DIL Sockets	£1.00
No. S69	4 x 2 pin DIL Sockets	£1.00
No. S70	3 x 28 pin DIL Sockets	£1.00

MAMMOTH I.C. PAK

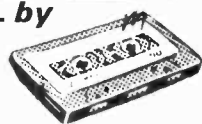
Approx. 200 Pieces. Assorted fall-out integrated circuits, including: Logic, 74 series, Linear, Audio and D.T.L. Many coded devices, but some unmarked — you to identify.

Order No. 16223 £1.00

MATCHED PAIRS OF PNP GERMANIUM MED. POWER TANS

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VCE	VCB	HFE	
NKT301	40 60	30-100	35p per pair
NKT302	40 60	50-100	35p per pair
NKT303	20 30	30-100	25p per pair
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UNIUNION TRANSISTORS

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FET's		
2N3819	15p	2N5458 18p

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BP202	Handbook of Integrated Circuits (IC) Equivalents and Substitutes	£0.75	£0.68
BP205	First Book of Hi-Fi Loudspeaker Enclosures	£0.75	£0.68
BP213	Electronic Circuits for Model Railways	£0.85	£0.77
BP214	Audio Enthusiast's Handbook	£0.85	£0.77
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BP220	Build Your Own Solid State Hi-Fi and Audio Accessories	£0.85	£0.77
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BP224	50 CMOS IC Projects	£0.95	£0.86
BP225	A Practical Introduction to Digital IC's	£0.85	£0.77
BP226	How to Build Advanced Short Wave Receivers	£1.20	£1.08

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500 off	£9.00
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Single-sided Fibre-glass Board. S143.

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16169	2 pieces Tuning gangs MW/LW	40p
16170	50 metres Single strand wire assorted wire	40p
16171	10 Reed switches	40p
16172	3 Microswitches	40p
16176	20 Assorted electrolytics	40p
16177	1 pack Assorted hardware nuts/bolts etc	40p
16179	20 Assorted tag strips and panels	40p
16180	15 Assorted control knobs	40p
16184	15 Assorted Fuses 100mA 5 amp	40p
16188	60 1/2W resistors mixed values	40p
16187	30 metres stranded wire assorted colours	40p
S100	120 1/2 watt resistors. Pre-formed 1978 Prod. Our mix	60p
S101	120 1/2 watt resistors. Pre-formed 1978 Prod. Mixed values	60p
S102	250 1/2 watt resistors Range 100 ohms-10 meg	£2.00
S103	250 1/2 watt resistors Range 100 ohms-10 meg	£2.00
S104	60 Low ohms 1/2 watt resistors 10-100 ohms	60p
S105	40 Low ohms 1/2 watt resistors 10 Ohms	60p
S106	25 Mixed wirewound resistors	60p
S107	20 Tantulum bead caps 0.22-100mF Our mix	£1.00
S108	High-quality electrolytics 10mF-500mF voltage range 15-50V Our mix 40 for	£1.00
16204	C280 Pak Contains 50 metal foil caps	£1.00

POTENTIOMETERS

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16191	6 x 470 Ohm LIN Single	40p
S24	6 x 1K LIN Single	40p
S25	6 x 5K LIN Single	40p
16193	6 x 22K LIN Single	40p
16195	6 x 47K LOG Single	40p
16194	6 x 47K LIN Single	40p
S27	6 x 100K LIN Single	40p
S28	6 x 100K LOG Single	40p
S29	6 x 500K LOG Single	40p

Slider 60mm TRAVEL

S30	6 x 2.5K LOG Single	40p
S32	6 x 50K LIN Single	40p
S34	4 x 5K LOG Dual	40p
S36	4 x 100K LOG Dual	40p
S37	4 x 1.3 MEG LOG Dual	40p
S94	6 x 220K LIN Single	40p
S95	6 x 100K LOG Single	40p
S96	6 x 500K LIN Single	40p

S38 Mixed slider pots—various values and sizes. our mix only £1.00

S39 6 x Chrome slider knots 40p

WIREWOUND

S90 Wirewound Pots. Linear 1 Watt ramping Mixed—useful values. 5 for £1.00

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S91 Car Radio type Dual Switched Pot P.C. mounting 100K Lin switched 2.5K Lin each 60p

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S92 4 x 100K Lin £1.00
S93 4 x 100K Log £1.00
16173 15 Rotary Pot Assorted 40p
16186 25 Pre-sets Assorted Values 40p

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No S56 mixed values 400mW Zener diodes 11-33V £1.00
No S57 10 mixed values 1W Zener diodes 3-10V £1.00
No S58 10 mixed values 1W Zener diodes 11-33V £1.00

SILICON POWER TRANS N.P.N.

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S98 2N5293 R.C.A. 36w 4 Amps 75Vceo Hfe 30-120—5 for £1.00

Crystal Ear Pieces

S126 Less plug £0.20

Plugs for above

No 16106 2.5 plastic £0.09
No 1667 3.5 plastic £0.11

Mono Crystal Cartridge

S127 GP91/15C Special Offer £1.00

Nickel Cadmium Rechargeable Batteries, 1.25v

S128 3500D Cell size = U2 £2.50
S129 900C Cell size = 1/2U11 £0.90
S130 Complete kit of parts to build nickel cadmium charger £3.50

Super Save Pak

S124 6x741P £1.00
S125 5x555 £1.00

S138 Surplus/End of Manufacturer's Line/Pre-amp. with Bass, Treble, Volume Control & circuit diagram supplied. **ONCE ONLY OFFER, £1.25.**

S137 20 Assorted Slider Knobs — Chrome/Black

£1.00

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COMPLETE AMPLIFIER KITS

STA15. 15 watts per channel amplifier kit. CONSISTS: 2xAL60 — 1xPA100 — 1xSPM80 — 1x2034 transformer — 2xcoupling capacitors. **£37.70 inc. V.A.T. + 85p p&p.**

STA25. 25 watts per channel amplifier kit. CONSISTS: 2xAL60 — 1xPA100 — 1xSPM120/45 — 1x2040 transformer — 1xreservoir capacitor — 2xcoupling capacitors. **£41.45 inc. V.A.T. + £1.16 p&p.**

STA35. 35 watts per channel amplifier kit. CONSISTS: 2xAL80 — 1xPA100 — 1xSPM120 — 1x2041 transformer — 1 reservoir capacitor — 2xcoupling capacitors. **£48.45 inc. V.A.T. + £1.16 p&p.**

STA50. 50 watts per channel amplifier kit. CONSISTS: 2xAL120 — 1xPA200 — 1xSPM120/65 — 1x2041 transformer — 1 reservoir capacitor — 2xcoupling capacitors. **£58.20 inc. V.A.T. + £1.16 p&p.**

STA125. 125 watts per channel amplifier kit. CONSISTS: 2xAL250 — 1xPA200 — 2xSPM120/65 — 2x2041 transformers — 1xreservoir capacitor — 2xcoupling capacitors. **£72.85 inc. V.A.T. + £1.25 p&p.**

TRANSISTORS

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AC107	25p	BC177	12p	BF194	9p	TIP32A	34p	2N1613	15p
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AC127	16p	BC179	12p	BF196	12p	TIP32C	36p	2N1893	28p
AC128	16p	BC182	9p	BF197	12p	TIP41A	34p	2N2218	15p
AC128K	24p	BC182L	9p	BF200	25p	TIP41B	35p	2N2218A	18p
AC176	16p	BC183	9p	BF209	22p	TIP41C	36p	2N2219	15p
AC176K	24p	BC183L	9p	BFX84	18p	TIP42A	36p	2N2219A	18p
AC187	16p	BC184	9p	BFY50	12p	TIP42B	37p	2N2221	16p
AC187K	26p	BC184L	9p	BFY51	12p	TIP2955	65p	2N2222	15p
AC188	16p	BC212	10p	BFY52	12p	TIP3055	42p	2N2222A	16p
AC188K	26p	BC212L	10p	MPSA05	22p	ZTX107	6p	2N2369	10p
AD161/162 MP	80p	BC213	10p	MPSA06	22p	ZTX108	6p	2N2904	14p
AF139	30p	BC213L	10p	MPSA55	22p	ZTX109	7p	2N2904A	15p
AF239	30p	BC214	10p	MPSA56	22p	ZTX300	7p	2N2905	14p
BC107	6p	BC214L	10p	OC44	12p	ZTX301	7p	2N2905A	15p
BC108	6p	BCY70	12p	OC45	12p	ZTX302	9p	2N2906	12p
BC109	6p	BCY71	12p	OC71	9p	ZTX500	8p	2N2906A	14p
BC117	10p	BCY72	12p	OC72	12p	ZTX501	10p	2N2907	12p
BC144	8p	BD115	40p	OC75	10p	ZTX502	12p	2N2907A	13p
BC148	8p	BD131	35p	OC81	14p	2N696	10p	2N2926G	8p
BC154	16p	BD132	37p	TIP29A	35p	2N697	10p	2N2926Y	7p
BC157	9p	BF115	17p	TIP29B	36p	2N706	8p	2N3053	12p
BC158	9p	BF173	20p	TIP29C	38p	2N708	8p	2N3055	35p
BC159	9p	BF180	25p	TIP30A	36p	2N1302	12p	2N3702	7p
BC169	10p	BF181	25p	TIP30B	37p	2N1303	15p	2N3703	7p
BC170	6p	BF182	25p	TIP30C	38p	2N1304	15p	2N3704	6p
BC171	6p	BF183	25p	TIP31A	32p	2N1307	18p	2N3903	11p
BC172	6p	BF184	25p	TIP31B	33p	2N1308	22p	2N3905	11p
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BA115	5p	8Y100	15p	BY219	28p	OA95	7p	IN5401	11p
BA144	5p	BY127	10p	OA47	5p	IN34	5p	IN5402	12p
BA148	10p	8Y210	32p	OA70	5p	IN60	6p	IN5404	13p
BA173	10p	8Y211	32p	OA79	7p	IN914	4p	IN5406	16p
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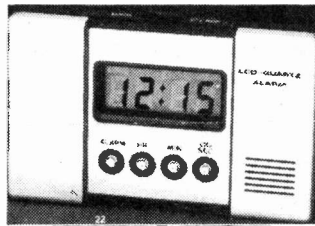
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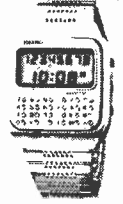
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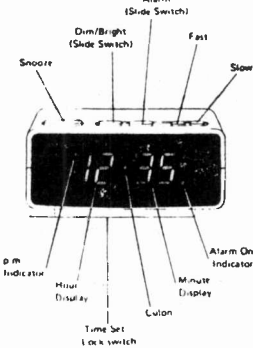
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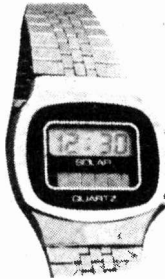
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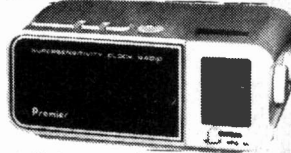
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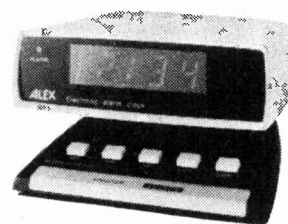
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MOD MAGS 1977 no 1

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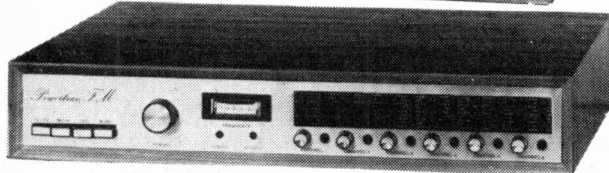
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cabinet size 17.2" x 17.2" x 6.7"

COMPLETE KIT ONLY £196.90 + VAT

READ THE REVIEW
IN SOUND INTERNATIONAL DEC. '78 !



T20 + 20 20W STEREO AMPLIFIER £33.10 + VAT

This kit, based upon a design published in Practical Wireless, uses a single printed circuit board and offers at very low cost, ease of construction and all the normal facilities found on quality amplifiers. A 30 watt version of this kit (T30 + 30) is also available for £38.40 + VAT.

POWERTRAN SFMT TUNER £35.90 + VAT

This is a simple low cost design which can be constructed easily without special alignment equipment but which still gives a first-class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the T20 + 20 and T30 + 30 amplifiers.

WWII TUNER £47.70 + VAT

This cost reduced model of our highly successful Wireless World FM Tuner kit was designed to complement the T20 + 20 and T30 + 30 amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with either. Facilities included are pre-aligned front-end module, switchable afc, adjustable switchable muting, LED tuning indication and both continuous and push-button channel selection (adjustable by controls on the front panel).

COMPLETE KITS: Our complete kits really are complete. All of the projects shown on this page are supplied with fully finished metalwork, ready assembled high quality teak veneer cabinet, cables, nuts, bolts, etc., and full instructions -- in fact everything!

All of the kits shown on this page are available as separate packs (except the Powertran SFMT Tuner) for those customers who wish to spread their purchase or perhaps make their own cabinets or metalwork. Prices are given in our FREE CATALOGUE.

PRICE STABILITY: Order with confidence irrespective of any price changes we will honour all prices in this advertisement until March 31st, 1979 if the February 1979 issue is mentioned with your order. Errors and VAT rate changes excluded.

EXPORT ORDERS: No VAT. Postage charged at actual cost plus 50p handling and documentation.

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SALES COUNTER: If you prefer to collect your kit from the factory, call at Sales Counter (at rear of factory). Open 9 a.m.-4.30 p.m. Monday-Thursday.

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As featured in *Electronics Today International*

400W rms continuous — 800W peak!

0.03% THD at FULL power!

PLUS all the following features too!

- * Each channel totally independent with its own stabilised power supply driven by custom designed TOROIDAL transformers!
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- * Easy to build — plenty of working space with ready access to all components, minimal wiring, extensive instruction suitable for both experience constructors and newcomers to electronics.
- * Value for money — quality and performance comparable with ready-built amplifiers costing over £600!

DE LUXE EASY TO BUILD LINSLEY HOOD
75W STEREO AMPLIFIER £99.30 + VAT

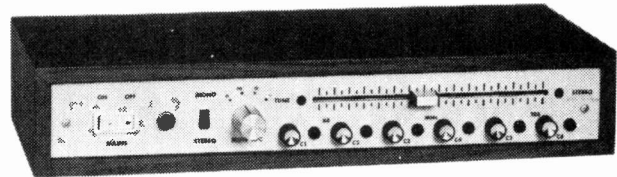
This easy to build version of our world-wide acclaimed 75W amplifier kit based upon circuit boards interconnected with gold plated contacts resulting in minimal wiring and construction delightfully straightforward. The design was published in Hi-Fi News and Record Review and features include rumble filter, variable scratch filter, versatile tone controls and tape monitoring whilst distortion is less than 0.01%.

WIRELESS WORLD FM TUNER £70.20 + VAT

A pre-aligned front-end module makes this Wireless World published design very simple to construct and adjust without special instruments. Features include an excellent a.m. rejection, push-button station selection as well as infinitely variable tuning and a phase locked loop stereo decoder incorporating active filters for "birdy" suppression.

LINSLEY-HOOD CASSETTE DECK £79.60 + VAT

This design, published in *Wireless World*, although straightforward and relatively low cost provides a very high standard of performance. There are separate record and replay amplifiers and switchable equalisation together with a choice of bias levels are also provided. The mechanism is the Goldring-Lenco CRV with electronic speed control.



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news digest.....



Light Emitting Damsels

FINDING a nice young lady on your desk first thing in the morning is a good way to start a day and, it happens, a nice way to start News Digest.

The lady this month is pictured with a new clock radio from Ingersoll Electronics. Featuring MW/FM/LW with a 12-hour LED display the clock incorpo-

rates the usual alarm, snooze features.

The model XK802 has push-button controls along the top of the unit allowing a fast and slow timeset facility.

The clock is available from most larger electrical stores and at a recommended price of £34.00, is good value.

Clubs From Newcastle

The formation of a new society, whose aim is to promote personal computing in the Newcastle area, should be of interest to some of our Northern friends.

Meetings usually comprise of a lecture, informal discussions and the demonstration of a particular

system.

Further details from Dr. W. G. Allen, Dept. of Elec. Eng. and Physical Elect.,

Newcastle upon Tyne Polytechnic, Newcastle upon Tyne.

Raspberries to EMI!!

A fruity tale this. I assure you we are not winding you up. Right? Read on. . . . A team of engineers has been disguising acceleration transducers, accelerometers — which convert force into electrical energy — as Raspberries. And hanging them out on bushes.

The number of comments one could make at this point is truly staggering, so one will say nothing at all.

As anyone (?) knows picking raspberries is a sticky process. When ripe they are soft and fragile and liable to squash flat at the drop of a basket. Furthermore they hide beneath leaves upon brittle and lethal canes.

Automation is called for. Automation has arrived.

Only problem is the prototypes smashed the berries to a pulp in no time flat. Slim pickings, and this is where our men in white

coats with the fake raspberries come in. Hang these little fakers out with the real berries and if the machine doesn't smash them to bits too, you know exactly what forces are being produced at the crucial parts, and can adjust your machinery accordingly. Clever eh?

EMI produce the transducers, called Entran, and the Scottish Institute of Agricultural Engineering are the loonies. . . . er engineers who produced the model raspberries and went out hanging them — full moon?)

The actual accelerometers are only 3.6mm square, and give out 1mV for every 'g' of acceleration they are subjected to. The false fruits are wired up to both magnetic and pen-recorders to give full details of the fall of the raspberries. (I didn't believe it first time either. . . .)

Projected Index

Now this is one of those ideas that someone should have thought of long ago, and now that someone has the rest of us must hang our heads in shame and wonder why we didn't. . . .

A very clever man called M. L. Scaife has compiled a complete index of all electronic projects appearing in all the relevant magazines from 1972-1977. Next year a second listing will appear which will bring the index completely up to the minute.

Some 2500 projects are listed, all with brief description where components where applicable, a list of how many components are

used in each — and what they are — method of construction PCB, Veroboard etc, and source. Our sister magazine ETI is naturally included as are all ETI Specials.

Subjects are sensibly grouped together to make browsing easy and the listings clearly and precisely done.

This truly amazing piece of work costs only £1.50 a copy from the patient M. L. Scarfe at: Central Library, Northumberland Square, North Shields, Tyne and Wear. Recommended in the strongest possible terms to all who ever intend to build a project again.

Pray Tell Prestel

LONDON'S Portman Hotel has become the first hotel to feature Prestel viewdata as a permanent feature at the hotel. The set, a Baird 26 colour model has been specially installed in the lobby where guests can access pages of information.

General Manager, Michel Favre, was first off the mark with Prestel with the help of Radio Rentals Contracts executives who, only eighteen months earlier, gave the Portman the first of 100 commercially installed teletext receivers at the hotel.

Technically Speaking

Computer Speech has come a long way since the Daleks first clanked their way across the TV screen. In the USA add-on devices for home systems (peripherals) can be purchased to make the small system talk in a reasonable — at least recognisable manner.

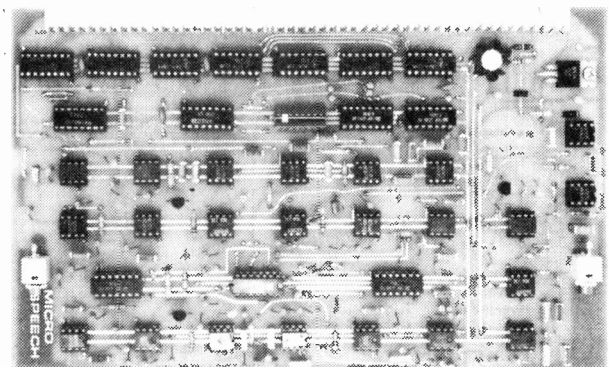
Microspeech is the first such unit to be released in the UK as far as we are aware. As you can see from the photo it is not a massive system at all. The program for the board converts typed in phonetic speech from the keyboard into sets of data which is then transmitted to the synthesiser.

There are nine parameters controlled by the unit which make possible manipulation of

the frequency, amplitude and resonance of the final sound, and in this manner male speech can be reasonably imitated.

Microspeech also has an external input which enables it to produce 'talking instrument' effects from guitars and the like. The data coming out is converted back to audio form by an 8-bit digital-to-analogue (DAC) converter using nine sample and hold circuits which can 'store' information for well over a minute.

Relatively little memory is used up by the system, and any system using BASIC in its language can be adopted to operate with Microspeech. Costronics, 13 Field Heath Avenue, Hillingdon, Middx.



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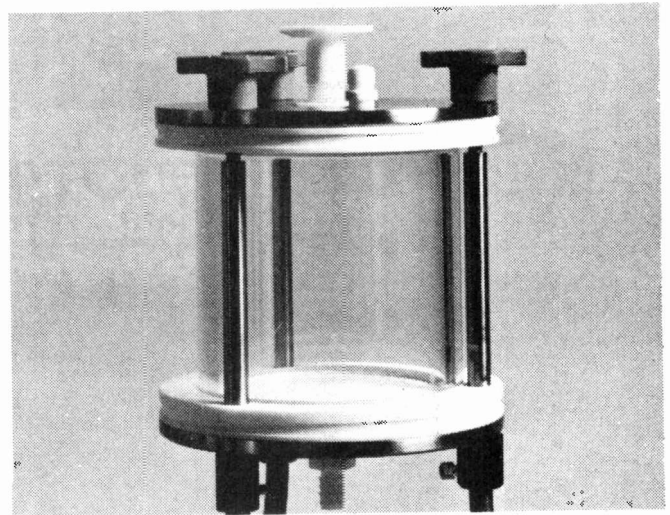
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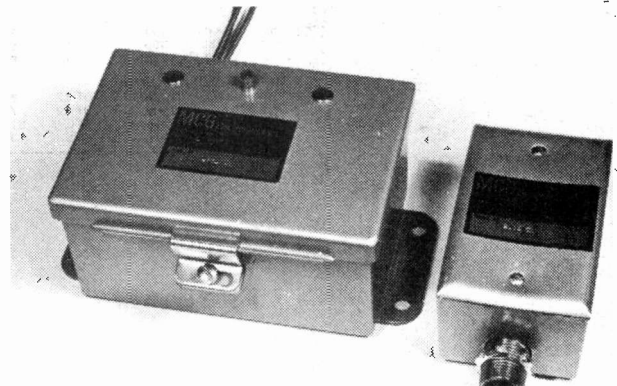
Technical Enquiry

WHEN this photo arrived on our desk it had been parted from the words which, probably, accompanied it when it entered our post

room.

We have no idea what it is or does — any suggestions would be gratefully received.

TRAP Transients



A RANGE of mains transient absorbers is now available from Rhopoint Ltd, of Oxted, Surrey. Manufactured by MCG Electronics Inc, of USA, these transient absorbers are designed to protect electrical and electronic equipment from mains borne high energy transients and spurious spikes, etc., on 120, 240 and 480 volts lines 50/60/400 Hz single phase and three phase, star or delta.

Operating in parallel with the mains supply, they control unwanted transients that appear on the mains supply to the user and are independent of the load drawn by the equipment from the

supply. All voltages are clamped to just above the peak value of the mains and up to 480 joules of energy can be absorbed. The transients are clamped to a level where they are unable to cause interference or corruption, for example, of digital logic in difficult control areas. As such these transient absorbers are ideal for use in computer installations, process control instrumentation and with equipment where reliability of data information is critical and random equipment failure due to transients would be serious. Strategically placed MCG transient absorbers can protect this vulnerable equipment.

OHIO SCIENTIFIC

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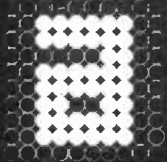


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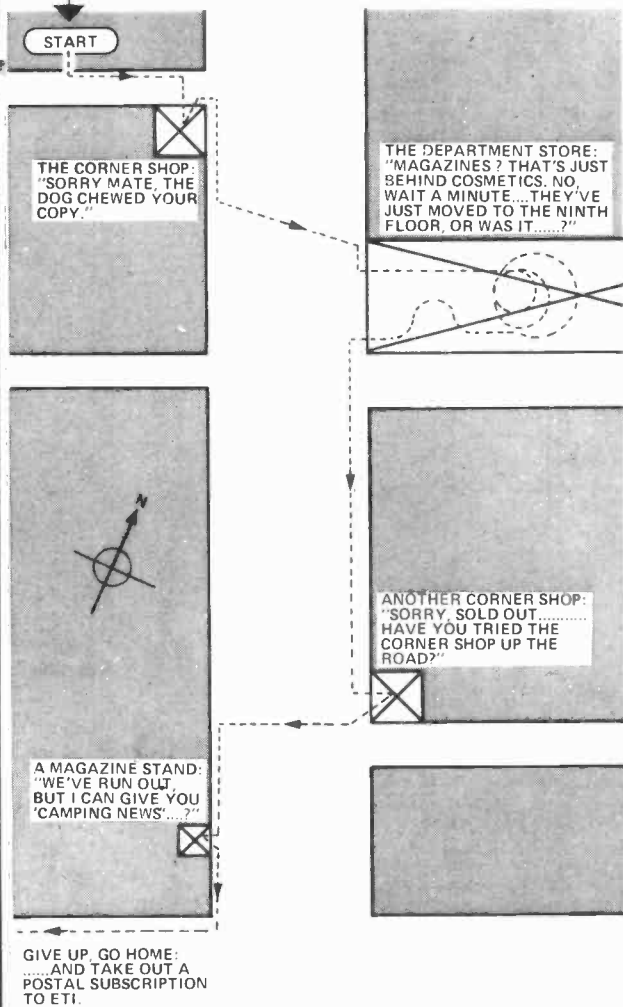
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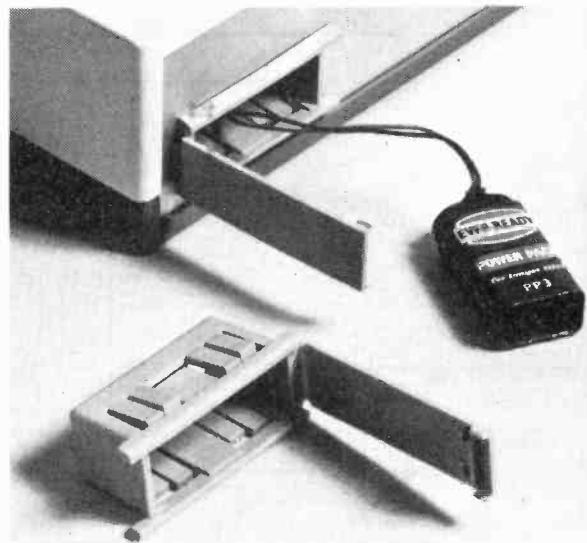
Although ETI is monthly, it's very rare to find it available after the first week. If it is available, the newsagent's going to be sure to cut his order for the next issue — but we're glad to say it doesn't happen very often.

Do yourself, your newsagent and us a favour. Place a regular order for ETI; your newsagent will almost certainly be delighted. If not, you can take out a postal subscription so there's nothing for you to remember — we'll do it for you.

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Now Hear The Word of VERO

MOST battery powered equipment inevitably has numerous screws connecting the front panel to the circuit board, the circuit board chassis, the chassis to the case — now hear the word of Vero.

No longer is it necessary to dismantle a complete project to get to a poor exhausted battery, with their inspection-moulded battery housing you can provide access to the battery from outside the unit.

The holder accepts a 9V battery and may be easily fitted to a panel or enclosure with a thickness of 1,5 to 3mm. All that

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Vero Electronics Limited, Industrial Estate, Chandler's Ford, Eastleigh, Hampshire SO5 3ZR.

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OK stock a range of several hundred different hand tools, from pliers and cutters to special wire strippers and screwdrivers. Additionally they offer an extremely broad range of electronic production and servicing aids which includes powered and manual terminal wire wrapping guns as well as conventional sol-

dering irons plus the necessary wire and dispensers.

From this selection the company can assemble kits to order, from simple canvas "rolls" to well-packed executive briefcases, and will quote for packages costing from just a few pounds to several hundred pounds. Furthermore, there is no minimum order requirement.

For further details contact: Michael Gouldsmith, OK Machine & Tool (UK) Ltd, 48a The Avenue, SOUTHAMPTON, Hants SO1 2SY.

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3.5mm 15p	10p	8p	8p	DPST 34p	4 pole 2-way	PUSH BUTTON	24p
MONO 23p	15p	13p	13p	DPDT 38p	4 pole on/off	Spring loaded	
STEREO 31p	18p	15p	15p	SUB-MIN TOGGLE	SPST on/off	DPDT 6 tag	60p
				SP changeover	SPST c/over	DPDT 6 tag	65p
				SPST on/off	MINIATURE	Non Locking	
				SPST biased	Push to Make	Push Break	15p
				DPDT 6 tags			25p
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				DPDT Biased			

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12V: 4.5V-1.3A 4.5V-1.3A 6V-1.2A 6V-1.2A	4x4x1 1/2 88	0-100uA
12V-5A 12V-5A 15V-4A 15V-4A 20V-3A	4x2 1/2x1 1/2 80	0-500uA
20V-3A 220p (20p p&p)	4x5 1/2x1 1/2 78	0-1mA
24VA: 6V-1.5A 6V-1.5A 9V-1.3A 9V-1.3A	4x2 1/2x2 84	0-5mA
12V-1A 12V-1A 15V-8A 15V-8A 20V-6A	5x4x2 82	0-10mA
20V-6A 280p (45p p&p)	6x4x2 86	0-50mA
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12V-2A 15V-1.5A 15V-1.5A 20V-1.2A 20V-1.2A	8x6x3 118	0-500mA
1 2A 25V-1A 25V-1A 30V-8A 30V-8A 350p	10x7x3 172	0-1A
(50p p&p)	10x4x3 142	0-25V
100VA: 12V-4A 12V-4A 15V-3A 15V-3A	12x5x3 165	0-50V AC
20V-2.5A 20V-2.5A 30V-1.5A 30V-1.5A	12x8x3 210	0-300V AC
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447	144	4024	66	4052	72	4097	372	4502	120
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		4029	99	4059	480	4162	109	4510	99
		4030	58	4060	115	4163	109	4511	150
		4031	205	4063	110	4174	110	4512	98
		4000	15	4031	100	4066	58	4175	99
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		4008	87	4036	325	4070	32	4410	720
		4009	50	4037	100	4071	21	4412F	1650
		4010	50	4038	108	4072	21	4412V	1380
		4011	18	4039	320	4073	21	4415F	795
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Radio Television and Audio Test Instruments King £5.90

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Electronic Fault Diagnosis Sinclair £3.20
Rapid Servicing of Transistor Equipment G. King £2.95
Tape Recorder Servicing Manual Gardner Vol. 1: 1968-70 £8.50
Vol. 2: 1971-74 £8.50
FM Radio Servicing Handbook King £4.80
Basic Electronic Test Procedures J. M. Gottlieb £2.45

COMMUNICATIONS

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Digital Signal Processing Theory & Applications L. R. Rabiner £23.80
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Frequency Synthesis. Theory & Design Mannassewitsch £21.70
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Transistor Circuit Design Texas Instruments £9.35
Essential Formulae for Electrical and Electronic Engineers N. M. Morris £1.65
Modern Electronic Maths Clifford £6.70
Semiconductor Circuit Elements T. D. Towers £6.40
Foundations of Wireless Electronics M. G. Scroggie £4.45
Colour Television Theory Hudson £6.20

REFERENCE

Transistor Tabelle (Includes physical dimensions) £4.10
Electronic Engineers Reference Book (Ed. 4) L. W. Turner £27.70
Solid State Circuit Guide Book B. Ward £2.25
Electronic Components M. A. Colwell £2.45
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World Radio TV Handbook 1978 (Station Directory) £8.00
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TV Technicians Bench Manual (New Ed.) Wilding £5.10

MISCELLANEOUS

Integrated Electronics J. Milman £7.90
Microelectronics Hallmark £3.90
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K006 Tantalum bead capacitors 10 each of the following: 0.1, 0.15, 0.22, 0.33, 0.47, 0.68, 1, 2.2, 3.3, 4.7, 6.8, all 35V; 10/25, 15/16, 22/16, 33/10, 47/6, 100/3. Total 170 tants for **£14.20**

K007 Electrolytic capacitors 25V working, small physical size. 10 each of these popular values: 1, 2.2, 4.7, 10, 22, 47, 100µF. Total 70 for **£3.50**

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K021 Miniature carbon film 5% resistors, CR25 or similar. 10 of each value from 10R to 1M, E12 series. Total 610 resistors **£6.00**

K022 Extended range, total 850 resistors from 1R to 10M **£8.30**

K041 Zener diodes, 400mW 5% BZY88, etc. 10 of each value from 27V to 36V, E24 series. Total 280 for **£15.30**

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Complete and ready built Controls. Bass, treble, volume/on-off, balance. 8 transistor circuit gives 2 watts per channel output. Just needs transformer and speakers for low cost stereo amp. Suitable metal cabinet (W374) **£2.00** — or buy the amp, case and transformer for **£10.00** and get DIN speaker sockets and knobs free!

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Mono gen purpose amp with tone and vol./on-off controls. Utilizes sim. circuitry to above amp. Output 2W into 8 ohms. Input matched for crystal cartridge. 4 transistor circuit. Simple to build on PCB provided. Can be either battery or mains operated. (For mains powered version add **£2.20** for suitable transformer). Blue vinyl covered aluminium case to suit (W372) **£1.30**.

BC182B OFFER

Special Offer for quantity users 1k 035 + VAT; 5k 032 + VAT Price negotiable on 10k + approx 80k available

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Now contains 200 sq ins. copper clad board, 1lb Ferric Chloride, DALO etch-resist pen, abrasive cleaner, two miniature drill bits, etching dish and instructions **£4.25**.

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Special purchase of these 0.1" pitch double-sided gold-plated connectors enables us to offer them at less than one-third of their original list price! 18 way **41p**; 21 way **47p**; 32 way **72p**; 40 way **90p**.

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2 pin switched speaker socket, PC mntg; 5 pin 180° PC mntg or chassis mntg. (clip fix). All the same price, any mix 10 for **70p**; 25 for **£1.60**; 100 for **£5.50**.

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Lots of diff. types illustrated in Bargain List No. 6 — send SAE for your copy

RELAYS

WB47 Low profile PC mntg 10 x 33 x 20mm 6V coil, SPCO 3A contacts **93p**. WB32 Sub min type, 10 x 19 x 10mm 12V coil DPCO 2A contacts **£1.15**. W701 6V SPCO 1A contacts 20 x 30 x 25mm. Only **56p**.

WB17 11 pin plug in relay, rated 24V AC, but works well on 6V DC. Contacts 3 pole c/o rated 10A **95p**.

WB19 12V 1250R DPCO 1A contacts Size 29 x 22 x 18mm min plug-in type **72p**.

WB39 50V ac (24V DC) coil 11 pin plug-in type 3 pole c/o 10A contacts. Only **85p**.

WB46 Open construction mains relay. 3 sets 10A c/o contacts **£1.20**.

Send SAE for our relay list — 84 types listed and illustrated.

LOW COST PLASTIC BOXES

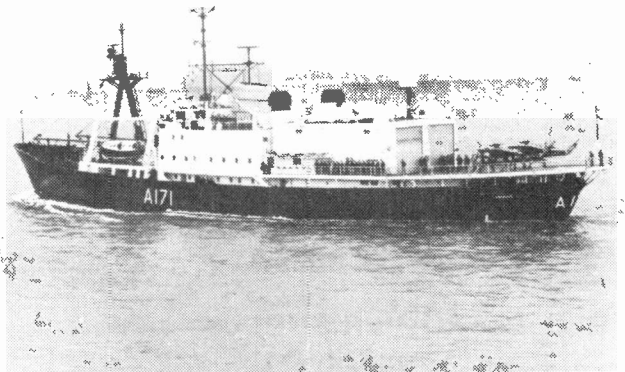
Made in high impact ABS. The lids are retained by 4 screws into brass inserts. Interior of box has PCB guide slots (except V219).

V210 80x62x40mm black **58p**
V213 100x75x40mm black **72p**
V216 120x100x45mm black **86p**
V219 120x100x45mm white **86p**

DIODE SCOOP!!!

We have been fortunate to obtain a large quantity of untested, mostly unmarked glass silicon diodes. Testing a sample batch revealed about 70% useable devices — signal diodes, high voltage rets and zeners may all be included. These are being offered at the incredibly low price of **£1.25**/1,000 — or a bag of 2,500 for **£2.25**. Bag of 10,000 **£8**. Box of 25,000 **£17.50**. Box of 100,000 **£60**.

.....news digest.....



IMRC SATCOM For RN

THE Royal Navy has had installed its first shipborne communications terminal for working via commercial maritime satellites. Supplied by International Marine Radio Company (IMRC) of Croydon, the terminal has been fitted into a Navy ice patrol vessel, HMS Endurance.

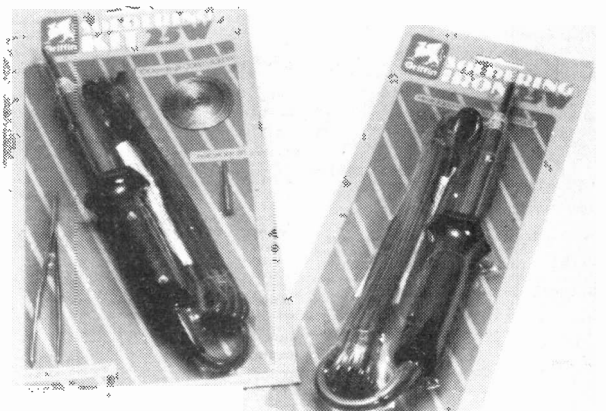
About a year ago the Navy, which had been watching the performance of the Marisat system, decided that there might be advantages in using commercial satellite communications for some of its non-strategic applications. The Navy sees the system being used, initially, on Naval auxiliary craft such as ice patrol vessels and perhaps, hydrographic survey ships. There are at present about 150 Marisat terminals on board merchant

ships — including one on the QE2.

The terminal receives and transmits via retransmission from a satellite in synchronous orbit. That is, one which maintains its position over a particular point on the globe.

At present there are three such satellites, at 22,240 miles altitude over the Atlantic, Pacific and Indian Oceans. Corresponding shore stations are in Connecticut and California, with one in Japan serving the Indian Ocean satellite. These shore stations interconnect with the worldwide telephone/data and telex networks. Thus, a ship equipped with an appropriate terminal can exchange messages with any other telephone or telex user. Telex, voice, facsimile and data communications are also possible.

Cast Iron Seller



DAVID Griffin Ltd of Blandford, Dorset, has produced the Griffin Soldering Kit, which includes a 25-watt soldering iron, a spare fine work bit, a reel of multi-core solder and a pair of tweezers. The

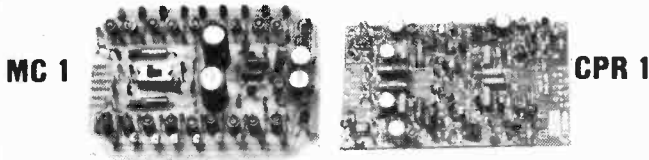
Griffin soldering iron is also available separately.

The expected retail price for the kit is £4.50 and £3.50 for the soldering iron.

TOTAL AMPLIFICATION FROM CRIMSON ELEKTRIK

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STEREO PRE-AMPLIFIERS



CPR 1—THE ADVANCED PRE-AMPLIFIER

The best pre-amplifier in the U.K. The superiority of the CPR 1 is probably in the disc stage. The overload margin is a superb 40dB, this together with the high slew rate ensures clean top, even with high output cartridges tracking heavily modulated records. Common mode distortion is eliminated by an unusual design R.I.A.A. is accurate to 1dB, signal to noise ratio is 70dB relative to 3.5mV, distortion < 0.05% at 30dB overload 20kHz. Following this stage is the flat gain/balance stage to bring tape, tuner, etc., up to power amp signal levels. Signal to noise ratio 86dB; slew-rate 3V/uS; T.H.D. 20Hz - 20kHz < 0.008% at any level. F.E.T. muting. No controls are fitted. There is no provision for tone controls. CPR 1 size is 138 x 80 x 20mm. Supply to be ± 15 volts.

MC 1 PRE-AMPLIFIER

Suitable for nearly all moving-coil cartridges. Sensitivity 70/170uV switchable on the p.c.b. This module brings signals from the now popular low output moving-coil cartridges up to 3.5mV (typical signal required by most pre-amp disc inputs). Can be powered from a 9V battery or from our REG 1 regulator board.

REG 1 — POWER SUPPLY

The regulator module, REG 1 provides 15.0-15v to power the CPR 1 and MC 1. It can be used with any of our power amp supplies or our small transformer TR 6. The power amp kit will accommodate it.

POWER AMPLIFIERS

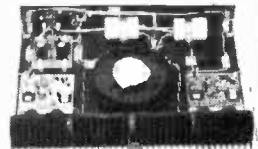
It would be pointless to list in so small a space the number of recording studios, educational and government establishments, etc., who have been using CRIMSON amps satisfactorily for quite some time. We have a reputation for the highest quality at the lowest prices. The power amp is available in five types; they all have the same specification T.H.D. typically 0.1% any power 1kHz 8ohms; T.I.D. insignificant; slew rate limit 25V/uS; signal to noise ratio 110dB; frequency response 10Hz-35kHz, -3dB; stability unconditional; protection devices any load safety; sensitivity 775mV (250mV or 100mV on request); size 120 x 80 x 25mm.

POWER SUPPLIES

We produce suitable power supplies which use our superb TOROIDAL transformers only 50mm high with a 120-240 primary and single bolt fixing (includes capacitors/bridge rectifier).

POWER AMPLIFIER KIT

The kit includes all metalwork, heatsinks and hardware to house any two of our power amp modules plus a power supply. It is temporarily styled and its quality is consistent with that of our other products. Comprehensive instructions and full back-up service enables a novice to build it with confidence in a few hours.



POWER AMPLIFIER MODULES			
CE 508 60W/8 ohms 35-0-35v	£16.30		
CE 1004 100W/4 ohms 35-0-35v	£19.22		
CE 1008 100W/8 ohms 45-0-45v	£23.22		
CE 1704 170W/4 ohms 45-0-45v	£29.12		
CE 1706 170W/8 ohms 60-0-60v	£31.90		
TOROIDAL POWER SUPPLIES			
CP51 for 2 x CE 608 or 1 x CE 1004	£14.47		
CP52 for 2 x CE 1004 or 2/4 x CE 608	£16.82		
CP53 for 2 x CE 1008 or 1 x CE 1704	£17.86		
CP54 for 1 x CE 1008	£15.31		
CP55 for 1 x CE 1708	£22.68		
CP56 for 2 x CE 1704 or 2 x CE 1708	£23.98		
HEATSINKS			
Light duty, 50mm, 2 C/W	£1.30		
Medium power, 100mm, 1.4 C/W	£2.20		
Disc/group, 150mm, 1.1 C/W	£2.85		
Fan, 80mm, state 120 or 240v	£18.50		
Fan mounted on two drilled 100mm heatsinks, 2 x 4 C/W, 65 C max with two 170W modules	£29.16		
THERMAL CUT-OUT, 70 C	£1.90		
POWER AMP KIT			£32.40
PRE-AMPS:			
These are available in two versions — one uses standard components, and the other (the SJ) uses MO resistors where necessary and tantalum capacitors.			
CPRI	£29.49	CPRI5	£39.98
MCI	£18.50	MCIS	£29.49
POWER SUPPLY:			
REG1	£6.75	TR6	£1.75
BRIDGE DRIVER, BDI			
Obtain up to 340W using 2 x 170W amps and this module, BDI			£5.40

Distributor
Mimic Teleprodukt
Box 12035
S-750 12
Uppsala 12
Sweden

CRIMSON ELEKTRIK

1A STAMFORD STREET, LEICESTER LE1 6NL. Tel. (0533) 537722

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BOWMAR 9 DIGIT CALCULATOR DISPLAY with PC connector 0.2 digits. Common cathode with red bezel £1.25 ea. 10 for £10, 100 for £85.

TEXAS 19 gold-plated snap key contact on gold-plated P.C. board. Size 70x80x2mm 75p ea. **ORP12** light dependent resistance (Eq = RPY30) 2 for £1, 10 for £4, 100 for £35.

FAIRCHILD FND100 15' 7 segment display. C cathode 50p, 10 for £4.50, 100 for £40.

TBA 120A T.V. I.C. amplifier Siemens 75p, 10 for £6, 100 for £50, 1,000 for £350.

BECKMAN 500 kcs Triggerable clocking oscillator for use with calculator chips 5v supply with circuit £1, 10 for £8, 100 for £65.

BURROUGHS 9 DIGIT Panaplex calculator display 7 segment 0.25" digits Neon type with red bezel socket and data £1.95 ea. 10 for £17.

ALMA PUSHBUTTON high reliability reed switches. Push to make 18x27x18mm 40p ea. 10 for £3.50, 100 for £30.

SMITHS INDUSTRIES Audible warning devices 8-12 volts, 2 transistors 30x10mm encapsulated 50p ea. 10 for £4, 100 for £35, 1,000 for £300.

HONEYWELL PROXIMITY DETECTOR integral amplifier 8v D.C. £2.50 ea. 10 for £20, 100 for £175.

OSMOR CHANGE OVER REED RELAY 12v coil 20m/α operating current 59x17x13mm 75p ea. 10 for £5, 100 for £45, 1,000 for £400.

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XES11 Erase	£1.25	£10.00

MULLARD AD161—AD162 Matched pairs 10 pairs 100 pairs 500 pairs
£1.00 £8.00 £70.00 £300.00
Cartons of 600 pairs £350 Ex-stock

SOLDER (multicore type) Servico
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RADIATION DETECTORS Quartz Fibre Dosimeters. Pen type with clip with lens and scale 0.50R Originally over £5 **OUR PRICE 95p EACH**, 10 for £8, 10 for £60, 1,000 for £500.

CLOCKING OSCILLATOR (Pye-Dynamics) thick film 1MHz supply 5v 19x25x6mm 85p, 10 for £7, 100 for £60

T.V. TUNERS by G.E.C. U.H.F. 38 mcs size 37x22x11 1/4 £2.50 ea. 10 for £20, 100 for £175, 500 for £750, 1,000 for £1,250.

TV SOUND TUNER KIT.

Through your F.M. tuner. Kit of parts with instructions £5.50. Ready-built tested £7.00.

JOYSTICK CONTROLS. (Ideal for TV Games model control) sturdily constructed compact giving full 360° movement and control. Each unit fitted 4-off 100K linear controls. Pair £4.00.

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SEVEN DIGIT MINIATURE COUNTER by Durant 12-24 volts D.C. 3 Watts. Size 40x25xH 55L mm £1 each, 10 for £9, 100 for £80.

2N3055A TO3 POWER 80 VOLT VERSION. 10 for £2.50, 100 for £22.00, 1,000 for £200.

TRANSISTORS BY MULLARD, TEXAS, FAIRCHILD

Price ea per	Quantity prices			
	10	100	500	1,000
AC128	0.230	0.200	0.180	0.150
AD149	0.750	0.650	0.550	0.490
AD161	0.380	0.330	0.290	0.250
AD162	0.380	0.330	0.290	0.250
BC107	0.100	0.085	0.075	0.065
BC109	0.110	0.095	0.080	0.070
BC109C	0.120	0.100	0.085	0.075
BC114	0.080	0.065	0.050	0.040
BC132	0.080	0.065	0.050	0.040
BC153	0.085	0.070	0.055	0.045
BC172	0.075	0.060	0.050	0.040
BC173	0.075	0.060	0.050	0.040
BC205	0.070	0.055	0.040	0.035
BC208C	0.075	0.060	0.050	0.040
BC209	0.075	0.060	0.050	0.040
BD181	0.600	0.500	0.440	0.400
BD182	0.700	0.600	0.500	0.440
BF181	0.240	0.200	0.185	0.160
BFY50	0.180	0.16	0.140	0.125
BFY51	0.180	0.160	0.140	0.125
BFY64	0.220	0.195	0.175	0.150
BFY90	0.750	0.680	0.630	0.550
BU205	1.00	0.900	0.800	0.750
BU208	1.250	1.100	1.000	0.950
BY127	0.110	0.090	0.075	0.065
CA3085	0.440	0.385	0.350	0.300
LM311H	0.700	0.600	0.550	0.500
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LD300K LIGHTDIMMER. £3.00.

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Based on the 7106 single IC 3 1/2 digit DVM the kit contains a PCB, resistors, capacitors, pre-sets, IC and 0.5 liquid crystal display. Components are also included to enable the basic DVM kit to be modified to a Digital Thermometer using a single transistor as the sensor.



ONLY £21.99

24 HR. CLOCK/APPLIANCE TIMER KIT

Switches any appliance of up to 1KW on and off at preset times once a day. KIT contains AY-5-1230 Clock/Appliance Timer IC, 0.5 LED display, mains supply, display drivers, switches, LEDs, triac complete with PCBs and full instructions. White box (56x131x71mm)—drilled £2.50 undrilled £2.20 Ready-built £22.50



Ready-built

TRIAC BARGAINS

400V Plastic Case	58p
3A	80p
6.5A with trigger	84p
8A	74p
12A	84p
16A	105p
20A	165p
25A	190p
SCR (C106D) 5A/400V	50p
Diac	21p

COMPONENTS

0.2" L.E.D.S.	
Red 12p	£1.10
Green 21p Yellow	25p
DL727 5 display	£1.10
LCD 5' 4 digit	£8.50
LDR 5" dia	50p
NE555 (4 for £1.00)	
741 (5 for £1.00)	
LM3911 temperature IC	£1.00
AY-5-1224	£3.25
AY-5-1230	£4.85
ZN1034E	£1.80
ICL7106 DVM IC	£9.25
1N4001	6p
1N4148	4p
8C182L	10p
2N3819	20p

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Standard 240V mains primary 100mA secondary	
6.0-6V	85p
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12 -0-12V	95p

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Buy it with Access **HENRY'S RADIO** All mail to: Henry's Radio 404 Edgware Rd London W2 Phone (01) 723 1008

COMPUTER SPEECH

Tim Orr takes a rest from his circuit mania this month to explain how speaking machines are moving off the TV screen and into the home computer market.

COMMUNICATION VIA SPEECH is a tremendously efficient way of transmitting information. A computer terminal with just a VDU or a hard copy printer compels the operator to be continually looking at the display. This limits the operator's freedom to do other jobs, such as controlling equipment, reading literature, typing, etc. If the computer had the option of being able to talk how much easier many operations would become. VDU's could also 'talk' their data and computer games could speak their instructions.

Computers have had this 'speech' option for many years, but as technology has improved, the size and cost of the equipment has been reduced to realistic proportions and the speech quality has got better. The microprocessor boom has helped this process and there are now several peripheral plug-ins that can be made to talk and even 'listen and understand'!

ROM For Improvement?

There are many methods by which a computer can generate speech. Some systems use a library of stored spoken text on a disc, just as the speaking clock does. Short phrases and individual words are sequentially selected by the computer programme and strung together to form the desired sentence.

This technique is fine for some applications, where the set of phrases is small or where there will be no need

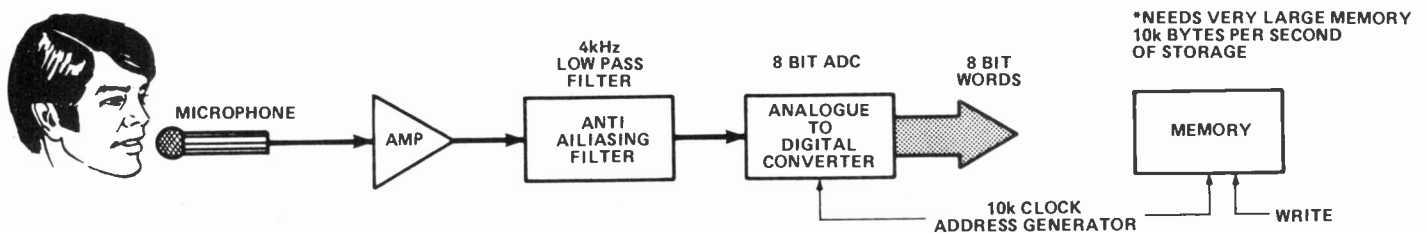
to change them, because this means changing the disc. However, the unit is physically large and suffers from all the faults of any mechanical system.

An all electronic method of speech storage can be implemented using ROM's. Spoken words can be converted into a digital code (using an ADC), and programed into a ROM. Various words and phrases can then be selected by the computer and used to generate sentences by converting the reassembled data back into analogue information. This technique is the same in concept as the disc method, only the storage medium is electronic.

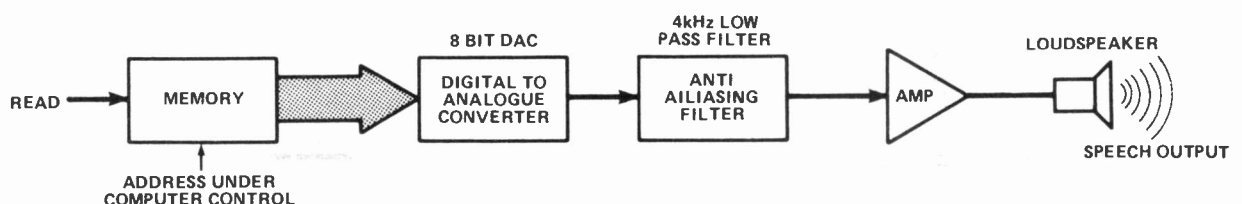
However, this type of storage would require enormous amounts of memory to generate short pieces of speech, because the unfortunate fact of life is that about 95% of the information stored by this method is redundant. The redundancy problem can be overcome by doing some special coding on the information. Linear predictive coding is one such technique, and this can result in very efficient ways of storing speech.

As A Rule

Yet another method of generating speech, which certainly gives the most versatile output (and is undoubtedly the most complicated solution) is SPEECH SYNTHESIS BY RULE, using a speech synthesiser model controlled by data from the computer. ▶



Block Diagram of the digital method of achieving voice storage.



The phonetic code reads almost as if it were written in English (maybe someone will write a program to convert English to phonetic code?). Before discussing the speech program or the synthesiser it is desirable to explain just how human beings generate speech.

The Vocal Tract

Speech production has been studied for centuries and there have been many historical examples of 'mechanical talkers', that is mechanical models that can be manipulated so as to produce synthetic speech. These models generally have employed bellows, reeds and moveable acoustic resonators to synthesise the speech sounds and this is not too dissimilar from the real thing, the vocal tract, Fig. 1.

Air from the lungs is expelled through the vocal cords causing them to vibrate (when you breathe in the vocal cords don't vibrate — try it!). These vibrations produce a buzz which the speaker can control in pitch and volume. This buzz is coloured by a set of acoustic resonators known as the vocal tract.

By opening and closing the mouth, by moving the tongue hump and by connecting or disconnecting the nasal cavity, the resonances of the tract can be manipulated so as to generate speech.

Take, for example some steady state vowels, AE as in HAD, EE as in HEED and OO as in WHO. Fig. 2 shows the acoustic frequency response for various vowels.

The operator types a phrase that is to be spoken. The phrase is spelled phonetically — it usually takes an operator a few hours to come to grips with the new way of spelling — and the computer converts the phrase into a series of parameters which control the speech synthesiser.

For example, the phrase 'Well, it can do with me' would be typed in as 'WEHL IHT KAN DOO WIHTH MEE'.

Fig 1. Vocal tract

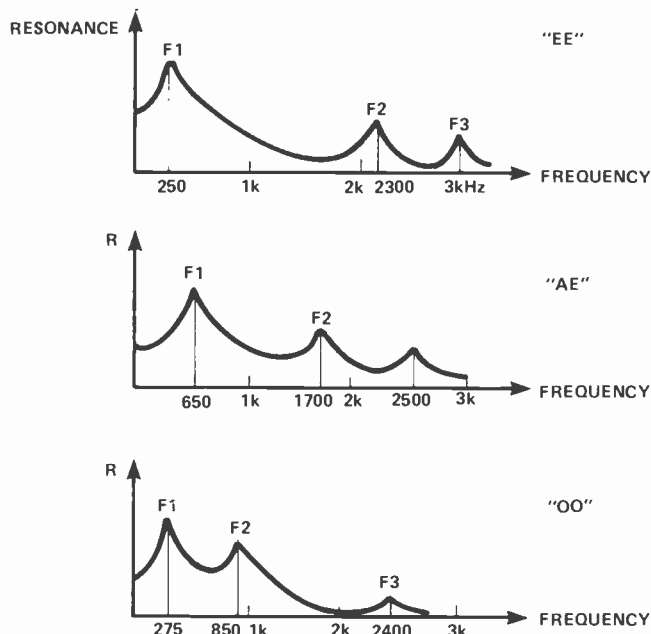
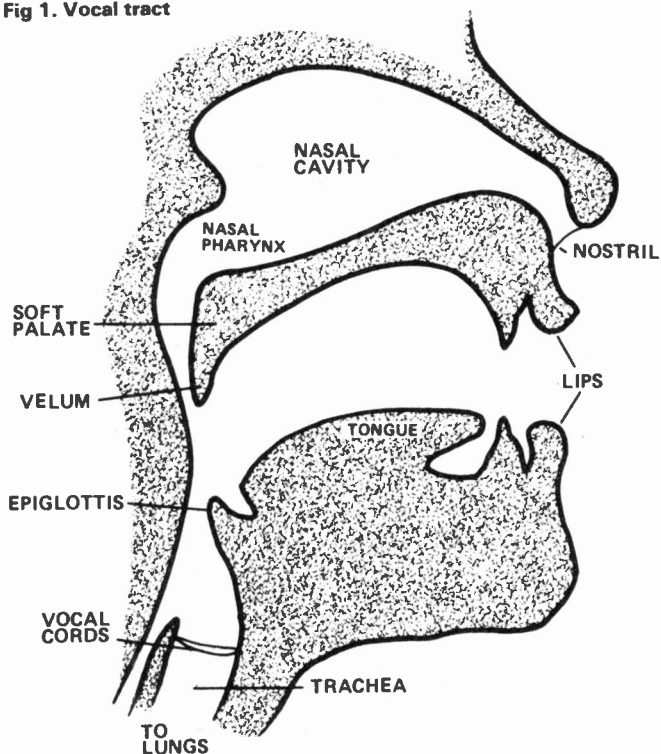


Fig 2. Acoustic response of some vowel sounds.

The first three peaks in the response, F1, 2, 3 are known as the first three formants. These are frequencies at which major resonances occur. For example, the 'OO' vowel has F1 and 2 close together at a low frequency and so the overall effect is a low frequency resonance. This is obtained by almost closing the mouth and pushing the tongue hump to the bridge of the mouth, whereas the 'AE' vowel is generated by opening the mouth and lowering the tongue hump.

Filter Vowels

It is possible to synthesise vowels by making an electronic model using active filters. If three band-pass filters ($Q=5$) are cascaded one after the other, set at frequencies of 660Hz, 1720Hz and 2410Hz and a saw-tooth wave form (100Hz) is injected into them, the resultant waveform will sound like the 'AE' vowel as in HAD.

A list of vowel resonances is given in Fig. 3. Note that they are for a typical MALE speaker.

A woman's voice is different in two respects. The resonances are about 10% higher because the vocal tract in women is about 10% smaller than that of a man.

Fig 3. Listing of vowel resonances.

		FORMANT (ALL IN Hz)		
		F1	F2	F3
HEED	EE	270	2290	3010
HID	I	390	1990	2550
HEAD	E	530	1840	2480
HAD	AE	660	1720	2410
HOD	AH	730	1090	2440
PAW	AW	570	840	2410
HOOD	U	440	1020	2240
WHO	OO	300	870	2240

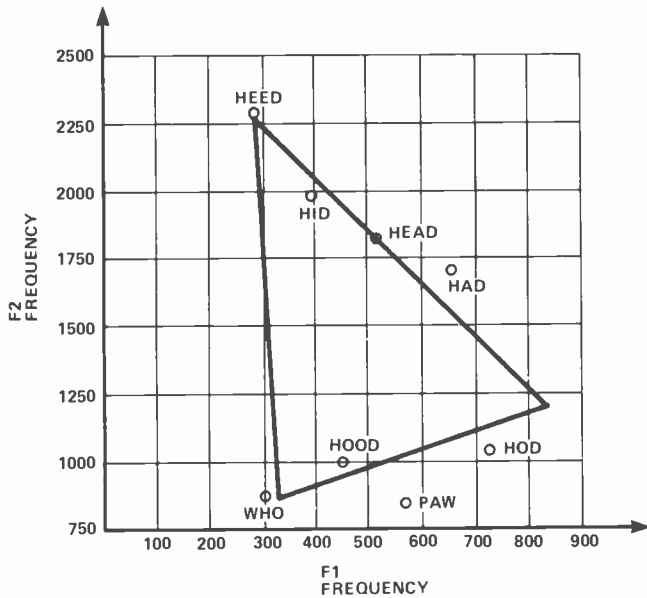


Fig 4. The vowel triangle!

Second, the pitch of the speech is perhaps an octave higher. These two effects characterise female speech as distinct from male.

Note that the formants 1 and 2 move over quite a wide range, but F3 doesn't move much at all.

However, including F3 in a model does help to improve the intelligibility. If we plot out F1 versus F2, we get what is called the 'vowel triangle', Fig. 4. Try gliding from the PAW vowel to the WHO vowel. The resulting

diphthong is that which is found in HOW. Others are:— BAY, BUY, BOY and HOE.

Say Through The Nose?

When the mouth is closed, virtually no sound comes out of it(!) However there is a secondary path via the nasal cavity, which is available when the velum is open. The group of sounds generated via this route are known as NASALS. They include such sounds as 'M' as in MAN, 'n' as in NUT and 'ng' as in STING. The nasal cavity is virtually a static resonator and so all nasal sounds have an undynamic quality about them.

Vowels, diphthongs and nasals are all voiced sounds, that is they are all pitched, being generated by the vocal cords. There is a group of sounds called fricatives which are pitchless and are generated by blowing air between the teeth and lips. These sounds are the 'th', 'f', 's' and 'sh' noises and are very similar to bandpass filtered noise. 'Th' can be modelled by a bandpass filter at 8kHz whereas at the lowest frequency, 'sh' is modelled by a 2k5 Hz filter.

Constantly Talking

There are many other types of sounds but for the purposes of brevity we will consider only one more, the STOP CONSONANT. These sounds are characterised by a sudden opening of the mouth. This produces two effects.

One, there must be a period of silence (if only briefly), before the sound is generated.

Two, as the mouth opens, the formants rapidly move toward temporary target positions.

The stop consonants, 'T', 'P', 'K', 'D', 'B', 'G' are shown in Fig. 5. The vowel 'AH' has been used in this

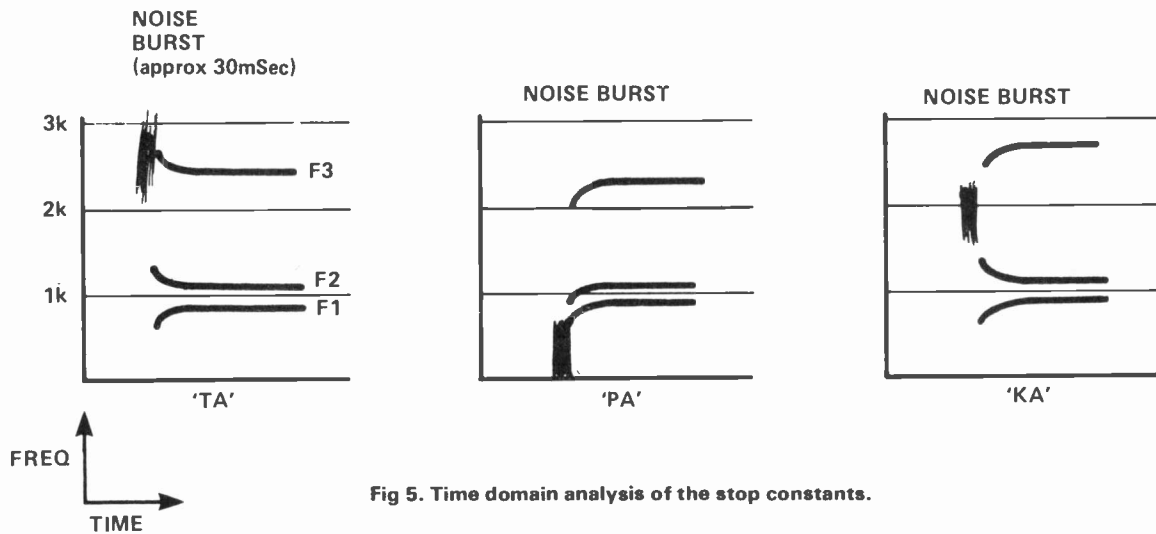
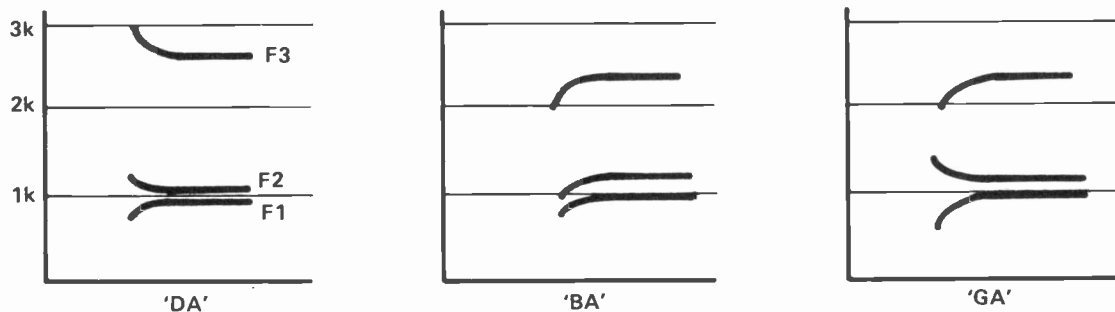


Fig 5. Time domain analysis of the stop constants.



example and so the stop consonants are 'Ta', 'Pa', 'Ka', 'Da', 'Ba', 'Ga'. The first group are characterised by having a small noise burst which precedes the opening of the mouth.

This burst only lasts for about 30 to 50 mS and it has a different resonant frequency for each of the examples. However, it is a very important phonetic element and does much to characterise the sound.

The lower group of stop consonants has no noise burst. This is the major difference between these two sets of sounds.

Verbal Circuits

Well, that's the end of the very rapid phonetics lecture, now for the electronics. The speech synthesiser must be able to model the vocal tract. It needs a voltage controlled oscillator, a noise generator, a controlled fricative formant, a controlled set of formants F1, 2, 3 and a nasal resonator. There are 9 parameters in this model which need controlling. These are:—

- AH — amplitude of aspirated sounds.
- AV — amplitude of vowels sounds.
- AF — amplitude of fricative sounds.
- AN — amplitude of nasal sounds.
- F1 — frequency of formant 1.
- F2 — frequency of formant 2.
- F3 — frequency of formant 3.
- Ff — frequency of fricative formant.
- Fv — frequency of oscillator.

The model is known as a serial 3 formant synthesiser with parallel fricative and nasal formants. The computer delivers data which is converted into 9 voltages which represent the 9 parameters.

It is entirely up to the computer to generate the

parameters correctly, the synthesiser merely does what it is told to do.

Speech Less Latches

The parameter generator is shown in Fig. 7. When the computer decides to deliver a frame of information it sends out an address and a data block. This address is unique to this peripheral device and is decoded by an address decoder inside the synthesiser. This decoded address generates a clock pulse which clocks a 12 bit latch.

Four of these 12 bits of data are another address which decides which of the 9 parameters is being updated. The other 8 bits are data which drive an 8 bit DAC. The analogue output from this DAC is fed to a demultiplexer which drives 9 sample and hold units.

Thus the 8 bit data word is converted into a control voltage and is then steered by the 4 bit address into the correct sample and hold. The whole frame of 9 parameters is updated 50 times a second. This consumes only a small percentage of the computer time, and yet it allows the speech program to be run on a slower time scale without the steps between frames becoming noticeable.

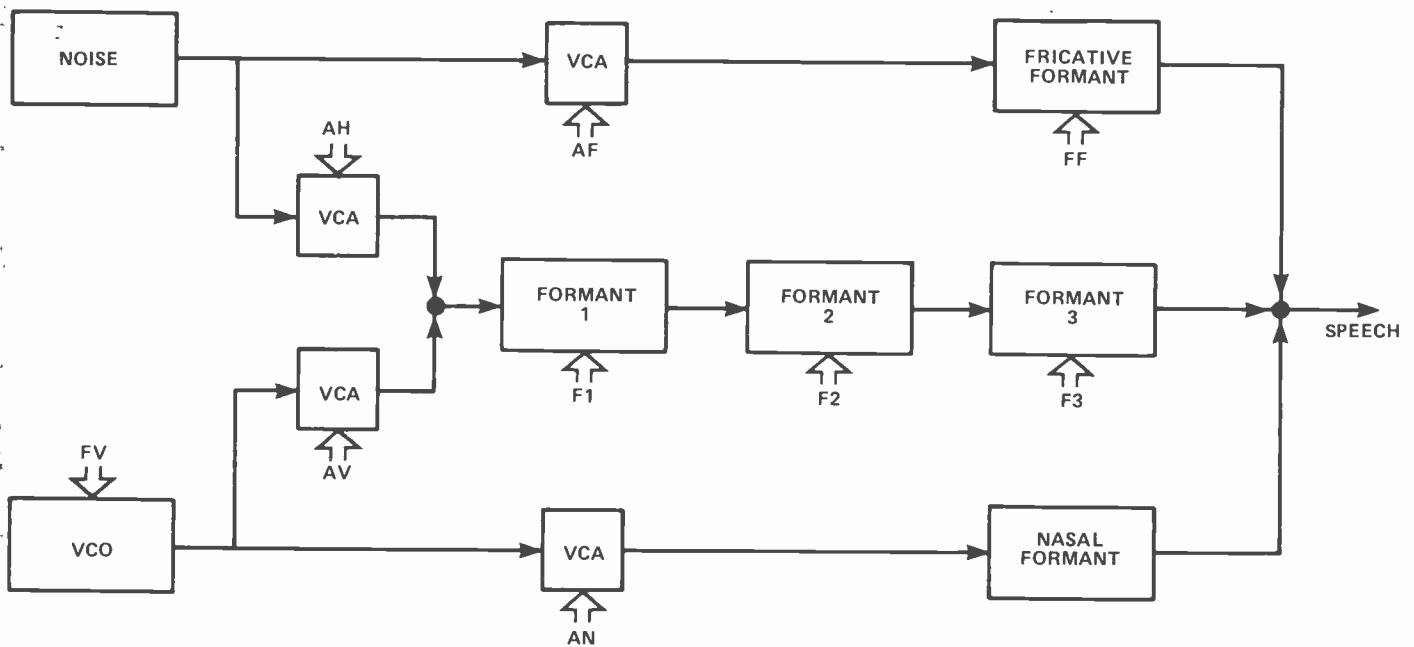
Pitch In

The program was written so as to make the operator's job as easy as possible. There is a listing of about 50 phonemes which can be used to generate speech. Gaps can be typed in and changes to existing sentences can easily be implemented.

The pitch of the speech is controllable so that the correct pitch inflections can be used to stress various words. Also, an external sound source can be used in place of the VCO so that effects such as 'talking music' can be produced.

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Fig 6. Block diagram of a three formant speech synthesiser.



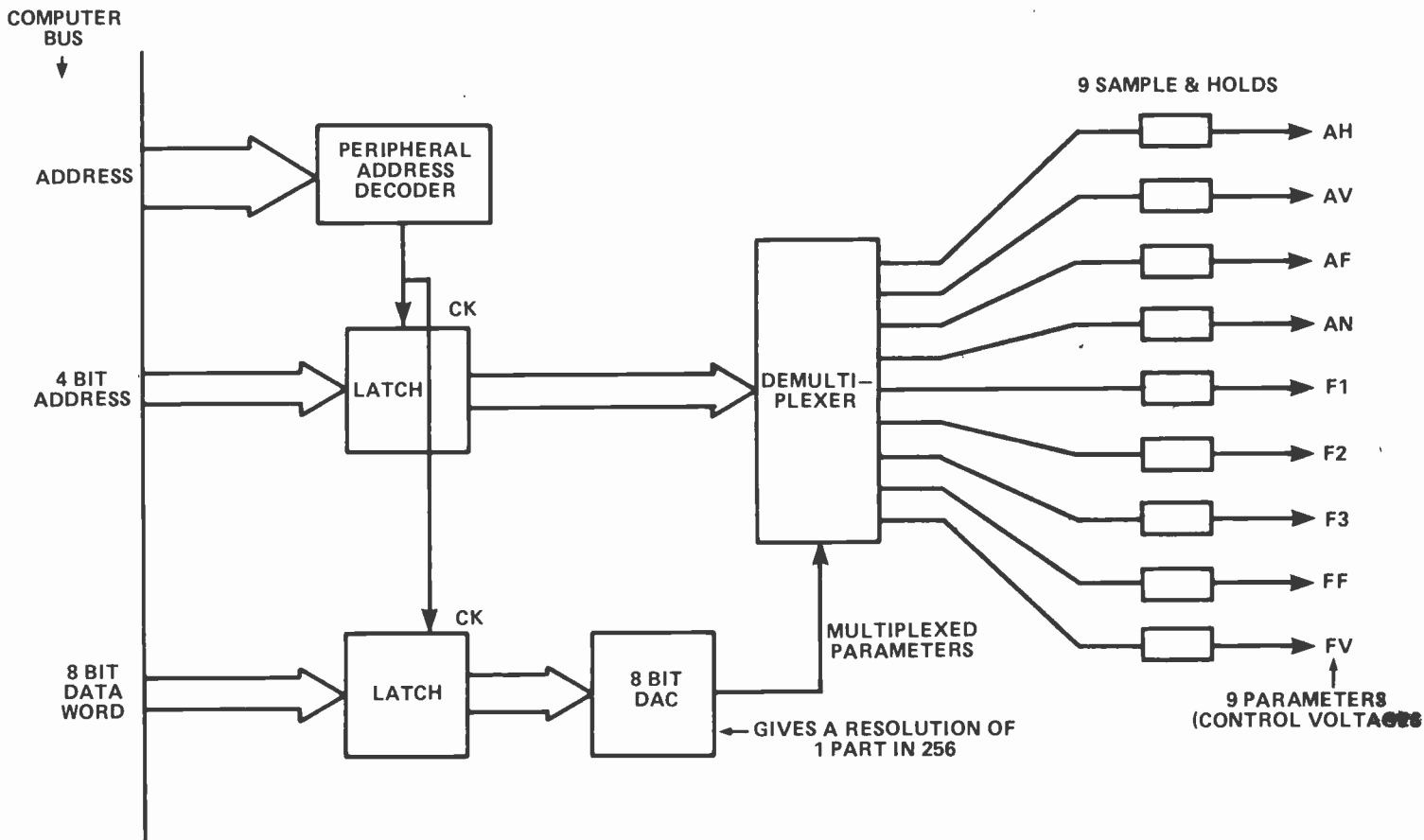


Fig 7. Block diagram of a parameter generator for a speech synthesis machine.

Resumé of Speech Products

The number of speech products that are being produced is rapidly increasing. Here is a list of some of them.

Texas Instruments have brought out a teaching aid called 'speak and spell'. This unit has an alphabetical keyboard plus display. The word that is typed in is spoken by a ROM that uses a linear predictive coding technique, enabling more than 200 words to be stored.

Federal Screw works make a speech synthesiser called **Votrax**. It generates speech by rule and it can be used as a computer peripheral or as a stand alone unit.

They also make a speech synthesiser which is a bit like a large pocket calculator, except that words are printed next to the buttons. This is intended as a limited talker for people with speech loss.

Telesensory systems make a 'talking' pocket calculator, a 'speaking chip set' and they are also working on a reading tool for the blind. This uses a little hand-held camera which converts the printed text into letters which are then converted into speech.

OVE III made by **Fonema** is a speech synthesiser similar to that described in this article. However, it uses lots of

parameters and the speech output can be better than the real thing!

Speech Lab made by **Heuristics** is a microprocessor peripheral. This device recognises the spoken word (after you have trained it to do so). The manufacturers claim real time operation and a 95% correct recognition rate.

Computalker made by **Computalker Consultants** is a microprocessor peripheral speech synthesiser using the vocal tract analogue as described in this article.

Microspeech made by **Richard Monkhouse** and **Tim Orr**. A microprocessor peripheral speech synthesiser designed to run from 6800 orientated systems.

Vocoder and Vocoder 2000. The first commercially available channel vocoders for the music market manufactured by **EMS**. Enables normally inarticulate sounds to speak. (For example, talking pianos.)

Vocaliser pedal made by **Coloursound**. A music product, not a Wah-wah pedal but a vowel pedal. Vowels available **EE** to **AH** to **OO**.

Diphthons made by **Coloursound**. Produces diphthong filter sweeps primarily for bass guitar. Sounds such as **BOW**, **YEH**, **WAH** and **YAE** are available.

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AC128 14p	BC301 30p	BFX87 15p	2N3702 8p	7452 13p	74164 70p	4035 60p	3A/400V 51p	1N5404 20p	ORP12 70p
AC141 24p	BC303 30p	BFY50 20p	2N3703 8p	7453 14p	74165 70p	4041 57p			OL704 100p
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AO149 65p	BCY34 66p	OC28 87p	2N3866 54p	7476 28p	74178 80p	4056 40p	CA3028A 85p		
AO161 35p	BCY59 24p	OC35 76p	2N3904 8p	7480 46p	74180 80p	4068 20p	CA3035 140p		DIL SOCKETS
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AF125 25p	BD121 70p	TIP29 37p	TTL	7491 45p	74190 72p	4072 16p	CA3080 70p		
AF126 25p	BD123 60p	TIP30 35p	7400 12p	7492 35p	74191 72p	4073 16p	CA3140E 51p		ZENER DIODES 400mw
AF127 25p	BD124 77p	TIP31 45p	7401 12p	7493 34p	74192 65p	4077 25p	LM301AN 28p		2.7V to 33V 8p
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BC108 7p	BD140 30p	TIP2955 65p	7409 14p	74107 25p		4516 64p	TBA810 100p		.15, .22, .33 uF 6p
BC109 7p	BF115 25p	TIP3055 55p	7410 12p	74109 30p	CMOS	4518 70p			47, 68 uF 12p
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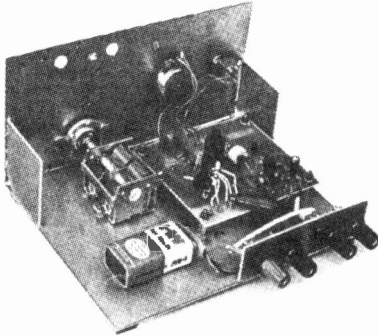
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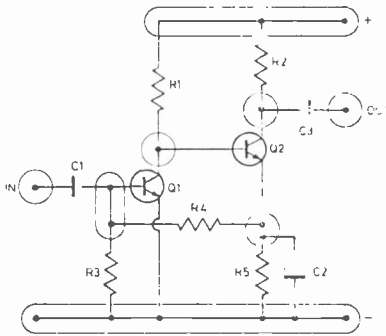
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Short Wave Receiver



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Instant Circuit Layout



Do you have trouble getting your brain to translate a circuit into a practical layout? If so you're in good company but next month join the elite by overcoming this. We give you practical advice on how to lay out components from practically any circuit diagram.

Scratch / rumble Filter

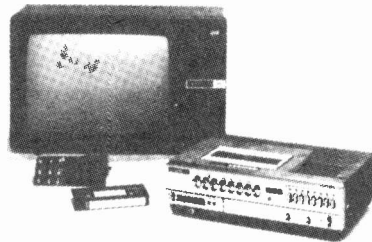
An add-on circuit to couple to an existing audio system, this project enables you to select the cut-off frequency of the system at both ends of the spectrum.

Radioactivity



Although most people shudder when they think of radioactivity, there's a lot more to it than fallout from nuclear bombs. Radioactivity is widely used in medicine and in industry and our article describes some of the uses and traces the history of its development.

Video Tape Recorders

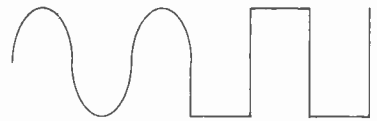


The age of the Video Cassette Recorder has arrived and soon they'll be common. However, they are the most complex, sophisticated, pieces of engineering that have ever crossed the doormat in reasonable numbers. Next month we explain how they work and take a look at the different systems being offered.

OST Rules, OK?

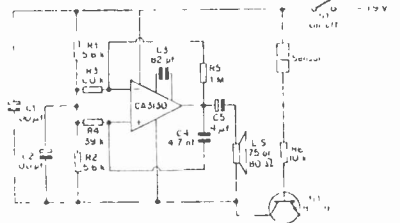
Got the hang of Ohms Law? No problem but the world isn't yours yet — have you ever found a problem it can't cope with? The chances are that you have. However, there are two other approaches to help you solve the nasty ones: Superposition and Thevenin's Theorem. They may sound complex but in reality they make life simpler.

Sine / Square Wave Generator



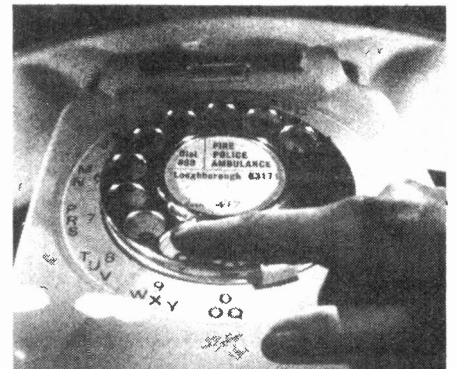
An essential part of anybody's test gear and our project next month enables you to add one to your workbench at low cost.

Projects Using The CA3130



We publish one chapter from R. A. Penfold's '50 Circuits using the CA3130' (brought out by Babani) and mighty interesting they are too. The projects include an electronic organ, metronome, alarm and latching circuits.

Holograms

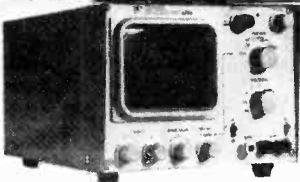


Today they are only a curiosity, shown as exhibits and as special effects but much work has been going on behind the scenes. Today's Holograms really make you wonder if you can believe your eyes.

The February issue will be on sale on January 12th

The items mentioned here are those planned for the next issue but circumstances may affect the actual content.

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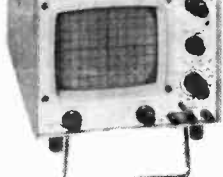
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Mag. issue	PROJECT	Ref.	PCB	Component Pack	Hardware Pack	Case (Screened)	Total	
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	R.F. Attenuator	603	—	.26	1.54	1.35	3.15	
	Watchdog	604	.85	4.69	7.68	5.53	18.75	
	Watchdog PSU	605	.65	1.49	3.95	—	6.09	
PROJECTS	Sweep Oscillator	606	2.60	21.07	8.16	4.28	38.11	
	Stereo Simulator	607	.60	2.30	.53	2.24	5.67	
	Freer Alarm	608	.55	.92	3.85	1.65	6.97	
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	Bench Amplifier	615	.70	3.40	2.93	3.95	11.00	
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6	50 watt High Power Amp	618	1.30	6.46	—	—	10.46	
	100 watt High Power Amp	619	1.30	9.16	—	—	7.76	
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	Flash Trigger	628	.65	3.48	.84	1.65	6.62	
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	Nov 76	541 Train Controller	T001	.75	5.27	5.84	3.95	15.81
	Jan 77	444 5-watt Stereo	T002	2.00	14.03	6.84	3.45	26.32
	Feb 77	448 Stereo Disco Mixer	T003	1.60	13.74	.87	—	16.21
	Dec 77	Clock B	T004	2.10	11.31	—	—	13.41
	Jan 78	House Alarm A	T005	2.00	10.93	3.05	9.50	29.37
	Jan 78	House Alarm B	T006	.85	3.04	—	—	4.79
Feb 78	Metal Locator Mk. II	T007	.92	5.91	8.76	3.38	20.89	
Mar 78	Frequencer Shifter PSU	T008	.65	4.14	—	—	25.62	
Mar 78	Frequencer Shifter	T009	1.50	16.99	—	2.40	7.07	
Mar 78	LCD Meter	T010	1.00	24.62	—	—	13.36	
Mar 78	Light Dimmer	T011	.55	3.40	3.12	—	7.86	
Apr 78	Gas Monitor	T012	.80	10.11	1.10	1.35	22.11	
May 78	Star Trek Radio	T013	.84	6.19	.83	—	65.10	
Jun 78	Stars & Dots	T014	.4	5.33	11.49	3.46	14.45	
Jun 78	Spectrum Analyser	T015	1.83	35.76	16.02	5.00	13.05	
Jun 78	Wain Oscillator	T016	.89	6.36	4.80	2.40	1.72	
Jul 78	UFO Detector	T017	1.45	10.80	.80	—	25.41	
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Jul 78	Temperature Meter	T019	1.00	24.41	—	—	12.64	
Aug 78	Etop	T020	.90	2.87	1.16	—	29.26	
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Sep 78	Stac Timer	T022	2.30	14.27	11.04	—	21.88	
Sep 78	Wheel of Fortune	T023	1.35	4.34	4.43	2.24	12.84	
Oct 78	Complex Sound Generator	T024	2.95	10.15	8.78	—	28.26	
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Oct 78	Power Bulge	T026	.65	.71	.78	.79	9.60	
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Feb 78	Ultra Sonic Transmitter	T030	.45	.82	3.20	—	12.66	
Nov 78	Cuts Cassette Interface	T031	2.80	26.12	.87	3.95	33.74	
Nov 78	Audio Oscillator	T032	2.25	10.13	.38	—	5.52	
Dec 78	Car Alarm	T033	1.80	2.80	.92	—	5.79	
Dec 78	Wine Temp Meter	T034	1.10	1.31	1.1	4.5	9.31	
Dec 78	Curve Tracer	T035	1.00	3.04	2.61	—	20.21	
Dec 78	Eprom Prog main board	T036	2.25	17.75	.20	—	5.09	
Dec 78	Eprom Prog PSU	T037	1.30	3.79	—	—		

SYSTEM 68

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TAPE SLIDE SYNCHRONISER

This must rate as one of the most requested projects of all time for us! This tape synchroniser uses a notched 100Hz tone to achieve its ends as neatly as possible.

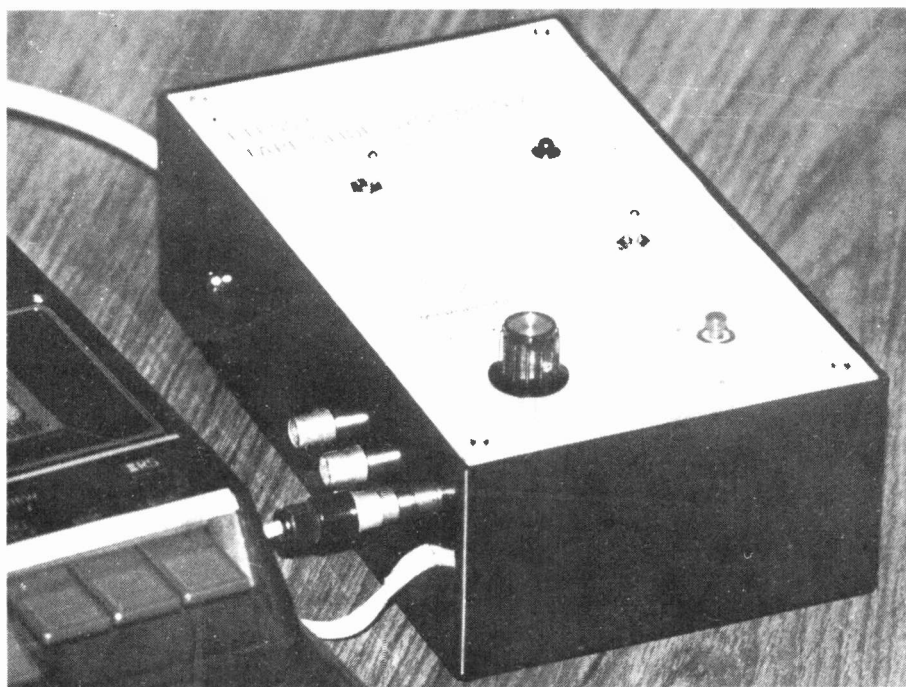
WHEN PUTTING on a slide show for your friends or a business meeting, it is usually necessary to have some commentary with it. If it is a one-time presentation this is no problem, but if the show is to be repeated or if you simply want to be able to recall good memories a couple of years later then a tape recording of the commentary is ideal. The problem now is to keep the slides changing in synchronization with the commentary, without having to record that obtrusive phrase 'change slide now' onto the tape.

This unit allows a control tone (100 Hz) to be recorded on the tape along with the normal voice recording; when replayed the tone will activate a relay which will change the slide while a notch filter removes the tone so it is not heard through the speaker.

Construction

Assemble the PCB with the aid of the component overlay in Fig. 1. With the 240 V wiring it is better not to use pins but solder the wires directly onto the PCB. A covering of epoxy glue over the tracks leading to the transformer will help to prevent accidental contact.

We built the prototype into a large plastic box with the controls on the front panel and the tape recorder/amplifier connections on the rear. The wiring of the front panel is given in Fig. 3. We used an electret microphone insert mounted just behind the front panel. However the noise of the relay operating could be heard on the tape and therefore an external microphone is



recommended. A socket can be mounted on the front panel in the microphone position.

Using the Unit

With this unit a separate amplifier/speaker system is needed. Also the slide projector must have a remote change button using normally open contacts. Connection has to be made between these contacts and the relay in the unit. Check that these wires are isolated from the 240 V mains and if

not be very careful with the connections.

Connect the unit to the tape recorder and projector, assemble the slides in the correct order and switch on. With the record/playback switch in the record position and the recorder set to record, commence the commentary, changing slides with the button on the unit. The high level input on the recorder should be used and the microphone level pot set to give the correct recording level.

When playing back simply set the record/playback switch to playback and replay the tape.

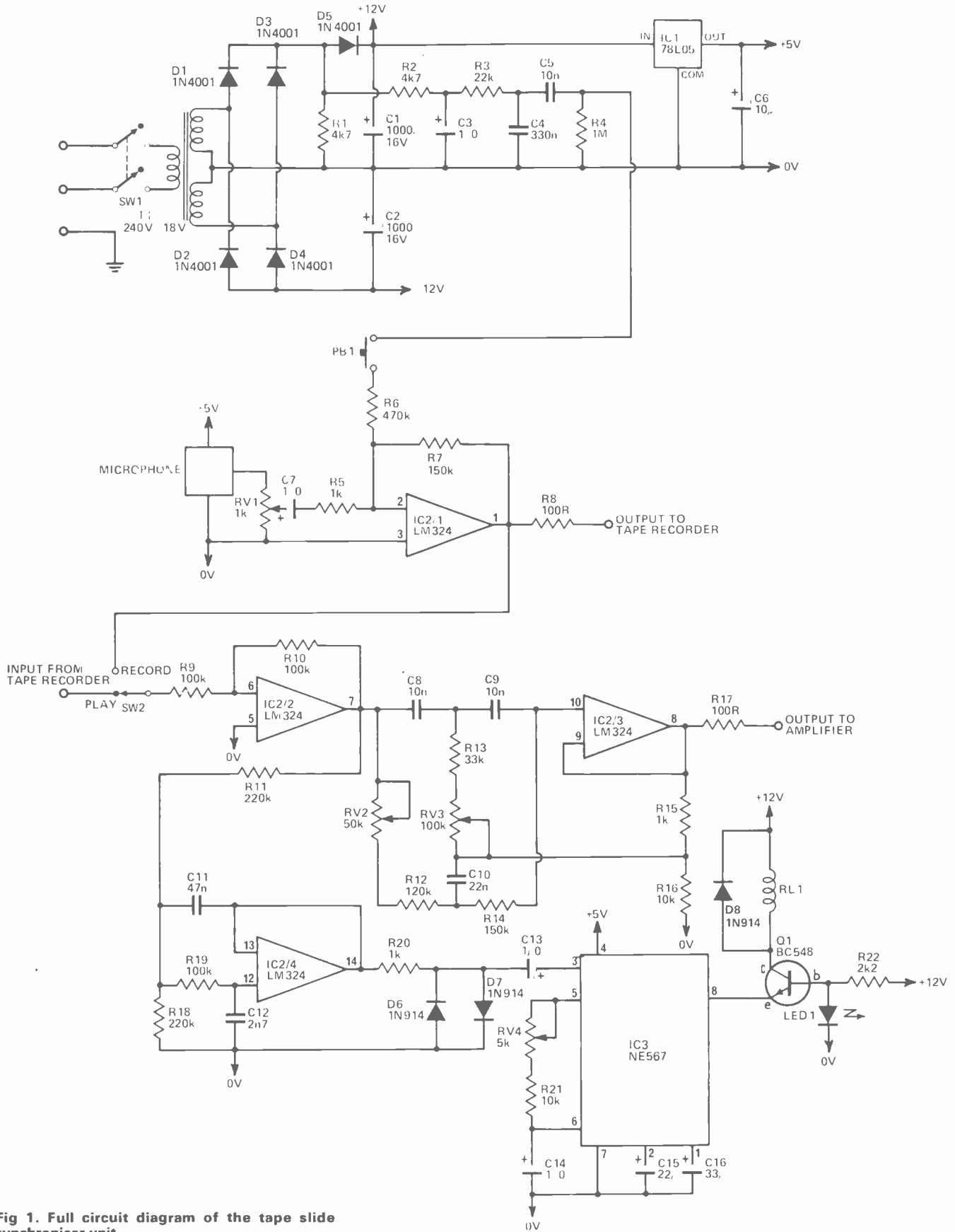


Fig 1. Full circuit diagram of the tape slide synchroniser unit.

HOW IT WORKS

With this unit, unlike our previous design, we record a 100 Hz tone burst on the same channel as the speech whenever we require a slide to be changed. The tone is derived by full wave rectifying the output of the transformer and filtering out the harmonics by R2, 3/C3,4.

Pressing the slide change button mixes this tone with the output from the microphone which is amplified by IC2/1. This combined output is recorded on the tape.

In the record mode SW2 connects the output of IC2/1 to the buffer amplifier IC2/2. In the playback mode it connects the output from the tape recorder to the amplifier. The output of this amplifier is split into two paths. One of these is through a 100 Hz notch filter to IC2/3 effectively removing the 100 Hz tone without much change to the rest of the spectrum. This is used to drive an amplifier/speaker system.

The other path for the signal after IC2/2 is via a low pass filter IC2/4. This removes frequencies above 150 Hz and has a response as shown in Fig. 2. When the 100 Hz tone occurs, this filter passes it, rejecting speech frequencies, and it is passed to IC3. This is a phase locked loop tone decoder and its output on pin 8 turns on when the correct frequency tone is received. The output stage of this IC is an open collector npn transistor which can sink but not source current. With no incoming tone this transistor will be off, preventing any emitter current in Q1, hence turning it off also. The voltage on the base of Q1 in this case will be set at 0V6 by LED1. When a tone occurs the output of the IC will saturate to about 0V6, forward biasing Q1, turning it on, and closing the relay. The current in R22 is now bypassed into the base of Q1, giving about 1V2 on the base. This is too low for the LED to conduct and it will go out.

The power supply is simply full wave rectified and filtered for IC2, and a 5V regulator is used for the PLL IC and the microphone amp.

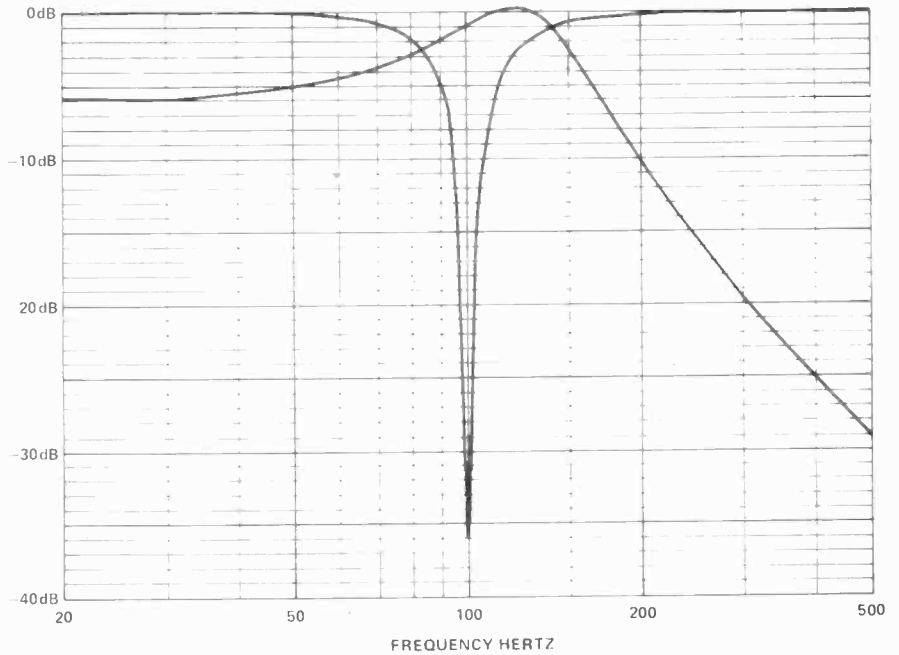


Fig 2. The frequency responses of the notch and low pass filter sections of the circuit.

Adjustments

Set the unit up to record and with all trimpots at the centre of their travel and the microphone level at minimum, hold the slide change button down. Probably some 100 Hz signal will be heard on the output of the amplifier. Alternately adjust RV2 and RV3 to minimise this signal. It should be necessary to wind up the volume of the amplifier to finally adjust for a minimum level.

The other adjustment is of the phase locked loop centre frequency. With the push button pressed slowly rotate RV4 until the relay either opens or closes. If it closes, continue to rotate it until it drops out then bring the pot back to the half way point. If the relay opened, reverse the rotation to find the other point at which it opens and leave RV4 midway between these two points.

Check the operation of the relay when pressing the button. There should be about half a second delay before it closes.

ETI

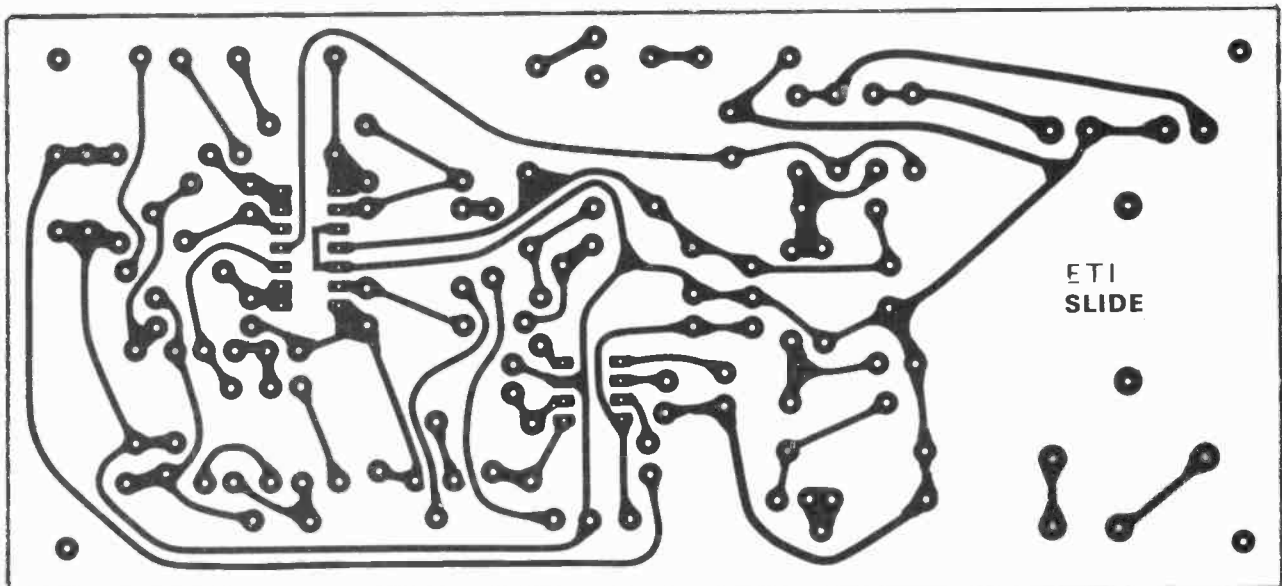
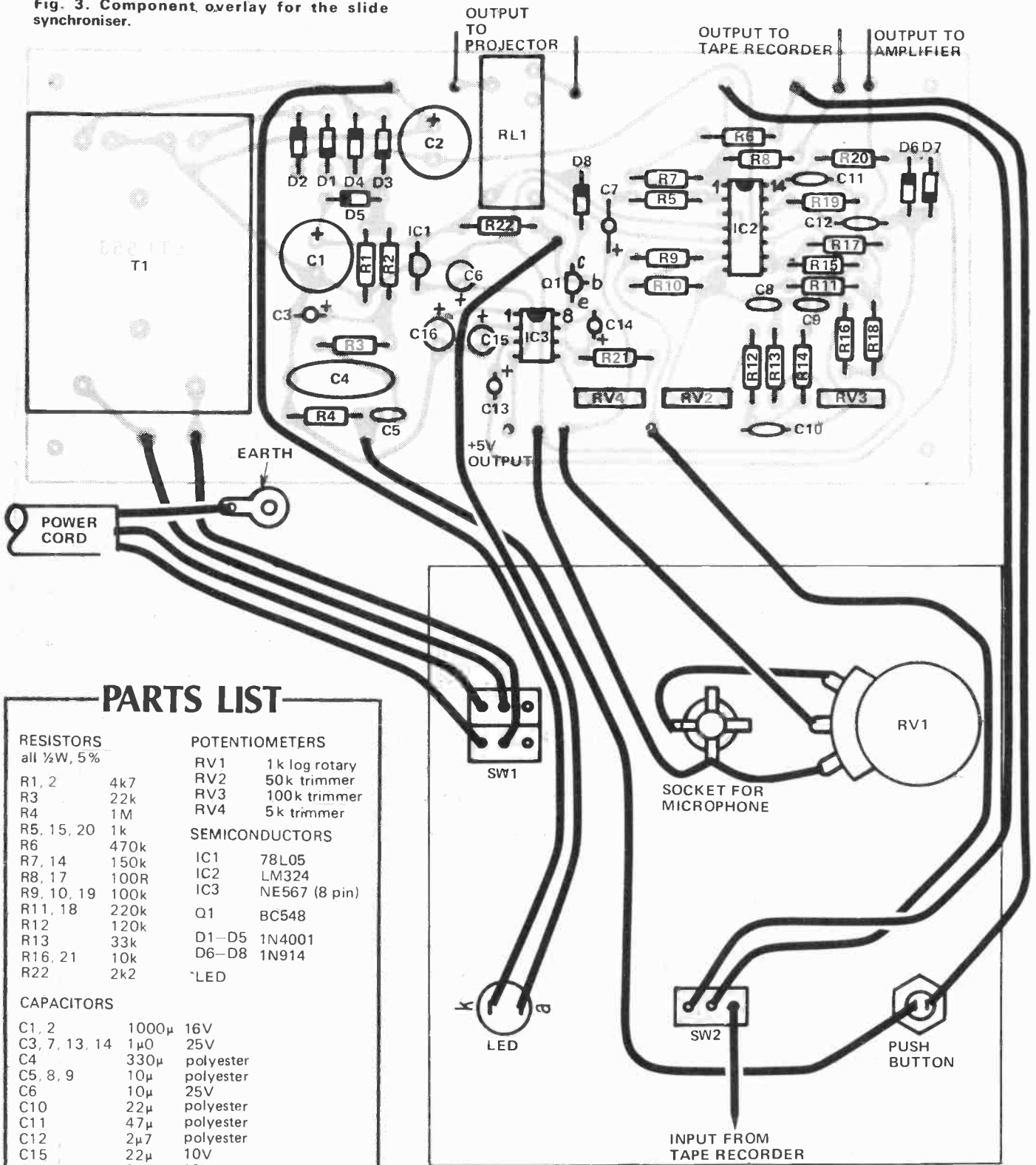


Fig. 3. Component overlay for the slide synchroniser.



PARTS LIST

RESISTORS

all ½W, 5%

R1, 2	4k7
R3	22k
R4	1M
R5, 15, 20	1k
R6	470k
R7, 14	150k
R8, 17	100R
R9, 10, 19	100k
R11, 18	220k
R12	120k
R13	33k
R16, 21	10k
R22	2k2

POTENTIOMETERS

RV1	1k log rotary
RV2	50k trimmer
RV3	100k trimmer
RV4	5k trimmer

SEMICONDUCTORS

IC1	78L05
IC2	LM324
IC3	NE567 (8 pin)
Q1	BC548
D1-D5	1N4001
D6-D8	1N914

*LED

CAPACITORS

C1, 2	1000µ	16V
C3, 7, 13, 14	1µ0	25V
C4	330µ	polyester
C5, 8, 9	10µ	polyester
C6	10µ	25V
C10	22µ	polyester
C11	47µ	polyester
C12	2µ7	polyester
C15	22µ	10V
C16	33µ	10V

MISCELLANEOUS

Relay 12V 280Ω
Transformer 240V-18V
Two toggle switches
One push button switch N/O
Box to suit
3 core flex and plug
Output sockets etc.

BUYLINES

Try as we might we can envisage - no problems obtaining the components required for this project. The semiconductors should all be available from such

stalwart companies as Marshall's, Technomatic, Watford et al. Any case will do, as will any transformer although some may not fit the PCB directly.

SINCLAIR PRODUCTS*

Microvision TV UK model £89.95, POM35 £27.25. Mains adaptor £3.24. Case £3.25. 30kv probe £18.95. DM350 £67.80. DM450 £96.50. DM235 £49.45. Rechargeable batteries £7.80. Mains adaptor/charger £3.70. Case £8.50. 30kv probe £18.95. Enterprise prog calculator complete with accessories £21.95. Cambridge prog calculator £13.13. Prog library £3.45. Mains adaptor £3.20.

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PRINTED CIRCUIT MATERIALS

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COMPONENTS

1N4148 1.4p. 1N4002 2.9p. 741 B dnl 16p. 723 14 dnl 29p. NE555 8 dnl 23p. bc182b. bc183b. bc184b. bc212b. bc213b. bc214c. bc547. bc548. bc549. bc550 4.8p. tip31c. tip32c 34p. tip41c. tip42c 45p. bd131. bd132 31p. Plastic equivs bc107. bc108 4.8p. Fuses 20mm x 5mm cartridge 1.5. 25. 5 1. 2 3. 5Amp quickblow 1p, anti-surge 3.4p. Resistors 5% 1/4W E12 10R to 10M 1p, 0.8p for 50+ for one value. Polyester capacitors 250V 015. 068. 1mf 1.8p, 01. 033. 33mf 2.7p, 022. 047mf 3.2p, 22. 47mf 4.8p. Polystyrene capacitors E12 63v 10 to 10000pf 3p. Ceramic capacitors 50v E12 22 to 1000pf 1.7p, E6 1n5 to 47n 2p. Electrolytic capacitors 50v 5.1. 2mf 5p, 25v 5 10mf 5p, 33mf 4p, 16v 22mf 5p, 100mf 6p, 220mf 4.1p, 330mf 9p, 470mf 11p, 1000mf 10p, 1500mf 10p 3.4p, 10v 1000mf 5.1p, 2200mf 5p. 2mf 10p 1.7p. Zeners 400mW E24 2v7 to 33v 7p. Preset pots sub-miniature 0 1 horiz or vert 100 to 4M7 6.8p. Potentiometers 1/4W 4K7 to 2M2 log or 1in single 26p, dual 76p.

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20	10	115	12.75	1.30
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Sec. 0-12-15-20-24-30V

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2.0	3	4.80	85
3.0	20	5.80	1.00
4.0	21	6.85	1.00
6.0	51	7.75	1.00
8.0	117	9.50	1.00
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BUILD A VCT

So far VCT has been the biggest non-event in component history. Two years of blank looks and still not released. In the meanwhile ETI shows you how to build your very own VCT to worry and amaze your friends!

THE CIRCUIT SYMBOL of the voltage-current transactor (VCT) is shown in Fig. 1 with both voltage input and current output terminals floating. In the future it is expected that single chip VCTs (Ron Harris, ETI) will challenge the familiar op-amp as the universal linear circuit building block. At present, however, these have yet to emerge. In the meantime considerable familiarity with the VCT concept and with its circuit applications may be achieved by building a PCB version using readily available IC transistor arrays.

A single-ended VCT (C.A. Holt, "Electronic Circuits: Digital and Analog" p.788) is shown in Fig. 2. The floating output version of Fig. 3 corresponds to the circuit discussed before (J. E. Morris, ETI August 1977). In both figures the unfamiliar symbols (boxes) are intended to represent current mirrors. Ideally, the output from the high impedance current source(s) exactly equals the input current into the low impedance terminal (arrow-head). VCT operation is based upon these current mirrors.

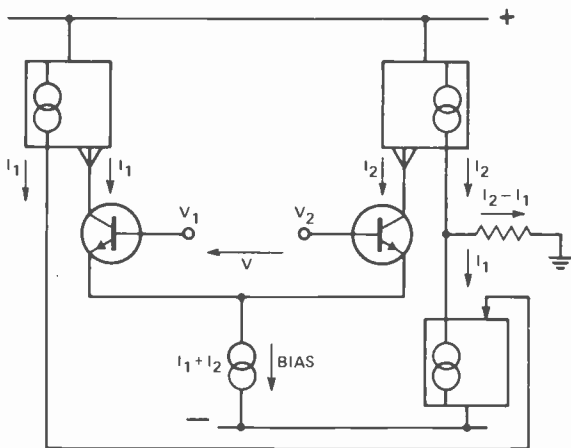


Fig. 2. Single-ended VCT (e.g. CA3080 operational transconductance amplifier).

No attempt will be made here to duplicate the earlier explanation of circuit operation which is expected to be reasonably clear from the diagrams (Figs. 2 and 3) anyway). The essential point is that the differential input voltage $V_1 - V_2$ leads to an imbalance in the currents flowing in the two halves of the symmetrical circuit and that this imbalance is translated into a load current I . The load is driven by constant current sources (high impedance) and the input impedance is high to minimise

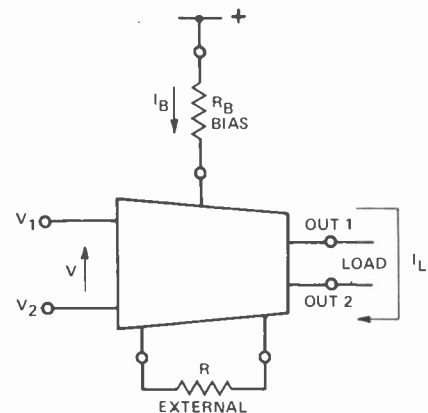


Fig. 1. VCT symbol and external connections.

input signal loading. With the system of Fig. 3, load current is given by

$$I_L = \frac{2}{3} I_B (V_1 - V_2) / R_{EXT}$$

up to the point where the bias current is exhausted, i.e. for $I_L < \frac{2}{3} I_B$.

Transistor Arrays

The original intention of the project described here was to build the current mirrors using perfectly matched transistor arrays in miniature flat IC packages. These were to be mounted on an alumina substrate with printed thick film interconnections in the circuit described in the earlier articles. As is often the case with electronics, however, the realities of the situation dictated a very different course.

In the first place both miniature package arrays and arrays of matched transistors were neither readily available nor acceptably priced! After some searching of the data books, we settled for the RCA arrays CA3084 and CA3086 on the basis of price and availability. (The pin diagrams for these are reproduced in Fig. 4). Not all of the components in these packages are used, in particular, the Darlington transistor D in the CA3084 is not employed in the VCT circuit.

The first point to be determined was the effectiveness of these transistor arrays in current mirror circuits. No claim is made for transistor matching in the CA3086 other than the obvious one of thermal matching. In the CA3084, Q_3 and Q_4 are obviously organized as current mirror outputs and Q_1 , Q_2 are described as a matched

$$I_L = I_1 - I_2$$

$$I_E = 3I_1 - I_B$$

$$I_E = I_B - 3I_2$$

$$I_E = (V_1 - V_2)/R_{EXT}$$

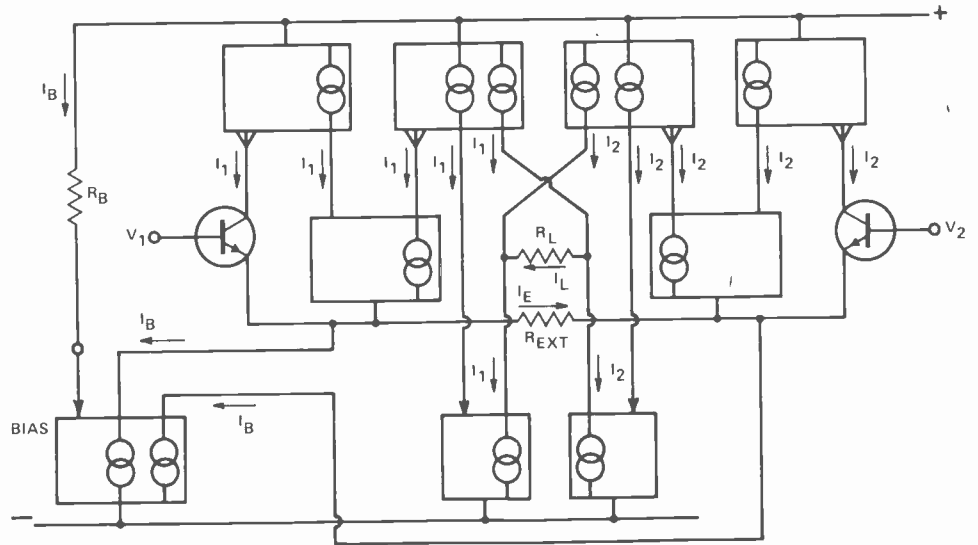


Fig. 3. VCT with floating input.

pair. The specifications on Q₁, Q₂ look impressive and those of Q₃, Q₄ seem rather inadequate (Fig. 4) but in fact for current mirror applications the reverse is true in both cases. To put these specifications into perspective, consider two similar base-emitter junctions where I_{E1}, I_{S1} exp (e V_{EB1}/kT) and I_{E2}, I_{S2} exp (e V_{EB2}/kT). Suppose these two junctions may be regarded as extremely well matched e.g. to ± 1 mV in V_{BE} carrying identical currents I_E. Substitution above leads to

$$I_E = I_{S1} \exp (eV_{EB}/kT)$$

$$= I_{S2} \exp (eV_{EB}/kT \exp (e 10^{-3}/kT))$$

and if equal V_{EB}'s are now specified for the current mirror application

$$I_{E2} = I_{S2} \exp (eV_{EB}/kT)$$

$$= I_{S1} \exp (-e 10^{-3}/kT)$$

$$= I_{E1} \exp (-e 10^{-3}/kT)$$

At room temperature, kT 1/40eV and I_{E2} 0.96 I_{E1}. So a ± 1 mV matching in V_{BE} leads to a 4-5% error in a current mirror application. In this light, Q₃ - Q₄ seem to be reasonably matched for the purpose and Q₁ - Q₂ less so.

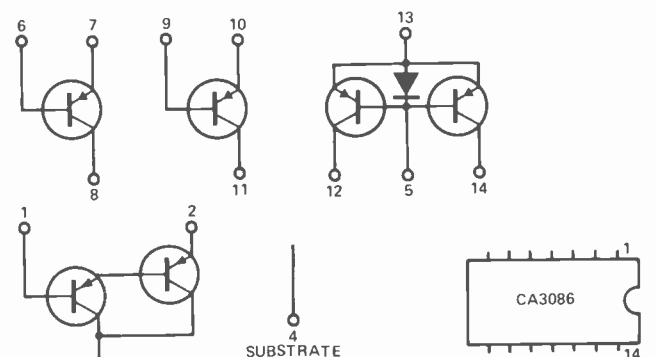
Clearly, the point is best resolved by direct measurement of current mirror performance using the arrays themselves.

Current Mirrors

As a first step, the transistors were checked for matching. For the CA3086, all transistors (except possibly the substrate transistor Q₅ whose measurements were later deemed to be suspect) were matched to within a 12 mV spread for a given current up to 500 μA. This figure reduces to a low 1 mV range at 1 mA and increases again with increasing current to about 9 mV at 10 mA. (All measurements at V_{CE} = 3V.) It is only possible to

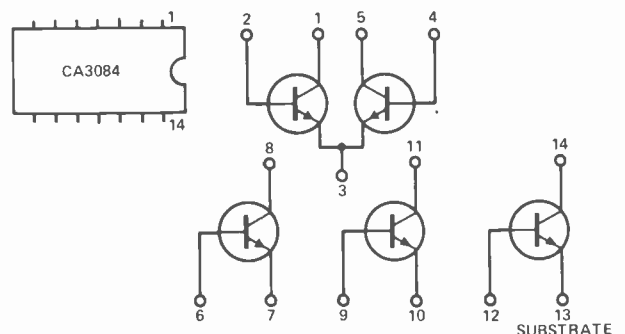
measure terminal characteristics of Q₁ and Q₂ in the CA3084 and from 10 μA to 10 mA, V_{BE} values were matched to within 1 mV. ▶

Fig. 4. IC transistor arrays — pin connections and CA3084 specifications. (S — substrate connection to most negative point).



$$I_{12}, I_{14} = I_{13} \mp 15\%$$

$$I_{12} = I_{14} \mp 10\%$$



$$Q_1, Q_2: \text{ for } I_7 = I_{10}, V_{BE1} = V_{BE2} \mp 6 \text{ mV}$$

(all specs at I_C = 100 μA).

The performance of the CA3084 current mirror is shown in Fig. 5 and that of a more complex system in Fig. 6. Clearly, the extra components of the more complicated circuit (which are all subject to variations from the nominal device parameters), lead to increased discrepancies in the output current. On the other hand, the simple circuit (as found within the CA3084 chip, for example), provides output matching within specification although the absolute level is lower than expected.

With the CA3086 a slightly different measurement technique was employed (Figs. 7 and 8) where transistor gain was permitted to vary with V_{CE} . This accounts for the curvatures of the output characteristics in Fig. 7. In Fig. 8, the performance of the more complex system is seen to be clearly inadequate. (The transistors in these two diagrams with base and collector shorted together function as diodes, as does Q_4 in Fig. 6).

The results of this section led immediately to the decision to use only the basic type of current mirror. Both types were examined in the earlier article (ETI August, 1977) and the more complicated form is used in the prototype single chip VCT. The advantage of the complex circuit is that it performs better with low gain transistors but the typical h_{FE} figures of 100 and 40 (for the CA3086 and CA3084 respectively) are expected to be adequate. The problem with the system being developed here is that of poor matching and an elementary worst case analysis demonstrates the superiority of a minimal component count.

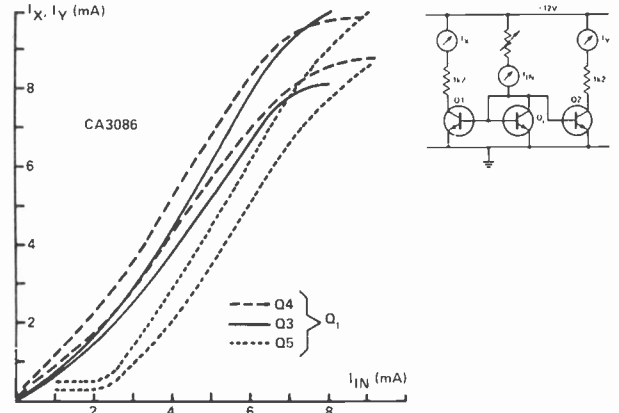


Fig. 7. Elementary current mirror — transistor matching.

Discrete VCT

The actual circuit employed is shown in Fig. 9 and differs markedly from the one discussed in the earlier articles. In the first place, the simple current mirror has been used throughout for reasons given above. Second, there is obviously no opportunity to provide current gain by utilising multiple emitter transistors since these are not provided in the arrays. (This is no disadvantage for the purpose of a familiarisation exercise.) The third discrepancy is apparent by comparison of Fig. 9 with Fig. 3. In recognition of device parameter variations and the asymmetry which these will necessarily cause, the bias circuit has been split into two independent sources. In effect, this provides both bias and offset capabilities. Usually one would employ Darlington's as the input transistors. This step would require an extra CA3086 and has been omitted.

A fifth difference lies with the elimination of any link between the input circuit current mirrors of the two sides. The circuit described in previous articles uses the complex current mirror with diodes shared between the two sides of the VCT. This set-up has been simulated

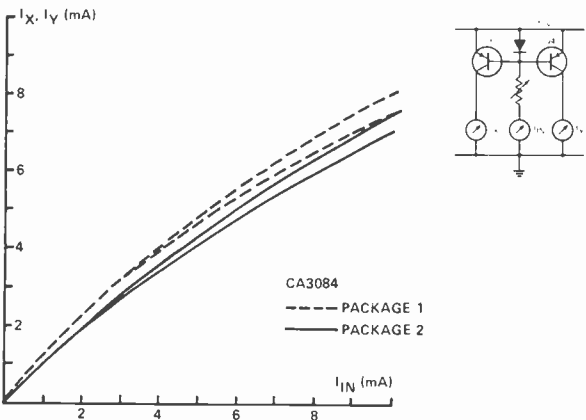


Fig. 5. Elementary current mirror — output matching test.

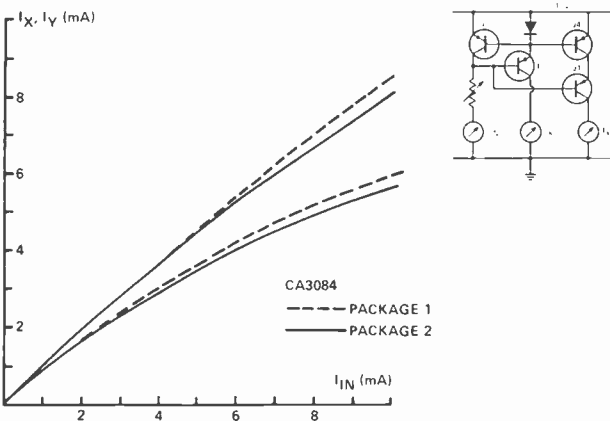


Fig. 6. Complex current mirror output matching test.

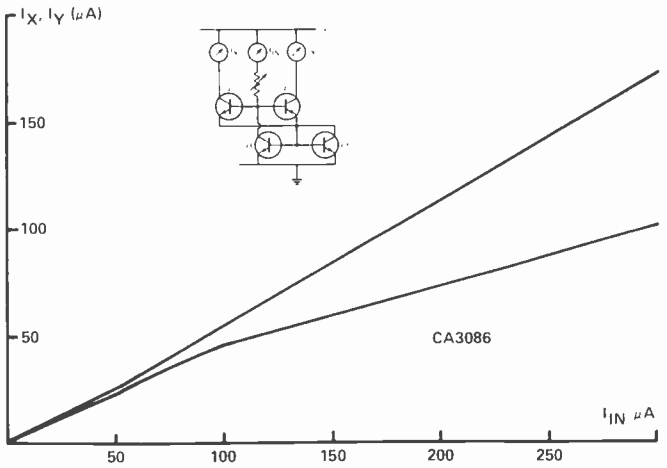


Fig. 8. Complex current mirror — output matching.

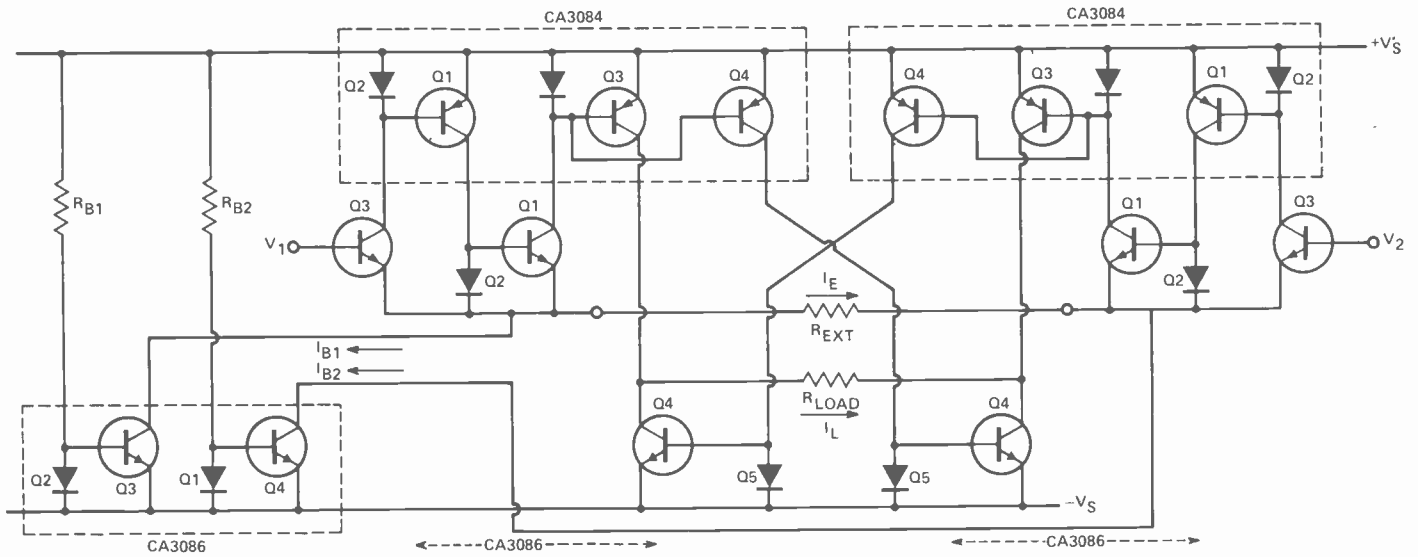


Fig. 9. Simplified VCT design employing IC transistor arrays.

(Fig. 10) and found to be ineffective as a means of compensation for bias imbalance between the two sides. If I_{IN2} is increased, for example, the base current of Q_2 and hence I_{O2} increase with a compensating decrease in I_{O1} . A link of this type is not possible with the simple mirror system adopted here, but would not have been employed with the more complicated circuit anyway.

A printed circuit board layout is shown in Fig. 11. No claim is made with regard to the optimal quality of this layout but it seems satisfactory.

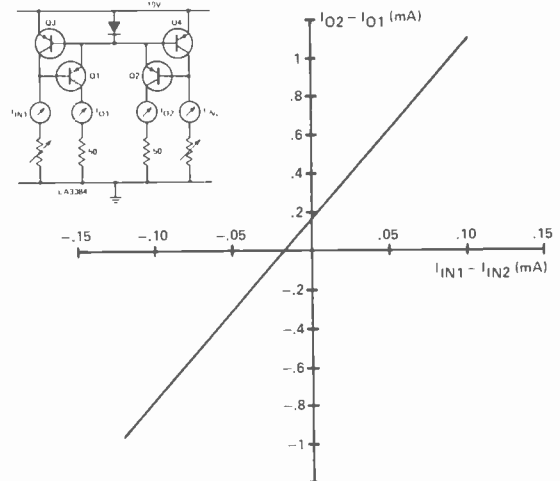


Fig. 10. Effect of linking current mirrors within the VCT.

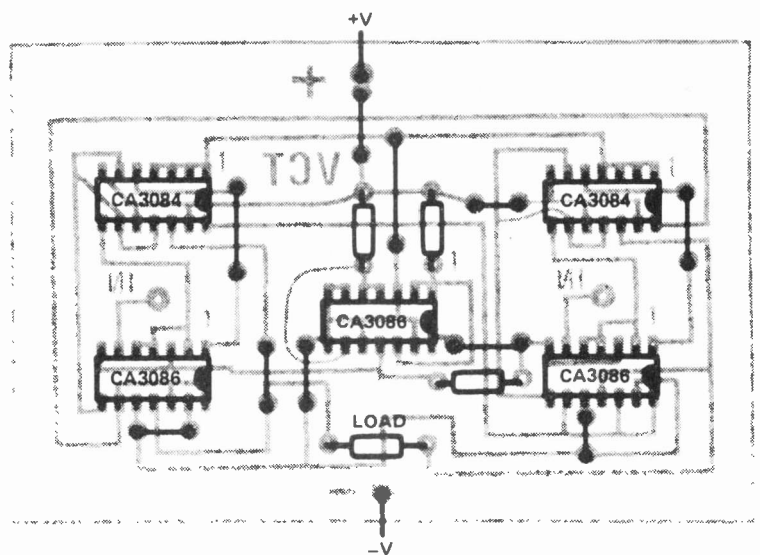
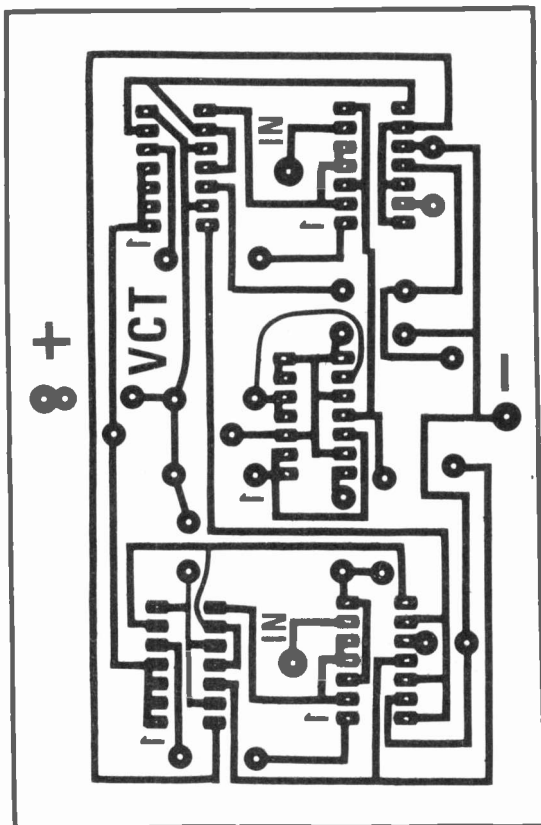


Fig. 11. PCB layout, showing external components, wire links, etc. — view from component side.

VCT Performance

It is not the function of this article to present an exhaustive survey of the circuit's performance in varied applications. Many of these have been proposed elsewhere (ETI, amongst others) and the reader is left to try these individually with his own discrete VCT. There are, however, a few pitfalls which warrant further discussion. Most of these may be classed as limitations of the non-ideal system.

Two VCTs were constructed and these are identified as 'a' and 'b' from here on. In general, they performed similarly, but there were some significant differences. Unless stated otherwise, below, supply voltages of ± 10 volts were employed with $R_{EXT} = 1k$ and only current monitoring as loads. The first test was to establish bias current levels to achieve a null output. R_{B1} was set to $4k$ with each unit. For VCTa, $R_{B2} = 5k212$ and for VCTb, $R_{B2} = 5k552$ established zero output currents for $V_1 = V_2 = 0V$. Drifts (of the order of $1 \mu A$ for VCTa and $40 \mu A$ for VCTb) were noted over the next few minutes and R_{B2} was finally set to $5k2$ for VCTa and $5k6$ for VCTb. In the test for common mode rejection (Fig. 12) the residual offset and the magnitude of short term drift effects are apparent (output levels must significantly exceed these drifts). As the supply voltages are approached, transistors begin to cut off and this may in turn lead to unpredictable effects depending on the relative parameters of the various devices. The lesson to avoid approaching the supply rails is clear. While the common-mode rejection ratio seems satisfactory for VCTa (Fig. 12), the curve for VCTb clearly indicates an asymmetry in the circuit, i.e. there is at least one transistor mismatched to its counterpart on the other side (this mismatch is most likely in a variation of gain with V_{CE}).

Fig. 13 shows the standard transfer characteristics. The slight variations in slope are due to R_{EXT} tolerances

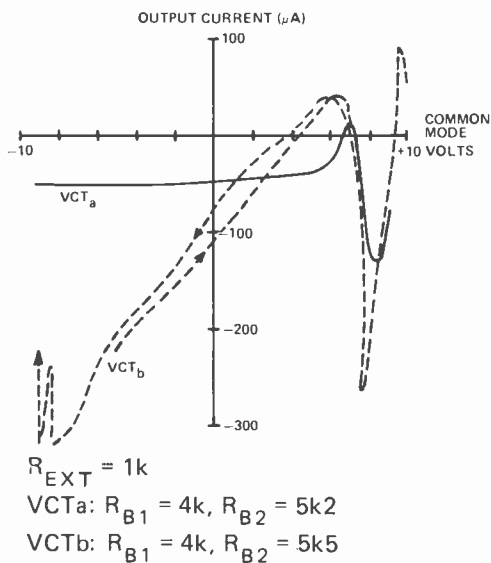


Fig. 13. Transfer characteristics.

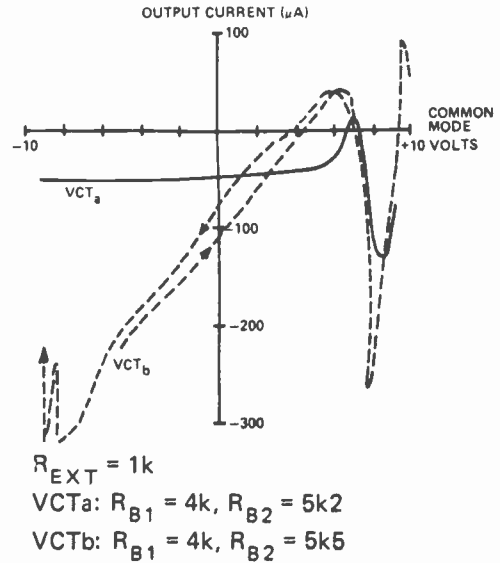


Fig. 12. Common mode signal transfer ($V_1 = V_2$).

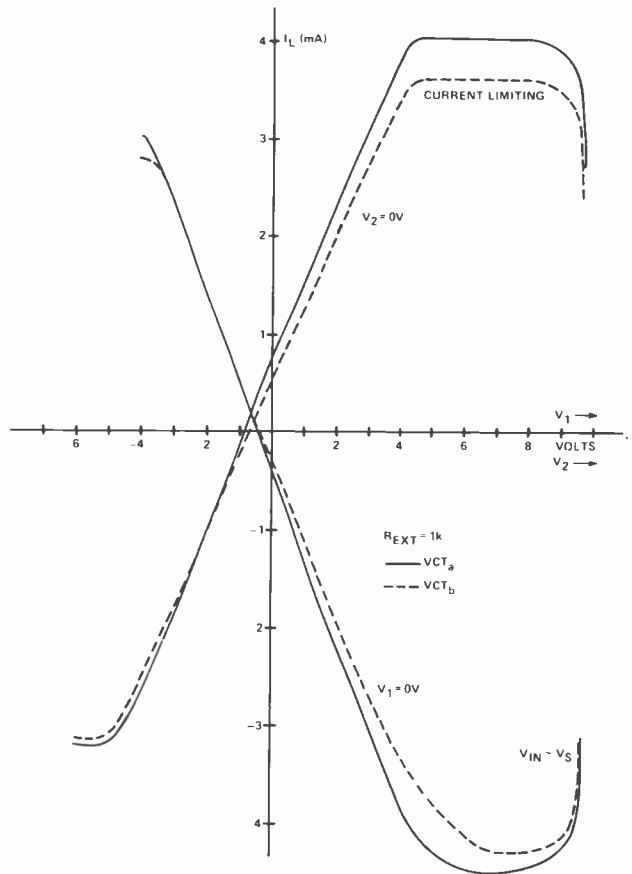


Fig. 14. Transfer characteristics with one end of the load grounded and with corresponding input grounded.

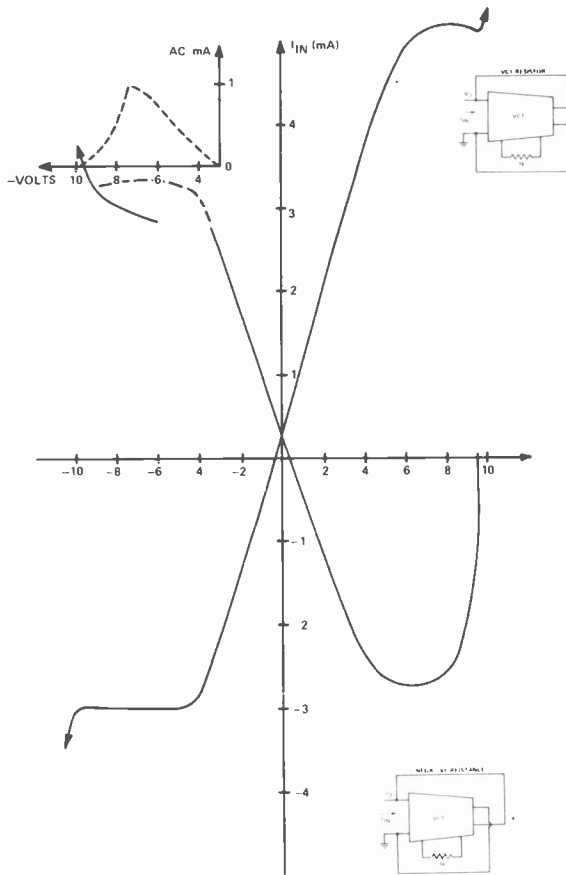


Fig. 16. VCT 'resistors' — positive and negative.

and the measured values (VCTa: 1mA/12V and 6mA/7.75V for $R_{EXT} \approx 10k, 1k$ exceed expectation slightly (c.f. 1mA/15V, 6mA/9V) due to a small current gain caused by transistor mismatching. This effect also leads to small discrepancies from the expected current limit levels (e.g. $\frac{2}{3} \times 20V/4k$ and $\frac{2}{3} \times 20V/5k2$).

The results described in the preceding paragraph were obtained with one input grounded as a matter of convenience. There is a dramatic shift in the offset current when one end of the load is also grounded (Fig. 14) and when both these fixed points are switched to the other side of the VCT. It would seem that the concept of 'floating' input and output require re-examination.

It must be noted that while one might expect the two ends of the floating load to sit at approximately zero volts, it does not take a great deal of device variation to produce extreme deviations from this. In both the circuits built here, two output transistors (Q_4, Q_5 of CA3086, see Fig. 9) were saturated at null output. (With different selection of devices, saturation of CA3084 Q_3 and Q_4 is equally likely). This creates no problems for the floating load unit high frequency or switching applications where performance will be down-graded by transistor saturation. It does, however, mean that the output must be zeroed if either end of the load is to be tied to a fixed potential as in Fig. 14.

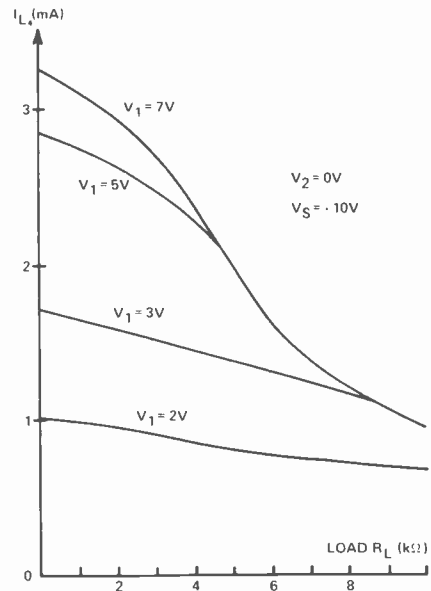


Fig. 15. Effect of output load resistance.

The four constant current sources which comprise the output circuitry lead inevitably to saturation as soon as there is an imbalance between them. In many cases zeroing the output current aggravates the problem. If device selection is contemplated, these are the transistors to consider first.

Variation of load current with load impedance (Fig. 15) suggests that the output impedance is about 40k substantially below the 60-100 k range expected from the transistor specifications because of saturation. The differential small signal input resistance has been measured at about 35k which is approximately $h_{FE} R_{EXT}$. This figure would be increased by the use of Darlington input transistors.

Applying Exotics

Up until this stage, none of the more exotic circuit applications has been discussed. A few remarks should be made, however, in closing. Ideally the output is a constant current and can be used to linearly charge a capacitor, e.g. to provide integration. The constant current sourcing is not perfect however and integrating applications will be limited to frequencies greater than $(2\pi R_{OUT}C)^{-1}$. A similar limitation will exist for gyrator performance.

A gyrator was built with the two VCTs but oscillated. The oscillation is believed to originate, however, with the use of inadequate power supplies — another point to note in investigating these circuits — rather than with that circuit itself. Gyrators operate on a negative imittance conversion principle so it is instructive to consider the resistance applications of the VCT in Fig. 16 where the terminal resistances are expected to be $\pm \frac{2}{3} R_{EXT}$. In the negative resistance case an oscillation region was identified (see inset). If the negative resistance circuit is examined, it clearly provides positive feedback if the driving source (V_2) impedance is not zero.

In closing I wish to acknowledge the assistance of Jock Howie and others with this project.

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Ready built. Designed in a slim form for compact, modern installation. Rotary Controls Vol On/Off, Bass, Treble, Balance. Push Buttons for Gram, Tape, VHF, MW, LW and 5 button rotary selection switch.

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£29.95 P&P £2.50

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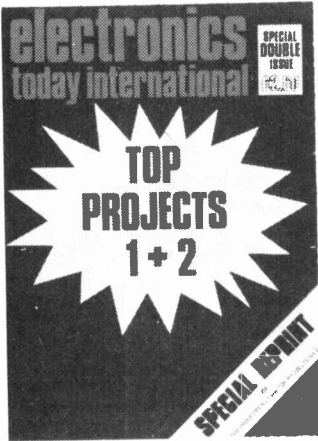


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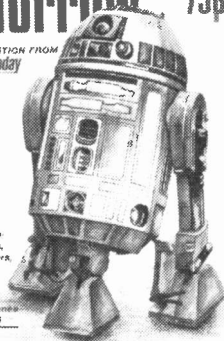
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by PETER H SYDENHAM
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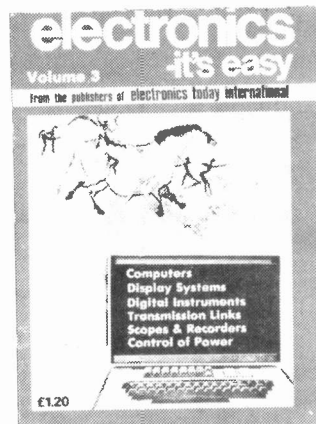
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7400	.08	.075	.07	.155	.14	.13	7490	.30	.28	.26	74167	2.20	2.05	1.95	4000	1.3	1.1	1.0	4072	1.4	1.3	1.2	4554	.90	.78	.68	CA3045-14	.30
7401	.11	.105	.10	.155	.14	.13	7491	.60	.55	.52	74168				4001	1.3	1.2	1.1	4073	1.4	1.3	1.2	4555	.75	.62	.56	CA3046-14	.40
7402	.11	.105	.10	.155	.14	.13	7492	.33	.30	.28	74169				4002	1.3	1.2	1.1	4074	1.4	1.3	1.2	4556	.75	.62	.56	LM308-14	.68
7403	.11	.105	.10	.155	.14	.13	7493	.28	.25	.23	74170	1.20	1.10	1.00	4006	1.0	1.25	1.1	4075	1.4	1.3	1.2	4557	3.20	2.80	2.40	LM318-14	.90
7404	.11	.105	.10	.155	.14	.13	7494	.50	.45	.42	74171	3.80	3.55	3.40	4007	1.3	1.2	1.1	4076	1.2	1.1	1.0	4558	.90	.80	.72	LM7108-14	.26
7405	.12	.115	.11	.16	.15	.135	7495	.50	.45	.42	74172	.90	.84	.80	4008	1.0	1.25	1.1	4077	1.3	1.2	1.1	4559	3.00	2.50	2.20	LM7109-14	.26
7406	.22	.21	.20				7496	.48	.42	.38	74173	.60	.54	.51	4009	1.3	1.2	1.1	4078	1.4	1.3	1.2	4560	1.45	1.20	1.05	MC1310P-14	1.30
7407	.22	.21	.20				7497	1.80	1.70	1.65	74174	.64	.60	.56	4010	1.3	1.2	1.1	4079	1.4	1.3	1.2	4561	.82	.75	.68	NE555-8	.23
7408	.13	.125	.12	.155	.14	.13	74100	.80	.72	.68	74175	.58	.54	.51	4011	1.3	1.2	1.1	4080	1.2	1.1	1.0	4562	4.20	3.60	3.25	NE556-14	.25
7409	.13	.125	.12	.155	.14	.135	74104	.40	.36	.34	74176	.56	.52	.49	4012	1.3	1.2	1.1	4081	1.2	1.1	1.0	4563	.98	.86	.80	ME25018-14	1.25
7410	.11	.105	.10	.155	.14	.13	74105	.37	.34	.32	74177	.56	.52	.49	4013	1.3	1.2	1.1	4082	1.2	1.1	1.0	4564	1.70	1.50	1.38	SN75110N	.40
7411	.17	.16	.15	.16	.15	.135	74107	.22	.20	.18	74178	.90	.80	.75	4015	1.3	1.2	1.1	4083	1.2	1.1	1.0	4565	1.37	1.15	1.05	SN75033N	1.65
7412	.14	.135	.13	.16	.15	.135	74109	.28	.26	.24	74179	1.08	1.00	.95	4016	1.3	1.2	1.1	4084	1.2	1.1	1.0	4566	4.20	3.65	3.40	SN75013N	1.25
7413	.23	.21	.20	.28	.26	.24	74110	.36	.34	.32	74180	.80	.70	.62	4017	1.3	1.2	1.1	4085	1.2	1.1	1.0	4567	1.98	1.71	1.40	SN75023N	1.65
7414	.46	.43	.40	.65	.67	.60	74111	.55	.52	.50	74181	1.15	.95	.80	4018	1.3	1.2	1.1	4086	1.2	1.1	1.0	4568	.82	.74	.68	SN75033N	1.65
7415				.16	.15	.135	74112				74182	.52	.47	.44	4019	1.3	1.2	1.1	4087	1.2	1.1	1.0	4569	.70	.60	.52	TA5508	.30
7416	.22	.20	.18				74113	.28	.26	.24	74183	1.25	1.06	1.00	4020	1.3	1.2	1.1	4088	1.2	1.1	1.0	4570	.80	.70	.62	TA5618	1.00
7417	.22	.20	.18				74114				74184	1.25	1.06	1.00	4021	1.3	1.2	1.1	4089	1.2	1.1	1.0	4571	.88	.78	.70	TBA1205	.58
7420	.11	.105	.10	.155	.14	.13	74116	1.10	1.00	.95	74185	2.20	2.00	1.95	4022	1.3	1.2	1.1	4090	1.2	1.1	1.0	4572	1.98	1.70	1.50	TBA614	1.60
7421	.22	.21	.20	.16	.15	.135	74118	.78	.75	.72	74189				4023	1.3	1.2	1.1	4091	1.2	1.1	1.0	4573	.88	.83	.80	TBA800	.80
7422	.17	.165	.16	.16	.15	.135	74119	1.10	1.00	.95	74190	.68	.60	.55	4024	1.3	1.2	1.1	4092	1.2	1.1	1.0	4574	.88	.83	.80	TBA810S	.75
7423	.20	.19	.18				74120	.80	.76	.74	74191	.68	.60	.55	4025	1.3	1.2	1.1	4093	1.2	1.1	1.0	4575	.88	.83	.80	TBA820S	.75
7425	.20	.19	.18				74121	.24	.22	.20	74192	.62	.55	.48	4026	1.3	1.2	1.1	4094	1.2	1.1	1.0	4576	1.15	1.11	.205	TC4270S0	1.70
7426	.21	.20	.19	.16	.15	.135	74122	.32	.29	.27	74193	.60	.50	.46	4027	1.3	1.2	1.1	4095	1.2	1.1	1.0	4577	1.25	1.12	.115	TC42820	3.00
7427	.21	.20	.19	.16	.15	.135	74123	.38	.35	.32	74194	.58	.50	.46	4028	1.3	1.2	1.1	4096	1.2	1.1	1.0	4578	.18	.16	.15	TM414	.90
7428				.16	.17	.16	74124	1.60	1.50	1.42	74195	.58	.50	.46	4029	1.3	1.2	1.1	4097	1.2	1.1	1.0	4579	.82	.74	.68		
7430	.11	.105	.10	.155	.14	.13	74125	.32	.30	.28	74196	.56	.50	.45	4030	1.3	1.2	1.1	4098	1.2	1.1	1.0	4580	.70	.60	.52	OP-AMPS	
7432	.21	.20	.19	.23	.20	.18	74126	.32	.30	.28	74197	.50	.44	.40	4031	1.3	1.2	1.1	4099	1.2	1.1	1.0	4581	.88	.83	.80	CA1310 TO99	.80
7433	.20	.19	.18				74128	.60	.55	.52	74198	.96	.85	.78	4032	1.3	1.2	1.1	4100	1.2	1.1	1.0	4582	.88	.83	.80	LM301A-8	.24
7437	.20	.19	.18	.24	.21	.185	74130	.40	.36	.32	74199	.98	.90	.85	4033	1.3	1.2	1.1	4101	1.2	1.1	1.0	4583	.88	.83	.80	LM301A-8	.24
7438	.20	.19	.18	.24	.21	.185	74132	.47	.44	.42	74201	1.20	1.00	.88	4034	1.3	1.2	1.1	4102	1.2	1.1	1.0	4584	.88	.83	.80	LM301A-8	.24
7440	.12	.115	.11	.18	.16	.15	74134	.32	.30	.28	74202	1.20	1.00	.88	4035	1.3	1.2	1.1	4103	1.2	1.1	1.0	4585	.88	.83	.80	LM301A-8	.24
7441	.48	.45	.43				74135	.62	.58	.55	74203				4036	1.3	1.2	1.1	4104	1.2	1.1	1.0	4586	.88	.83	.80	LM301A-8	.24
7442	.40	.36	.34	.50	.44	.40	74136	.52	.48	.46	74204				4037	1.3	1.2	1.1	4105	1.2	1.1	1.0	4587	.88	.83	.80	LM301A-8	.24
7443	.65	.60	.57				74137	.74	.68	.66	74205	1.00	.82	.74	4038	1.3	1.2	1.1	4106	1.2	1.1	1.0	4588	.88	.83	.80	LM301A-8	.24
7444	.64	.59	.56				74138				74206				4039	1.3	1.2	1.1	4107	1.2	1.1	1.0	4589	.88	.83	.80	LM301A-8	.24
7445	.53	.50	.48				74139				74207				4040	1.3	1.2	1.1	4108	1.2	1.1	1.0	4590	.88	.83	.80	LM301A-8	.24
7446	.55	.52	.50				74141	.52	.48	.46	74208				4041	1.3	1.2	1.1	4109	1.2	1.1	1.0	4591	.88	.83	.80	LM301A-8	.24
7447	.50	.44	.40	.67	.60	.56	74142	1.85	1.75	1.68	74209	1.90	1.70	1.55	4042	1.3	1.2	1.1	4110	1.2	1.1	1.0	4592	.88	.83	.80	LM301A-8	.24
7448	.55	.50	.48	.67	.63	.65	74143	2.30	2.10	2.00	74210	1.90	1.70	1.55	4043	1.3	1.2	1.1	4111	1.2	1.1	1.0	4593	.88	.83	.80	LM301A-8	.24
7449				.67	.60	.56	74144	2.30	2.10	2.00	74211	1.90	1.70	1.55	4044	1.3	1.2	1.1	4112	1.2	1.1	1.0	4594	.88	.83	.80	LM301A-8	.24
7450	.12	.115	.11				74145	.55	.50	.48	74212	1.90	1.70	1.55	4045	1.3	1.2	1.1	4113	1.2	1.1	1.0	4595	.88	.83	.80	LM301A-8	.24
7451	.12	.115	.11	.16	.15	.135	74147	1.00	.92	.88	74213	1.90	1.70	1.55	4046	1.3	1.2	1.1	4114	1.2	1.1	1.0	4596	.88	.83	.80	LM301A-8	.24
7452	.12	.115	.11				74148	.84	.78	.75	74214	1.90	1.70	1.55	4047	1.3	1.2	1.1	4115	1.2	1.1	1.0	4597	.88	.83	.80	LM301A-8	.24
7454	.12	.115	.11	.155	.14	.13	74150	.60	.55	.50	74215	1.90	1.70	1.55	4048	1.3	1.2	1.1	4116	1.2	1.1	1.0	4598	.88	.83	.80	LM301A-8	.24
7455				.16	.15	.135	74151	.46	.41	.38	74216	1.90	1.70	1.55	4049	1.3	1.2	1.1	4117	1.2	1.1	1.0	4599	.88	.83	.80	LM301A-8	.24
7460	.12	.115	.11				74153	.46	.41	.38	74217	1.90	1.70	1.55	4050	1.3	1.2	1.1	4118	1.2	1.1	1.0	4600	.88	.83	.80	LM301A-8	.24
7470	.25	.23	.21				74154	.78	.68	.60	74218	1.90	1.70	1.55	4051	1.3	1.2	1.1	4119	1.2	1.1	1.0	4601	.88	.83	.80	LM301A-8	.24
7472	.22	.20	.18				74155	.50	.46	.44	74219	1.90	1.70	1.55	4052	1.3	1.2	1.1	4120	1.2	1.1	1.0	4602	.88	.83	.80	LM301A-8	.24
7473	.23	.21	.20	.26	.23	.21	74156	.50	.46	.44	74220	1.90	1.70	1.55	4053	1.3	1.2	1.1	4121	1.2	1.1	1.0	4603	.88	.83	.80	LM301A-8	.24
7474	.23	.21	.20																									

TAPE NOISE LIMITER

Takes the hiss out of the quiet bits of your music, and does in a way which is simple yet effective, and is a replay only process so it will work on any tape!

DESPITE the small size, the performance obtainable from a cassette tape in a good recording deck is quite remarkable. In fact the latest top quality decks are so good that it is difficult to tell the difference between the recording and the original sound.

Unfortunately this is not true of the cheaper units — in which 'tape hiss' can be very prominent. Tape hiss is caused by random irregularities in a tape's surface coating. The effect is common to all tapes but some are marginally worse than others.

The annoying characteristic of tape hiss delayed the acceptance of cassette tape recorders in hi-fi systems for some years — until the advent of the Dolby system which was primarily developed as a cure for the phenomenon.

The Dolby system is often misunderstood — *it only works if the cassette tape itself has been recorded using the Dolby process* — and few commercially produced tapes are. Unless the tape cassette says specifically that it is Dolby processed then it's not! You can of course record your own tapes using Dolby if you own a Dolby machine.

Upper Limit

To overcome this limitation a number of cassette recorders are fitted with noise reduction circuitry which reduces the level of hiss on non-Dolby recordings. Most of these noise reducing circuits work by progressively reducing all high frequency signals when the output level falls below a preset minimum. Above that minimum level all sounds are allowed through because tape hiss cannot be heard once the sound

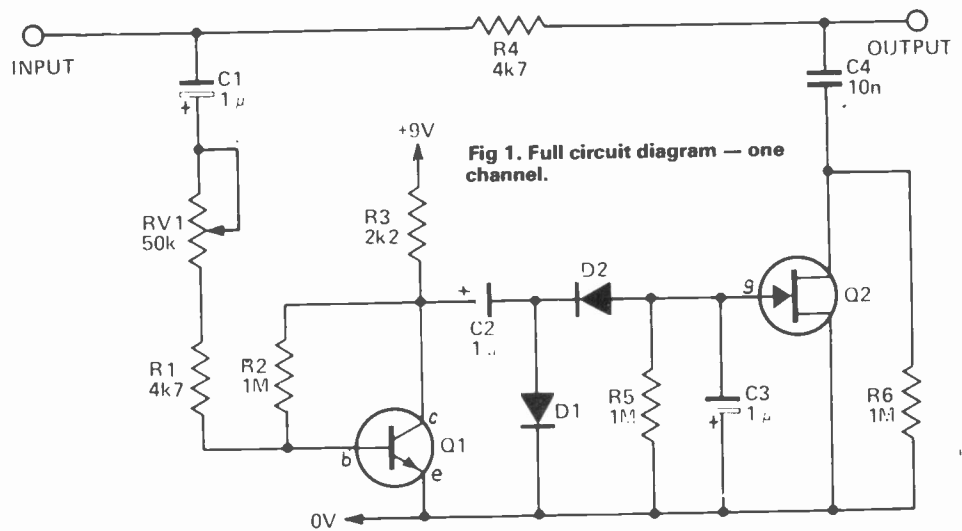


Fig 1. Full circuit diagram — one channel.

HOW IT WORKS

The circuit passes all frequencies (without attenuation) if the incoming signal is above a set minimum level. Signals below the preset minimum are progressively attenuated from 1 kHz upwards. The maximum attenuation of about 10 dB is applied at approx 10 kHz.

Resistor R4 and capacitor C4 form a filter in which Q2 is used as a variable resistor with the degree of resistance dependant on gate voltage. Thus, if the input voltage is at or near 0V then Q2 appears as a low resistance and C4 is in circuit. If on the other hand the input signal is higher than (say)

four volts negative, Q2 has a very high resistance and C4 is effectively out of circuit.

The voltage applied to the gate of Q2 is that derived from Q1 — after rectification by D1 and D2. Transistor Q1 amplifies the input signal and with RV1 in minimum position, input signals above 10 mV or so will cause Q2 to be off.

Increasing RV1 raises the level below which high cut will occur. The change from full to zero cut occurs over a range of approx 5 dB input level change.

level is substantially louder than the hiss. This effect is called 'acoustic masking'.

The circuit described in this project is a simple but very effective unit which may be used with any cassette recorder which is connected to a hi-fi system.

The unit should preferably be connected between the cassette

recorder and the amplifier input — using short lengths of screened cable and suitable connecting plugs. If you really know what you're doing it may be actually built into the tape recorder or amplifier. Alternatively it may be connected between the pre-amplifier and power amplifier on those units which are so separated (note that many apparently integral

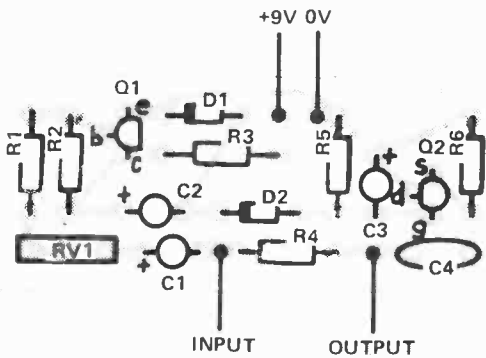
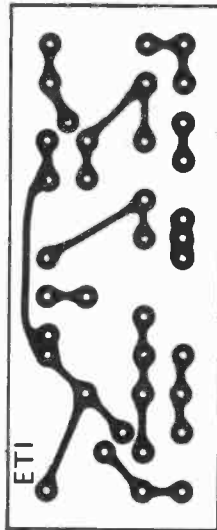


Fig 2. Above: Component overlay.



Foil pattern shown full size

amplifiers still have 'pre-amp out' and 'power-amp in' connectors on the rear panel. These connectors are normally bridged by 'U' shaped links — which should be removed to enable this unit to be plugged in).

Construction

As with most projects in this series you can use either Veroboard or the special printed circuit board shown here.

Take the usual precautions about inserting components the right way round — taking particular care with the field effect transistor Q2. Note that the cathode lead of the diodes

(shown as a horizontal bar on the circuit diagram) will be identified on the component by a black band or similar marking.

Unless the leads between this unit and the tape deck and amplifier are very short it is advisable to connect it via screened cable. Note that the 0V line shown on the circuit is also the 'earthy' side of the input/output connections.

To set up the unit simply choose a

PARTS LIST

RESISTORS 0.5 W 5%

R1, 4	4k7
R2, 5, 6	1M
R3	2k2

POTENTIOMETER

RV1	50 k trimpot
-----	--------------

CAPACITORS

C1-C3	1 μ F 25 V
C4	10n polyester

TRANSISTORS

Q1	BC548
Q2	2N5459

DIODE

D1-D2	1N914
-------	-------

MISCELLANEOUS

Nine volt battery and clip, PCB case.

recording with a longish quiet passage and then adjust RV1 for the best compromise between tape hiss reduction and minimum loss of high frequency programme content.

ETI

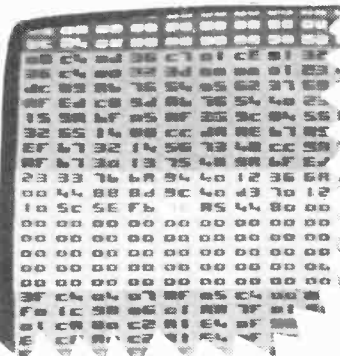
NOTE: If you listen only to hard rock — where there aren't any quiet passages — then this unit will be of little value to you. Its main effect is to reduce annoying tape hiss during otherwise quiet programme material.

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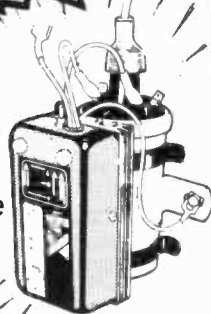


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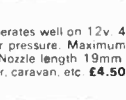
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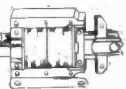
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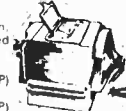
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A HISTORY OF CAR IGNITION

Ian Sinclair takes us back through the clouds of time (and exhaust!) to the beginnings of ignition, and sparks some interest on the way.

EVER SINCE the first motor car made its first coughing movements, designers have had the problem of ignition. Perhaps that's what encouraged the development of steam cars so long, it's worth remembering that the Stanley Steamer held several speed records in its day, and was still being manufactured in the twenties.

The petrol engine still works in the same way as it did then. As the piston descends, a valve opens and lets the mixture of petrol vapour and air enter the cylinder. At about the end of this induction stroke, the valve closes and then the piston starts to rise, compressing the mixture (compression stroke). Near the top end of its travel, the mixture has to be fired—and that's the job of the ignition department. Firing the mixture is what provides the power, driving the piston down, and keeping things going. At the next upward movement of the piston another valve opens, letting the exhaust gases escape. This four-stroke scheme has survived pretty well unaltered in principle, though with many improvements in details. The ignition of the mixture is one of the rather important details which has changed quite a lot since the first four stroke petrol engines were tried out.

What A Gas!

The first petrol engines used for ignition a scheme which had been quite acceptable for large gas engines. A small hole is drilled at the top of the cylinder (into the cylinder-head) and a lamp flame is allowed to burn close to the hole. This is easily done in a gas-engine by having a pilot-jet burning near the hole.

On the compression stroke, mixture is driven out of the hole, meets the flame, ignites, and the burning mixture blows back through the hole to ignite the rest of the mixture. Primitive, certainly, but quite effective for a large gas engine as long as you're not looking for high performance. The main problem here is that much of the mixture is lost, and it's very difficult to be sure that ignition won't be too soon.

Hot Tubes

For petrol engines, this was soon replaced by hot-tube ignition. As the name suggests, the end of the cylinder-head was formed into the shape of a sealed tube

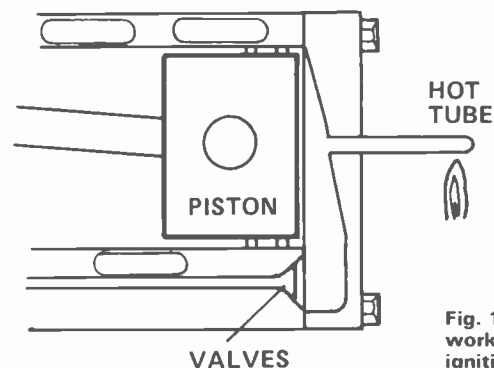


Fig. 1. Diagram of the workings of hot tube ignition.

the end of which was kept hot by a small blowlamp. The timing of the ignition still isn't under much control, but at least no mixture is lost, and the hot tube ignition was used on a lot of famous cars of the veteran period (before 1904).

Modern times start with electric ignition systems, and there are still plenty of cars running around with electrical ignition systems which would have been familiar to a mechanic seventy years ago. Oddly enough, it's not all that well understood so let's take a close look at it.

Highs And Lows

There are two parts to the ignition system, the LT and the HT (sparks). The LT circuit consists of the contact breaker and the primary winding of the ignition coil and the HT of the secondary winding of the coil, the distributor (which ensures that the spark goes to the correct plug) and the plugs themselves.

The contact breaker is a switch operated by a cam which runs at half of engine speed and has as many bumps (lobes) on it as there are cylinders in the engine. The spark occurs just as the switch contacts (the points) open, so that we can alter the timing of the spark by rotating the switch assembly slightly.

When the contact points are closed, current flows in the circuit through the primary of the coil and the points. The primary winding of the coil has a large inductance, and obeys exactly the same laws as any other large inductance—if we want the current through the coil to

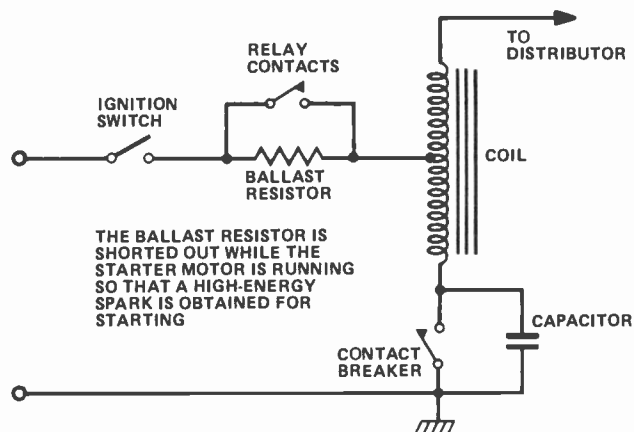


Fig 2. Simple electrical ignition

charge rapidly we need a high voltage; if we cause the current to charge rapidly, the coil will generate a very high voltage.

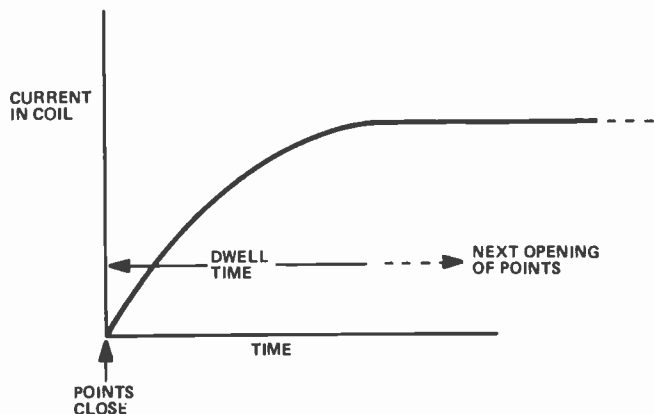
Make A Point Of It

When the points close, the current through the coil increases following the graph of Fig. 3. This time is called the dwell time, and the points must remain closed for long enough to give the current time to reach its final value. When the points open, the current is rapidly broken, causing the coil to generate a high voltage pulse from the collapsing magnet field.

This high voltage pulse is then stepped up by the transformer action of the secondary winding, giving about 20-25 kV to send a good spark cracking across the gap of the spark plug — we hope.

With such a simple system the life of the points can be rather short, and the spark at the plug low in voltage because of sparking at the points. The reason is that the voltage pulse which occurs whenever the points separate is enough to cause a spark at the points. This keeps some current flowing in the coil, so that the change is not so rapid as it should be. We can avoid these problems to some extent by connecting a capacitor (they still call it a condenser in garages) across the

Fig 3. Graph of current through coil.



points. When the points open, the voltage pulse produced by the coil (Fig 4) starts charging the capacitor, giving the points time to open and so avoid the worst of the sparking. Because this also results in a more rapid charge of current, the spark at the plugs is very much better when a capacitor is used.

Bad Points

The whole system works very well indeed, and is remarkably reliable but suffers from two disadvantages. One is that a fast revving engine with a large number of cylinders may not permit enough dwell time to allow current to build up fully before the next opening of the points. The other problem is that there is still some sparking at the points, so that the contacts wear unevenly and have to be reset at intervals, and ultimately replaced.

Electronic ignition systems use the same coil and HT equipment, but a different method of obtaining a quick charge of current through the coil. Most modern systems

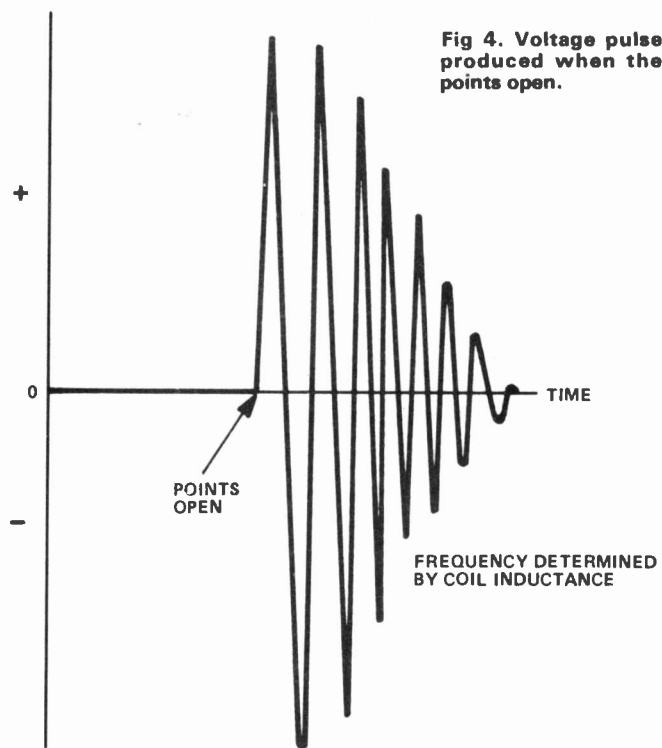


Fig 4. Voltage pulse produced when the points open.

use capacitor discharge in which an inverter circuit is used to generate about 400 V DC to charge a capacitor.

When the points open the capacitor is discharged through the primary winding of the coil, and this voltage pulse is stepped up by the transformer action of the coil to provide the high voltage from firing the plugs. Because the capacitor can be recharged quickly, the dwell time that is needed is reduced, and because the contact points only have to cause a thyristor to fire, they need carry only a fairly small current and because they do not carry current to the coil, there is no voltage pulse across them.

The points still need periodic adjustment though, because the rubbing of the cam against the fibre peg which operates the points causes wear, altering the

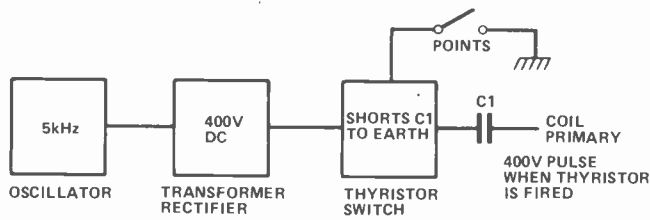


Fig 5. Typical modern system.

timing. To avoid such mechanical problems the cam can be replaced with a slotted cover rotating around an infra-red source (an LED), and so interrupting a beam which strikes a photocell. This then triggers the thyristor. Using this system, no adjustments are needed to compensate for mechanical wear until the gears on the shaft which drives the ignition system wear down—by which time the rest of the engine will have worn out anyway.

This is the system which enables car manufacturers to offer five year guarantees, and to promise 100,000 miles between adjustments of the ignition system.

Point Of No Return

Unfortunately, all this ingenuity does not ensure reliability, and electronic ignition systems have obtained a very bad name for causing accidents. The most common heart-stopper is that the ignition simply ceases—and if you're overtaking at the time it can be fatal. The other is completely erratic timing, with the engine knocking horribly and the sparks happening at any old time in the cycle—I limped home several miles like this once.

These problems can be solved, and car manufacturers who have gone over to electronic ignition have solved them. Nothing on earth, however, would persu-

ade me to use an electronic ignition system unless each component was marked with a manufacturer's name and the ratings. A lot of DIY systems seem to use Brand X components—and that's asking for trouble.

The components which are critical are the inverter circuit, the transformer for the inverter, the charge-discharge capacitor, and the thyristor itself Fig 6. The inverter circuit must keep oscillating (though the frequency may change) even as the thyristor fires, shortcircuiting the output of the transformer. This is, in turn, possible only if the transformer is correctly designed for the job.

The charge-discharge capacitor has to provide large pulses of current, and must be rated to take much more than the normal 400 V to allow for surges. The thyristor must also be able to withstand the full voltage of the inverter, plus any surges, and to pass the pulses of current to the coil. A 1000 V 10 A thyristor may seem excessive, but is very much more reliable than the usual 600 V 1A component.

Good Points

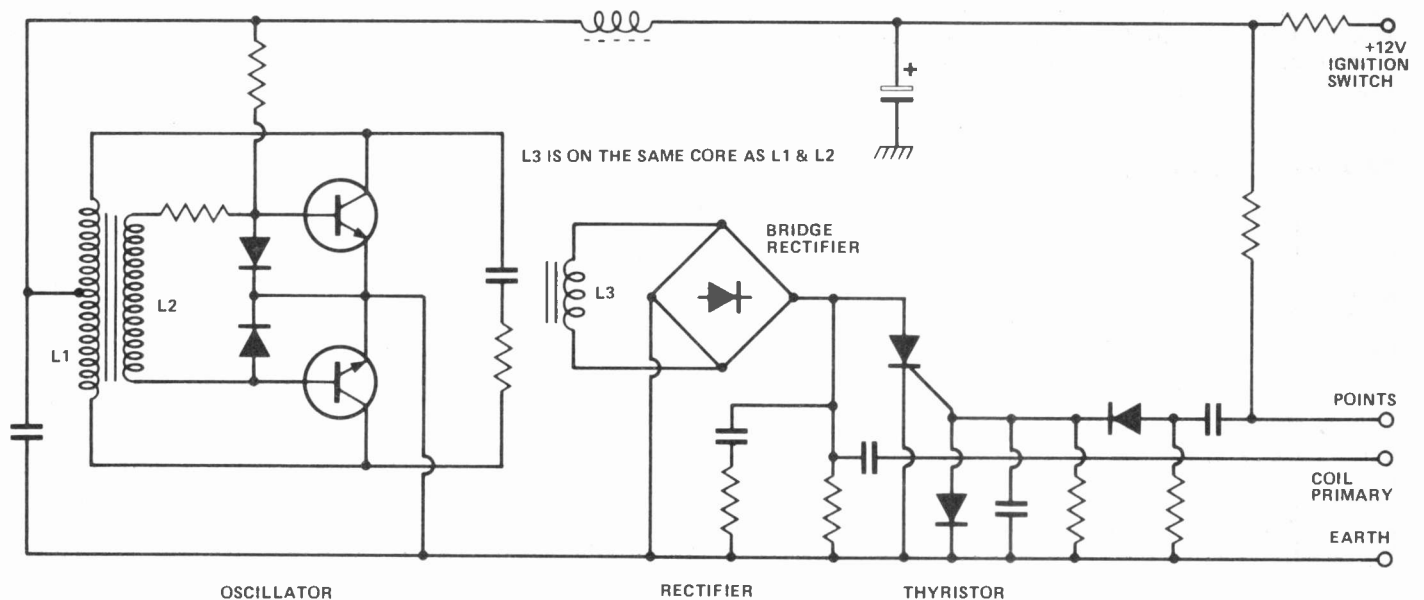
Many exaggerated claims are made for electronic ignition system, but the hard facts are that the main advantage is a longer time between ignition setting, particularly if the infra-red beam system is used. Cold starting can be better but only if the inverter uses a voltage regulator, which is rather rare.

Against this, reliability may be less, unless the whole circuit is built from top-grade military-specification components, rated to work at temperatures from well below freezing (you want it to start in the winter) to near boiling point (after it has stood out in the blazing sun for several hours).

However, there's little doubt that the well designed electronic ignition systems now being designed into cars by the manufacturers are quite definitely up to the job, with very great reliability and freedom from adjustment.

ETI

Complete Ignition system. Note the position of critical components.



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4035	120p	4174	104p	4583	84p
4036	250p	4175	95p	4584	63p
4037	100p	4194	95p	4585	100p
4038	105p	4501	23p		
4039	250p	4502	91p		
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4043	85p	4508	248p		
4044	80p	4510	99p		
4045	150p	4511	149p		
4046	130p	4512	98p		
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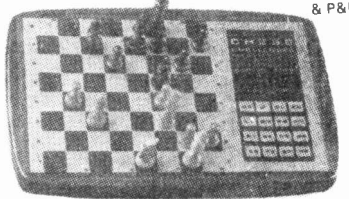
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TERMS etc: CWO please, VAT on Ambit Items is generally 12½%, except where marked (*). Catalogue part 1:45p, part 2 50p all inclusive. Postage 25p per order, carriage on tuner kits £3. Phone Brentwood (02771) 216029/227050 9am-7pm. Callers welcome inc. Saturdays.

At last, DIY HiFi which looks as if it isn't.

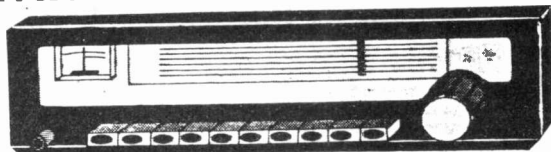
That's not to say it doesn't look like HiFi - just that it doesn't look like the usual sort of thing you have come to associate with DIY HiFi. The Mk3 outstrips and outperforms all British made HiFi tuners, and most imported ones too. Certainly at the price, there isn't one near it. But more than that, it looks superb. A small pic here would be an insult, so send an SAE for details on the kit that looks as if it isn't. It's something else.....

- * Exceptionally high performance - exceptionally straightforward assembly
- * Baseboard and plug-in construction. Future circuit developments will readily plug in, to keep the MkIII at the forefront of technical achievement
- * Various options and module line-ups possible to enable an installment approach to the system

and now previewing the matching 60W/channel VMOS amplifier:

- * Matching both the style and design concepts of the MkIII HiFi FM tuner
- * Hitachi VMOS power fets - characterized especially for HiFi applications
- * Power output readily multiplied by the addition of further MOSFETs
- * VU meters on the preamp - not simply dancing according to vol level
- * Backed with the usual Ambit expertise and technical capacity in audio

The PW Dorchester LW, MW, SW, & FM stereo tuner



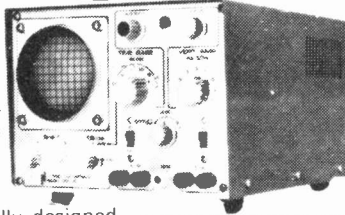
In much the same way as we have swept away the 'old technology' in frequency/timer counters - with the OKI and Intersil single IC counters, we now offer a single IC "All Band" radio tuner. Don't confuse this one chip radio with things like the ZN414 - for this is a genuine superhet receiver with a mechanical AM IF filter, and ceramic IF filters for FM. The AM section employs a balanced input mixer section, covering all broadcast bands - plus a BFO and MOSFET product detector for SSB/CW - though at this price, the tuner is not intended as a "communications receiver" - although we know of many lesser designs that make that claim. The AM sensitivity is nevertheless better than 5uV, and FM sensitivity is 1.2uV for 30dB S/N. As a multiband broadcast superhet receiver, it is a unique constructor project that fulfills the requests we very frequently get for a general coverage circuit that isn't over complicated. The set has CA3089E FM performance, with mute etc., and a PLL stereo decoder with full pilot tone filtering.

The tuner board - with "on board" PCB mounted switching, all components etc : £33.00
 The case/cabinet with PSU, meter and mechanics etc £25.00
 An SAE for full details please. See the feature article in Practical Wireless (Dec/Jan)

2 Gresham Road, Brentwood, Essex.

OSCILLOSCOPE FEATURES

- Response: DC to 5MHz.
- Sensitivity: 100mV to 50V/division.
- Fully calibrated time-base circuit and automatic blanking.
- 100% solid state - utilising 13 transistors, 1 FET and 1 specially designed time-base module.
- Stabilised power supplies and active sync circuits.
- Rugged construction together with portability.
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SPECIFICATIONS

ELECTRICAL DATA
VERTICAL AXIS (Y)
 Deflection Sensitivity - 100mV/division
 Bandwidth (between 3dB points) - DC - 5MHz
 Input Attenuator - (calibrated) - 9 steps: 0.1, 0.2, 0.5, 1, 2, 5, 10, 50V/div
 Input Impedance - 1 Meg/40pF in shunt
 Input Voltage - Max - 600V P-P
HORIZONTAL AXIS (X)
 Deflection Sensitivity - 0.400mV/division
 Bandwidth (between 3dB points) - 1 Hz - 350KHz
 Gain Control - Calibrated, when time base in EXT position
 Input Impedance (Meg)
 Input Voltage - Max - 600V P-P

TIME BASE
 Sweep Range (calibrated) - 100msc/div to 10 sec/div in 5 steps.

Fine Control - Variable between steps - includes time-base calibration position
Blanking - Internal - on all ranges

SYNCHRONISATION
 Selection - Internal, external
 Synchronisation Level - Continuous from positive to negative.

POWER SUPPLY
 Input Voltage - 115/220V AC 10% at 50/60Hz
 Power Dissipation - 18W

CRT DATA
 - 5" round display - single beam
 - Maximum high voltage - 750V
 - fitted with 10 sections, blue filter graticule

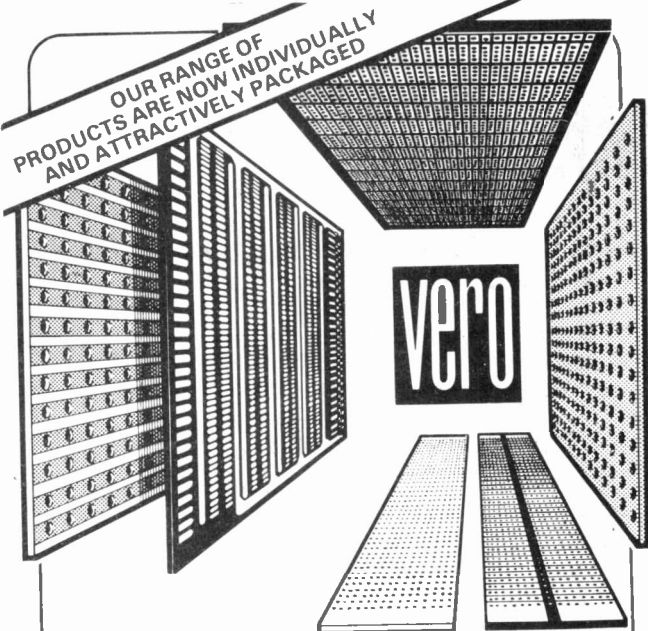
PHYSICAL DATA
 Dimensions - 15cm (h) x 20.5cm (w) x 28cm (d)
 Weight - 3.8kg (approx.)
 Stand - 2 position: flat and inclined
 Case - Steel, epoxy enamelled
 Colour - Light blue
 Front Panel - Anodised aluminium, epoxy printing

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LIGHT ACTIVATED TACHOMETER

By using optical sensing this unit allows measurement of rotational speed without the need for actual contact!

THE USE OF a non-contact method of measuring RPM is not only convenient but sometimes the only method possible. Some motors used for model aircraft have a capacity of only 0.15cc yet run at speeds in the 25000 RPM region. The power required to turn a mechanical tachometer would be many times the power of such a motor. Also on some machines there is no convenient place a normal tachometer can be fitted.

Design Features

As the main application for this unit was to be outdoors it was decided that an LCD display would be preferable to an LED and more easy to read than an analogue meter. Unfortunately LCDs are not yet readily available, and nor are the ICs needed to drive them.

However the Intersil Evaluation kit which we have used in the past is fairly easy to get hold of, and so we based the design around this unit. This meant converting the pulses from the sensor into a voltage. This however has another benefit in that a greater resolution can be obtained more quickly. To have a resolution of 10 RPM with a two bladed propeller a sample time of three seconds would be necessary.

The use of the BPW34 photodiode in the photovoltaic mode, ie actually generating a voltage, simplifies the biasing otherwise needed.

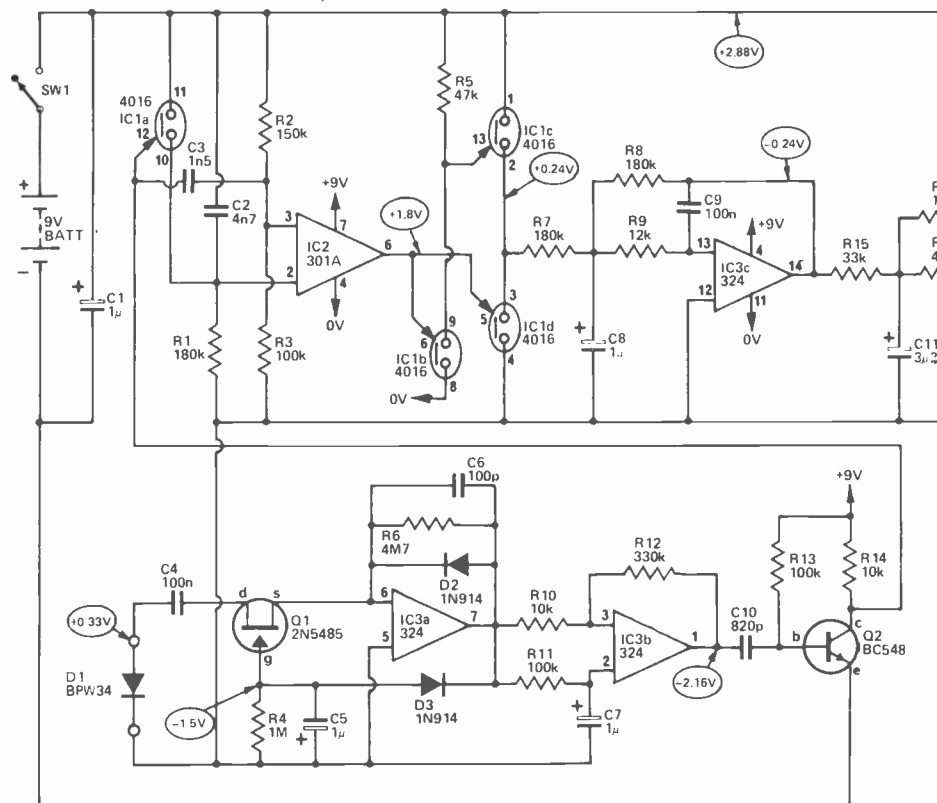
Construction

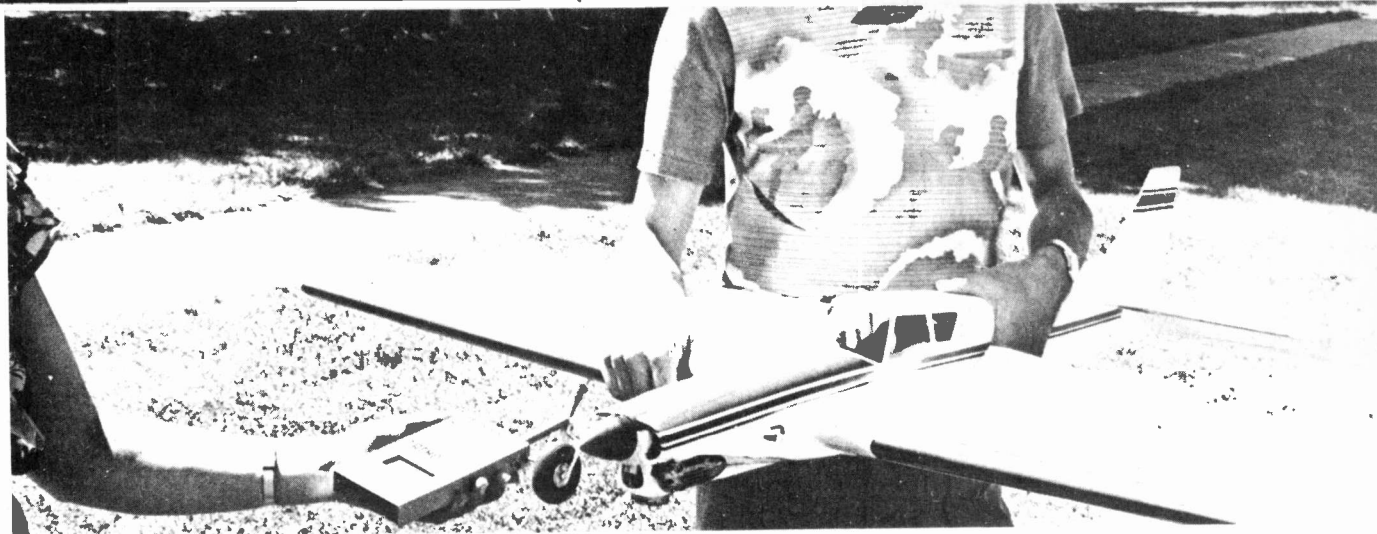
All the electronic components are mounted on a single card with the exception of the photodiode. To save on real estate the main voltmeter IC is mounted under the display.

Initially, assemble all the components apart from the ICs and the

SPECIFICATION

RPM range	
Low	0 - 20000
High	10000 - 30000
Resolution	10 RPM
Display	12mm LCD
Detection method	reflected light
Power	9V @ 4mA
Battery life (216)	about 150 hours





HOW IT WORKS

When using this unit to measure RPM, be the application a model aircraft motor or some other rotating object, the propeller or the white line (see operation section) gives rise to a changing light level. D1 which is a photo diode used in the photovoltaic mode, sees this light level and gives out a voltage proportional to the light. As this is only a small signal it has to be amplified before it can be used. This is done by IC3a. The transistor Q1 is included to provide some gain control allowing the unit to be used in differing light conditions without the need for any adjustment. The output of the amplifier is rectified by D3 to provide a negative

voltage on the gate of Q1. When the output of the amplifier is small the gate to source voltage will be near zero and the FET will appear as a low value resistor giving high gain to the amplifier. If the light change is such that the output of the amplifier is large, the rectified voltage on the gate of Q1 will cause the resistance of the FET to increase decreasing the amplifier gain. In this way the output of the amplifier is held relatively constant irrespective of the light level. Diode D2 is necessary to prevent the amplifier from saturating on the positive swing.

The output is then squared up by IC3b

where the positive feedback provided by R12 ensures that the output switches quickly. The output from this IC then triggers the monostable formed by Q2. What we have now is a pulse about 50µs long every time the propeller blade passes the light sensor.

Before continuing, you may have noticed that besides the +9V and 0V we also have a line marked V_{ref}. This is derived from IC4 which is a voltmeter chip and is a stable voltage of about 2.8 volts below the +9V line.

The output of the monostable (Q2) turns on IC1a for 50µs, discharging C2 which is then allowed to recharge to V_{ref}. This voltage is compared (by IC2) to the voltage set by R2 and R3. The output of IC2 is a negative pulse of about 900µs. As it is on a stable voltage supply, variations in battery voltage will have very little effect on the output pulse width. Capacitor C3 is used to force the positive input of IC2 above the negative one for the 50µs pulse ensuring that this time is not included in the output pulse. IC1b is used to invert this pulse and its output, and the output of IC2, control IC2c/IC2d. The output of IC2c/IC2d is a positive pulse switching between V_{ref} and the +9V line.

This is then filtered by two 2 pole active low pass filters, IC3c and IC3d. As these have a cutoff frequency of around 10 Hz the output for most applications will be the DC voltage component only. This is measured by IC4 which is a complete voltmeter.

As offset voltages and currents can cause the output of the filters not to be exactly zero with no input, the positive input of IC3d is biased up about 30mV and then by injecting a current into the negative input (by R19 and RV1) correction can be made. For measuring RPMs above 20000 and below 30000 a current is injected into the negative input via R18 and this subtracts 10000 RPM from the reading.

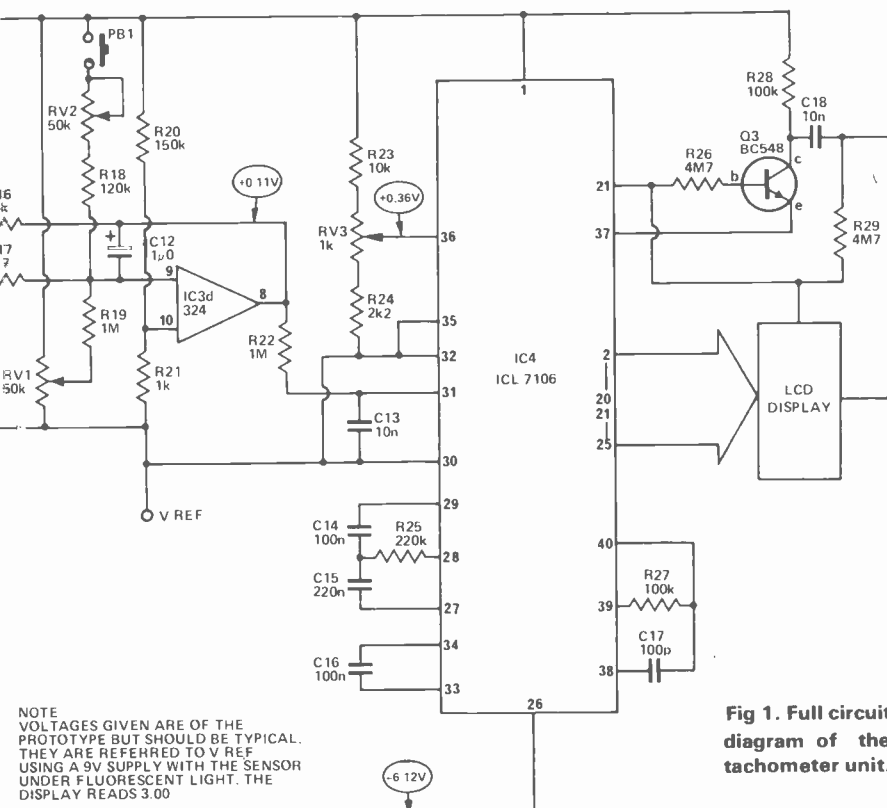


Fig 1. Full circuit diagram of the tachometer unit.

BUYLINES

The only awkward component here will be the BPW 34 photo diode. However a quick hunt through some catalogues showed us that Electrovalue sell the item at £1.73. Evaluation kits should be available from people like Technomatic and Marshalls.

PARTS LIST

RESISTORS (all 1/4 w 5%)

R1, 7, 8	180k
R2, 20	150k
R3, 11, 13, 27, 28	100k
R4, 19, 22	1M
R5	47k
R6, 26, 29	4M7
R9	12k
R10, 14, 23	10k
R12	330k
R15	33k
R16	15k
R17	4k7
R18	120k
R21	1k
R24	2k2
R25	220k
POTENTIOMETERS	
RV1, 2	50k trimmer
RV2	1k trimmer — 10 turn type

CAPACITORS

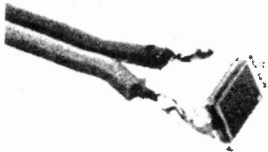
C1, 5, 7, 8, 12	1u 35V tantalum
C2	4n7 Polystyrene
C3	1n5 Polyester
C4, 14, 16, 9	100n Pollyester
C6, 17	100p Ceramic
C10	820p Ceramic
C11	3u3 16V Tantalum
C13, 18	10n Polyester
C15	220n Polyester

SEMICONDUCTORS

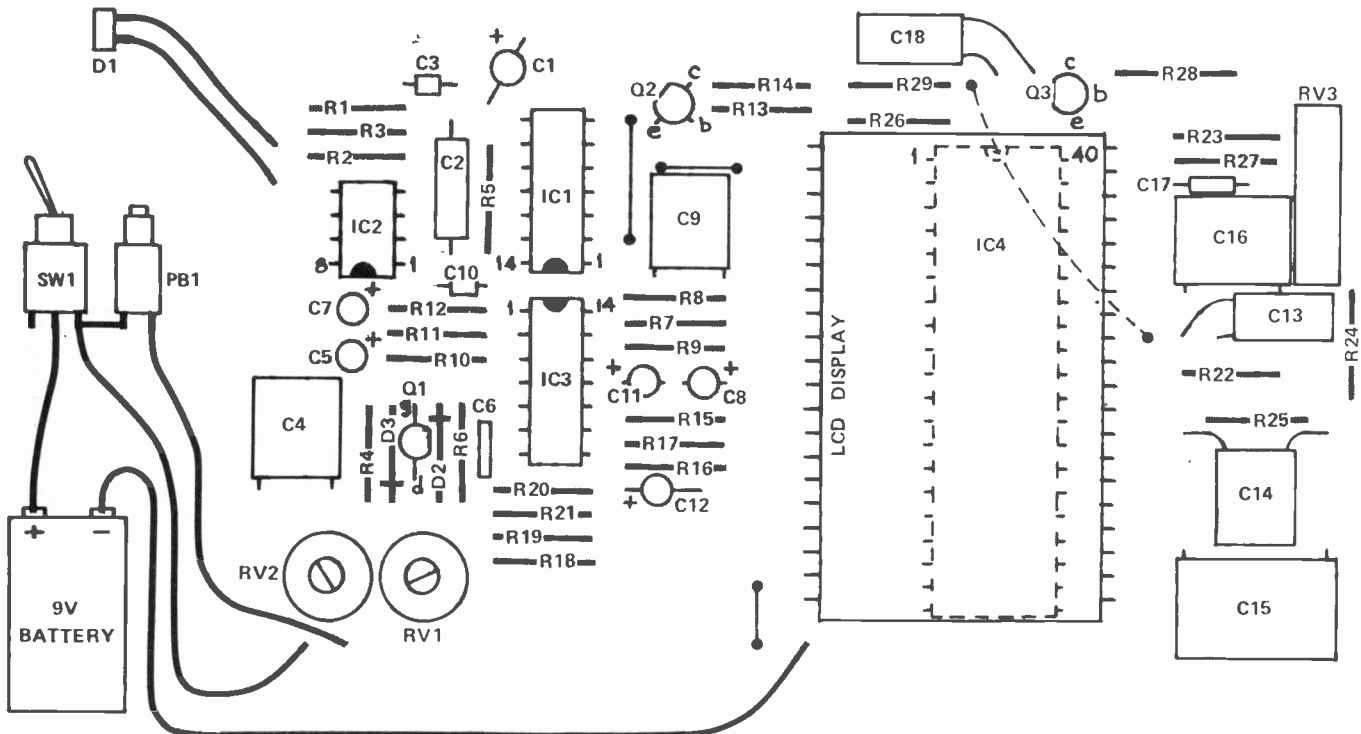
IC1	4016
IC2	301A
IC3	324
IC4	ICL 7106
Q1	2N5485
Q2, 3	BC548
D1	BPW34
D2, 3	1N914

MISCELLANEOUS

PCB, toggle switch, pushbutton, LCD display (evaluation kit?) case, battery clip.



Left: the BP34 photo-diode mounted on its lead. Shielding it from ambient conditions, in a tube for example, helps operation. Below: Fig 2 the overlay and wiring diagram. Note the D1 polarity is not important.



display, taking care not to bridge between the tracks with solder. Also note that some of the capacitors have to be laid on their side to give a low height.

The ICs can now be added being careful to polarize them correctly. Due to the display being mounted over the main IC it is not possible to use a socket. A socket can be used for the display if desired however it will have to be modified by cutting it into two strips.

As there are no polarity marks on the display it is necessary to hold it at the light and look for the outline of the digits. A link for the decimal point should be added as shown in the diagram.

We mounted our unit in a metal box we made with the photodiode mounted about 25mm from the end of a 75mm long tube in front of the box. This narrows the field of view of the diode as well as giving a little more clearance between high speed propellers and the fingers!

Calibration

Switch on the unit and cover the photodiode to prevent any light reaching it. Now adjust RV1 until the display reads zero.

Uncover the diode and point it at a fluorescent light. It will now give a reading and RV3 should be adjusted to indicate 3000 RPM.

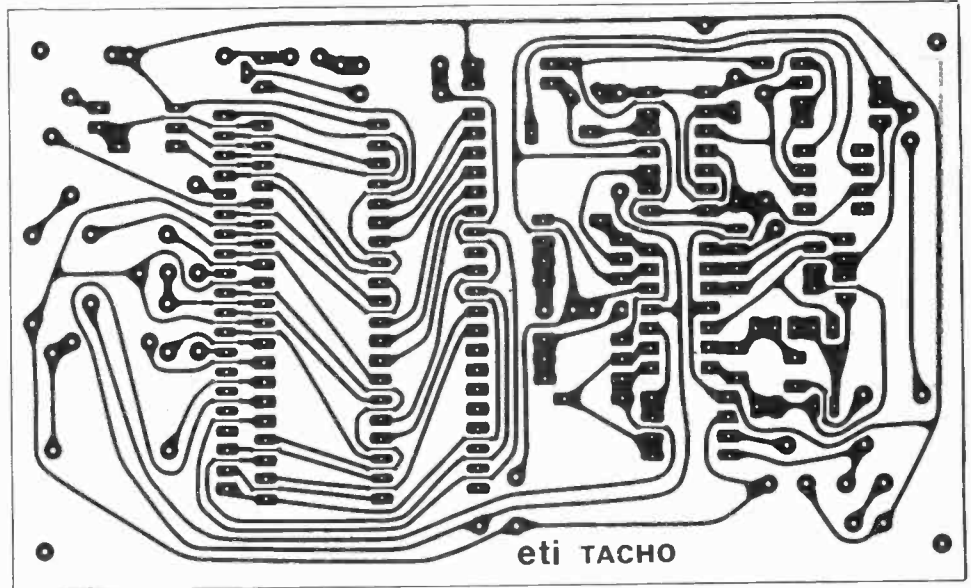
Again cover the diode, then press the high range button and adjust RV2 to give a reading of -10000 RPM. Under fluorescent light it should read -7000 RPM

Operation

This unit relies on a changing light level for its operation. For use with a model aircraft, holding the unit near the propeller enables detection of the changes in the reflected light level. To measure the speed of other rotating equipment it may be necessary to paint a series of white lines to give the sensor something to 'see'.

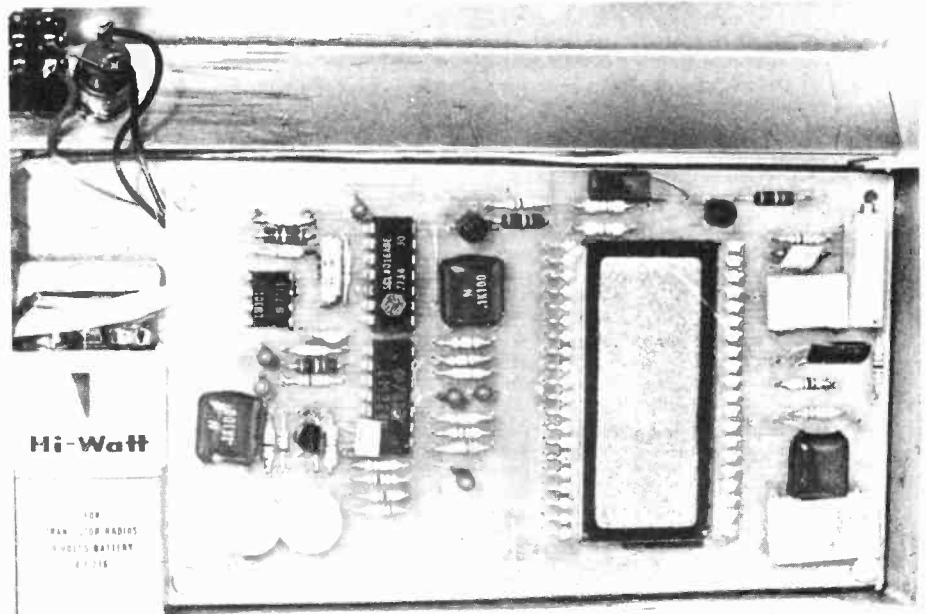
However the unit cannot be used under fluorescent lights as it will see the 100 cycle flicker (see calibration section). In cases where this has to be done, and places where the ambient light is low, a small incandescent globe can be used to shine on the spot looked at by the sensor.

The unit, as described, is scaled to read up to 20000 RPM with a 10 RPM resolution, assuming two input pulses per revolution. If a different number of



Above: full size foil pattern for the tacho unit.

Below: An assembled PCB. Comparing this with the overlay shown opposite should help with construction.



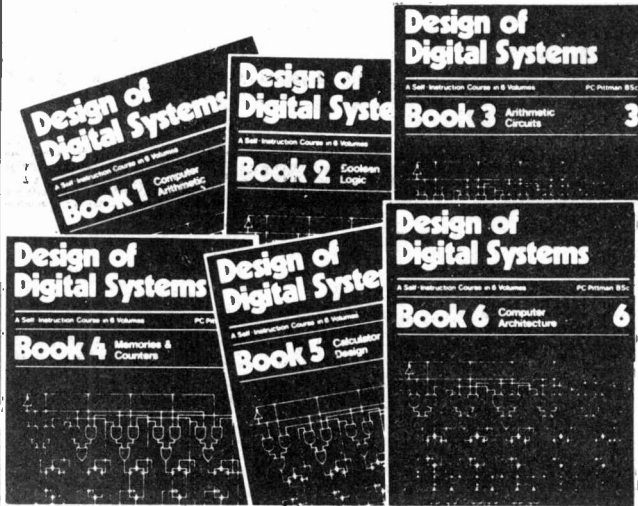
input pulses is to be used, e.g. a three or four bladed propeller, the value of R1 can be changed. ($R1 \approx 360k / \text{number of pulses}$). The use of more than four pulses per revolution is not recommended on this range. If 2000 RPM is more than is needed for your application the value of R1 can be increased by a factor of 10, preferably with more than ten pulses per revolution.

Unlike a frequency meter, overranging this unit will cause the display to blank and greater resolution cannot be obtained simply by using a lower range. However an offset of a fixed number of RPM can be used as described in the 'How It Works' section. Using the values given, when the high range button is pressed, 10000 RPM must be added to the reading.

ETI

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ETI 15

data sheet.....

AY-5-1317A CHORD GENERATOR

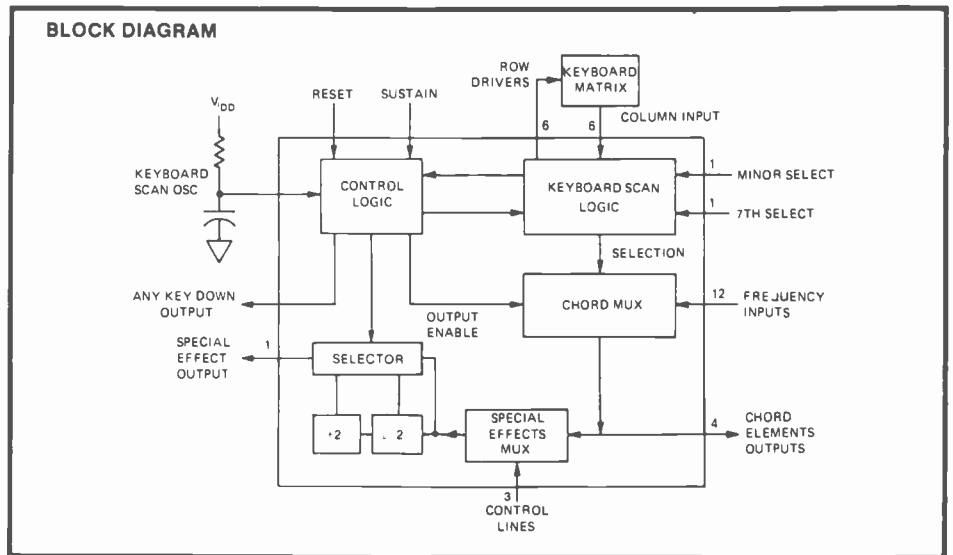
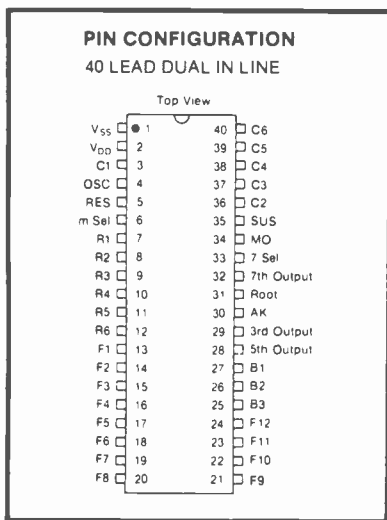
NATIONAL

FEATURES

- ROOT, 3rd, 5th, 7th Chord Elements
- Additional output for special effects
- Sustain capability
- Top key priority
- Self-contained oscillator circuit
- Operated with single pole, single throw switch matrix

DESCRIPTION

The AY-5-1317A is a P-Channel MOS IC which accepts twelve basic frequencies (one full octave) and outputs the notes necessary to form Major, Minor and Seventh chords. This is the only known standard chord generator IC that performs these functions. The chord elements (ROOT, 3rd, 4th, 5th, 6th and 7th) can be multiplexed internally to perform special effects such as walking bass, rhythm arpeggio, alternating bass, etc. The AY-5-1317A will operate in conjunction with and, through the KEY DOWN output, synchronize a rhythm generator such as the General Instrument AY-5-1315. The AY-5-1317A has a keyboard priority system with the C Major chord having the highest priority.



ELECTRICAL CHARACTERISTICS

Maximum Ratings*

V_{DD} with respect to V_{SS} -20V to +0.3V
 Logic Input Voltages with respect to V_{SS} -20V to +0.3V
 Storage Temperature -65°C to +150°C
 Operating Temperature (T_A) 0°C to +70°C

Standard Conditions (unless otherwise noted)

V_{DD} = -15V ±3V
 V_{SS} = 0V (substrate voltage)
 Operating Temperature (T_A) = +25°C

*Exceeding these ratings could cause permanent damage. Functional operation of this device at these conditions is not implied —operating ranges are specified below.

Characteristic	Sym	Min	Typ**	Max	Conditions
Input Logic Levels					
Logic 0	V _{IL}	V _{DD}	—	±8.5	
Logic 1	V _{IH}	-1.0V	—	+0.3V	
Input Capacitance	C _{IN}	—	—	10 pF	
Note Outputs					
Logic 0	R _{OFF}	160KΩ	—	—	
Logic 1	R _{ON}	—	—	500Ω	
Row Drivers Output Impedance			750 Ω	—	V _{DD} = -15V
Control Input		10K Ω	—	1000K Ω	
Keyboard Row Input Impedance		24KΩ	—	100KΩ	
Keyboard Scan Frequency		—	25KHz	—	500 pF, 750K, V _{DD} = -15V

**Typical values are at +25°C and nominal voltages.

AY-5-1317A CHORD GENERATOR

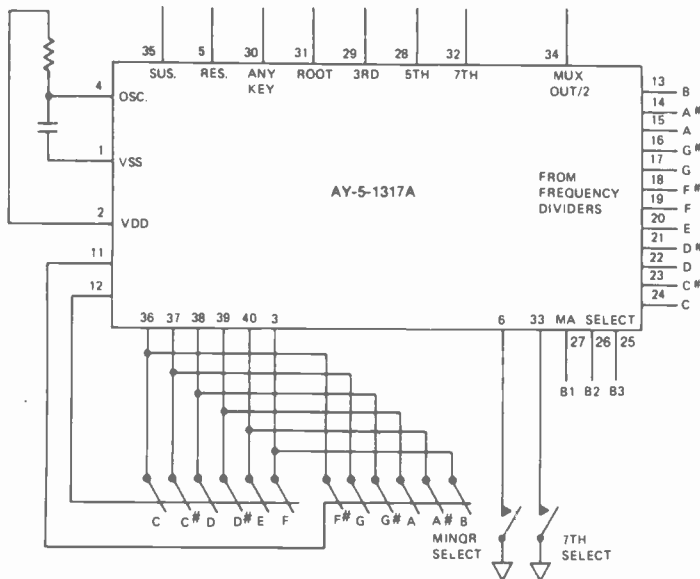
Pin No.	Name (Symbol)	Function																																
1	Ground (Vss)	Ground																																
2	Power Supply (V _{DD})	Negative Supply																																
3, 36-40	Column Inputs (CI-C6)	Column inputs from Keyboard Matrix																																
4	Oscillator Input (OSC)	R/C network connection for keyboard scan oscillator																																
5	Reset (RES)	A logic '1' (ground) will reset the keyboard scanner, and the memorized key																																
6	Minor Select (m Sel)	A Ground on this line changes the 3rd output from Major to Minor																																
7-12	Row Outputs (R1-R6)	Row outputs to Keyboard Matrix																																
13-24	Frequency Inputs (F1-F12)	These are the input lines for the 12 frequencies (one full octave B thru C) used to generate the chords.																																
25-27	Control Inputs (B3-B1)	<p>These 3 lines will be internally latched and decoded to select either the ROOT, 3rd, 4th, 5th, 6th, or 7th frequency as the special effect output.</p> <table border="1"> <thead> <tr> <th>B1</th> <th>B2</th> <th>B3</th> <th>Selection</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> <td>No change from last selection.</td> </tr> <tr> <td>0</td> <td>0</td> <td>1</td> <td>ROOT</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> <td>5th</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> <td>3rd</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> <td>7th</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> <td>4th</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> <td>6th</td> </tr> </tbody> </table>	B1	B2	B3	Selection	0	0	0	No change from last selection.	0	0	1	ROOT	0	1	0	5th	0	1	1	3rd	1	1	1	7th	1	1	0	4th	1	0	1	6th
B1	B2	B3	Selection																															
0	0	0	No change from last selection.																															
0	0	1	ROOT																															
0	1	0	5th																															
0	1	1	3rd																															
1	1	1	7th																															
1	1	0	4th																															
1	0	1	6th																															
28	5th Output (5th)	This line will output the 5th frequency element of the selected chord.																																
29	3rd Output (3rd)	This line will output the 3rd frequency element of the selected chord. Minor 3rd will be provided if a Minor chord is selected. Major 3rd will be provided if a Major or 7th chord are selected.																																
30	Any Key Down (AK)	This line goes to a logic '1' whenever a chord selection key, is depressed.																																
31	Root Output (Root)	This line will output the ROOT frequency element of the selected chord.																																
32	7th Output (7th)	This line will output the 7th frequency element of the selected chord if a 7th chord is selected otherwise the output is logic '0' (voltage).																																
33	7th Select (7 Sel)	A ground on this line turns the 7th output on.																																
34	Special Effect Output (MO)	This line will output one of the six frequency elements as programmed by the control lines B1- B3. The 7th chord element frequency will be provided independently of the chord selection.																																
35	Sustain (SUS)	A logic '1' on this line will activate the memory circuit which memorizes the last key played.																																

TRUTH TABLE FOR SPECIAL EFFECT OUTPUT

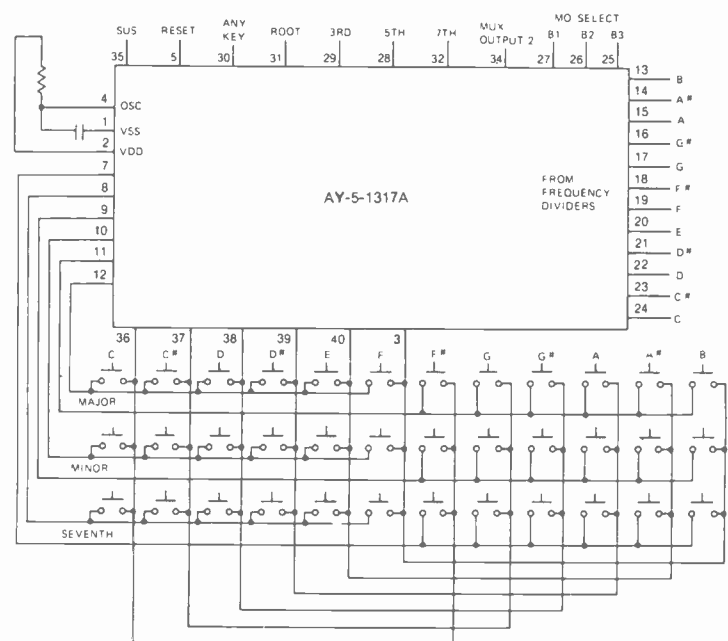
FREQUENCY OUTPUTS

Chord Selection	Root	3rd Minor	3rd Major	4th	5th	6th	7th
C	C (+2)	D# (+2)	E (+2)	F (+2)	G (+2)	A (+2)	A# (+2)
C#	C# (+2)	E (+2)	F (+2)	F# (+2)	G# (+2)	A# (+2)	B (+2)
D	D (+2)	F (+2)	F# (+2)	G (+2)	A (+2)	B (+2)	C (+2)
D#	D# (+2)	F# (+2)	G (+2)	G# (+2)	A# (+2)	C (+2)	C# (+2)
E	E (+2)	G (+2)	G# (+2)	A (+2)	B (+2)	C# (+2)	D (+2)
F	F (+2)	G# (+2)	A (+2)	A# (+2)	C (+2)	D (+2)	D# (+2)
F#	F# (+2)	A (+2)	A# (+2)	B (+2)	C# (+2)	D# (+2)	E (+2)
G	G (+2)	A# (+2)	B (+2)	C (+2)	D (+2)	E (+2)	F (+2)
G#	G# (+2)	B (+2)	C (+2)	C# (+2)	D# (+2)	F (+2)	F# (+2)
A	A (+2)	C (+2)	C# (+2)	D (+2)	E (+2)	F# (+2)	G (+2)
A#	A# (+2)	C# (+2)	D (+2)	D# (+2)	F (+2)	G (+2)	G# (+2)
B	B (+2)	D (+2)	D# (+2)	E (+2)	F# (+2)	G# (+2)	A (+2)

STANDARD INTERCONNECTION FOR A SINGLE ROW KEYBOARD WITH SEPARATE KEY FOR MINOR AND SEVENTH



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7400	.10	74181	.58	74522	.38	27X500	.18
7401	.12	74154	1.00	74537	.38	28X053	.20
7402	.12	74157	.54	74551	.28	28X054	.57
7403	.12	74160	1.04	74574	.38	28X702	.12
7404	.10	74182	1.18	745112	.66	28X704	.12
7406	.27	74183	.80	745124	3.25	28X819	.29
7408	.12	74184	.87				
7409	.13	74185	.93				
7410	.12	74175	.67				
7411	.21	74176	.64				
7412	.21	74180	.86				
7413	.24	74193	.98				
7414	.64	74194	1.04				
7416	.26	74196	.86				
7417	.33	74197	.86				
7420	.12	74198	1.41				
7425	.24	74199	1.41				
7427	.24						
7430	.12						
7432	.23						
7433	.50						
7437	.23						
7438	.23						
7440	.16						
7441	.50						
7442	.38						
7443	.85						
7445	.67						
7446	.67						
7447	.59						
7448	.48						
7450	.16						
7451	.16						
7453	.16						
7454	.16						
7460	.16						
7470	.36						
7472	.32						
7473	.21						
7474	.26						
7475	.29						
7476	.31						
7483	.68						
7485	.84						
7486	.25						
7489	1.95						
7490	.38						
7491	.62						
7492	.42						
7493	.29						
7495	.51						
7496	.67						
74104	.48						
74105	.48						
74107	.27						
74109	.45						
74121	.29						
74122	.47						
74123	.38						
74141	.71						

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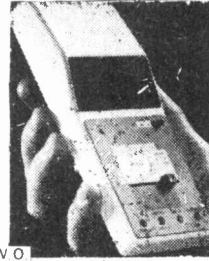
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TRANSISTORS																													
2N2956	0.39	2N2118	0.35	2N3393	0.17	2N4037	0.60	2N5192	0.80	2N6124	0.45	BC108A	0.16	BC178B	0.35	BC213L	0.17	BC337	0.20	BD240A	0.49	BF160	0.33	BF79	0.30	ME4001	0.16	TIP30C	0.70
2N2957	0.31	2N2119	0.38	2N3394	0.17	2N4058	0.22	2N5193	0.75	2N6125	0.47	BC108B	0.16	BC179	0.25	BC213A	0.17	BC547	0.23	BD240C	0.59	BF161	0.65	BF80	0.30	ME4002	0.16	TIP31A	0.54
2N2958	0.49	2N2120	0.38	2N3395	0.19	2N4059	0.17	2N5194	0.80	40361	0.55	BC108C	0.17	BC179A	0.25	BC213B	0.17	BC547A	0.13	BD241C	0.65	BF173	0.37	BF82	0.34	ME4101	0.16	TIP31C	0.72
2N2959	0.58	2N2121	0.39	2N3396	0.19	2N4060	0.19	2N5245	0.37	40362	0.55	BC109	0.16	BC179C	0.25	BC213C	0.17	BC547B	0.13	BD242C	0.55	BF173	0.27	BF83	0.34	ME4102	0.11	TIP32A	0.82
2N706	0.30	2N2220	0.39	2N3438	0.85	2N4062	0.20	2N5246	0.38	40408	0.82	BC109C	0.17	BC182	0.12	BC214	0.17	BC548	0.13	BD243C	0.62	BF178	0.27	BF84	0.30	ME4103	0.11	TIP41A	0.76
2N706A	0.30	2N2221	0.25	2N3440	0.75	2N4064	1.35	2N5247	0.44	40409	0.82	BC109E	0.18	BC182A	0.15	BC214A	0.17	BC549	0.14	BD244A	0.65	BF179	0.33	BF85	0.38	ME4104	0.11	TIP41C	0.87
2N709	0.30	2N2222A	0.25	2N3441	0.82	2N4074	2.65	2N5248	0.44	40410	0.82	BC1141	0.32	BC182B	0.13	BC214C	0.17	BC549B	0.14	BD244C	0.87	BF180	0.37	BF86	0.30	ME6101	0.22	TIP42C	1.08
2N718	0.54	2N2222A	0.25	2N3442	1.45	2N4121	0.27	2N5294	0.44	40411	3.10	BC1147	0.13	BC182C	0.15	BC214B	0.18	BC550	0.15	BD245C	0.69	BF181	0.37	BF87	0.35	ME1295	1.35	TIP3055	0.59
2N720A	0.85	2N2369	0.27	2N3638A	0.17	2N4123	0.19	2N5296	0.44	40595	0.98	BC1148	0.13	BC182D	0.15	BC214B	0.18	BC551	0.14	BD246A	0.87	BF182	0.37	BF88	0.31	MJ3E40	0.62	TIP3055	0.59
2N722	0.45	2N2369A	0.27	2N3702	0.14	2N4124	0.19	2N5298	0.44	40673	0.80	BC1148	0.13	BC182E	0.15	BC214B	0.18	BC552	0.14	BD246C	0.87	BF183	0.37	BF89	0.31	MJ3E40	0.62	TIP3055	0.59
2N727	0.50	2N2546	0.80	2N3703	0.14	2N4125	0.19	2N5447	0.16	40699	1.30	BC1149	0.13	BC182F	0.15	BC214B	0.18	BC553	0.15	BD246C	0.93	BF194	0.16	BF90	0.50	MJ3E40	0.50	TIP430	0.47
2N914	0.38	2N2547	1.55	2N3704	0.14	2N4126	0.19	2N5448	0.16	40712	0.48	BC1149	0.15	BC183	0.13	BC238B	0.13	BC772	0.18	BD433	0.44	BF195	0.16	BF90	1.35	MJ3E51	1.65	TIP51	0.22
2N916	0.33	2N2903	1.60	2N3705	0.14	2N4126	0.19	2N5448	0.16	40713	0.48	BC1149	0.15	BC183	0.13	BC238B	0.13	BC772	0.18	BD433	0.44	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N917	0.38	2N2904	0.31	2N3706	0.14	2N4126	0.19	2N5448	0.16	40714	0.48	BC1149	0.15	BC183	0.13	BC238B	0.13	BC772	0.18	BD433	0.44	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N918	0.45	2N2904A	0.31	2N3707	0.14	2N4287	0.22	2N5458	0.35	40715	0.48	BC157A	0.15	BC183A	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N929	0.37	2N2905	0.31	2N3708	0.12	2N4288	0.22	2N5459	0.32	40716	0.54	BC158A	0.15	BC183A	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N929A	0.37	2N2905A	0.31	2N3709	0.12	2N4288	0.22	2N5459	0.32	40717	0.54	BC158A	0.15	BC183A	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N930	0.37	2N2906	0.25	2N3710	0.12	2N4288	0.22	2N5459	0.32	40718	0.54	BC158A	0.15	BC183A	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N930A	0.37	2N2906A	0.25	2N3711	0.12	2N4288	0.22	2N5459	0.32	40719	0.54	BC158A	0.15	BC183A	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1711	0.30	2N3073	0.25	2N3712	0.20	2N4348	0.65	2N5485	0.40	40720	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1889	0.30	2N3074	0.25	2N3713	0.20	2N4348	0.65	2N5485	0.40	40721	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1890	0.30	2N3075	0.25	2N3714	0.20	2N4348	0.65	2N5485	0.40	40722	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1891	0.30	2N3076	0.25	2N3715	0.20	2N4348	0.65	2N5485	0.40	40723	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1922	0.50	2N2925	0.19	2N3820	0.26	2N4921	0.54	2N5494	0.65	40724	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1923	0.58	2N2926	0.17	2N3821	0.26	2N4922	0.54	2N5494	0.65	40725	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1953	0.50	2N3053	0.25	2N3903	0.20	2N4924	1.15	2N5617	0.45	40726	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1954	0.42	2N3055	0.75	2N3905	0.18	2N5087	0.30	2N6109	0.55	40727	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1954A	0.45	2N3390	0.50	2N3906	0.18	2N5088	0.30	2N6111	0.49	40728	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1955	0.40	2N3391	0.40	2N4031	0.55	2N5089	0.30	2N6121	0.41	40729	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N1955A	0.40	2N3391A	0.45	2N4032	0.65	2N5090	0.65	2N6122	0.44	40730	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22
2N2217	0.55	2N3392	0.17	2N4036	0.72	2N5191	0.75	2N6123	0.48	40731	0.54	BC158B	0.15	BC183B	0.15	BC239B	0.16	BD115	0.88	BD434	0.46	BF196	0.16	BF91	1.35	MJ3E51	1.65	TIP51	0.22

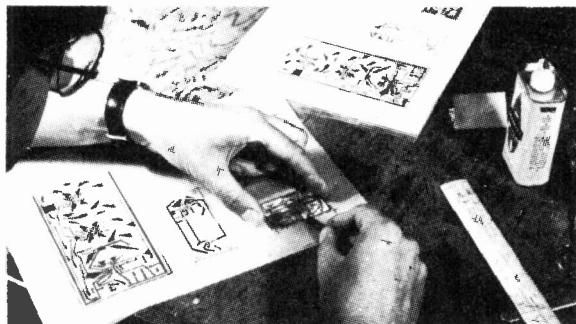
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CA302	2.20	LM3801A	1.08	LM7815CZ	0.30	TA540	2.60
CA302A	2.50	LM381A	2.70	LM7815CZ	0.30	TA540	2.70
CA302BA	2.80	LM381B	1.69	LM7815CZ	0.30	TA540	2.60
CA302BB	1.25	LM382N	1.32	MMS314	4.50	TA550	3.60
CA3030	1.50	LM384N	1.50	TA550	4.60	TA550	3.00
CA3030A	2.20	LM382N	0.88	NE555	0.33	TA570	2.10
CA3038	2.90	LM387N	1.10	NE555	0.85	TA570	2.20
CA3038A	4.10	LM388N	1.00	NE558N	1.98	TA700	2.20
CA3045	1.55	LM390N	1.00	NE560	4.50	TA720	2.06
CA3046	2.45	LM709	0.81	NE561	4.50	TA720	2.06
CA3052	1.78	LM709B	0.50	NE562	2.40	TA720	2.45
CA3080	0.85	LM7091A	0.49	NE565	1.39	TA800	1.30
CA3080A	2.10	LM710	0.67	NE567	1.90	TA820	0.80
CA3086	0.50	LM7101A	0.64	NE571A	4.95	TA820	2.99
CA3088	1.87	LM711CN	0.72	SAS560	2.70	TA160C	2.36
CA3089	2.90	LM723C	0.75	SAS570	2.70	TA160B	2.55
CA3090	4.40	LM723C14	0.45	SAJ110	2.10	TA270	2.99
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CA3140	1.04	LM741C	0.70	SO42P	1.35	TA740	4.30
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LM308N	0.95	LM741C	0.95	SN76013N	1.50	TA105	1.49
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LM317K	3.35	LM7481A	0.90	SN76033M	2.35	TA01022	7.50
LM318N	2.45	LM1303N	1.15	TA2633	1.35	TA01034	1.24
LM3207S	2.15	LM1304N	1.52	TA300	3.70	TA01034	4.75
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LM320712	1.15	LM1458N	0.45	TA550	0.48	TL081CP	0.90
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ETIPRINTS are a fast new aid for producing high quality printed circuit boards. Each ETIPRINTS sheet contains a set of etch resistant rub down transfers of the printed circuit board designs for several of our projects. ETIPRINTS are made from our original artwork ensuring a neat and accurate board. We thought ETIPRINTS were such a good idea that we have patented the system (patent numbers 1445171 and 1445172).

HOW IT WORKS



Lay down the ETIPRINT and rub over with a soft pencil until the pattern is transferred to the board. Peel off the backing sheet carefully making sure that the resist has transferred. If you've been a bit careless there's even a 'repair kit' on the sheet to correct any breaks!

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	Metronome Shutter Time	Feb 78 Feb 78
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007	Star Trek Radio CD Ignition CCD Phaser White Line Follower	May 78 May 78 May 78 April 78
008	Tank Battle Helping Hand	May 78
009	AM / FM Radio Bridge Oscillator CMOS Stars & Dots	June 78
010	Bench Amplifier Freezer Alarm Marker Generator LED Dice Watchdog (2 PCBs) Stars & Dots PSU	Project Book Six
011	Noise Generator General Preamp Flash Trigger Componder Active Crossover (2 PCBs)	Project Book Six
012	Disco Lightshow Stereo Simulator Digital Thermometer	Project Book Six
013	Amplifier Module Amplifier PSU Equaliser Equaliser PSU	Project Book Six
014	Skeet Game Sweep Oscillator Burglar Alarm GSR Monitor	Project Book Six
015	UFO Detector Torch Finder (twice) Etiwet (twice)	July 78 July 78 Aug 78
016	Stac Timer Xhatch Gen Wheel of Fortune	Sept 78
017	Complex Sound Gen Tele Bell Extender Power Bulge	Oct 78
018	RF Power Meter Proximity Switch Audio Oscillator (2)	Oct 78 Oct 78 Nov 78
019	Car Alarm (2) Wine Temp (2) Curve Tracer	Dec 78 Dec 78 Dec 78
020	Digital Tacho Module Digital Dial	Jan 79 Jan 79 Jan 79

OBITUARY: John Miller-Kirkpatrick

I AM probably the worst person to write about John Kirkpatrick: I liked him too much to be objective. But I *am* going to write about him because John died on December 12th, 1978. I don't remember how old he was; you rarely do know how old good friends are but he was 30 or 31 — it doesn't matter which for it's far too young. John leaves behind a wife, Jane, and two young daughters.

When I first met John I can't quite remember, but it was probably shortly after he had developed the first digital clock that I'd ever seen. This would have been in 1971 or 1972 — way before the chips that make these things so simple today.

The circuit comprised a mass of TTL and the whole thing had been worked out from first principles.

Yes, John was one of the few people I know who could work from first principles.

It was also John who introduced me to ETI — a magazine I'd hardly heard of at the time. When I became editor of this magazine it was natural that the first person I contacted to write for me was John. He, of course, wrote Electronics Tomorrow for us, a series which we carried from mid-1973 until illness prevented him doing it some three months ago.

John's main business was Bywood Electronics which was one of the first companies to bring the new high-technology chips to the general public. It was John who designed System 68 which, although it suffered from a few teething troubles, was miles and away the first DIY computer ever described.

John's latest venture was the Scrumpi Series — we reviewed the Mk 3 not too long ago. To emphasise how close John was to me and the magazine we had to get an outsider to review it for objectivity.

John Miller was very nearly a genius but above all he was a damned good chap: I don't think there was an ounce of badness in him. I will miss him but our hobby will miss him as well.

Halvor Moorshead
Editorial Director

microfile.....

GEORGE DAVIES IS INNOCENT, innocent that is of any blame for my last minute summons to talk to the Croydon branch of the British Computer Society. Mr Davies is chairman of said society and having found himself with no speaker on the subject of Home Computing, drafted myself and another speaker to fill the gap.

My talk was concerned with a description of the various items that one has to hang around an MPU in order to produce a system, power supply, input, output, RAM, ROM, control circuitry etc, using an Mk14 as an example of a minimum system and working up to an outline of the likes of the Triton, PET, and TRS 80.

The other speaker, John Sanderson, described a project that he has been working on for some time, a system aimed at the educational market.

A modular concept has been adopted in a system that allows a number of pupil "work stations" to be connected to the main processor card (based on a GI micro). Each work station consists of a VDU, cassette recorder and pair of head phones.

The system is flexible to say the least and a full description of it would take up far more spare time than I

have available here — I shall, however, be reporting in more detail soon. One part of the hardware grabbed my attention immediately however — the keyboard.

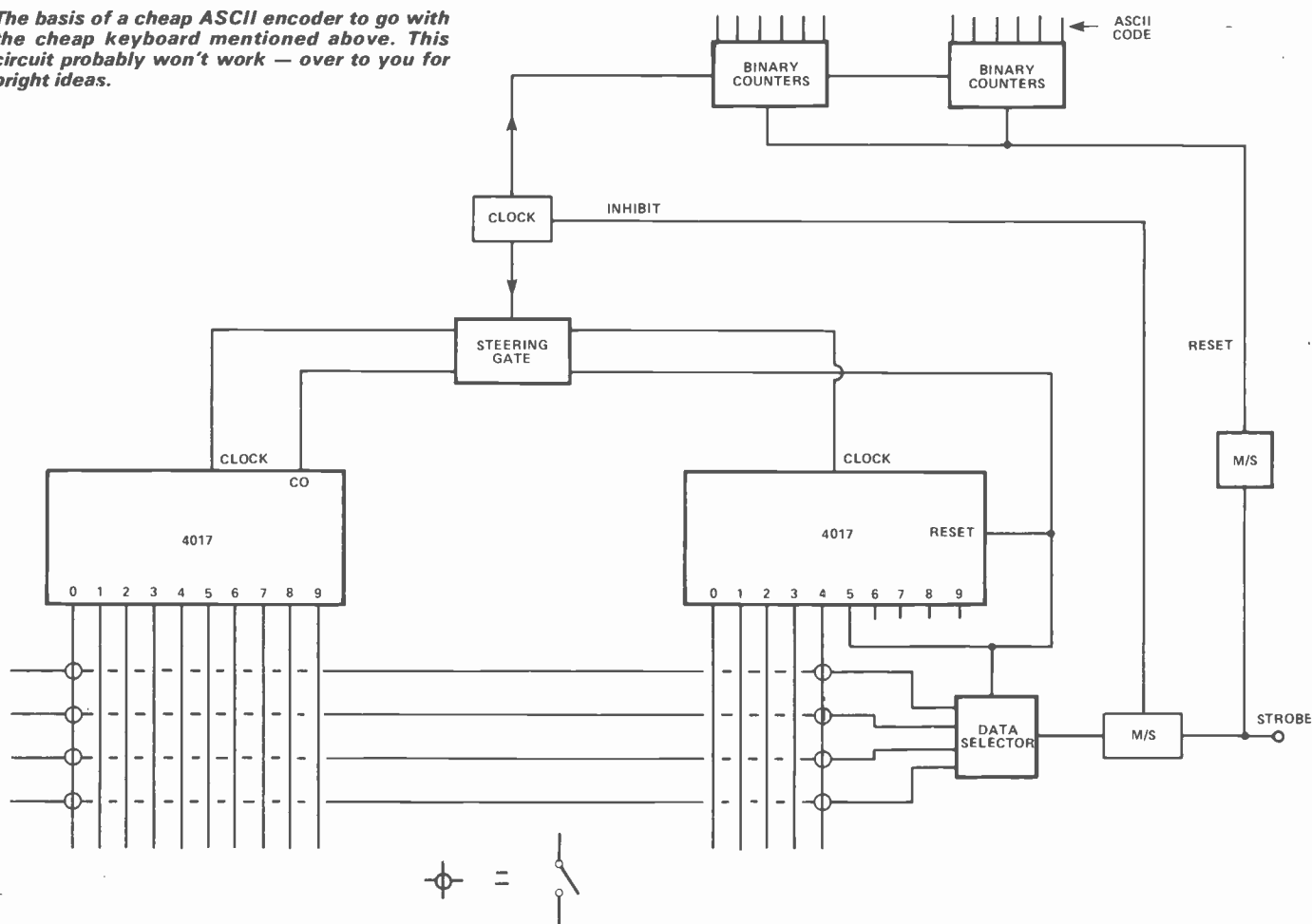
This was of very simple construction forming a formed A 60 station (15 × 4 matrix) input terminal at a cost of about £5.00.

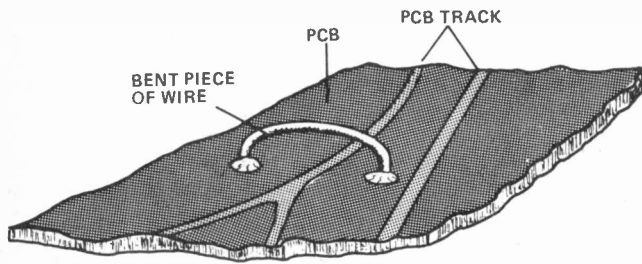
Construction of the keyboard was kept as simple and straightforward as possible by forming the keys from a piece of bent wire as shown in the diagram. Although this sounds like a recipe for trouble, the design has proven itself over the past few months. To make the keyboard more attractive a layer of film, with appropriate ledgenos can be placed over the pcb to keep the cost right down, housing for the terminal is provided by a picture frame.

The finished product is both attractive, robust and above all cheap.

As it stands at present a certain amount of software is necessary to decode the output of the board but this set me thinking along the lines of a keyboard with the same system for providing the keys but with additional, hopefully simple, circuitry to produce an ASCII output with strobe — for more attractive. ▶

The basis of a cheap ASCII encoder to go with the cheap keyboard mentioned above. This circuit probably won't work — over to you for bright ideas.





How to make a cheap keyboard using only a PCB and bent wire.

My deadline for these words was almost upon me so the diagram below is very much a first attempt at such a scheme and I'm hoping some of you will take the basic idea and see if something can be made of it.

The idea is that clock pulses will, via the steering gate be fed to two 4017 ICs such that these devices form a 15 bit shift register, placing a logic '1' on each of the 15 'vertical' lines of the keyboard matrix. The horizontal lines are taken to a four input data selector that selects the output from one of the four "horizontal" lines and feeds this to a mono stable.

The line selected will initially be the top row of switches but at the end of a row scan will advance to the second.

The output from the data selector will be low at all times unless a key has been pressed when it will trigger

the monostable. This will stop the clock for a short time. The output of 7Hz has also been fed to a couple of binary counters, the outputs of which will form a unique code corresponding to the key that has been pressed.

If the keyboard layout and markings have been chosen carefully. This binary code will be the ASCII code for the key pressed.

As the first monostable returns to its stable state it triggers a second device to reset all the counter stages.

In the time available I've not been able to put any detail in the design but hopefully the data selector and steering gate could be easily implemented. Roll over might be a problem — but over to you — If you've any thoughts on this scheme please let me know.

Micro digital of 25 Brunswick Street, Liverpool, L2 0BJ have been busy over the past few months, expanding the range of products available in their Computing Store.

They have one of the largest ranges of literature available in the country at present, all on display in the shop. Microdigital are also producing blank, high quality, cassette tapes and coding forms for MPU work.

Paying them a visit or sending an SAE for their latest catalogue could bring to light that book, component, whatever — that you've been searching high and low for.

ETI

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AD143	.90	.82	.68	TP42A/B	.53	.48	.40	7403	.19	.17	.14	74145	.36	.33	.27	4168/1/2	1.04	.94	.80
AD149	.95	.86	.72	TP42C	.57	.52	.44	7404	.16	.15	.15	74147	.71	.65	.55	41758	1.23	1.11	.94
AU106	2.16	1.89	1.85	TP47	1.45	1.32	1.11	7405	.20	.18	.15	74148	.74	.67	.57	41948	1.24	1.12	.94
AU110	2.08	1.89	1.59	TP48	1.54	1.39	1.17	7406/7	.27	.24	.21	74150	.45	.40	.34	4409P	6.04	6.00	5.06
AU113	2.08	1.89	1.59	TP110	1.00	.82	.77	7408	.16	.15	.13	74151/3	.29	.26	.22	4433P	6.73	7.90	6.65
BC107A/B	.12	.11	.095	TP111	1.05	.95	.80	7409	.20	.18	.15	74154	.68	.63	.53	4450P	3.48	3.15	2.85
BC106A/B	.12	.11	.095	TP112	1.20	1.10	.92	7410	.16	.15	.13	74155	.25	.25	.21	4501CP	.26	.23	.20
BC108C	.13	.115	.10	TP115	1.02	.92	.78	7412	.20	.18	.16	74156	.36	.33	.27	4507A	.44	.40	.34
BC109A/B	.12	.11	.095	TP116	1.07	.96	.81	7413	.22	.20	.17	74157	.29	.26	.22	45068	.74	.67	.56
BC109C	.13	.115	.10	TP117	1.24	1.13	.95	7413A	.22	.20	.17	74159	.77	.70	.59	DIN SOCKETS			
BC142	.26	.24	.20	TP120	1.63	.83	.78	7418/7	.24	.22	.19	74160/1	.36	.33	.27	8 pin	.13	.115	.095
BC143	.28	.26	.22	TP121	1.05	.95	.80	7420	.16	.15	.13	74182	.40	.36	.31	14 pin	.14	.125	.105
BC182A/B	.87	.86	.85	TP125	1.02	.92	.80	7422/3	.20	.18	.15	74183/4/5	.36	.33	.27	18 pin	.16	.14	.12
BC182L	.10	.09	.075	TP126	1.07	.96	.81	7425/8/7/8L	.21	.19	.16	74168	.32	.27	.23	40 pin	.22	.195	.165
BC183A/B/C	.07	.06	.055	TP127	1.24	1.13	.95	7430	.18	.16	.14	74170	1.26	1.14	.97	20 pin	.23	.21	.18
BC184B/C	.07	.06	.055	TP2855	.82	.57	.48	7432	.18	.16	.14	74172	1.08	.99	.83	22 pin	.25	.225	.19
BC184L	.10	.09	.075	TP3855	.82	.57	.48	7433	.23	.21	.18	74173	2.07	1.87	1.58	24 pin	.26	.235	.20
BC212A/B	.07	.065	.055	2N1132	.29	.23	.20	7437/8	.20	.18	.16	74174	.71	.65	.55	28 pin	.34	.31	.26
BC212L	.10	.09	.075	2N1192	.38	.34	.29	7440	.16	.15	.12	74175	.54	.49	.42	40 pin	.49	.44	.37
BC213A/B/C	.07	.065	.05	2N2218/A	.24	.21	.18	7441M	.74	.67	.56	74176/7	.38	.35	.29	TUBES			
BC214B/C	.07	.065	.05	2N2219/A	.24	.21	.18	7442	.29	.25	.21	74178/7	.40	.36	.30	7805	.78	.71	.60
BC214L	.10	.09	.075	2N2221/A	.17	.16	.13	7443	.44	.40	.33	74180	.99	.90	.76	7805	.78	.71	.60
BC300/1/3	.25	.23	.20	2N2646	.41	.37	.31	7445	.45	.40	.34	74182	.40	.36	.30	7912	.90	.82	.69
BC337	.98	.86	.85	2N2904/5	.24	.21	.18	7445	.50	.45	.38	74184/5	.94	.85	.72	TRIACS TO220			
BC441	.29	.27	.22	2N2904A/5A	.25	.22	.19	7447	.40	.36	.30	74186A	4.00	3.89	3.11	2A 100V	.45	.41	.35
BC461	.30	.27	.23	2N2904A/5A	.25	.22	.19	7448	.50	.45	.38	74186/1	.31	.28	.24	2A 200V	.46	.42	.35
BC548/B/9/7	.07	.065	.055	2N2906/7	.15	.14	.12	7450/1/3	.19	.17	.15	74192/3	.36	.33	.28	2A 400V	.50	.45	.38
BC550/B/7	.07	.065	.055	2N2907A	.16	.15	.12	7454/B0	.19	.17	.15	74194	.50	.45	.38	6A 100V	.51	.46	.39
BC550/B/8	.07	.065	.055	2N3053	.23	.20	.17	7454/B0	.19	.17	.15	74195	.27	.24	.21	6A 200V	.52	.47	.40
BC550/B/9/80	.07	.065	.055	2N3054	.67	.60	.51	7470/2	.34	.30	.28	74196/7	.38	.35	.29	10A 100V	.82	.74	.63
BC710	.16	.16	.135	2N3055	.68	.61	.52	7473/4	.26	.23	.20	74198	.38	.35	.29	10A 200V	.84	.76	.64
BD131	.39	.36	.30	2N3055	.68	.61	.52	7475	.21	.19	.16	74199	.60	.54	.48	10A 400V	.91	.82	.69
BD132	.40	.37	.31	2N3232	.83	.76	.64	7475	.21	.19	.16	74202	.37	.33	.28	THYRISTORS TO220			
BD142	.68	.60	.67	2N3440	.80	.73	.61	7476	.36	.33	.27	74221	.91	.82	.69	3A 50V	.37	.34	.28
BD220/1	.45	.40	.34	2N3442	1.42	1.39	1.09	7480	.57	.52	.44	74900	.28	.26	.22	3A 100V	.41	.37	.31
BD222	.47	.42	.36	2N3442	1.42	1.39	1.09	7481/2	.57	.52	.44	74905	.32	.29	.25	5A 100V	.37	.34	.28
BD223/4	.49	.44	.37	2N3703	.99	.87	.86	7482	.31	.28	.23	74905	.28	.26	.22	5A 200V	.41	.37	.31
BD229	.32	.29	.24	2N3771	2.06	1.87	1.57	7484	.45	.40	.34	74910/11	.28	.26	.22	5A 400V	.37	.34	.28
BD240	.34	.30	.26	2N3772	2.08	1.89	1.59	7485	.47	.42	.36	74920	.28	.26	.22	5A 600V	.50	.45	.38
BD241	.32	.28	.24	2N3773	3.45	3.12	2.83	7486	.28	.18	.15	74910	.31	.28	.24	BRIDGE RECT			
BD242	.37	.33	.28	2N3804/6	.98	.87	.86	7489	2.42	2.19	1.84	CH303	.19	.175	.15	2A 50V	.38	.35	.29
BD243	.42	.38	.32	2N4036	.28	.23	.20	7490/1	.28	.18	.15	4000A	.19	.175	.15	2A 100V	.42	.38	.32
BD244	.45	.40	.34	2N4037	.25	.22	.19	7491M	.20	.18	.15	4001A	.19	.175	.15	2A 200V	.47	.42	.36
BF257	.26	.23	.20	2N4037	.46	.42	.35	7492	.31	.28	.24	4011/12A	.83	.75	.63	2A 400V	.59	.54	.45
BF258	.27	.24	.20	2N5294	.46	.42	.35	7493	.29	.18	.15	40138	.95	.86	.72	2A 100V	.42	.38	.32
BF337	.27	.24	.20	2N5296	.49	.45	.38	7494	.40	.36	.30	4014A	.85	.86	.72	2A 200V	.47	.42	.36
BFR39/40/1	.19	.18	.15	2N5415	1.08	.87	.82	7495	.23	.21	.18	4017A	.93	.92	.79	2A 400V	.59	.54	.45
BFR79/80/1	.19	.18	.15	2N5416	.56	.54	.44	7497	1.82	.94	.79	4021/22A	1.03	.92	.79	LEDs			
BFY52/1/2	.23	.21	.18	2N5416	.39	1.28	1.06	7498	.28	.18	.15	4023A	.19	.18	.15	TL209	.17	.155	.13
BFX184/5/6	.24	.21	.18	2N5494	.64	.58	.49	74105	.86	.78	.66	4024B	.93	.84	.71	TL212	.21	.19	.16
BFX187/88	.25	.23	.19	2N5496	.66	.59	.50	74107/9	.35	.32	.27	4025A	.19	.175	.15	TL216	.21	.19	.16
TP29	.33	.30	.25	2N6090	.58	.53	.45	74110	.42	.38	.32	4027B	.45	.40	.34	TL220	.16	.14	.12
TP29A/B	.35	.32	.27	2N6101	.60	.54	.46	74111/16	.27	.25	.21	4029B	.84	.76	.64	TL228	.23	.21	.175
TP29C	.38	.35	.29	2N6101	.60	.54	.46	74118	.89	.81	.68	4029A	1.20	1.08	.82	TL234	.23	.21	.175
TP30	.34	.31	.26	40406	.41	.37	.32	74121	.40	.36	.30	4030A	.45	.40	.34	TL232	.21	.19	.16
TP30A/B	.35	.32	.27	40407	.41	.37	.32	74122	.44	.40	.34	4042B	.86	.78	.66	DIODES			
TP30C	.38	.35	.29	40411	.88	.80	.68	74123/5/6	.42	.38	.32	4043/44B	.80	.73	.61	IN915	.03	.015	.014
TP31A/B	.38	.35	.29	40594	1.18	1.08	.90	74129	.45	.40	.34	4045A	.44	.40	.34	IN916	.03	.015	.014
TP31C	.38	.35	.29	7400	.16	.15	.13	74132	.45	.40	.34	4049A	.44	.40	.34	IN918	.03	.015	.014
TP32	.35	.32	.27	7401	.16	.15	.13	74136	.24	.22	.18	40510	1.24	1.12	.95	IN919	.03	.015	.014

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3.75 x 5	60p	60p	0.15in 40p
3.75 x 17	195p	180p	

TRANSFORMERS

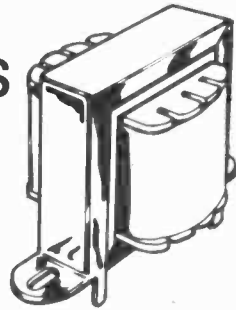
PRIMARY 240 Volts

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A1	6 - 0 - 6 at 0.5A	155p
A4	9 - 0 - 9 at 0.4A	155p
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B4	12 - 0 - 12 at 0.5A	205p
B8	15 - 0 - 15 at 0.4A	205p
C4	9 - 0 - 9 at 1.2A	305p
C8	12 - 0 - 12 at 1A	305p
D12	0 - 12 - 15 - 20 - 24 - 30 at 1.5A	395p
E12	0 - 20 - 25 - 33 - 40 - 50 at 2A	525p

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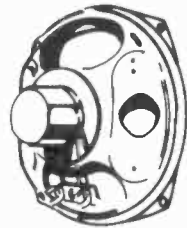
CRYSTALS

WIRE ENDED TYPE

Freq. MHz					
0.100	380p	4.000	250p	12.000	250p
0.300	380p	5.000	250p	18.000	300p
1.000	320p	6.000	250p	20.000	300p
2.000	320p	8.000	250p	32.000	300p
3.276	250p	10.000	250p	48.000	300p

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64mm dia.	64 ohms	75p
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70mm dia.	80 ohms	110p



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BC108	8p	BD140	35p	2N3053	18p
BC109	8p	BF244B	36p	2N3055	50p
BC147	7p	BFY50	15p	2N3442	135p
BC148	7p	BFY51	15p	2N3702	8p
BC149	8p	BFY52	15p	2N3704	8p
BC158	9p	MJ2955	98p	2N3705	9p
BC177	14p	MPSA06	20p	2N3706	9p
BC178	14p	MPSA56	20p	2N3707	9p
BC179	14p	TIP25C	60p	2N3708	8p
BC182	10p	TIP30C	70p	2N3819	22p
BC182L	10p	TIP31C	65p	2N3904	8p
BC184	10p	TIP32C	80p	2N3905	8p
BC184L	10p	ZTX107	14p	2N3906	8p
BC212	10p	ZTX108	14p	2N4058	12p
BC212L	10p			2N5457	32p
BC214	10p			2N5458	30p
BC477	19p	1N914	4p	2N5459	32p
BC478	19p	1N4001	4p	2N5777	50p
BC479	19p	1N4002	4p		
BC548	10p	1N4004	5p		
BCY70	14p	1N4006	6p		

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747	50p	LM38C	75p	NE567	170p
748	30p	LM382	120p	SN76003	200p
CA3046	55p	LM1830	150p	SN76013	140p
CA3080	70p	LM39C0	50p	SN76023	140p
CA3130	90p	LM39C9	60p	SN76033	200p
CA3140	70p	MC1496	60p	TBA800	70p
LM301AN	28p	MC1458	35p	TDA1022	650p
LM318N	125p	NE555	25p	ZN414	75p

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Green	TIL211	TIL221	13p
Yellow	TIL213	TIL223	13p
Clips	3p	3p	

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RADIAL LEAD ELECTROLYTIC						
63V	0.47	1.0	2.2	4.7	10	5p
			22	33	47	7p
	100					13p
			220			23p
25V	10	22	33	47		5p
	100					3p
		220				19p
			470			13p
	1000					23p
10V		220				5p
			470			9p
	1000					13p
		2200				23p

74LS

LS00	16p	LS95	65p
LS01	16p	LS123	56p
LS02	16p	LS125	40p
LS03	16p	LS126	40p
LS04	16p	LS132	60p
LS08	16p	LS136	36p
LS10	16p	LS138	54p
LS13	30p	LS139	50p
LS14	70p	LS151	50p
LS20	16p	LS153	50p
LS30	16p	LS155	80p
LS32	24p	LS156	80p
LS37	26p	LS157	45p
LS40	22p	LS164	90p
LS42	53p	LS174	60p
LS47	70p	LS175	60p
LS48	48p	LS190	80p
LS54	16p	LS192	70p
LS73	29p	LS193	70p
LS74	29p	LS196	80p
LS75	44p	LS251	60p
LS76	35p	LS257	55p
LS78	35p	LS258	55p
LS83	60p	LS266	40p
LS85	70p	LS283	60p
LS86	33p	LS290	55p
LS90	45p	LS365	45p
LS93	45p	LS366	45p
		LS367	45p
		LS368	45p
		LS386	35p
		LS670	180p

TTL

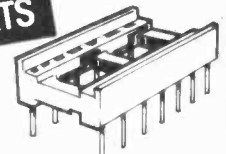
7400	12p	7493	34p
7401	12p	7494	52p
7402	12p	7495	52p
7404	12p	7496	50p
7408	14p	74121	25p
7410	12p	74122	33p
7413	25p	74123	40p
7414	48p	74125	35p
7420	12p	74126	35p
7427	24p	74132	50p
7430	12p	74141	56p
7442	43p	74148	90p
7447	55p	74150	70p
7448	58p	74151	50p
7454	14p	74156	52p
7473	25p	74157	52p
7474	25p	74164	70p
7475	32p	74165	70p
7476	28p	74170	125p
7485	70p	74174	68p
7489	145p	74177	58p
7490	32p	74190	72p
7492	35p	74191	72p
		74192	64p
		74193	64p
		74196	55p
		74197	55p

CMOS

FULL DETAILS IN CATALOGUE

4001	15p	4029	60p
4002	15p	4040	68p
4007	15p	4042	54p
4011	15p	4046	100p
4013	35p	4049	28p
4015	60p	4050	28p
4016	35p	4066	40p
4017	55p	4068	20p
4018	65p	4069	16p
4023	15p	4071	16p
4024	45p	4075	16p
4026	95p	4093	48p
4027	35p	4510	70p
4028	52p	4511	70p
		4518	70p
		4520	65p

SKTS



Low profile by Texas

8 pin	10p	24 pin	24p
14 pin	12p	28 pin	28p
16 pin	13p	40 pin	40p

Soldercon pins: 100: 50p
1000: 370p

AT LAST! OUR NEW 40 PAGE CATALOGUE OF COMPONENTS IS AVAILABLE. SEND S.A.E.



100 W DISCO MIXER AMPLIFIER

Designed by Richard Becker of Powertran this unit can deliver any way you want, and for less than £50!

Build it as a disco amp — it provides four inputs and three tone controls as well as 100W RMS.

Build the power amps for home use — check the spec — for low cost high quality sound.

NOT LONG AGO we published a super-fi 200W amplifier for the most demanding professional and domestic applications and this circuit is being highly acclaimed (by those who know about amplifiers!)

See for example the review in 'Sound International' December 1978 issue. However, exotic circuitry does not come at a low price.

This project does!

For less than £50 you can build a rugged general purpose high power amplifier complete with built in adaptable mixer. Using the newest of Motorola's extra strong power transistors this design pushes out 100 watts (genuine RMS type) and a bit to spare into 8 ohms. Overload protection is built-in and distortion is less than 0.1% right up to clipping level.

Mixing It

The mixer takes a wide range of inputs such as disc, microphone, guitar or just about anything you fancy as the sensitivities of the buffered input stages can be simply changed. There are three tone controls — bass, middle and treble each having a range of 15dB boost and 15dB cut and also a master volume control.

Mechanically the design is simplicity in the extreme with the absolute minimum of wiring. The power transistors fit onto the power

amplifier board so there are no wires to give stability problems and all the controls mount directly onto the mixer board. Even the input jacks are soldered to the board! All the components are cheap and with the possible exception of the power transistors and transformer readily available.

These can all be obtained from Powertran who are supplying this project as a complete kit which includes fully finished metalwork to give the professional finishing touches.

Construction

Assemble the printed circuit boards following the overlays. On the power amplifier board sandwich the cooling bracket between the power transistors and the circuit board as shown in the drawing not forgetting to smear silicon grease onto the mica washers. Fitting Q104 is easier accomplished after the bracket is in position. Smear some grease on this too before sitting it in the hole in the bracket

Even when there is no signal, Q105 is dissipating over 500 mW so get rid of the heat from this with a cooling clip pressed onto it. Wind L1 onto R128 with 10 turns of 25g wire before fitting to the board. The wire supplied in the kits is self fluxing polyurethane covered and can be soldered directly to the board. Before fitting any components to the mixer board press in pins, from the

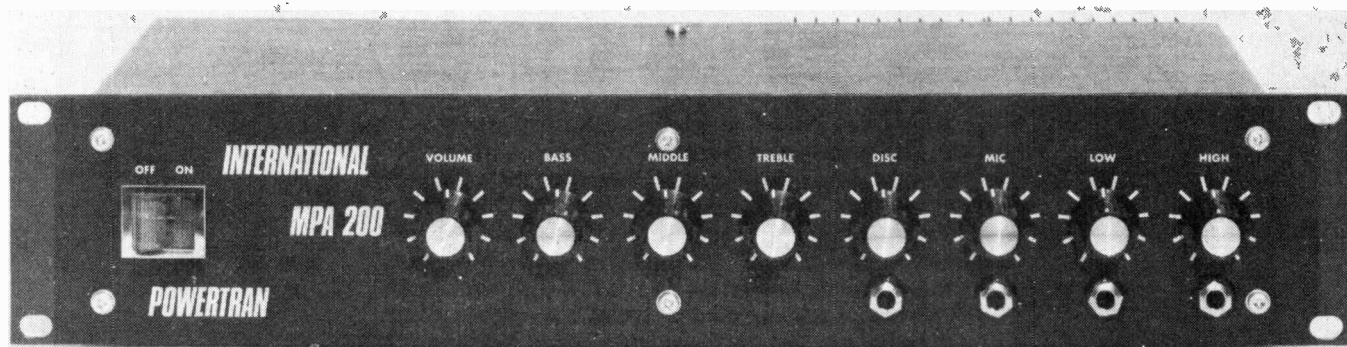
component side of the board at the 16 points marked x. These are for connecting to the jack sockets but do not fit them yet. Now fit all the components taking particular care to solder the potentiometers squarely on the board and when complete secure to the front panel with the potentiometer nuts. Remove all but three spacer washers from the jack sockets and bending their tags to fit over the pins on the board screw to the panel and solder in position.

Press capacitors C115, 116 into their mounting clips and connect the rectifier diodes and C113, 114 across them as shown in the diagram then complete the mechanical assembly and wiring noting that ALL ground (OV) connections are made to a stack of solder tags fitted to the chassis near the power supply capacitors.

Testing and Setting Up

Without F2, 3 fitted check the power supply. Being off-load the voltage on each rail will be nearer 54 volts than 50 volts. Switch off and discharge the capacitors. No fireworks by using screwdrivers please! Use a resistor of about 100R. Fit the fuses, turn down the master volume control, turn RV101 to its midway position and turn RV102 fully clockwise.

Turn on and set the voltage between the can of Q111 and the amplifier output terminal to 33mV with RV 102. This corresponds to a



SPECIFICATION

SPECIFICATION (power amplifier)

Power output: 112 into 8 ohms

Harmonic distortion: 0.07% at 1KHz, 8R at clipping level.

Frequency response: (3dB) 10Hz — 30KHz

Damping factor: 100

Sensitivity: 0.775V (0dBm) for 100W into 8Ω

Hum & Noise: —99 dB

Input impedance: 22k

SPECIFICATION (mixer)

input DISC disc equalization sensitivity 3mV input impedance 47K

input MIC flat response sensitivity 1mV input impedance 1K

input LOW flat response sensitivity 10mV input impedance 10K

input HIGH flat response sensitivity 100mV input impedance 100K

Bass control +15dB —15dB at 30Hz

Middle control +15dB —15dB at 1KHz

Treble Control +15dB —15dB at 15KHz

By simple component changes all four inputs can have flat response for any sensitivity between 1mV and 100mV

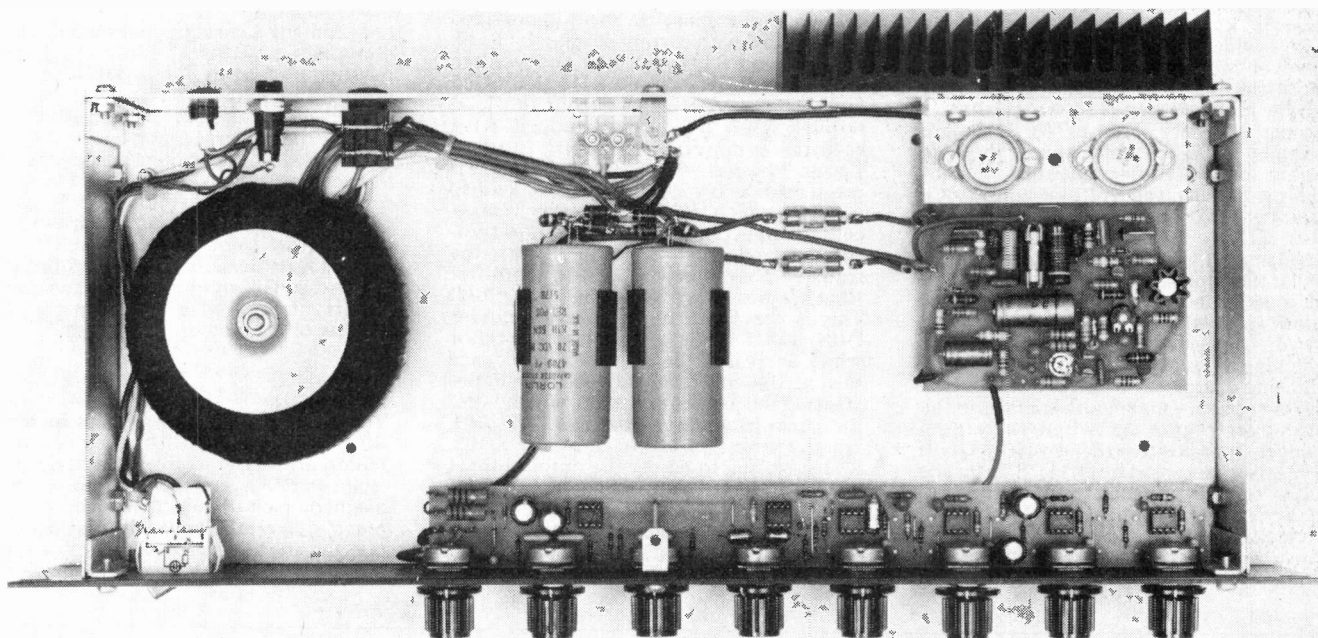
current of 100mA in the output stage. Adjust RV101 for zero off-set voltage at the output terminal. Make re-measurements of these voltages for about 10 minutes or until they stop changing whilst the amplifier is becoming thermally stabilized.

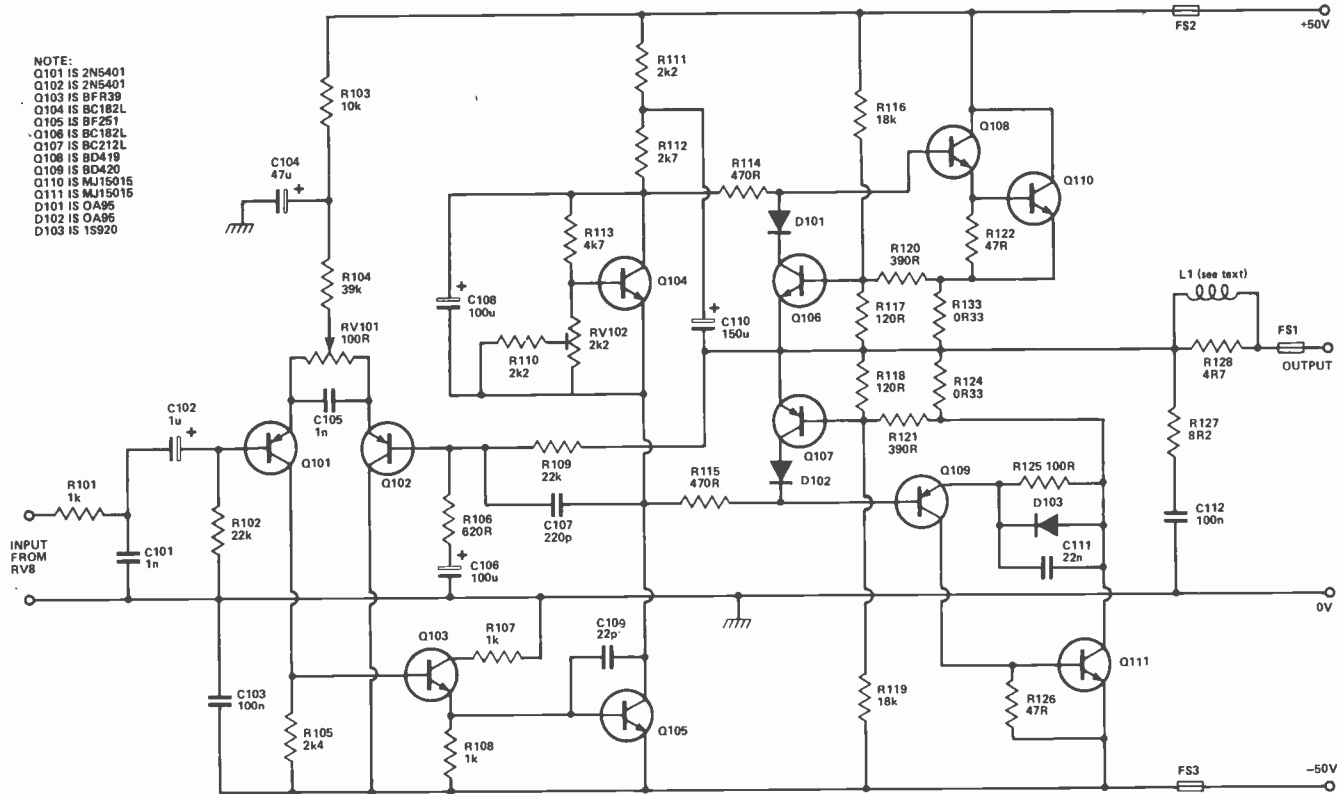
Switch off, fit the cover and your amplifier is now ready for use. **ETI**

BUYLINES

A complete kit of parts for this project, including all metalwork, nuts, bolts, PCBs and components will be available from Powertran Electronics, Portway Industrial Estate, Andover, Hants SP10 3NM for £49.90+VAT. The PCBs will be available only from them as they are their design.

In addition the parts for both the mixer and power amp boards are available separately at a cost of £10.40 and £10.60 all inc. respectively.





HOW IT WORKS

Power amplifier.

To achieve reliable high power delivery at low cost 'Power Base Technology' type power transistors are the obvious choice, offering an excellent safe operating area at a very favourable price. One such device is the well known and readily available 2N3773 which can be used in this design, however Motorola have recently introduced the MJ15015 which will not only handle more power (180 watts) but is cheaper too (only about £1.50). These are driven by Q108, 109 which supply the base current for the output transistors without loading heavily the voltage amplifying stage of Q105. The combination of R125, D103, C111 is used to simulate the input impedance of a power transistor to make similar the impedances at the bases of Q108, 109 so as to increase the symmetry of the output stage which is necessary to achieve low distortion. R122, 126 improve the switching times of the output transistors by removing charge carriers from their bases. This is necessary for smooth transfer in the cross-over region i.e. when the signal changes from positive (delivered by Q110) to negative (accepted by Q111). Bias for the output stage is provided by Q104, the voltage across which is adjusted by RV 102. For thermal stability of quiescent current this transistor is in thermal contact with the cooling bracket. C108 is an AC bypass.

R123, 124 are the resistors which sense the current in the output stage, the voltage across these will be the voltage across TR104 less the voltage of the three base-emitter junctions of TR108, 110, 111 and the junction of D103.

Protection against overload is provided by Q106, 107 with current sensing by R117, 120, 123 and R118, 121, 124 and voltage sensing by R116, 117 and R118, 119. R115 limits the current drawn from the load through Q107, 105 during overload. R114 restores symmetry for positive going signals. However, the presence of R114, 115 can, under heavy load conditions, lead to voltages which can turn on the base-collector junctions of the protection transistors introducing a discontinuity into the transfer characteristic of the amplifier (that's a posh way of saying distortion!) This is prevented by germanium diodes D101, 102. C110 is a bootstrap capacitor which increases the effective impedance seen at the collector of Q105, thereby increasing the gain of that stage which takes the signal from differential pair Q101, 102, via the emitter follower buffer Q103. RV101 is used to adjust the output off-set voltage to zero. The overall voltage gain of the amplifier is determined by R106, 109 and is about 36 corresponding to 0dBm (0.775V) for full power. R101, C101 are an input filter to remove RF interference and prevent

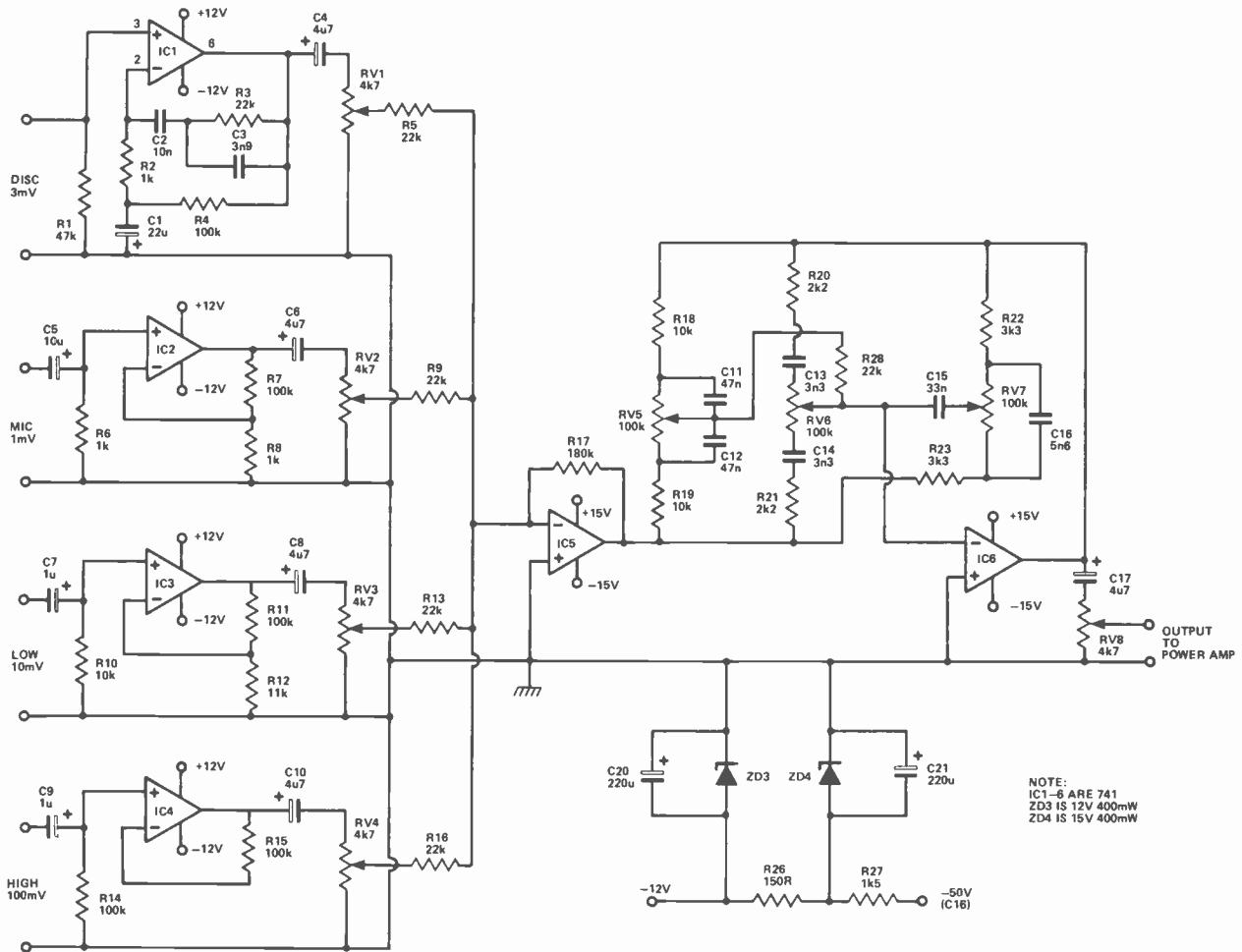
overload by transients. Frequency compensation and stabilization is performed by C105, 107, 109, 112, R127, 128, and L1.

Power supply

For economy the supply to the amplifier is unregulated. D104-107 form a full wave rectifier filtered by C115, 116. C113, 114 remove high frequency transients from the power rails. A toroidal transformer is used because the stray magnetic field is very low thereby reducing the hum introduced into the system. The mixer is supplied by zener diode regulators fed from the 50V power rails. Two stages of regulation are used to prevent low frequency feedback to the input stages. Because of the bass boost of the disc equalization characteristic this is important otherwise low frequency instability of the system could result.

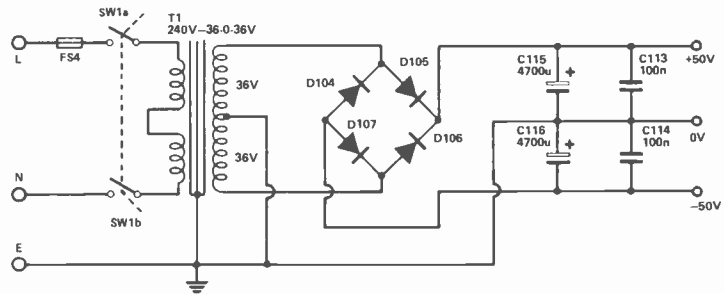
Mixer

The actual mixing is carried out by RV1-4, R5, 9, 13, 16, 16 and IC5 but before that the inputs are buffered by IC1-4 stages. IC1 stage is RIAA equalized for use with a magnetic pick-up but if this facility is not required it can be built with flat equalization for another purpose such as a guitar pick-up (10 or 15 mV sensitivity being suit-

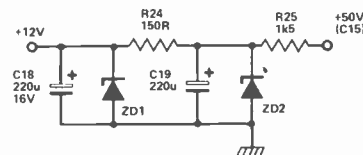


NOTE:
IC1-6 ARE 741
ZD3 IS 12V 400mW
ZD4 IS 15V 400mW

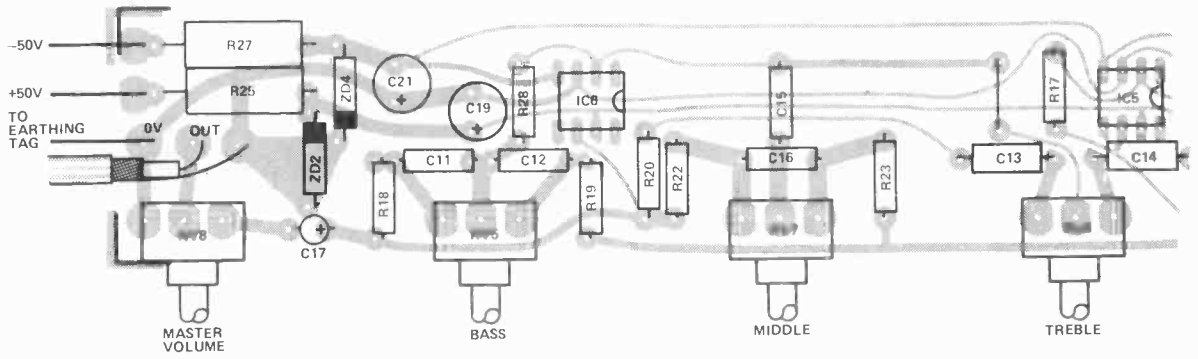
Above left: the full circuit for the power amplifier section of the mixer amp. This builds onto its own PCB and can be employed to good advantage in other systems. Above right: the mixer circuit itself. Note the provision of a third-mid-tone control circuit which will be found to be useful in disco applications. Below right: power supply circuit for the whole unit.



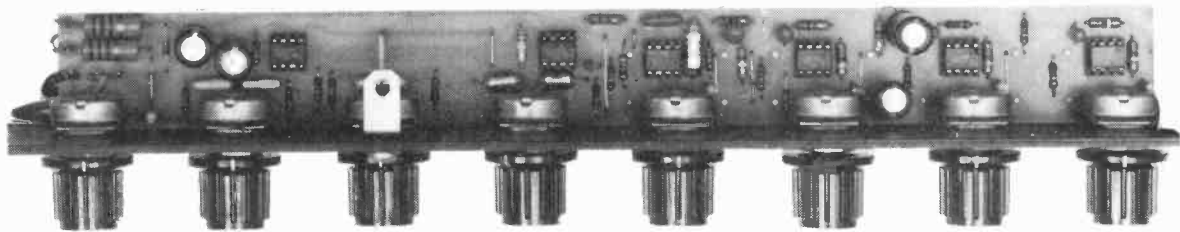
NOTE:
ZD1 IS 12V 400mW
ZD2 IS 15V 400mW
D104-106 IS 1N5402



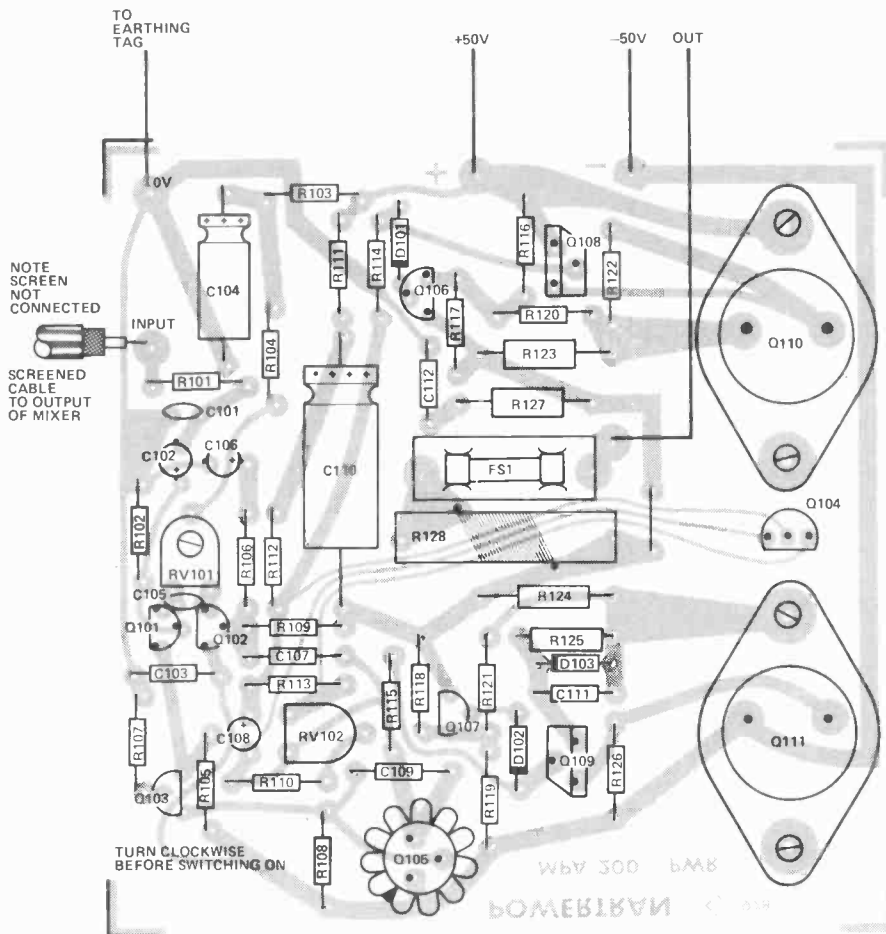
able for most pick-ups). For 15 mV sensitivity omit C3, R4, use wire links in place of C1, 2, use 15K, 18K, 100K for R1, 2, 3 respectively and replace link A with a 1u tantalum capacitor. All the buffer stages produce an output of 100mV for their rated input. Changing the resistor values alters the sensitivity for example IC3 stage could also be built for 15mV sensitivity, 15K, 18K, 100K then being used for R10, 12, 11 respectively, provision is also made for disc equalisation components on the IC2 stage.



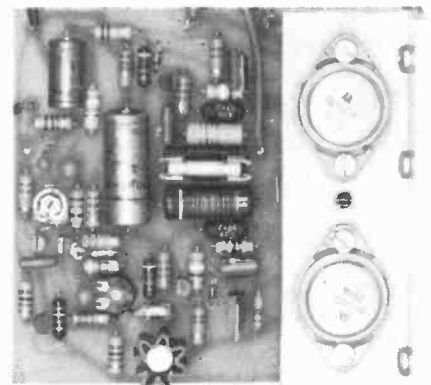
Above: the somewhat protracted overlay for the mixer board of the amplifier unit. This fixes onto the back of the controls to make construction easier. Below: the main power amplifier overlay. Read the setting-up procedures carefully before turning this on!

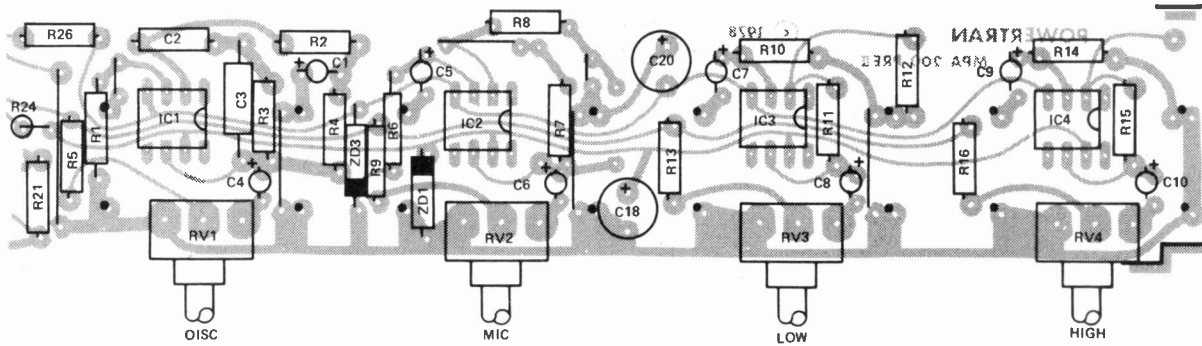


Component overlays for the boards within the unit. The mixer board is shown above — unfortunately in two pieces—(we're not fond of that kind of centre fold-out!) to make the components clear.

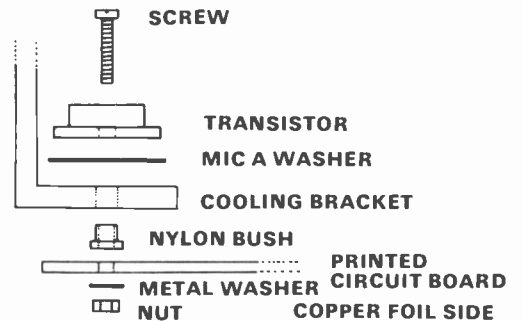
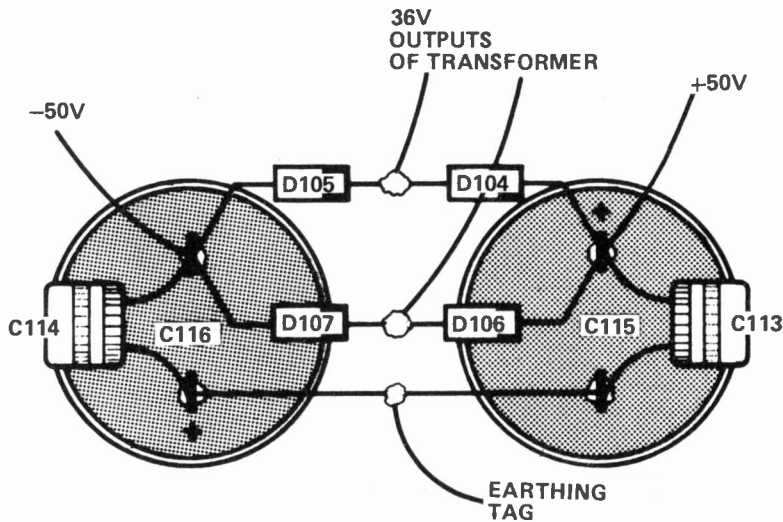


Below left is the 100W amplifier board. Take care when fitting the power transistors to their heatsinks, follow the diagram opposite. Note that RV102 should be set fully clockwise before switch on.





Left: the method of mounting the PSU components around the large reservoir capacitors C116 and C117.
Below: fitting the power transistors to the heatsink.



PARTS LIST

RESISTORS ¼W 5% Carbon Film

R1	47k
R2,6,8,	1k
R3,5,9,13,	
16,28	22k
R4,7,11,14,15	100k
R10,18,19,	10k
R12	11k
R17	180k
R20,21	2k2
R22,23	3k3
R24,26	150R
R25,27	1k5(1W)

RESISTORS ¼W 5% Carbon Film

R101,107,108	1k
R102,109	22k
R103	10k
R104	39k
R105	2k4
R106	620R
R110,111	2k2
R112	2k7
R113	4k7
R114,115	470R
R116,119	18k
R117,118	120R
R120,121	390R
R122,126	47R
R123,124	OR33 (2½W)
R125	100R
R127	8R2 1W
R128	4R7 2W

CAPACITORS

C1	22u 16V tantalum
C2	10n polyester
C3	3n9 polystyrene
C4,6,8,10,17	4u7 16V tantalum
C5	10u 16V tantalum
C7,9	1u 16V tantalum
C11,12	47n polyester
C13,14	3n3 polystyrene
C15	3n3 polyester
C16	5n6 polystyrene
C18,19,20,21	220u 16V electrolytic
C101, 105	1n ceramic
C102	1u 16V tantalum
C103,112,	
114	100n polyester
C104	47u 63V electrolytic
C106, 108	100u 3V tantalum
C107	220p polystyrene
C109	22p 100V polystyrene
C110	150u 63V electrolytic
C111	22n polyester
C115,116,	4700u 63V electrolytic

SEMICONDUCTORS

IC1-6	741
ZD1,3	12V 400mW
ZD2,4	15V 400mW
101,102	2N5401
103	BFR39
104,106	BC182L
105	BF257

107	BC212L
108	BD419
109	BD420
110,111	MJ15015 or 2N3773
D101,102	0A95
D103	1S920
D104-107	1N5402 or BY254

FUSES

F1	4A fast
F2,3	3A fast
F4	1A5 anti surge

POTENTIOMETERS

RV1-4,8	4k7 log
RV5-7	100k 1in
RV101	100R pre-set
RV102	2k2 pre-set

TRANSFORMER

T1 0-117V — 234V to 36V-0-36V with electrostatic screen

MISCELLANEOUS

Power transistor mounting bracket, two heat sinks 3in x 3in x 1in, TO5 cooling clip, six IC sockets, five ¼in mono jack sockets, two chassis mounting fuse holders, PCB mounting fuse holder, panel mounting mains fuse holder, illuminated mains switch DPDT, eight knobs, fibre glass ready drilled PCB's, metalwork and cabinet to suit, two capacitor clips, cable clamp, nuts, bolts, brackets, cable etc.

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ditto 20p, 2K Helitrim 20p, 5K PCB 20p, 1M
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audiophile.....

Seconds away — round one. Two well known tape recorder manufacturers locked in combat! Ron Harris presides over the trial by transconductance.

I RECEIVED an Xmas card this morning. No, it wasn't my first ever you irreverent lot, but it was my first and last from Strathearn Audio. Later the very same day a press statement arrived on my ever receptive desk. I quote:

"It is with a great deal of regret that I have to announce the closure of Strathearn Audio. Basically the reasons of this closure can be put into one sentence: the treasury was unwilling to consider providing additional funding until Autumn 1979 — but which time our proposed tie-up with Aiwa would have been in effect." Unquote.

And so effective December 31, 1978, our natimised hi-fi company ceases to be, five years and £9,000,000 later. One question oh ye powers that be — WHY NOW?

Strathearn's past has been one of huge losses, bad press and inadequately researched products. Through all this the government stood by them, while loud indeed the wolves did howl for blood.

In the past months, however, all has begun to change. Their record deck SM2000 and 21000 speaker system are very fine pieces of work. Export orders were growing, and by the end of '79 they could probably have been paying their way. At last.

Surely *more* cash should be made available — advertise the stuff don't kill it — with the excellent original thought evident in the products Strathearn had a future in the hi-fi market, and as we've already lost over £9,00,000 tax money it seems sheer lunacy to 'cut losses' at the first sign that those losses are about to end.

the gospel according to revox

ACTILINEAR or "old wine in new bottles"

COMPETITION IS HOTTING up and not only against products from the Far East. Even among the "European alternatives" aggressively formulated headlines and the big treatment in advertisements and sales leaflets clamour for attention. Indeed, more and more arguments are being taken over by competitors, even word for word — which not only shows lack of imagination, but confuses the issue, at least for a time.

But it's a different matter when circuit arrangements that have been common property for years are trotted out as a new system and elevated to the status of main support for an advertising campaign.

What we are talking about is the "invention" published by a Norwegian manufacturer (and even put forward for patenting) known as ACTILINEAR. It is perfectly understandable if even test engineers don't

There is hope that the 21000 can be saved from all this and marketed separately. I hope so. In the meanwhile if there is anyone reading this out there connected with this decision, I say again WHY NOW?

Sorry I'll Leave That again!

DUE to circumstances never entirely within my control I've had to leave the description of Sonys TAE88 FET pre-amp until next issue. Before any of you write in accusing me of whiling away the month with wine, soft music and Felicity Kendal, I assure it ain't true — if it had been 'Ah . . . what a thought . . .) I most definitely would not be here now, and neither would the Sony review.

Since I didn't spend the month with you-know-who, and there is no TAE88 review — let's call it quits eh? (I think I lose on this deal by a factor of about six million to one.)

Gloves on, Record Amps Away

MUST be the silly season again. Below I reproduce word for word two releases which arrived at ETI on the same day in the same post on the same subject — Actilinear.

There is a dispute. Revox v Tandberg. Read all about it here, folks. No comments from me, take your pick and make up your own minds.

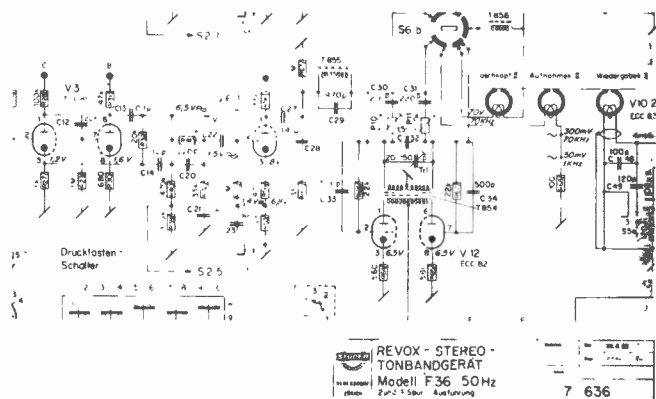


Fig. 1
Transconductance converter with filter coupling in valve technique. Recording amplifier of the REVOX F36 magnetic tape recorder. Circuit diagram drawn 26.2.62.

know every detail of the circuit by heart. After all, they've got other things to do besides concentrating on the subject of voltage-current conversion (transconductance converter) in the output stage of a recording amplifier.

Nor will a filter for decoupling the HF bias make them sit up too sharply, because they've been around for too long as well. A very long time, in fact. To be exact, at least since 1962 when valves were in use and since 1965 in transistorised circuits. We have no intention of making any assertions, for the fact is that the old REVOX F36 tape recorder (Fig. 1), the studio machines STUDER C37 (Fig. 2) and STUDER A62 (Fig. 3) used separate circuits for an equalising -reamplifier, a transconductance converter and a direct supply to the recording head via a filter circuit, with all the known advantages of such an arrangement.

These are well-proven techniques of long standing and are, for instance, still used in the latest REVOX B77 (Fig. 4). Interestingly enough, that machine too has an overload margin of approximately 20dB and a filter system prevents the bias oscillator voltage from interfering with the wanted signal.

Of course, we have no objections whatsoever if other manufacturers use these circuit details, which we had 16 years ago and did not consider worth patenting, since in the meantime they have become common property.

On the contrary, we assume that we are not the only ones who are prepared for sharpened competition, which benefits us all — as long as it is fair competition.

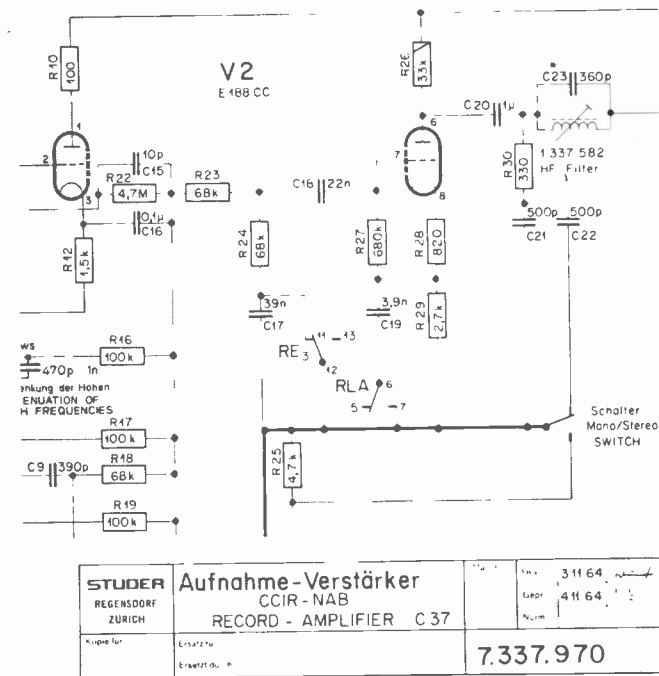


Fig. 2 Transconductance converter with filter coupling in valve technique. Recording amplifier of STUDER C37 magnetic recorder. Circuit diagram drawn on 3.11.64.

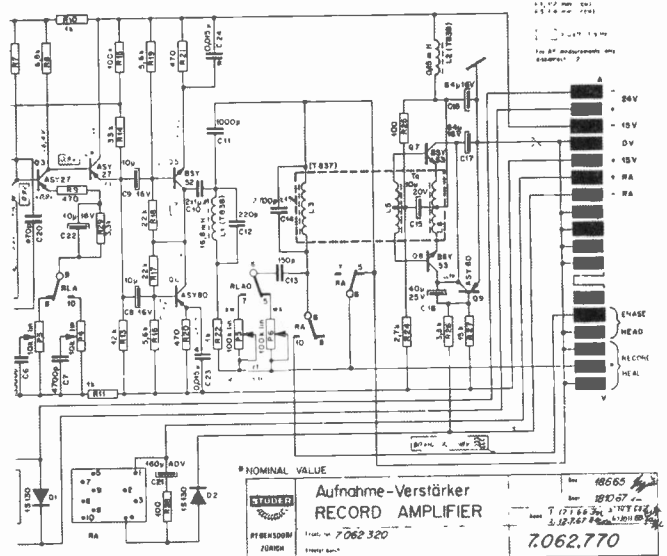


Fig. 3 Transconductance converter with symmetrical output stage, driven active generator and filter coupling in transistorised technique. Recording amplifier of the STUDER A62 magnetic tape recorder. Circuit diagram drawn on 18.6.65.

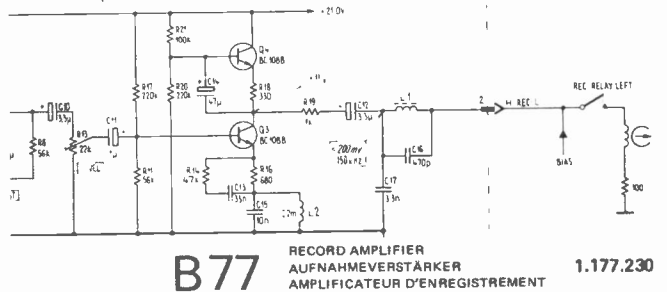


Fig. 4 Transconductance converter with free active generator and filter coupling. Recording amplifier of magnetic tape recorder B77.

the tandberg gospel

Deeper Into Tandberg Actilinear

A SWISS MANUFACTURER of reel to reel tape recorders has released a "press information" claiming that the new Tandberg "Actilinear" Recording System, used in our tape recorders TD 20A and TCD 340A has been known to the industry for several years. This we believe is based on an incomplete understanding of the circuitry. We are, therefore, issuing the following information which will help clarify the matter.

Figure 1 shows the schematic diagram of the Tandberg Actilinear Recording Amplifier chain which consists of three modules, an Equalizer, a Transconductance Converter and a Filter module. A more detailed explanation of the recording chain is given in a technical article "A New Recording System" by Senior Engineer Mr. Herman Lia, Dept. of Magnetic Research and

Development, Tandbergs Radiofabrikk A/S (printed in Audio Magazine, USA, July 1978), which also describes the ability of the Actilinear Recording System to be adjusted to fully exploit the potential of the new high coercivity tapes, such as the new metal particle tapes.

The claim is made that the principle of Transconductance has been well known for quite some time. This is, of course, a fact. Transconductance is the principle action of every transistor. Transconductance amplifiers have been a well known means of converting voltage to current for quite some years. Tandberg has employed such amplifiers before in their instrumentation recorder TIR 100/115 and in their professional portable audio tape recorder Arrivox-Tandberg.

There are, however, an almost infinite number of ways to design transconductance amplifiers, or voltage-to-current converters, of which very few satisfy *all* the requirements of an optimum tape recording amplifier.

It is the Tranberg *application* of the transconductance principle which is of interest in the Actilinear System, and which is one of the distinguishing characteristics of the system. In Actilinear, we have used transconductance in such a manner as to create a high output impedance which is *symmetrical*. This gives minimum even harmonic distortion, which is not only an audible improvement for the consumer, but is also clearly and measurably superior to other applications of the transconductance principle.

Third World.

When it is so well known that 3rd harmonic distortion is inherent in all tape recording due to the tape characteristics themselves, it is of principal interest to eliminate other distortion components which will degrade the audible/measurable performance of a tape recorder. This is, of course, one advantage of Actilinear and clearly differentiates it from other known systems.

Figure 2 shows the wiring diagram for the Actilinear transconductance module, and Figure 3 shows a "similar" circuit in another well known reel to reel tape recorder. Common for both circuits is that Q2 is used as a *constant current source* and there is no feedback loop from the output so that the linearity of the recording signal is only determined by the linearity of Q1 and Q2.

However, the difference lies in the fact that the Actilinear System (Fig. 2) is made *symmetrical* regarding

output impedance, as the collector of Q1 is connected to the collector of Q2. Thereby, the circuit produces minimum even harmonic distortion. In fig. 3 the point "R" is *unsymmetrical* because the output impedance varies as the output conductance h_{oe} of Q1 varies, and as h_{oe} will be different for the positive and negative amplitudes, even harmonic distortion will be produced.

Measurements of the TD 20A and the machine employing circuitry in Figure 3 show that the Tandberg TD 20A gives significantly higher output level in the very

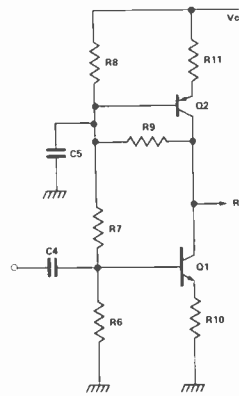


Fig. 2. Actilinear

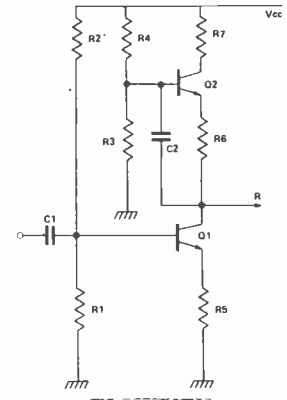


Fig. 3. Transconductance module by a different manufacturer.

critical segment of the frequency range between 1 kHz and 10 kHz at the same measured distortion level, and consequently gives a better performance.

We suggest that the public before jumping to conclusions about similarity between circuits, realize that we are talking about second and higher order effects in a circuit which is supposed to handle large amplitude audio signals and bias voltage applied to the output at the same time.

In discussing such matters, we consider a comparison of small-signal equivalents of the various possible applications of transconductance to be a sub-optimal exercise, and of no value.

Our solution is, in so far as is known, unique in the tape recorder industry, can be adjusted to optimally exploit metal particle tape and gives audibly superior results with conventional tape formulations. **ETI**

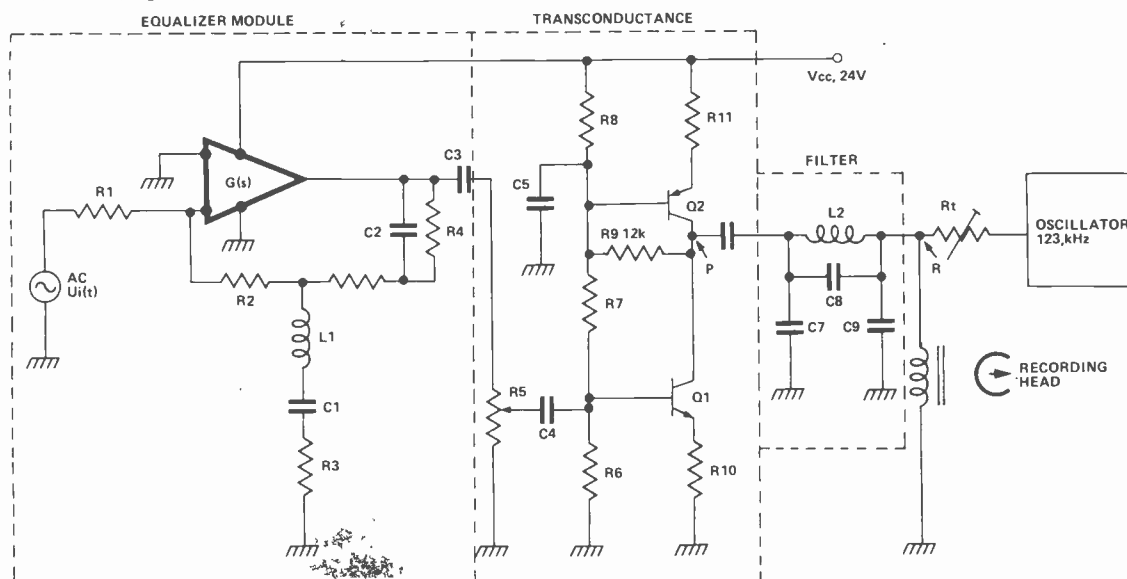


Fig. 1. Circuit diagram of Tandberg recording amp employing Actilinear circuitry.

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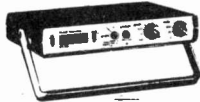
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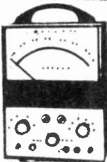
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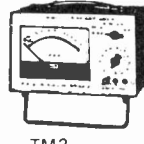


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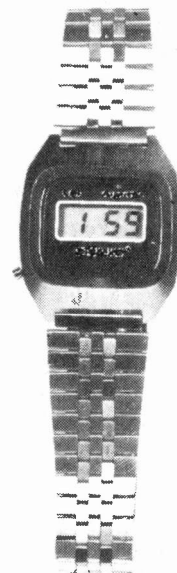
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7425	20p	7496	45p	74165	60p	4018	55p	CA 3046	60p	LM 555	25p	SN 76228 N	180p	TDA 2020	300p	
7426	22p	7497	120p	74166	75p	4019	40p	CA 3060	225p	LM 709 C	40p	SN 76660 N	75p	TL 084	120p	
7427	22p	74100	80p	74167	160p	4020	50p	CA 3065	200p	LM 710 TO5	60p	TAA 300	100p	XR 320	250p	
7428	25p	74104	40p	74170	100p	4022	50p	CA 3076	250p	LM 710 DIL	65p	TAA 350	190p	XR 2206	450p	
7430	12p	74105	40p	74173	80p	4023	12p	CA 3080	75p	LM 723 TO5	40p	TAA 550	35p	XR 2207	450p	
7432	20p	74107	25p	74174	60p	4024	40p	CA 3084	250p	LM 723 DIL	40p	TAA 570	220p	XR 2208	600p	
7433	28p	74108	100p	74175	60p	4025	12p	CA 3085	85p	LM 733	120p	TAA 661B	140p	XR 2216	650p	
7437	20p	74166	75p	74176	50p	4026	80p	CA 3086	60p	LM 741	20p	TAA 700	350p	XR 2567	250p	
7438	20p	74109	25p	74177	50p	4027	30p	CA 3088	190p	LM 748	40p	TAA 790	350p	XR 4136	150p	
7440	12p	74118	75p	74178	75p	4028	45p	CA 3089	160p	LM 1303 N	100p	TAD 100	150p	XR 4202	150p	
7441	45p	74120	80p	74179	120p	4029	50p	CA 3090	130p	LM 1458	100p	TAD 110	130p	XR 4212	150p	
7442	40p	74121	25p	74180	90p	4030	30p	CA 3123 E	130p	LM 3080	75p	TBA 120 S	60p	XR 4739	150p	
7443	60p	74122	35p	74181	130p	4032	80p	CA 3130	100p	LM 3900	55p	TBA 120 T	85p	ZN 414	100p	
7444	60p	74123	40p	74182	50p	4033	100p			IN 4148 Diodes by ITT/Texas, 100 for £1.50 Static Ram 2102 1024x1 bit 450 nano sec, £1.00 each 2112 256x4 bit 450 nano sec, £2.50 Murata Ultrasonic Transducers 40kHz, £2.00 each, £3.50 pair All prices include post and VAT						
7445	65p	74125	35p	74184	120p	4040	60p									First grade LEDs .125 or 0.2" red 10p each, 100 for £7.50, 1,000 for £60.
7446	50p	74126	35p	74185	100p	4043	60p									
7447	50p	74128	60p	74188	320p	4046	90p									
7448	50p	74130	120p	74190	70p	4047	80p									
7450	12p	74131	90p	74191	70p	4048	50p									
7451	12p	74132	45p	74192	60p	4049	25p									
7453	12p	74135	90p	74193	60p	4050	25p									
7454	12p	74136	80p	74194	55p	4054	100p									

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12FE06	6+6	1A each	2.00	60p	20FE24	24+24	0.4A each	2.50	70p
20FE06	6+6	1.6A each	2.60	70p	50FE24	24+24	0.8A each	3.10	70p
50FE06	6+6	3A each	3.10	70p	60FE24	24+24	1.2A each	3.60	85p
60FE06		4A each	3.60	85p	80FE24	24+24	1.5A each	4.50	1.00
06FE09	9+9	0.3A each	1.50	50p	50FE28	28+28	0.75A each	3.10	70p
08FE09	9+9	0.5A each	1.80	50p	60FE28	28+28	1.1A each	3.60	85p
12FE09	9+9	0.75A each	2.00	60p	80FE28	28+28	1.4A each	4.50	1.00
20FE09	9+9	1A each	2.60	70p	20FE30	30+30	0.35A each	2.60	70p
50FE09	9+9	2.5A each	3.10	70p	50FE30	30+30	0.75A each	3.10	70p
60FE09	9+9	3A each	3.60	85p	60FE30	30+30	1A each	3.60	85p
08FE12	12+12	0.25A each	1.50	50p	80FE30	30+30	1.2A each	4.50	1.00
08FE12	12+12	0.3A each	1.80	50p	Multi-Tap Range: Voltage Available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 12-0-12 CR 15.0-15 0-12-15				
12FE12	12+12	0.5A each	2.00	60p	20FE30	24+30	1A	3.40	70p
20FE12	12+12	0.8A each	2.60	70p	60FE30	24+30	2A	3.70	85p
50FE12	12+12	2A each	3.10	70p	80FE30	24+30	3A	4.50	1.00
60FE12	12+12	2.5A each	3.60	85p	100FE30	24+30	4A	5.60	1.15
08FE12	12+12	3A each	4.50	1.00	Centre Tap Secondary				
06FE15	15+15	0.2A each	1.50	50p	FE06	6-0-6	1A each	2.00	60p
08FE15	15+15	0.25A each	1.80	50p	FE09	9-0-9	1A each	2.60	70p
12FE15	15+15	0.4A each	2.00	60p	FE12	12-0-12	1A each	2.60	70p
20FE15	15+15	0.6A each	2.60	70p	FE15	15-0-15	1A each	3.10	70p
50FE15	15+15	1.6A each	3.10	70p	FE20	20-0-20	1A each	3.10	70p
60FE15	15+15	2A each	3.60	85p	60FE52	26-0-26	1A each	3.60	1.00
80FE15	15+15	3A each	4.50	1.00	60FE28	28-0-28	1A each	3.60	1.00
06FE20	20+20	0.15A each	1.50	50p	60FE30	30-0-30	1A each	3.60	1.00
08FE20	20+20	0.2A each	1.80	50p	100FE26	26-0-26	2A each	5.15	1.15
12FE20	20+20	0.25A each	2.00	60p	100FE30	30-0-30	2A each	5.15	1.15
20FE20	20+20	0.5A each	2.60	70p	100FE36	36-0-36	2A each	5.15	1.15
50FE20	20+20	1.2A each	3.10	70p	Air cored Audio Cross Over Coils				
60FE20	20+20	1.5A each	3.60	85p	FE01	0.1mH		0.26	20p
80FE20	20+20	2A each	4.50	1.00	FE03	0.3mH		0.26	20p
					FE05	0.5mH		0.30	20p

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48FE12	0-6-12	4A	3.10	70p
66FE12	0-6-12	5A	3.80	85p
70FE12	0-6-12	6A	4.85	1.00

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TWONKY

May Hadley has designed an MPU music box that plays random tunes to the rules laid down by a compositional algorithm.

EVER SINCE THE computer was invented, whenever that was, there have been people who have sought to apply it in previously untouched fields. Doubtless the same will happen with the microprocessor to a much greater extent because of its vastly lower cost and wider circle of users. Certainly the amateur constructor can do far more than simply make miniature computers. Twonky is one such application in the field of computer music.

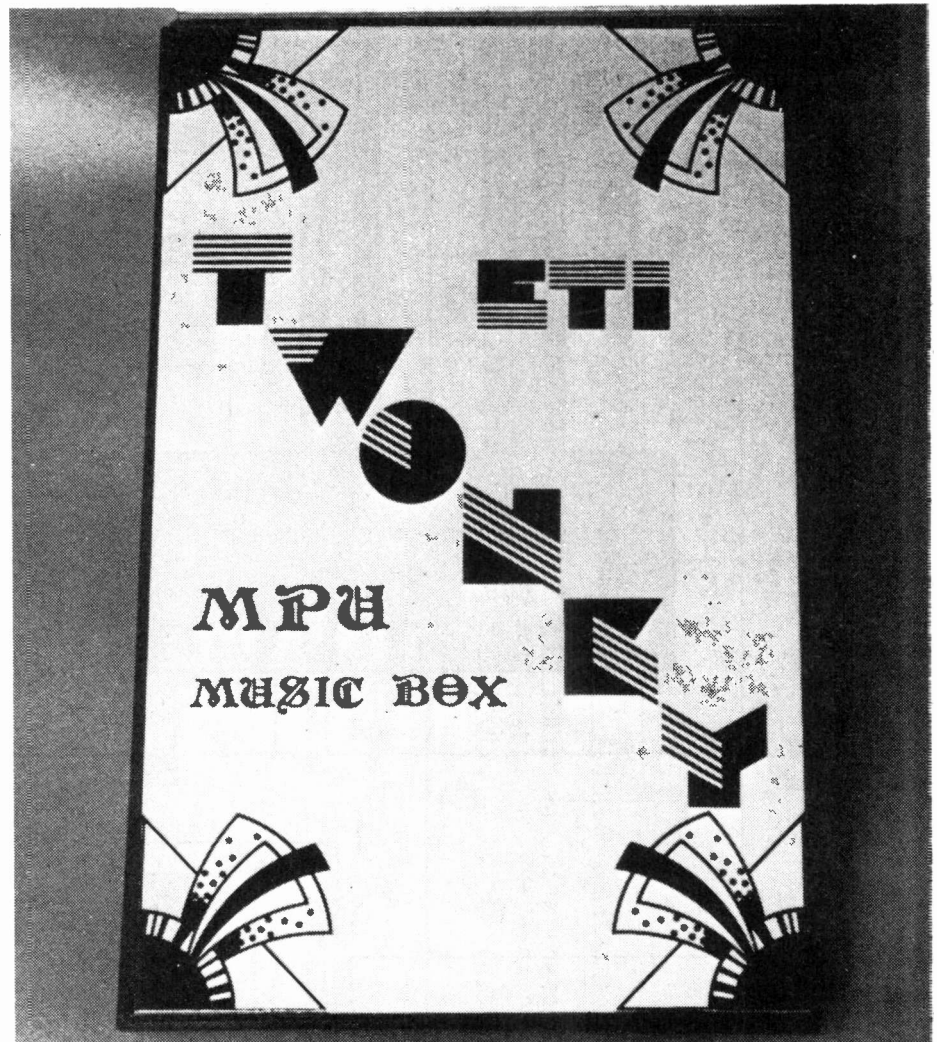
Macro Music

Music was first applied to computers in the late '50s. Machines of that vintage were often fitted with loudspeakers monitoring a register or address bit, to aid in software and hardware fault tracing. Cunning programmers soon realised how to make such computers play tunes when no-one was around to stop them, and so computer music was born. It grew rapidly.

One of its earliest exponents was Professor Lejaren Hiller of Illinois University who together with his colleague Prof. Leonard M. Isaacson conducted a series of studies which are described in their book 'Experimental Music' (McGraw Hill 1959). They began by using the computer to test the classical compositional rules of species counterpoint, developed in the seventeenth century by J. J. Fux and taught to music students ever since. A program was written which would generate random notes, test them against the rules and insert them where a suitable match was found. Though this sounds simple enough, it took several years to do, as the 'rules' were by no means complete: many things were assumed as being obvious by the musical theorists which had to be explicitly stated for the computer.

Suite Illiac

By this time, the original aim, which was to test the compositional



rules in question, had become secondary to the fun of using the computer to generate new music.

Other styles and principles, ranging from the sixteenth to the twentieth centuries, were applied in something of a mixture, and the result served up as the 'Illiac Suite for String Quartet' (named after the famous ILLIAC IV computer on which they were composed.) This proved rather disappointing, sounding almost a

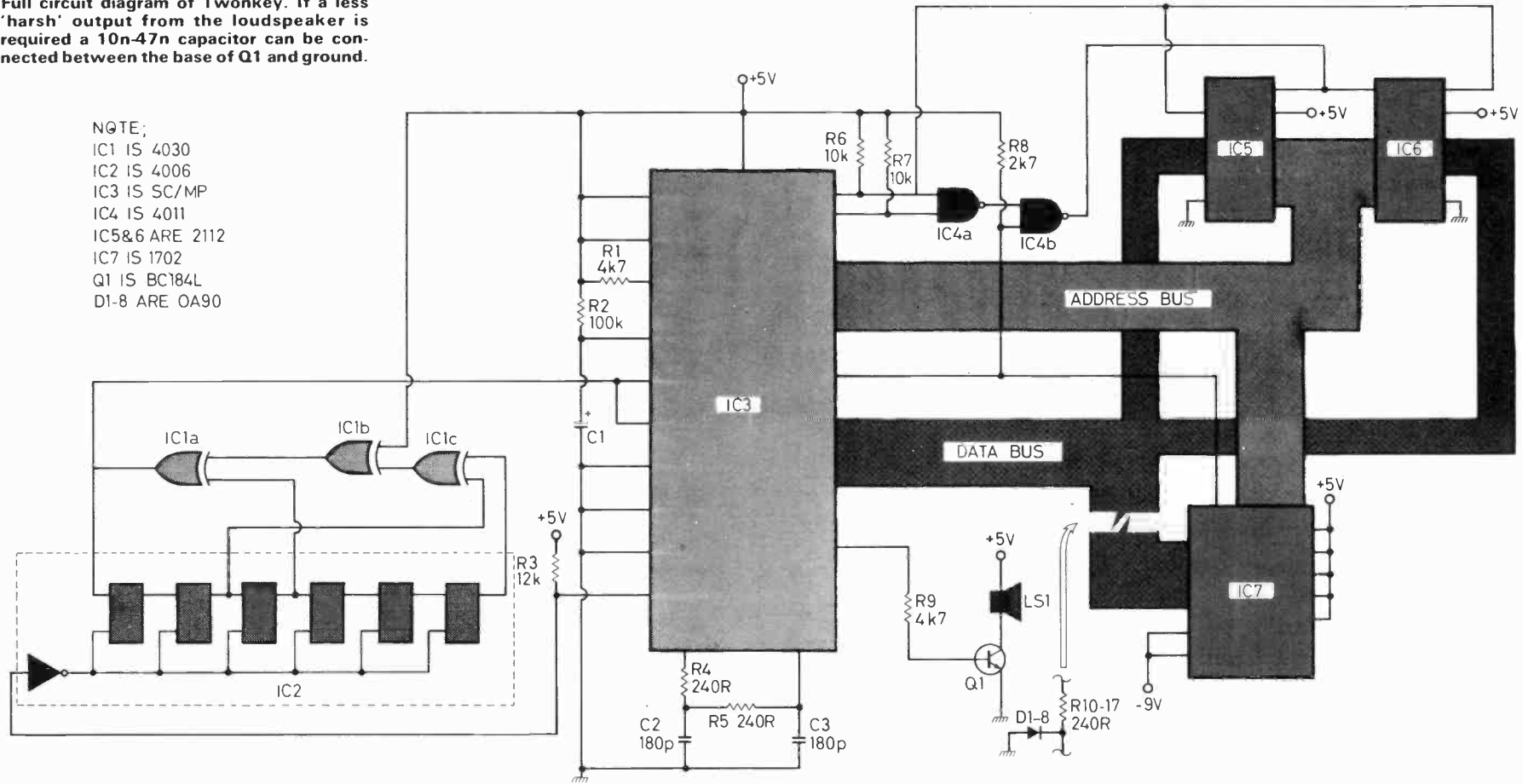
parody of twentieth century chamber music.

Other workers, such as Professor J. K. Randall of Princeton University, developed slightly different lines of approach, including the one used by Twonky. Prof. Randall's work 'Prelude to Mudgett' may be heard on disc (Nonesuch 71245), and is a typical example of this style and approach.

While this effort was going into composition and stylistic analysis, ►

Full circuit diagram of Twonky. If a less 'harsh' output from the loudspeaker is required a 10n-47n capacitor can be connected between the base of Q1 and ground.

NOTE;
 IC1 IS 4030
 IC2 IS 4006
 IC3 IS SC/MP
 IC4 IS 4011
 IC5&6 ARE 2112
 IC7 IS 1702
 Q1 IS BC184L
 D1-8 ARE OA90



HOW IT WORKS ~ HARDWARE

The National Semiconductor SC/MP is a simple, cheap, 8-bit processor designed for use in minimal systems; to this end it has an on-chip clock generator and I/O facilities, and needs no bus buffers in small systems. The instruction set is not large, but contains such useful features as a wide range of addressing modes and the capability of double-indexed memory references.

Internally, the chip has seven main registers; an 8-bit accumulator, an 8-bit status register, four 16-bit pointer or index registers (one of which is dedicated as the program counter), an 8-bit extension register. All memory references (including jumps) are via an index register; the second byte of each memory reference instruction is a displacement which is added to the index register and

NWDS, and NRDS high, to prevent spurious memory enables while the MPU outputs are in the high impedance mode between memory accesses.

Components R5, R8, C2, and C3 set the processor clock frequency at about 4MHz. R5 can be made variable to act as a tuning control, but must be between 100 ohms and 2kilohms. The MPU is reset on power-up by R3 and C1, and the first instruction is fetched from location OOH.

IC6 and IC7 form a PRBS generator. An 18-stage shift register, clocked by the NADS strobe from the MPU has exclusive OR feedback arranged around it such that it will produce a stream of bits in a repeating sequence $2^{18}-1$ (262,143) bits long. Within this overall sequence, the bit stream is random,

other people were engaged in turning the computer into a new musical instrument, a 'super synthesiser' (although this work was begun before Dr Moog invented the voltage controlled analogue synthesiser). Several programs have been developed; TEMPO by Glough and Sosman on an IBM 360/44, MUSIGOL at the University of Virginia, and the most widely used, MUSIC 4 (and its derivatives MUSIC's 4B, 4BF, and 5) at Bell labs and Princeton.

This is a program, mainly in FORTRAN IV but with some assembly language sections, which

play tunes monophonically using squarewaves. The compositional algorithm (due to Prof. Randall) is based on two simply observations:-

1. Every tune has at least one highest note
2. Every tune can be split into two subtunes at least one not long, which may then themselves be regarded as tunes.

To compose a tune using these rules, we assume also that each tune only has one highest note, and that each subtune is half the length of the tune. We take a given note as the highest note in the whole tune and

may be in the range -127 to 127. If the displacement has the value -128 the contents of the extension register are used as the displacement to be added (doubly indexed memory reference). There is, however, no explicit subroutine call instruction.

The status register contains carry, overflow, and interrupt enable flags, two sense input bits, and three user definable flags. These last five are taken to package pins to provide limited I/O capability. Twonky uses the sense-B input to read random bits from the pseudo-random binary sequence generator (PRBS generator) and the flags to drive the audio amplifier. Out of the total of 46 instructions, only 17 are used and these are shown in fig. 1 along with the status register bit allocation.

The program itself is 256 bytes long and lives in a 1702A EPROM at addresses 000H to 0FFH. 256 bytes of RAM in the shape of 2, 2112-A4 256 x 4 bit static chips are provided at addresses 100H to 1FFH. Address lines A0 to A7 are common to IC2, 3, and 4, while A8 is taken to the CE input of IC2 to enable it at the correct range of addresses. Note that IC2 will be enabled by any memory access, read or write, in the correct address range. If a faulty program goes berserk and tries to write to ROM, two devices will be enabled onto the data bus at the same time. This might be fatal, were it not for R9-R16 which prevent a short circuit. Additionally, in conjunction with D1-D8, they prevent negative voltages from the PMOS ROM appearing at the inputs of the other, NMOS, devices on the bus.

The RAM is enabled by the signal from pin 11 of IC5, which will be low (RAM enabled) when A8 is high and either NWDS (not write data strobe) or NRDS (not read data strobe) is low. The resistors R7, 8, and 18 tie A8,

i.e. the probability of the next bit at any point in the sequence being a one is constant at 0.5. This random sequence is fed to sense-B on the MPU and is used by the software to provide the random element in each tune.

Also, since the sense -B input is not sampled by the MPU internal logic during the NADS strobe time, the random bit will always be read unambiguously.

The power to IC6 and IC7 is not switched; they are CMOS devices which when not being clocked draw only about a microamp. This is necessary, as should the shift register be in the all zero state on switch on, the generator will stick and produce a continuous stream of zeros. Logic could be incorporated to force ones into the register on switch-on, but unless it was very devious, would result in the same sequence of pseudo-random bits (and hence tunes) occurring every time.

The audio output is taken from the MPU flag O output and amplified by Q1 to drive the speaker. A line level output may also be taken from flag 1 or 2 if desired.

There are two types of SC/MP processor available; this circuit uses the NMOS variety, which is cheaper, faster, uses less power and needs only +5V and ground. The older PMOS type can be used, but not all the control signals are the same, and so the circuitry around IC5 will need to be altered. The pitch will also be about an octave lower. Owners of SC/MP development systems, such as the introkit, MK14, or Scrumpi will be able to hook up a PRBS generator and loudspeaker to their systems with little trouble, and to relocate the code as appropriate. For further details on the SC/MP chip the data sheet, Nat. Semi pub. No. 426305290-001B (!) may be consulted.

generates musical sounds as a series of digital samples which are fed to a D/A converter, usually via the intermediate medium of magtape. Sounds are described in terms of instruments, which are routine that use stored tables of sinewaves, exponentials, ramps and other waveforms to generate complex sound sources. These are coupled via filter, reverberations, stereo position and other modules into an 'orchestra,' which outputs the final sound onto tape. The music to be played is input in the form of note cards. These punched cards carry such details as pitch, rate of rise and fall of the envelopes, start time, and other, user-defined parameters.

One Hundred 'seconds

In the early days, it took as much as 50 to 100 seconds of computer time to generate a second of music, but with modern machines, synthesis can take place in real time or faster. The program is not, however, suitable for live performance use. The result of such programs can be most impressive, particularly in the hands of a skilled 'player.' Certainly, they are far more flexible and versatile than analogue synthesisers. They have the particular merit that if, for example, 96 oscillators are needed, the function OSCIL is merely called 96 times. This uses more processor time, but does not need any additional hardware.

MUSIC 4B, together with analogue sound synthesisers, is described in Hubert S. Howe's book 'Electronic Music Synthesis.' The field of digital sound synthesis is certainly an exciting one, but is somewhat beyond the reach of the amateur, although with powerful 16 bit machines such as the LSI 11 and TMS9900 becoming cheaper, it may not remain so for long.

A Little Micro Music

Twonky is a composing machine which also incorporates software to

assign it randomly to one or other of the subtunes. The highest note in the other subtune must be lower than that in the first: we assume it is the next note down whatever scale we are using. However, each subtune may now itself be regarded as a new tune, provided it is at least two notes long. Hence in each first-level subtune, we take the highest note and assign it randomly to one or other of the second-level subtunes, adding the next lowest note in our scale as the highest note in the other. By repeating the process, we double the number of known notes in our tune (each of which is the highest note of some subtune) and increase the number of pitches by one for each level of splitting we indulge in. This process can hence be described as a random tree.

Seventh Level

In Twonky, seven levels of division are used to generate 128 subtunes each one note long, with a total range of 8 pitches (one octave of the scale of C major). The random decision at each level is produced by a hardware random number generator.

The rhythmic element in each tune is produced by selecting one of a small number of rhythm units or bars on a random basis and fitting the notes of the tune to that bar. The melodic algorithm weights the distribution of notes binorally, thus there are 2 F s (one of each octave), 7 G s 21 A s, 35 B s, 35 C s, 21 D s, and 7 E s. The tonic or key-note C occurs most frequently, lending a definite key to the melody. However, it is usual for the dominant G also to occur frequently, which it does not do. This gives all Twonky's compositions a unique and unusual style, somewhat like Mediaeval music (nothing to do with the use of a SC/MP MPU) this is enhanced by the ready tone of the square wave output.

```
0000 08 04 01 36 04 FE 32 C4 01 CA 00 C4 00 36 C4 00
0010 32 C6 01 C4 80 31 C4 80 01 C4 01 35 C1 00 C9 80
0020 01 F4 02 02 01 C9 80 06 D4 20 98 0A C1 80 F4 01
0030 02 C9 80 01 90 10 01 F4 FE 02 01 C1 80 F4 01 02
0040 C9 80 01 F4 02 02 98 05 01 C5 02 90 CF C4 00 32
0050 F4 F9 02 98 06 F4 07 02 32 90 B6 C4 EF 32 35 C4
0060 01 37 C4 FF 33 06 D4 20 9C 06 C4 97 31 3D 90 F5
0070 06 D4 20 9C 06 C4 9B 31 3D 90 08 C4 9F 31 3D C4
0080 9F 31 3D 06 D4 20 9C 06 C4 9B 31 3D 90 D7 C4 9F
0090 31 3D C4 9F 31 3D 90 CD C4 01 90 06 C4 02 90 02
00A0 C4 03 35 C7 FF 01 C2 80 CB 00 01 F4 08 02 01 C2
00B0 80 01 C4 00 35 19 F4 FF 02 9C FA 01 CB 01 33 98
00C0 04 33 C7 FF 3D 33 C3 01 31 C4 07 07 C4 0F 8F 00
00D0 C3 00 F4 FF 02 9C FB C4 00 07 C3 00 F4 FF 02 9C
00E0 FB 31 F4 FF 02 9C E1 8F 3A C7 02 33 9C D7 35 3D
00F0 32 35 3C 44 48 51 5B 67 FE F0 D6 BD B3 A0 8F 7F
```

Hex dump of the
PROM program for
the Twonky composer


```

5F C4 01      LDI 1
61 37        XPAH PTR 3
62 C4 FF      LDI FFH
64 33        XPAL PTR 3
65 06        NXNOTE CSA
66 D4 20      ANI 00100000B
68 9C 06      JNZ RHYTH1
6A C4 97      LDI 97H
6C 31        XPAL PTR 1
6D 3D        XPPC PTR 1
6E 90 F5      JMP NXNOTE
70 06        RHYTH1 CSA
71 D4 20      ANI 00100000B
73 9C 06      JNZ RHYTH2
75 C4 9B      LDI 9BH
77 31        XPAL PTR 1
78 3D        XPPC PTR 1
79 90 08      JMP SECPART
7B C4 9F      RHYTH2 LDI 9FH
7D 31        XPAL PTR 1
7E 3D        XPPC PTR 1
7F C4 9F      LDI 9FH
81 31        XPAL PTR 1
82 3D        XPPC PTR 1

```

will be stored here)

Set PTR 3 = 511 = 1FFH (top of RAM)

Start of note length writing loop
input random bit and either:

Write long note by subroutine at 97H,
on return, jump back to NXNOTE

or input random bit and either:

Write middle sized note by subroutine
at 9BH, on return go to SECPART

or write 2 short notes by 2 calls to
subroutine at 9FH

```

E5 9C E1      JNZ POS
E7 8F 3A      DLY 58
E9 C7 02      LD@ PTR 3+2
EB 33        XPAL PTR 3
EC 9C D7      JNZ PLAY
EE 35        XPAH PTR 1
EF 3D        XPPC PTR 1
F0 32        DEFB 50
F1 35        DEFB 53
F2 3C        DEFB 60
F3 44        DEFB 68
F4 48        DEFB 72
F5 51        DEFB 81
F6 5B        DEFB 91
F7 67        DEFB 103

F8 FE        DEFB 254
F9 F0        DEFB 240
FA D6        DEFB 214
FB BD        DEFB 189
FC B3        DEFB 179
FD A0        DEFB 160
FE 8F        DEFB 143
FF 71        DEFB 127

```

Inter note gap
Move note counter to next note
If PTR 3/200H go to play (next note)

Else go back to start for another tune!

F	350.875 HZ	Pitches at 4MHZ
E	332.005 HZ	
D	294.985 HZ	
C	261.645s HZ	
B	247.645 HZ	
A	221.045 HZ	
G	197.47 HZ	
F	175.07 HZ	

0.362 SECS	Length of long note at
0.361 SECS	
0.363 SECS	
0.361 SECS	
0.361 SECS	
0.362 SECS	
0.362 SECS	
0.363 SECS	

HOW IT WORKS - SOFTWARE

The programme itself falls naturally into four parts, which are shown in the four flowcharts. Of these, three (START, NOTE and WRNOTE) write the tune, and one (PLAY) plays it. Before describing the operation of each in more detail, a couple of notes are relevant.

- enclosing an expression in brackets turns it from a number into an address. Thus 510 is a number, but (510) means 'the contents of location 510'.
- all variables used in the flowcharts are actual machine registers except for the dummy variables A and B in WRNOTE. Of these, B is introduced only to improve readability, while A is an argument passed to this subroutine from the main program. It is implemented in object code by calls to 3 different addresses for its 3 possible values.

START

This is the program section which implements the random decision tree to select the pitches used in the tune. In this section the notes are numbered from 1 to 8 (highest to lowest). The code for each note consists of two bytes, one for pitch and one for duration, which occupy consecutive locations. Pitches are always in even-numbered locations.

On reset, a 1 is written to the last note pitch location (510), and the loop counter PTR 2 is reset. The program then enters a loop in which each note in the top half of RAM,

starting at the bottom and going up, is written to two successive note locations, starting at the bottom of RAM and going up. The writing address catches up with the read address at location 510, which is written to 508 and back into 510. At each step one or other of the two locations is incremented, depending on the state of the random number generator.

Thus after one complete pass through this loop, our tune, which started out as one note — a one — in location 510, is now twice as long and has two notes, a one and a two, randomly arranged in locations 508 and 510. So far so good. We now repeat this loop a total of seven times, each time doubling the number of notes written, until the memory is full (128 notes). We will then have 8 different note numbers or pitches. In fact, what we have done is identical to the decision tree method in the text (try it yourself with pencil and paper).

This section occupies addresses 00H to 60H. PTR 2 is the loop counter which goes from one to seven. On reaching seven, the program branches to NOTE. Within the section, PTR 1 points to the location being read, and EXT contains the displacement from this address to that of the location being written into.

SC/MP fanatics may notice that a separate read-increment-write instruction sequence is used (at 2CH to 33H and at 3BH to 41H) instead of the increment and load single instruction. This is because the ILD instruc-

tion does not allow doubly-indexed addressing to be used. This is not made very clear in the databook, and had to be found out the hard way!

NOTE

NOTE is the program section concerned with writing the rhythm of the tune. It has three different note lengths to play with, of relative values 4, 2, and 1. Each bar or rhythm unit can be one of 4, 2 + 2, 2 + 1 + 1 + 1, 1 + 1 + 2, or 1 + 1 + 1 + 1, determined by random decisions. The flowchart for this section is more or less self explanatory. The notes of different lengths are written by calls to the subroutine WRNOTE. This has three different entry points (98H, 9CG, AOH) which determine the length of note (long, medium or short). There is no explicit test for leaving the loop in this section as this is done in WRNOTE.

WR NOTE

On being called, this section reads the value of pitch code from RAM (starting at location 510 and going downwards) and uses it as an index to the table of pitches at locations FOH to F7H. The pitch obtained from this table is then stored in the same RAM location from which was read its code. Thus 3 will be replaced by 3CH, 8 by 67H etc. These pitches represent the length of a half cycle at the desired frequency in multiples of the time taken to go round the delay loops in PLAY.

By adding 8 to the pitch code the table of durations (F8H to FFH) is accessed in the same way. The duration is then divided by 2, 4 or 8 to give the required note length in terms of a number of cycles at its particular frequency. This number is then stored in the RAM location immediately above its corresponding pitch. WRNOTE then tests for the last note in the tune (PTR 3 = 255); if the last note has not been reached, control is returned to NOTE, otherwise control passes to PLAY.

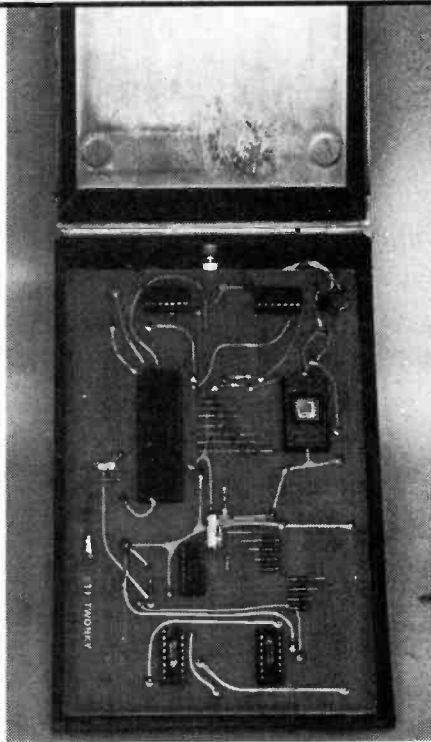
PLAY

This section is quite simple, consisting of two delay loops for pitch, and counters for duration and number of notes played. For each note in turn, the duration is first loaded to PTR 1. The pitch is loaded to the accumulator and the output taken high. The output remains high while the accumulator is decremented and tested for equality to zero. This gives a delay dependant on the initial pitch value. When zero is reached, the output is taken low and the pitch again loaded and decremented to zero. At the end of the second half cycle PTR 1, the duration counter, is decremented and tested for equality to zero. If not zero, another cycle of the same note is produced, otherwise the next note is played, after the end of tune test (PTR 3 = 512). When the end of the tune is reached, control returns to START to write and play a new tune.

Construction is quite straightforward. Sockets should be used for all IC's and normal MOS handling precautions taken. Begin by installing all through board links and testing them for continuity. Then add the resistors, capacitors, and discrete semiconductors. IC 5 may be fitted and the memory decoding checked. IC 6 & 7 should be added next, and the production of random bits at IC 7 pin 6 as pin 3 is clocked by shorting it to ground verified. Finally, add the LSI chips and switch on. Music should greet your ears within about 0.25 secs. Gaps of about this length occur every 128 notes as a new tune is written. The circuit meets all timing requirements with the 1702A only up to 3.5 MHz. Most 1702As will work happily at 4MHz, but the odd one may not. Reducing the clock frequency should effect a cure.

The PCB is single Eurocard size (100 x 160 mm) and will fit in one of the larger size veroboxes, which are designed for this standard. Batteries, either 4 x 1.5V + 1 x 9V dry cells or the equivalent nicads, will then fit under the circuit board, or the PCB may be left uncased. The only major problem which may arise is getting the EPROM programmed. Several firms offering such a service advertise on the pages of ETI and one of these should be able to help.

ETI



Photograph showing Twonky mounted in the larger sized Vero flip top case. The speaker and batteries are mounted under the PCB. The case is not very deep and a 'shallow' speaker must be used if Twonky is to be built in this case.

PARTS LIST

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R2		100k
R3		12k
R4, 5, 10-17		240R
R6, 7		10k
R8		2k7
CAPACITORS		
C1		4u7 16V electrolytic
C2,3		180p 16V ceramic
SEMICONDUCTORS		
IC1		4030
IC2		4006
IC3		SC/MP
IC4		4011
IC5, 6		2112
IC7		1702
Q1		BC184L
D1-8		0A90

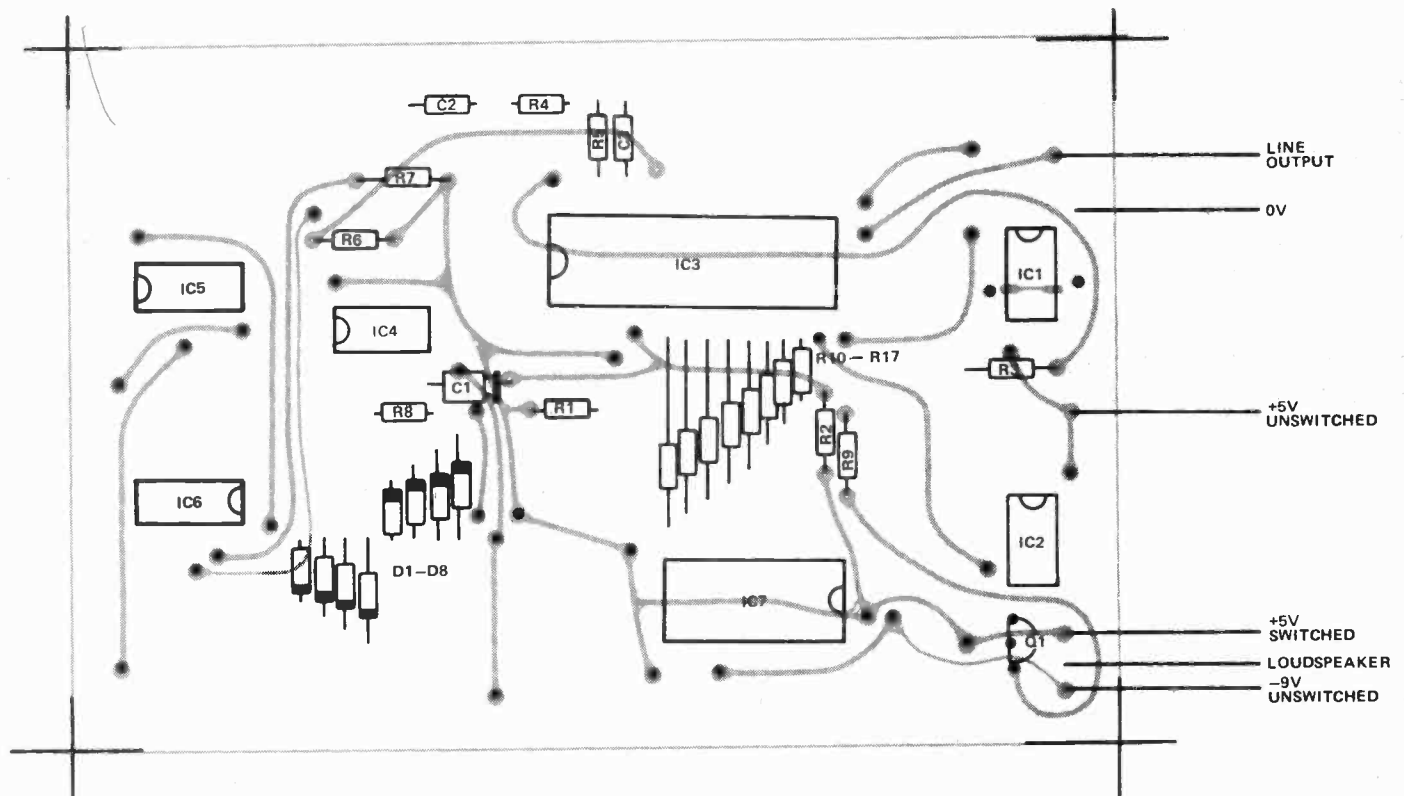
MISCELLANEOUS

PCB, loudspeaker, case batteries and clips.

BUYLINES

Marshalls, see their advert in this issue for addresses, will be supplying an EPROM with the Twonky program burned in. They will also be able to supply all the other parts for this project except the PCB which will be available from Tamtronix, Ramar, Crofton etc.

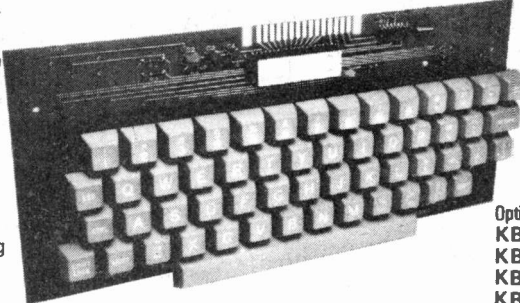
Component overlay for the ETI Twonky. The wire link that is visible on the photo or the prototype's PCB has been replaced with a foil track.



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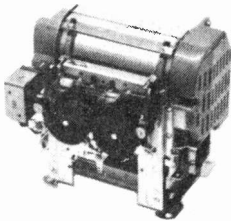
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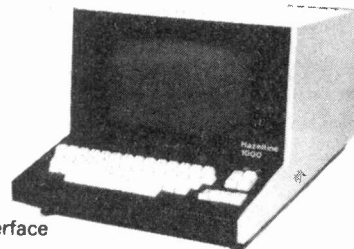


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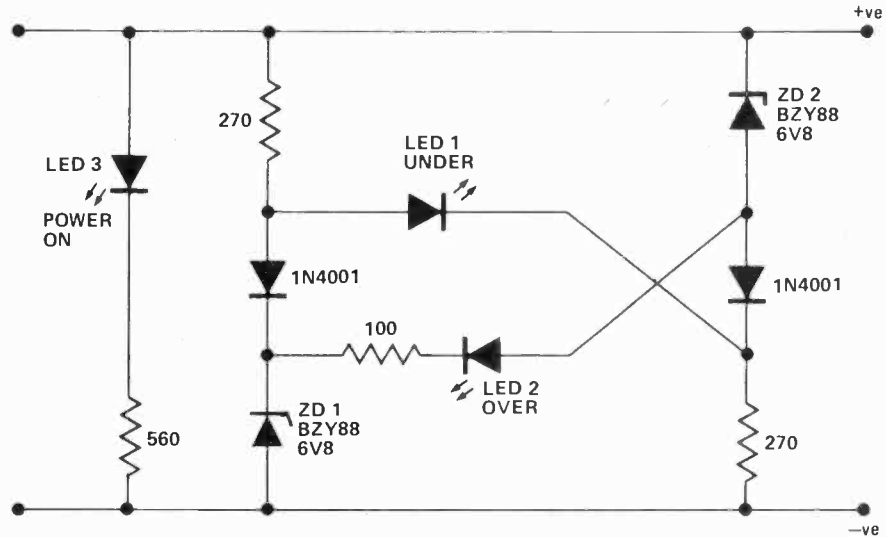
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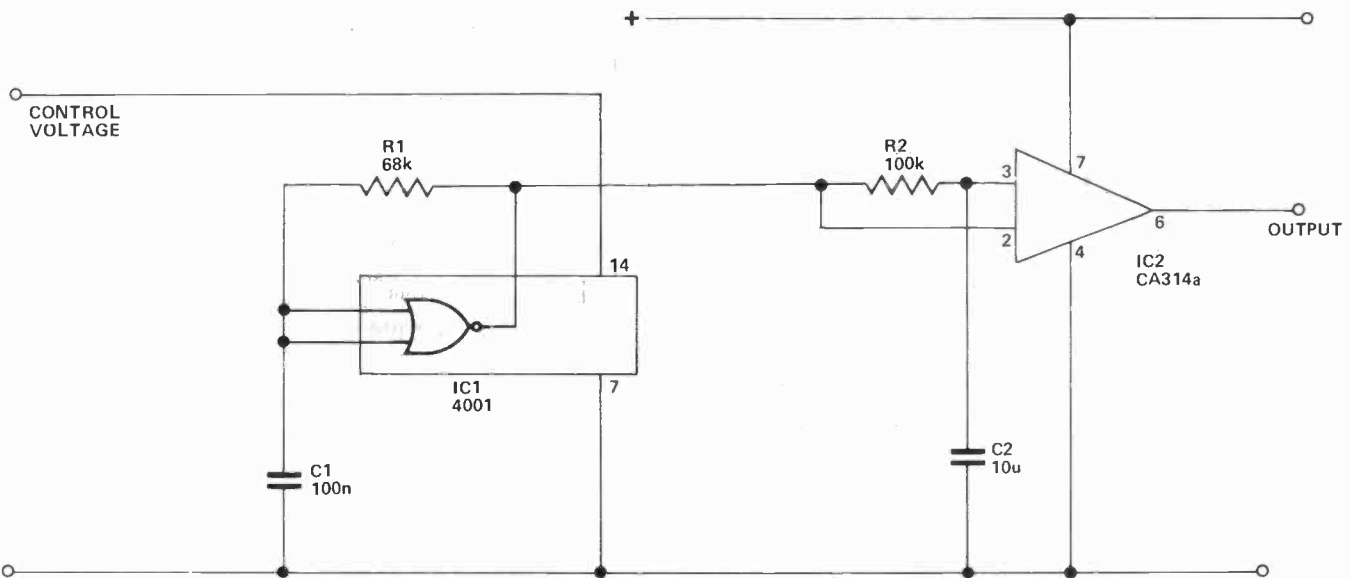
Here is an idea for supply voltage monitoring, in the form of a voltage monitor for 12V supplies, indicating both over or under tolerance voltages. Using three LED's the user can see at a glance whether power is on, over-voltage or under-voltage.

This is achieved by means of a balanced bridge that uses zener diodes ZD1 and ZD2 in the bridges opposite arms and back-to-back LED's between the mid-points of the bridge arms, if the input voltage does not exceed the two zener breakdown voltages ($2 \times 6V8 = 13V6$), LED1 lights but above 13V6 LED1 becomes reverse biased and remains off when



the input voltage increases to the extent that at the junction of ZD2, it exceeds the zener voltage of ZD1, plus the LED voltage of 1.6V, then

LED2 is turned on, with resistor 100R limiting the current through the LED. Note total drain of unit is about 50 mA.



Simple Wide Range VCO

A. J. Richardson

Any section of IC1 can be used but all unused inputs must be taken to ground.

This circuit takes advantage of the fact that CMOS gates readily oscillate

in the circuit configuration shown. The control voltage, which ideally is in the range 1V5 to 3V5, is applied to the power supply connection of IC1. IC2 is used to square up and buffer the output of IC1 and can be operated from any suitable voltage rail.

With the values shown a frequency

range of approximately 50 Hz to 20 kHz is obtained with almost equal mark to space ratio, but if this is unimportant the lower end can be extended down to approximately 1 Hz. Other frequency ranges can be obtained with suitable values of R1 and C1.

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 25-27 Oxford St., London W1R 1RF.

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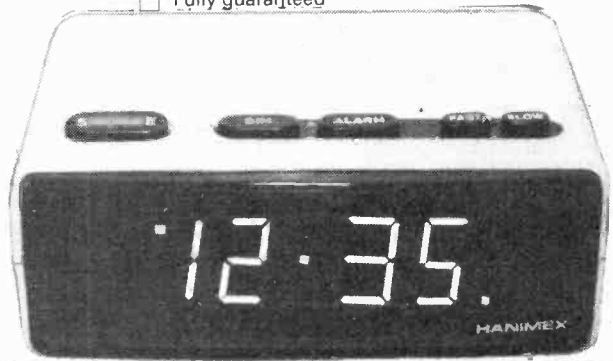
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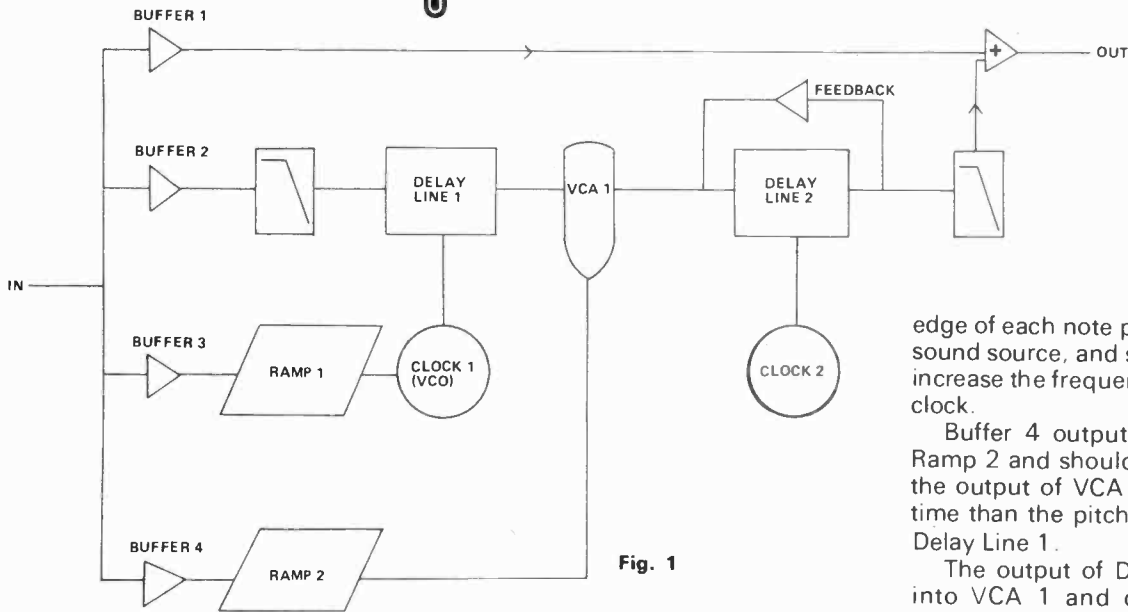


Fig. 1

Audio Harmoniser using Bucket Brigade Analog Delay Lines

S. Giles

Object:

To create an audio signal which is increased in pitch by up to one octave from the original, and sustain it for the duration of the original.

Applications:

- (a) electric guitar
- (b) synthesisers with one VCO
- (c) human voice???

Description of Block Diagram (fig. 1)

The input signal is buffered into four

separate paths which are dealt with as follows:

Buffer 1 output is unprocessed and will appear at the mixer as original signal.

Buffer 2 output is low pass filtered and fed to the input of Delay Line 1. This should consist of as many TDA 1022's that are required to create a one octave pitch change when clocked by a VCO which is modulated by Ramp 1.

Buffer 3 output is converted into Ramp 1 for modulating Delay Line 1 clock to produce the pitch change. The ramp is triggered by the leading

edge of each note played on the input sound source, and should be set up to increase the frequency of Delay Line 1 clock.

Buffer 4 output is converted into Ramp 2 and should be set up to hold the output of VCA 1 for slightly less time than the pitch change is held in Delay Line 1.

The output of Delay Line 1 is fed into VCA 1 and controlled as described above.

The output of VCA 1 is fed into Delay Line 2 which is wired as a reverberator with it's feedback set very high, but not over-loading.

The output of Delay Line 2 is low pass filtered and mixed with the original unprocessed input from Buffer 1 in the required proportions.

Alternative Approach (fig. 2)

This should enable Ramps 1 and 2 to be triggered more than once during each note thus sustaining the signal which is changed in pitch even longer. Only three input buffers are required in this arrangement.

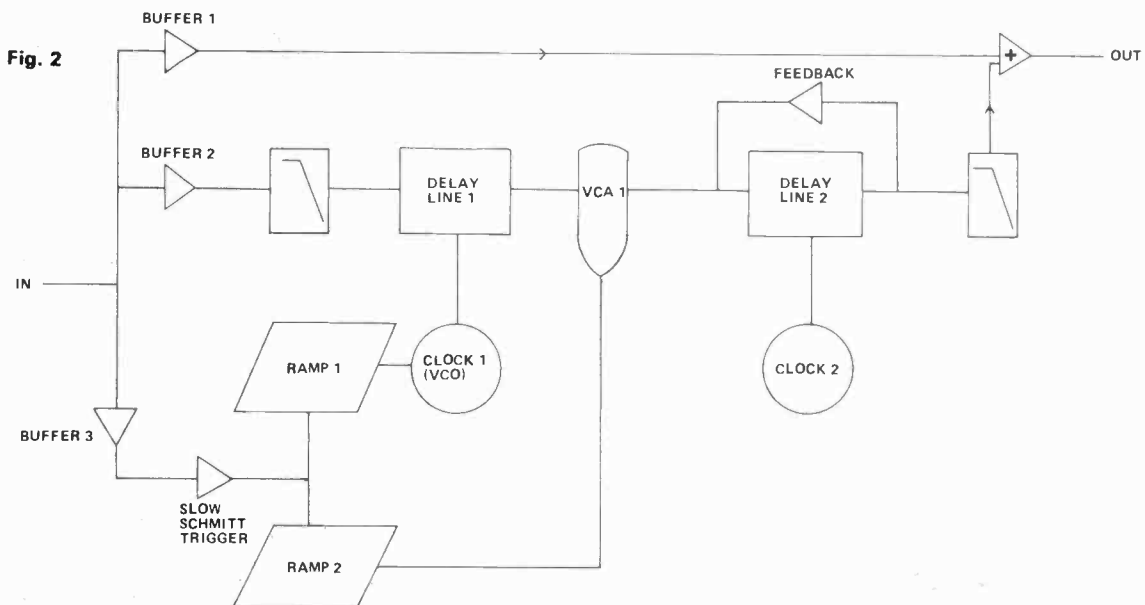
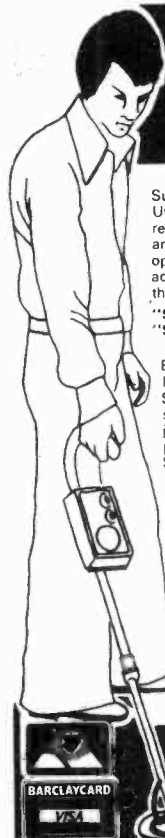


Fig. 2

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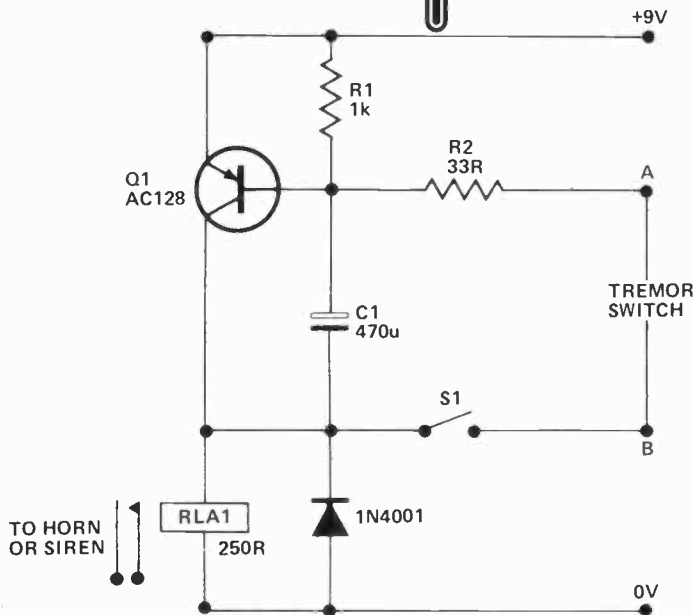
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7401	.13'	.19'	7478	.29'	74171	1.41'	1.41'	4001	.16'	4081	.21'	2102A-2 (650ns)	1.29'	1.15'	1.08'	LM345K	8.10'						
7402	.15'	.19'	7482	.73'	74174	1.01'	1.05'	4002	.16'	4082	.21'	2111A-1 (500ns)	2.46'	2.19'	2.05'	L129/30/31	.85'						
7403	.15'	.19'	7483	.75'	74175	.81'	1.05'	4006	.92'	4085	.92'	2112A-2 (250ns)	2.14'	1.90'	2.14'	1.78'	I.C.s						
7404	.18'	.21'	7485	1.18'	.88'	74176	1.01'	—	4007	.18'	4086	.92'	2112L2 (350ns)	1.07'	.96'	86'	CA3080	.75'					
7405	.18'	.21'	7486	.25'	.29'	74177	1.01'	—	4008	.92'	4093	.81'	MMS257 (TMS4044)	8.10'	7.19'	6.75'	CA3130E	.90'					
7406	.26'	—	7489	2.80'	.85'	74180	1.01'	—	4009	.54'	4099	1.81'	2114 (450ns)	8.10'	7.19'	6.75'	CA3140E	.37'					
7407	.28'	—	7490	.34'	.62'	74181	2.21'	2.99'	4010	.54'	4502	.92'	6810	3.50'	2.97'	2.52'	LM301AN	.30'					
7408	.17'	.19'	7491	.73'	1.05'	74182	.81'	—	4011	.18'	4508	2.46'	Dynamic RAM	8.251	5.97'	5.97'	LM324N	.73'					
7409	.17'	.19'	7492	.46'	.75'	74184	1.81'	—	4012	.18'	4510	1.07'	4116	12.75'	8.253	8.10'	LM348N	.99'					
7410	.15'	.19'	7493	.34'	.65'	74185	1.62'	—	4013	.48'	4511	9.5'	CPUs	8.255	5.51'	5.51'	LM380N	.97'					
7411	.25'	.19'	7495	.54'	.88'	74188	2.97'	—	4014	.92'	4514	2.70'	8080	5.95'	Regulators	—	LM381N	1.73'					
7412	.18'	.19'	7496	.87'	1.85'	74189	3.17'	2.25'	4015	.92'	4515	2.70'	6800	8.99'	78L series	—	LM382N	1.33'					
7413	.27'	.40'	74107	.27'	.35'	74190	1.21'	.75'	4016	.43'	4516	1.07'	9900	42.50'	All 30p each	—	LM3900N	.65'					
7414	.71'	.79'	74109	.44'	.35'	74191	1.21'	.75'	4017	.81'	4517	4.10'	E-Prom's UV	7.87'	+ (POS) 100mA	—	SN76003N	.70'					
7415	—	.19'	74112	—	.35'	74192	1.21'	1.85'	4018	.92'	4518	.95'	1702AQ	5.75'	5v, 6v, 8v, 12v & 15v	—	SN76001N	1.02'					
7416	.25'	—	74113	—	.35'	74193	1.21'	1.85'	4019	.56'	4521	2.54'	2708Q	7.87'	78M series	—	SN76003N	2.32'					
7417	.34'	—	74114	—	.35'	74194	1.21'	—	4020	.92'	4522	1.89'	TriState Buffers	—	+ (POS) 500mA	—	SN76013N	1.55'					
7420	.16'	—	74121	.27'	—	74195	1.01'	1.05'	4021	.92'	4526	1.89'	81LS95	.75'	All 60p each	—	SN76023N	1.55'					
7421	—	.19'	74122	.60'	.75'	74196	1.18'	1.05'	4022	.92'	4528	.92'	81LS96	.75'	5v, 6v, 8v, 12v, 15v, 20v & 24v	—	TB4810AS	.90'					
7422	—	.19'	74123	.60'	.78'	74197	1.18'	1.05'	4023	.18'	4534	7.12'	81LS97	.75'	All 60p each	—	TC9A40	1.75'					
7423	.25'	—	74124	—	1.25'	74198	1.81'	—	4024	.65'	4536	3.74'	81LS98	.75'	79M series	—	ZN414	.90'					
7425	.25'	—	74125	.51'	.39'	74199	1.81'	—	4025	.18'	4543	1.62'	74365	.75'	— (NEG) 500mA	—	ZN424E	1.35'					
7426	.25'	.19'	74126	.51'	.39'	74221	—	.99'	4026	1.84'	4553	4.53'	74366	.75'	5v, 6v, 8v, 12v, 15v, 20v & 24v	—	ZN425E	3.78'					
7427	.39'	.19'	74132	.78'	.66'	74240	—	.25'	4027	.51'	4566	1.51'	74367	1.49'	All 85p each	—	ZN459CT	3.54'					
7428	.38'	.21'	74133	—	.19'	74241	—	.225'	4028	.70'	4583	1.02'	74368	.75'	78 series	—	ZN1034E	2.03'					
7430	.16'	.19'	74136	—	.39'	74242	—	2.25'	4029	1.18'	4585	1.07'	Buffers	—	+ (POS) 1A	—	ZN1040E	8.43'					
7432	.25'	.25'	74138	—	.55'	74243	—	2.25'	4030	.56'	I.C.	—	8T26P	1.65'	5v, 6v, 12v, 15v, 18v & 24v	—	ZN116E	6.75'					
7433	—	.28'	74139	—	.55'	74247	—	.95'	4032	1.08'	SOCKETS	—	8T28P	1.65'	All 85p each	—							
7437	.25'	.25'	74141	.76'	—	74248	—	.95'	4034	1.89'	DIL (Texas)	—	8T95P	1.49'	79 series	—							
7438	.25'	.25'	74145	.75'	1.05'	74249	—	.95'	4035	1.06'	8pin	.10'	8T96P	1.49'	— (NEG) 1A	—							
7440	.17'	.19'	74147	1.59'	—	74251	—	.83'	4040	.92'	14pin	.12'	8T97P	1.49'	5v, 6v, 12v, 15v, 18v & 24v	—							
7441	.70'	—	74149	1.38'	—	74253	—	.83'	4042	.70'	18pin	.18'	8T98P	1.49'	All £1.00 each	—							
7443	.50'	.55'	74150	1.08'	—	74257	—	.99'	4043	.81'	16pin	.13'	Interface	—	uA723 (DIL)	—							
7445	.60'	—	74151	.67'	.88'	74258	—	.99'	4046	1.06'	20pin	.20'	8212	2.21'	L200	.40'							
7446	.60'	—	74153	.67'	.48'	74259	—	1.50'	4049	.43'	22pin	.24'	8216	2.35'	LM304H	2.40'							
7447	.60'	.87'	74154	1.31'	1.35'	74266	—	2.25'	4050	.43'	24pin	.26'	8224	3.59'	LM322K	6.25'							
7448	.16'	.87'	74155	.67'	.78'	74273	—	.99'	4051	.81'	28pin	.30'	8228	5.51'	LM325N	2.60'							
7449	.87'	.87'	74156	.67'	.78'	74279	—	.99'	4052	.81'	40pin	.44'	OPTO	—									
7450	.16'	—	74157	.67'	.55'	74283	—	.83'	4053	.81'	40pin	1.05'	125	1+	10+	50+	100+	2"	1+	10+	50+	100+	
7451	.16'	.19'	74158	—	.52'	74290	—	.83'	4054	1.29'	Wire Wrap	—	16pin	.23'	TIL209 Red X .15'	.10'	.10'	.09'	2"	1+	10+	50+	100+
453	.16'	—	74160	1.21'	.99'	74293	—	.83'	4056	1.48'	18pin	.34'	TIL209 Red X .15'	.10'	.10'	.09'	2"	1+	10+	50+	100+		
454	—	.19'	74161	1.21'	.65'	74298	—	1.25'	4060	1.24'	16pin	.37'	TIL212 Yel X .20'	.18'	.16'	.14'	TIL220	1.6'	1.6'	1.25'	1.25'	.11'	
455	—	.19'	74162	1.21'	1.85'	74305	—	1.05'	4062	.48'	18pin	.43'	TIL216 Red X .20'	.18'	.18'	.14'	TIL224 Yel X .23'	.23'	.21'	.195'	.17'	.17'	
7460	.16'	—	74163	1.21'	.65'	74365	—	.51'	4066	.48'	18pin	.43'	TIL232 Gre X .20'	.18'	.18'	.14'	TIL228 Red X .23'	.23'	.21'	.195'	.17'	.17'	
7470	.27'	—	74164	1.08'	1.15'	74366	—	.51'	4068	.21'	20pin	.55'	X = High Brightness	—	—	—	TIL234 Gre X .23'	.23'	.21'	.195'	.17'	.17'	
7472	.23'	—	74165	—	.78'	74367	—	.51'	4069	.21'	24pin	.60'	—	—	—	—	—	—	—	—	—	—	—
7473	.28'	.29'	74166	1.02'	—	74368	—	.51'	4070	.21'	26pin	.65'	—	—	—	—	—	—	—	—	—	—	—
7474	.28'	.29'	74168	—	1.85'	74386	—	.39'	4071	.21'	36pin	.95'	—	—	—	—	—	—	—	—	—	—	—
7475	.44'	.43'	74169	—	1.85'	74670	—	1.85'	4072	.21'	40pin	1.05'	—	—	—	—	—	—	—	—	—	—	—

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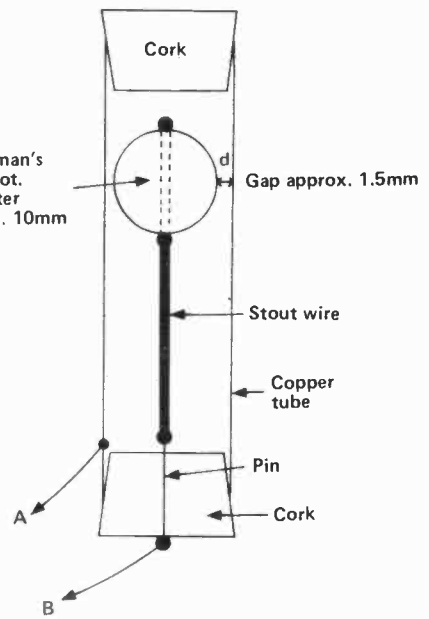


Motorbike Alarm

P. Mann

When the motorcycle is tampered with its horn (better to have a siren independent of the motorcycle's battery) blares for ten seconds before the device is reset. Battery drain is

approximately 20-30 μ A, so low that no on-off switch has been incorporated for riding. R2 prevents high current flowing on discharge of the capacitor which was found to weld the lead shot to the copper tube. Design of the tremor switch I think is up to the



TREMOR SWITCH

constructor and the bits and pieces he or she has available. Sensitivity lies solely on the construction of this, (weight of shot, gap and length of wire).

My siren consists of a NE555 design from ETI Jan '77 and an LM380 power amp.

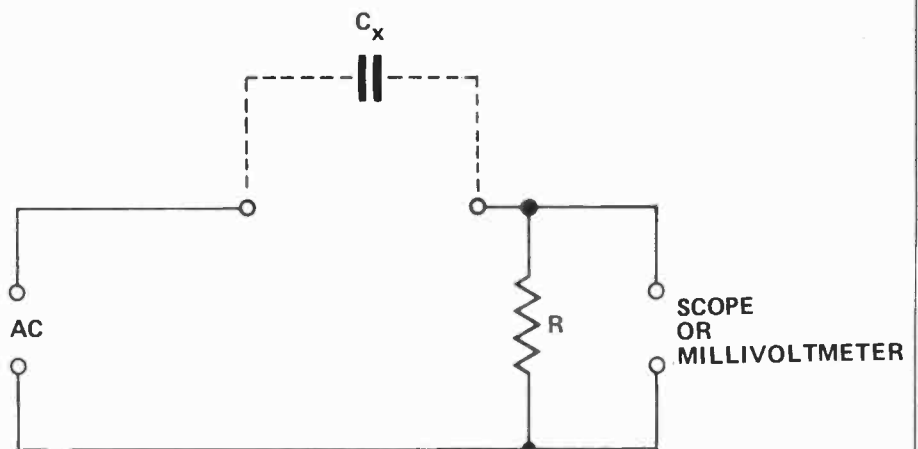
Capacitance Measurement

W. Winder

Few amateurs have a reliable method for measuring small capacitors. They may have a 50 Hz bridge, but the reactance of 10 pfs. at 50 Hz is some 320 megohms, which can well be of the same order as the bridge insulation, which leads to indeterminate and incorrect results. However if one has an A.F. signal generator and a measuring oscilloscope (or a.c. millivoltmeter), one can measure down to 2 or 3 pfs. with quite as good an accuracy as more complicated methods using square wave generators and diode pumps. The following very simple circuit is all that is necessary.

As long as the reactance of the capacitor is several times larger than the resistance of R, the output voltage will be directly proportional to the capacitance of C. By supplying a 1.6 volt input signal, the mathematics are simplified, and the output measurements are as the table given below.

The input wave form should be



Capacity Range	Input Frequency	Value of R	Output
0 to 20 p	100 kHz	10 k	10 mV, per p
20 to 200 p	10 kHz	10 k	1 mV per p
200 to 2000 p	1 kHz	10 k	0.1 mV per p
2000 to 20,000 p	1 kHz	1 k	0.01 mV per p
0.02 to 0.2 μ F	1 kHz	100 R	0.001 mV per p

fairly good, as any harmonics present are exaggerated by the capacitor, and the shape of the output waveform can

be anything but a pretty sine wave. However it has to be a poor signal generator that does this.

ELECTROVALUE Buying Guide

Section 3

With this advertisement we complete our series in which we have presented a wide and useful cross-section of our most demanded lines. We hope it will have encouraged you to have purchased from us and sample our service. We go to great effort to make this as efficient and as personal as possible. NOW WE ANNOUNCE PRODUCTION OF 120-PAGE CATALOGUE NO. 10. Completely revised, enlarged and better than ever — AND IT'S YOURS FOR THE ASKING — FREE.

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7401	14p
7402	14p
7403	14p
7404	14p
7405	14p
7407	22p
7408	18p
7409	18p
7410	14p
7413	22p
7414	60p
7420	14p
7430	14p
7440	14p
7442	54p
7443	60p
7444	60p
7447	70p
7450	14p
7451	14p
7453	14p
7454	14p
7460	14p
7470	24p
7472	24p
7473	23p
7474	23p
7475	45p
7476	32p
7480	41p
7482	61p
7483	58p
7485	74p
7486	74p
7490	40p
7491	71p
7492	46p
7493	40p
7494	66p
7495	57p
7496	63p
74100	73p
74104	40p
74107	27p
74121	27p
74123	51p
74141	54p
74151	60p
74154	1.07
74190	94p
74191	94p
74192	94p
74193	94p

CMOS (All buffered and protected types)

4000	19p
4001	19p
4002	19p
4006	96p
4007	19p
4008	80p
4009	54p
4010	54p
4011	19p
4012	19p
4013	40p
4014	96p
4015	1.14
4016	40p
4017	80p
4018	88p
4019	64p
4020	96p
4021	88p
4022	83p
4023	19p

4024	90p
4025	19p
4026	1.75
4027	58p
4028	95p
4029	1.23
4030	54p
4041	84p
4042	80p
4043	93p
4044	93p
4046	1.28
4049	48p
4050	48p
4060	1.33
4069	19p
4070	19p
4071	19p
4072	19p
4081	19p
4082	19p
4510	1.28
4511	1.36
4514	3.30
4516	1.37
4518	1.25
4520	1.25
4543	1.30
4583	1.28

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SAS211A	2.08
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SAS570	2.14
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SAS590	2.22
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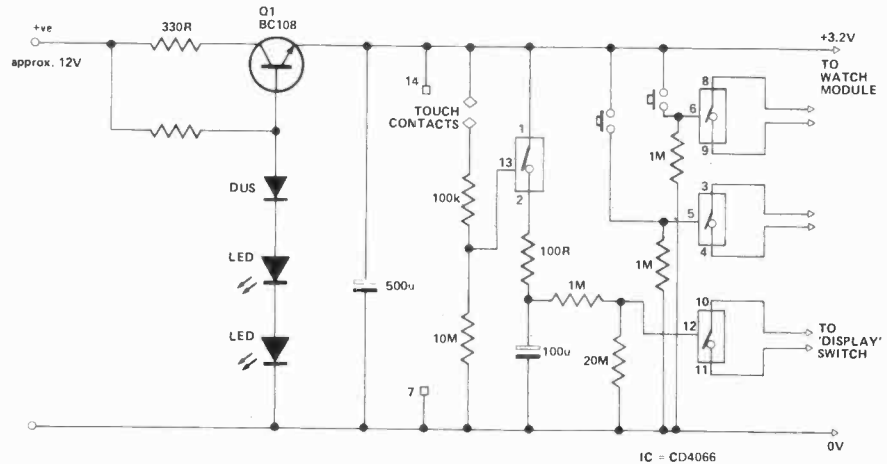
With the availability of economical LCD wristwatches has come a surplus of very cheap LED types which, with a little ingenuity, are eminently suitable for a permanent display installation; one obvious use is a cheap digital car clock.

The majority of these timepieces use two silver oxide cells in series to give 3.2 volts; current consumption, with the display on, is rarely more than 30 mA, easily provided by a simple stabiliser circuit.

Remove the back of the watch-case and discard the cells; the contacts of one cell holder are shorted together and the 3V2 supply soldered, noting polarity, to the two remaining contacts: with the 'display on' switch shorted out the result is a highly accurate mini-clock with negligible current drain as long as the vehicle is in regular use; even 35 mA will eventually flatten a car battery that receives no charge. Most simple LED watches have a brass tag, bearing on the metal case, as a common terminal to the various controls, these generally being spring loaded pins pressed, as required, into contact with clips on the perimeter of the module. These connections can be extended to panel mounting push switches, allowing the unit to be housed in a suitable box.

If the car is used infrequently it is prudent to arrange for the display to automatically extinguish at the end of a fixed amount of time; this also implies the simplest possible 'on' switch to minimise loss of attention when driving. One half of a CD4066 quad bilateral switch is connected as a touch-operated monostable and wired, as shown, across the LED display switch: C and R may be selected for a shorter or longer time period, those specified will enable the display for about 15 minutes. The remaining two sections of the 4066 are used to control the other functions, set time, etc., of the watch module.

Note that, in the stabiliser section, LED's are deliberately used to provide the reference voltage at the base of T1



since they 'zener' at appreciably smaller currents than a normal zener diode; total current of the stabiliser

and clock (display off) is about 2 mA — the smallest car battery should be able to supply this for about a year!

Passionometer

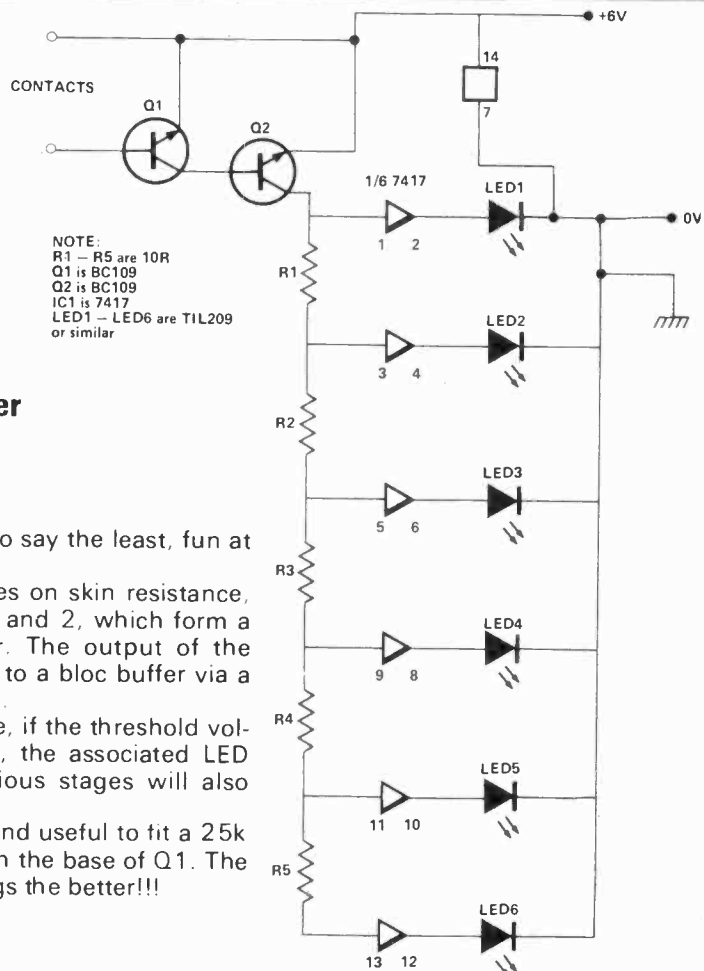
D. Geary

This device is, to say the least, fun at parties!!!

The unit relies on skin resistance, picked up by 1 and 2, which form a Darlington Pair. The output of the Amplifier is fed to a bloc buffer via a resistor network.

At each stage, if the threshold voltage is reached, the associated LED will light. Previous stages will also light.

It may be found useful to fit a 25k pot in series with the base of Q1. The higher the ratings the better!!!



15 — 240 Watts!

HY5 Preamplifier

The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (Mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.

FEATURES: Complete pre-amplifier in single pack — Multi-function equalization — Low noise — Low distortion — High overload — two simply combined for stereo

APPLICATIONS: Hi-Fi — Mixers — Disco — Guitar and Organ — Public address.

SPECIFICATIONS:

INPUTS: Magnetic Pick-up 3mV, Ceramic Pick-up 30mV, Tuner 100mV, Microphone 10mV, Auxiliary 3-100mV, input impedance 47k Ω at 1kHz

OUTPUTS: Tape 100mV, Main output 500mV R.M.S.

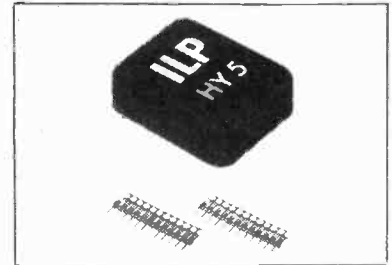
ACTIVE TONE CONTROLS: Treble \pm 12dB at 10kHz, Bass \pm at 100Hz

DISTORTION: 0.1% at 1kHz, Signal/Noise Ratio 68dB

OVERLOAD: 38dB on Magnetic Pick-up, SUPPLY VOLTAGE \pm 16-50V

Price £6.27 + 78p VAT. P&P free.

HY5 mounting board B1 48p + 6p VAT P&P free.



HY30 15 Watts into 8 Ω

The HY30 is an exciting New kit from I.L.P., it features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.

FEATURES: Complete kit — Low Distortion — Short, Open and Thermal Protection — Easy to Build

APPLICATIONS: Updating audio equipment — Guitar practice amplifier — Test amplifier — Audio oscillator

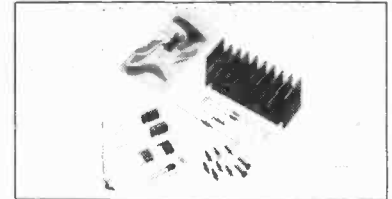
SPECIFICATIONS:

OUTPUT POWER: 15W R.M.S. into 8 Ω , **DISTORTION:** 0.1% at 15W

INPUT SENSITIVITY: 500mV, **FREQUENCY RESPONSE:** 10Hz-16kHz — 3dB

SUPPLY VOLTAGE: \pm 18V

Price £6.27 + 78p VAT. P&P free.



HY50 25 Watts into 8 Ω

The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.

FEATURES: Low Distortion — Integral Heatsink — Only five connections — 7 Amp output transistors — No external components

APPLICATIONS: Medium Power Hi-Fi systems — Low power disco — Guitar amplifier

SPECIFICATIONS: INPUT SENSITIVITY 500mV

OUTPUT POWER: 25W RMS in 8 Ω LOAD IMPEDANCE 4-16 Ω , **DISTORTION:** 0.04% at 25W at 1kHz

SIGNAL/NOISE RATIO: 75dB, **FREQUENCY RESPONSE:** 10Hz-45kHz — 3dB

SUPPLY VOLTAGE: \pm 25V, **SIZE:** 105.50 x 25mm

Price £8.18 + £1.02 VAT. P&P free.



HY120 60 Watts into 8 Ω

The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection, this amplifier sets a new standard in modular design.

FEATURES: Very low distortion — Integral Heatsink — Load line protection — Thermal protection — Five connections — No external components

APPLICATIONS: Hi-Fi — High quality disco — Public address — Monitor amplifier — Guitar and organ

SPECIFICATIONS:

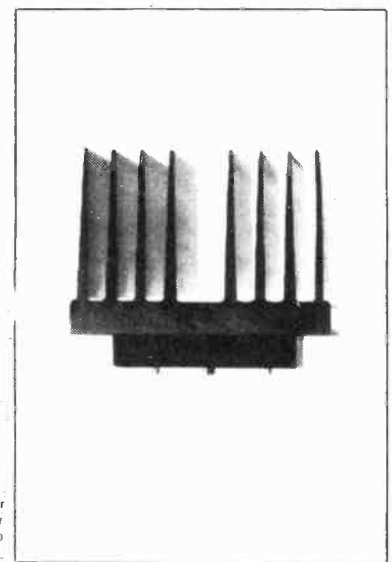
INPUT SENSITIVITY: 500mV

OUTPUT POWER: 60W RMS into 8 Ω , **LOAD IMPEDANCE:** 4-16 Ω , **DISTORTION:** 0.04% at 60W at 1kHz

SIGNAL/NOISE RATIO: 90dB, **FREQUENCY RESPONSE:** 10Hz-45kHz — 3dB, **SUPPLY VOLTAGE:** \pm 35V

Size: 114 x 50 x 85mm.

Price £19.01 + £1.52 VAT. P&P free.



HY200 120 Watts into 8 Ω

The HY200, now improved to give an output of 120 Watts, has been designed to stand the most rugged conditions, such as disco or group while still retaining true Hi-Fi performance.

FEATURES: Thermal shutdown — very low distortion — Loadline protection — Integral Heatsink — No external components

APPLICATIONS: Hi-Fi — Disco — Monitor — Power Slave — Industrial — Public address

SPECIFICATIONS:

INPUT SENSITIVITY: 500mV

OUTPUT POWER: 120W RMS into 8 Ω , **LOAD IMPEDANCE:** 4-16 Ω , **DISTORTION:** 0.05% at 100W at 1kHz

SIGNAL/NOISE RATIO: 96dB, **FREQUENCY RESPONSE:** 10Hz-45kHz — 3dB, **SUPPLY VOLTAGE:** \pm 45V

SIZE: 114 x 100 x 85mm.

Price £27.99 + £2.24 VAT. P&P free.

HY400 240 Watts into 4 Ω

The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4 Ω ! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.

FEATURES: Thermal shutdown — Very low distortion — Load line protection — No external components

APPLICATIONS: Public address — Disco — Power slave — Industrial.

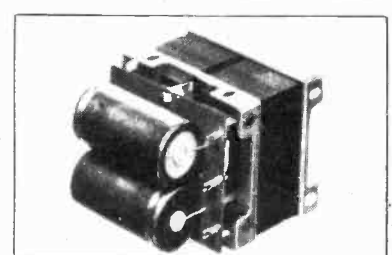
SPECIFICATIONS:

OUTPUT POWER: 240W RMS into 4 Ω , **LOAD IMPEDANCE:** 4-16 Ω , **DISTORTION:** 0.1% at 240W at 1kHz

SIGNAL/NOISE RATIO: 94dB, **FREQUENCY RESPONSE:** 10Hz-45kHz — 3dB, **SUPPLY VOLTAGE:** \pm 45V

INPUT SENSITIVITY: 500mV, **SIZE:** 114 x 100 x 85mm

Price £38.61 + £3.09 VAT. P&P free.



POWER SUPPLIES

PSU36 suitable for two HY30's £6.44 + 81p VAT

PSU50 suitable for two HY50's £8.18 + £1.02 VAT

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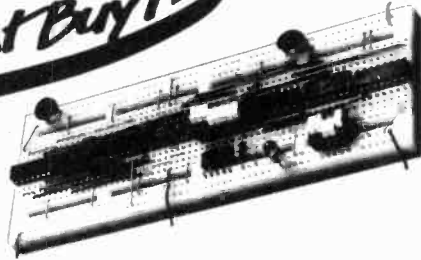
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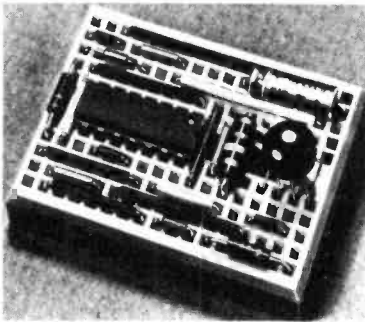
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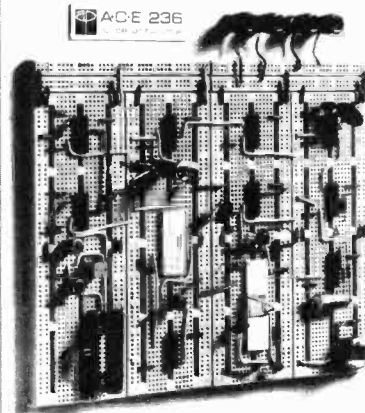
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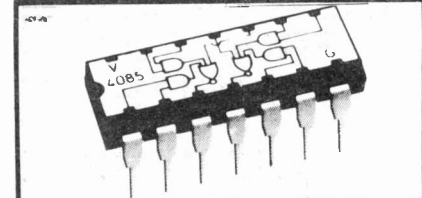
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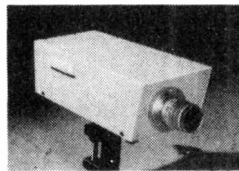
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AC127	0.16	BC125	0.15	BC2208	0.09	BC771	0.13	BF194A	0.07	BU406	3.60	2N1711	2.20
AC127K	0.23	BC125B	0.16	BC2212A	0.10	BC772	0.13	BF195	0.06	BU769A	6.75	2N1835	0.25
AC128	0.14	BC126	0.15	BC2213A	0.10	BC775	0.30	BF195D	0.07	BU799	2.00	2N1905	0.25
AC128K	0.23	BC126B	0.15	BC2214	0.10	BC776	0.30	BF196	0.06	BU799C	7.50	2N1990	0.25
AC128/176	0.23	BC126C	0.15	BC2215	0.10	BC777	0.30	BF196	0.06	BU799D	7.50	2N2206	1.00
AC142	0.18	BC138	0.30	BC237A	0.16	BC1028	1.02	BF197	0.06	BU771	4.50	2N2188	0.20
AC153	0.55	BC140	0.27	BC237C	0.21	BC1031	0.35	BF199	0.06	MP5517	0.48	2N2218A	0.22
AC154	0.50	BC141	0.29	BC238	0.15	BC1033	0.40	BF222	0.10	MP5523	0.27	2N2222	0.18
AC176	0.16	BC142	0.20	BC238B	0.16	BC1035	0.30	BF253	0.18	MP5A06	0.30	2N2222A	0.20
AC187	0.50	BC147	0.07	BC251A	0.15	BC1037	0.30	BF254	0.18	MP5A09	0.72	2N2270	0.30
AC188K	0.55	BC148	0.06	BC251B	0.17	BC1038	0.30	BF255	0.18	MP5A12	0.25	2N2484	0.18
AC192	1.02	BC148A	0.07	BC252A	0.15	BC1039	0.30	BF256	0.20	MP5A22	0.27	2N2904	0.18
AC192K	1.02	BC148B	0.07	BC252B	0.17	BC1040	0.30	BF259	0.20	MP5A26	0.20	2N2906	0.18
AD142	0.87	BC149	0.06	BC252C	0.20	BC1044	0.30	BF324	0.28	MP5A30	0.85	2N3053	0.15
AD143	0.87	BC157	0.06	BC256	0.20	BC1088	0.50	BF335	0.25	MP5A36	1.00	2N3117	1.00
AD149	0.65	BC157A	0.07	BC261A	0.10	BC1078	0.72	BF338	0.45	MP5A44	0.12	2N3440	0.70
AD161	0.35	BC158	0.07	BC262	0.20	BC1081	1.32	BF347	0.60	MP5A45	0.12	2N3638	0.15
AD161/182	0.70	BC158A	0.08	BC267A	0.21	BC1083	1.50	BF523	0.22	MP5A46	0.09	2N3638A	0.16
AD162	0.35	BC158B	0.09	BC267B	0.22	BC1082	0.60	BF594	0.10	MP5A47	0.10	2N3643	0.24
AD202	0.36	BC159	0.06	BC268	0.21	BC1033	0.60	BF991	0.50	MP5A48	0.10	2N3692	0.24
AD263	0.36	BC159A	0.07	BC269	0.25	BC234	0.60	BF743	0.54	MP5A49	0.48	2N3706	0.06
AD276	0.47	BC160	0.07	BC270	0.20	BC235	0.60	BF749	0.50	MP5A50	0.20	2N3706	0.06
AD211	4.05	BC161	0.25	BC307A	0.15	BC236	0.40	BF344	0.70	MP5A51	2.50	2N3707	0.06
AD106	0.45	BC167	0.06	BC307B	0.15	BC237	0.40	BF344	0.70	MP5A52	2.70	2N3711	0.06
AD109A	0.36	BC168	0.06	BC308	0.15	BC238	0.40	BF345	0.40	MP5A53	2.50	2N3819	0.20
AD124	0.25	BC169	0.06	BC309A	0.15	BC344	0.40	BF348	0.20	MP5A54	2.50	2N3899	3.00
AD125	0.25	BC170	0.07	BC317B	0.15	BC357	0.50	BF318	0.50	MP5A55	2.10	2N3904	0.06
AD128	0.25	BC171	0.07	BC322	0.10	BC358	0.50	BF319	0.50	MP5A56	2.10	2N3904	0.06
AD127	0.25	BC171	0.06	BC327	0.16	BC359	0.50	BF333	0.50	MP5A57	2.10	2N3906	0.06
AD139	0.32	BC171A	0.07	BC328	0.16	BC357	1.02	BF344	0.50	MP5A58	2.10	2N4037	0.25
AD178	0.38	BC171B	0.07	BC329	0.10	BC357	1.02	BF345	0.50	MP5A59	2.10	2N4057	0.25
AD179	0.38	BC172	0.06	BC330	0.16	BC357	1.90	BF351	0.12	MP5A60	2.10	2N4222A	0.65
AD200	0.36	BC172A	0.07	BC335A	0.15	BC357	1.90	BF352	0.12	MP5A61	2.10	2N4348	2.00
AD201	0.36	BC172B	0.07	BC335B	0.17	BC357	1.90	BF351	0.12	MP5A62	2.10	2N4348	2.00
AS273	0.30	BC172C	0.07	BC341	0.20	BF115	3.35	BF339	0.35	MP5A63	1.18	2N4514	3.50
AS215	0.60	BC173	0.07	BC342	0.24	BF121	0.20	BF320	0.18	MP5A64	0.38	2N5172	0.25
AS216	0.60	BC173B	0.07	BC346	0.10	BF123	0.20	BF320	0.33	MP5A65	0.45	2N5245	0.40
AS217	0.60	BC174	0.07	BC347	0.11	BF125	0.20	BF320	0.21	MP5A66	0.48	2N5296	0.30
AD163	0.60	BC175	0.12	BC348	0.11	BF127	0.20	BF320	0.30	MP5A67	0.48	2N5458	0.25
AD107	1.00	BC177A	0.12	BC347B	0.11	BF157	0.21	BF320	0.30	MP5A68	0.48	2N5458	0.25
AD110	0.90	BC178	0.12	BC347C	0.11	BF157	0.15	BF320	0.30	MP5A69	3.50	2N5670	0.65
AD210	0.90	BC179	0.12	BC348A	0.11	BF154	0.15	BF320	0.54	MP5A70	0.10	2N5692	0.35
BC107	0.06	BC182A	0.09	BC548B	0.11	BF157	0.37	BF329	0.15	MP5A71	0.10	2N6123	0.65
BC107A	0.07	BC182B	0.09	BC548C	0.11	BF158	0.15	BF352	0.33	MP5A72	0.11	2N6063	0.75
BC107B	0.07	BC182C	0.09	BC548A	0.11	BF157	0.25	BF354	0.39	MP5A73	0.12	2N6363	0.90
BC108	0.06	BC183A	0.07	BC549	0.11	BF158	0.25	BF354	0.39	MP5A74	0.12	2N6363	0.90
BC108A	0.07	BC183B	0.10	BC550	0.11	BF174	0.20	BF350	0.36	MP5A75	0.15	2N6305	1.00
BC108B	0.07	BC183C	0.10	BC551	0.11	BF177	0.25	BF354	0.30	MP5A76	0.15	2N6323	1.00
BC109	0.06	BC184	0.08	BC552	0.11	BF178	0.25	BF354	0.30	MP5A77	0.15	2N6323	1.00
BC109B	0.07	BC184A	0.10	BC553	0.11	BF178	0.25	BF354	0.30	MP5A78	0.15	2N6323	1.00
BC109C	0.07	BC184B	0.10	BC554	0.11	BF178	0.25	BF354	0.30	MP5A79	0.15	2N6323	1.00
BC113	0.12	BC187	0.10	BC555	0.11	BF181	0.20	BF354	0.30	MP5A80	0.15	2N6323	1.00
BC114	0.15	BC204	0.08	BC556A	0.11	BF182	0.20	BF354	0.30	MP5A81	0.15	2N6323	1.00
BC116	0.13	BC204B	0.09	BC556B	0.11	BF183	0.20	BU204	1.30	MP5A82	0.50	2N1309	0.50

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AD121	0.11	BAK13	0.06	BY164	0.50	BY204-10	0.75	ITT921	0.20	0A90	0.07	1N5404	0.15
AD129	0.08	BAK15	0.07	BY176	0.45	BY206	0.30	ITT923	0.35	0A91	0.06	1N5405	0.25
AD143	0.10	BAK18	0.10	BY179	0.60	BY210-600	0.45	ITT1075	0.25	0A95	0.06	1N5406	0.20
AD144	0.09	BAK18B	0.09	BY182	0.45	BY210-600	0.55	ITT2001	0.25	DA292	0.07	1N5407	0.19
BA102	0.30	8B105C	0.35	BY184	0.70	BY210-600	0.55	ITT2002	0.20	ST 12	0.14	1N5408	0.20
BA101	0.98	8B1106	0.45	BY187	1.30	BYX10	0.35	MAR502	0.75	1K4001	0.04	1N5409A	0.60
BA115	0.25	8B142	1.25	BY198	0.75	BYX35-350	0.45	MAR813	0.90	1K4002	0.05	1N5761	0.75
BA145	0.15	8R100	0.20	BY199	0.35	BYX55-500	0.55	MAR954	1.80	1K4003	0.05		
BA148	0.10	8R150	0.10	BY210	0.60	BY210-600	0.45	MAR955	2.10	1K4004	0.06		
BA154	0.10	8R100	0.20	BY210-3	0.40	BYX71-800	1.15	MAR956	1.55	1K4005	0.06		
BA155	0.12	8Y103	0.35	BY201-4	0.45	BZK61 series	0.18	MV2203	1.60	1K4006	0.07		
BA156	0.12	8Y118	1.45	BY201-5	0.55	BZK66 series	0.18	MV5460	0.65	1K4007	0.08		
BA157	0.45	8Y126	0.15	BY201-5	0.55	BZK66 series	0.18	0A47	0.07	1K4148	0.04		
BA158	0.55	8Y127	0.10	BY203-12	0.80	0A80	0.70	0A70	0.07	1K4150	0.45		
BA159	0.87	8Y128	0.10	BY203-2	0.80	DK13	0.45	0A71	0.35	1K4954	0.25		
BA182	0.45	8Y133	0.10	BY203-20	1.00	IT744	0.10	0A81	0.12	1N5401	0.12		
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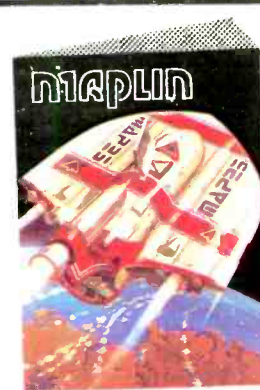
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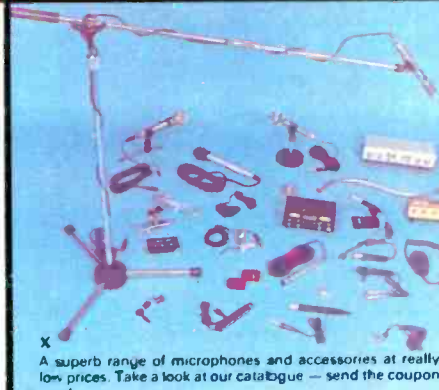


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