electronics today

INTERNATIONAL

FEBRUARY 1979

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

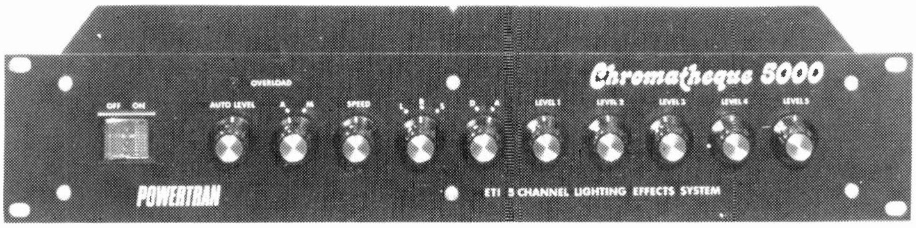
Noise Reduction

...NEWS....PROJECTS....MICROPROCESSORS....AUDIO...

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

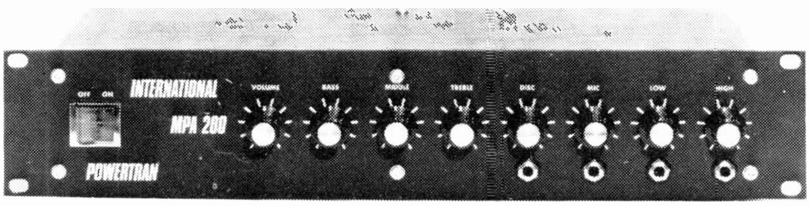
£49.50 + VAT!

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 8Ω) 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!

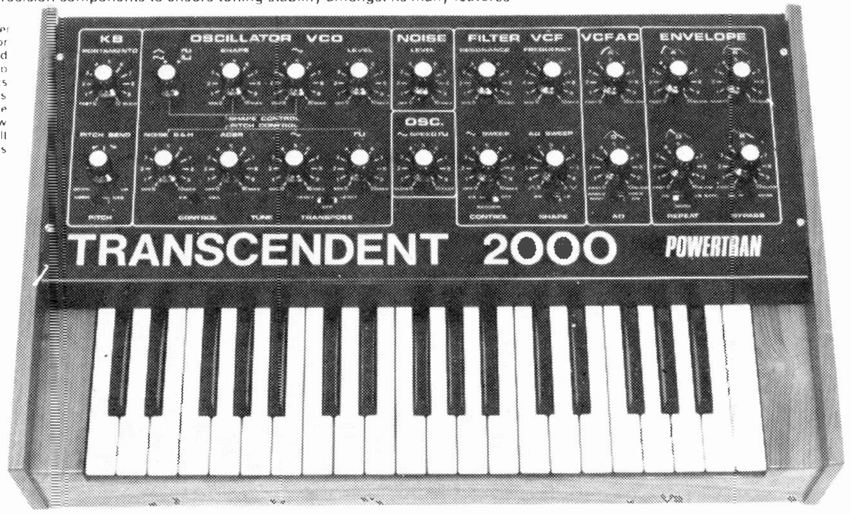
TRANSCENDENT 2000

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 ½W 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 contruction 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!



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

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

ORDERING INFORMATION AND MORE KITS ON PAGE 6

electronics today INTERNATIONAL

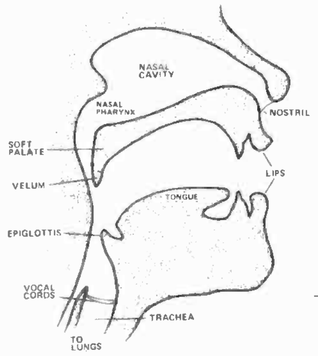
FEBRUARY 1979 VOL 8 NO 2

FEATURES

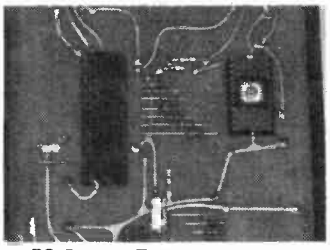
PROJECTS

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

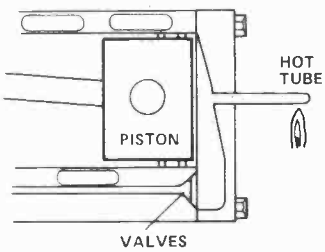
INFORMATION



p.19 Speak for yourself



p.79 Scamp Tunes



p.45 Old Flame!

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PUBLISHED BY Modmags Ltd., 25-27 Oxford Street, London W1R 1RF
DISTRIBUTED BY Argus Distribution Ltd. (British Isles)
Gordon & Gotch Ltd. (Overseas)
PRINTED BY QB Limited, Colchester

Electronics Today International is normally published on the first Friday of the month prior to the cover date

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	£0.18	74107	£0.22	74165	£0.85
7401	£0.09	7428	£0.25	7473	£0.22	74110	£0.35	74166	£0.75
7402	£0.09	7430	£0.08	7474	£0.22	74111	£0.55	74167	£2.00
7403	£0.09	7432	£0.20	7475	£0.27	74118	£0.75	74174	£0.80
7404	£0.09	7433	£0.28	7476	£0.22	74119	£1.10	74175	£0.80
7405	£0.09	7437	£0.20	7480	£0.40	74121	£0.22	74176	£0.55
7406	£0.22	7438	£0.20	7481	£0.80	74122	£0.35	74177	£0.55
7407	£0.22	7440	£0.10	7482	£0.65	74123	£0.38	74180	£0.80
7408	£0.12	7441	£0.45	7483	£0.55	74136	£0.50	74181	£1.25
7409	£0.12	7442	£0.38	7484	£0.82	74141	£0.50	74182	£0.55
7410	£0.09	7443	£0.68	7485	£0.65	74145	£0.54	74184	£1.00
7411	£0.15	7444	£0.68	7486	£0.22	74150	£0.65	74190	£0.68
7412	£0.14	7445	£0.64	7489	£1.60	74151	£0.45	74191	£0.68
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7420	£0.09	7451	£0.09	7494	£0.70	74157	£0.48	74196	£0.60
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7422	£0.15	7453	£0.09	7496	£0.48	74161	£0.60	74198	£1.00
7423	£0.20	7454	£0.09	74100	£0.80	74162	£0.60	74199	£1.00
7425	£0.18	7460	£0.09	74104	£0.35	74163	£0.60	74279	£1.00
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CD4006	£0.80	CD4020	£0.80	CD4040	£0.78	CD4070	£0.15
CD4007	£0.14	CD4021	£0.75	CD4041	£0.68	CD4071	£0.15
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CD4009	£0.40	CD4023	£0.13	CD4043	£0.78	CD4081	£0.15
CD4010	£0.42	CD4024	£0.55	CD4044	£0.78	CD4082	£0.16
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Regulated Current	0-2A
AC Input Maximum	25v

Eliminates the use of batteries and thus saves £s — can be used time and time again. **ONLY £7.60+V.A.T.**

BRAND NEW ITT 923 Silicon Diodes 200mA 200v.

100 off	£2.00
500 off	£9.00
1,000 off	£15.00
10,000 off	£130.00

Single-sided Fibre-glass Board. S143.
12"×3½" approx. 2 pcs
£0.60

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No. THY3A/50	3 amp.	50 volt	TO64	**25p**
No. THY3A/200	3 Amp.	200 volt	TO64	**32p**
No. THY3A/400	3 Amp.	400 volt	TO64	**40p**
No. THY5A/50	5 Amp.	50 volt	TO66	**25p**
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No. THY5A/600	5 Amp.	600 volt	TO66	**50p**
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S84 8 Amp. 400 volt TO220 Plastic **80p**

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All 3 at SPECIAL PRICE of £1.20*

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16161	24 Ceramic Caps	100pF — 390pF
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All 4 at SPECIAL PRICE of £1.60

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16213	60¼W	100 ohm — 820 ohm
16214	60¼W.	1K — 8.2K
16215	60¼W.	10K — 82K
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16217	40½W.	100 ohm — 820 ohm
16218	40½W.	1W — 8.2K
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No. MVR7818	μA7818	TO220	**55p**
No. MVR7824	μA7824	TO220	**55p**

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No. MVR7918	μA7918	TO220	**75p**
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μA723C TO99 **38p** 72723 14 pin Dil **38p**
LM309K TO3 **£1.20**

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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 BC107/8	**40p***
No. 16138	30 PNP Plastic trans. like BC177/8	**40p***
No. 16139	25 NPN trans. like 2N697/2N1711 TO39	**40p**
No. 16140	25 PNP trans. like 2N2905 TO39	**40p**
No. 16141	30 NPN trans. like 2N706 TO18	**40p**
No. 16143	30 NPN Plastic trans. like 2N3906	**40p***
No. 16144	30 PNP Plastic trans. like 2N3905	**40p***
No. 16145	30 PNP Germ. trans. like OC71	**40p**
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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
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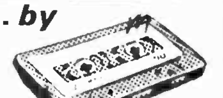
2 amp 750mW

	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
NKT304	20	30	50-150	**25p** per pair

From U.S.A. by
DINDY
SCREW CASED LOW NOISE CASSETTES



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HEAD-CLEANING CASSETTE 45p each

RETURN OF THE AL20A

By popular demand — this useful 5 watt RMS Power Amplifier is offered at the re-introductory price of **£2.75+V.A.T.** — Hook-up and data supplied.

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FET's

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2 AMP. BRIDGE RECTIFIERS

Metal Stud Mounting

No. S45	50V	(K8S 005)	**28p**
No. S46	100V	(K8S 01)	**30p**
No. S47	200V	(KBS 02)	**34p**

SILICON BRIDGE RECTS.

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SIMILAR IN 4000 SERIES

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No. S42	20 Like IN4002 (1A/100V)	**60p**
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SALE T-T-TIME again!

SPECIAL OFFER!

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Order No.	Quantity	
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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 Micro switches	40p
16176	20 Assorted electrolytics Trans types	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 ½W resistors mixed values	40p
16187	30 metres stranded wire assorted colours	40p
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S101	120 ½ watt resistors. Pre-formed 1978 Prod. Mixed values	60p•
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S104	60 Low ohms ⅛ watt resistors 10-100 ohms	60p•
S105	40 Low ohms ½ watt resistors 10-0ohms	60p•
S106	25 Mixed wirewound resistors	60p•
S107	20 Tantalum 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

Slider 40mm TRAVEL

Order Now.

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 22 K	LIN Single	40p•
16195	6 x 47 K	LOG Single	40p•
16194	6 x 47 K	LIN Single	40p•
S27	6 x 100 K	LIN Single	40p•
S28	6 x 100 K	LOG Single	40p•
S29	6 x 500 K	LOG Single	40p•

Slider 60mm TRAVEL

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

S38 Mixed slider pots—various values and sizes, our mix only £1.00•
S39 6 x Chrome slider knots 40p•

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6mm Shaft

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Crystal Ear Pieces
S126 Less plug £0.20

Plugs for above
No. 16106 2.5 plastic £0.09
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S127 GP91/1SC Special Offer £1.00

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S134	2× Magnets suitable for reed switches	£0.10
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STA50. 50 watts per channel amplifier kit. CONSISTS: 2×AL120 — 1×PA200 — 1×SPM120/65 — 1×2041 transformer — 1 reservoir capacitor — 2×coupling capacitors. **£58.20 inc. V.A.T. + £1.16 p&p.**

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TRANSISTORS

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AC107	25p	BC177	12p	BF194	•9p	TIP32A	34p	2N1613	15p
AC126	14p	BC178	12p	BF195	•9p	TIP32B	35p	2N1711	15p
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	BFX29	22p	TIP41C	36p	2N2219	15p
AC176K	24p	BC183L	•9p	BFX84	18p	TIP42A	36p	2N2219A	18p
AC187	16p	BC184	•9p	BFY50	12p	TIP42B	37p	2N2221	15p
AC187K	26p	BC184L	•9p	BFY51	12p	TIP42C	38p	2N2221A	16p
AC188	16p	BC212	•10p	BFY52	12p	TIP2955	65p	2N2222	15p
AC188K	26p	BC212L	•10p			TIP3055	42p	2N2222A	16p
AD161/		BC213	•10p	MPSA05	•22p	ZTX107	•6p	2N2369	10p
162 MP	80p	BC213L	•10p	MPSA06	•22p	ZTX108	•6p	2N2904	14p
AF139	30p	BC214	•10p	MPSA55	•22p	ZTX109	•7p	2N2904A	15p
AF239	30p	BC214L	•10p	MPSA56	•22p	ZTX300	•7p	2N2905	14p
BC107	6p	BC251	•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
BC118	•10p	BCY72	12p	OC72	12p	ZTX501	•10p	2N2907	12p
BC147	•8p	BD115	40p	OC75	10p	ZTX502	•12p	2N2907A	13p
BC148	•8p	BD131	•35p	OC81	14p	2N696	•10p	2N2926G	•8p
BC149	•8p	BD132	•37p			2N697	10p	2N2926Y	•7p
BC154	•16p	BF115	17p	TIP29A	35p	2N706	7p	2N3053	12p
BC157	•9p	BF167	19p	TIP29B	36p	2N706A	8p	2N3055	35p
BC158	•9p	BF173	20p	TIP29C	38p	2N708	8p	2N3702	•7p
BC159	•9p	BF180	25p	TIP30A	36p	2N1302	12p	2N3703	•7p
BC169	•10p	BF181	25p	TIP30B	37p	2N1303	15p	2N3704	•6p
BC170	6p	BF182	25p	TIP30C	38p	2N1304	15p	2N3903	•11p
BC171	•6p	BF183	25p	TIP31A	32p	2N1307	18p	2N3904	•11p
BC172	•6p	BF184	25p	TIP31B	33p	2N1308	22p	2N3905	•11p
BC173	7p	BF185	25p	TIP31C	34p	2N1309	22p	2N3906	•11p

DIODES

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AA119	5p	BAX16/		BYZ16	30p	OA85	7p	IS44	3p
AAZ13	4p	OA202	5p	BYZ17	28p	OA90	6p		
BA100	6p			BYZ18	28p	OA91	7p	IN5400	10p
BA115	5p	BY100	15p	BYZ19	28p	OA95	7p	IN5401	11p
BA144	5p	BY127	•10p	OA47	5p			IN5402	12p
BA148	10p	BYZ10	32p	OA70	5p	IN34	5p	IN5404	13p
BA173	10p	BYZ11	32p	OA79	7p	IN60	6p	IN5406	16p
BAX13/		BYZ12	32p	OA81	7p	IN914	4p	IN5407	17p
OA200	5p	BYZ13	30p			IN148	4p	IN5408	19p

LINEAR I.C.'s

TBA800	•£0.75	uA709	£0.20	748P	£0.28
TBA810	•£0.85	uA711	£0.25	uA748	£0.28
TBA820	•£0.65	uA703	£0.20	72558	£0.45
LM380	•£0.80	741P	£0.18	MC1310P	£1.25
LM381	•£1.25	72741	£0.20	76115	£1.25
72709	£0.20	uA741C	£0.20	NE555	£0.22
		72747	£0.55	SL414A	£1.80

ZN 414 RADIO CHIP 75• OPTOELECTRONICS

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to take 6 x HP7's
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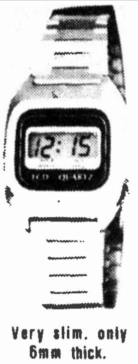
COMPONENTS SHOP: 18 BALDOCK STREET, WARE, HERTS.

SAME AS ETI OFFER



5 FUNCTION LCD

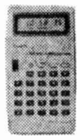
Hours, mins, secs, month, date, auto calendar, back-light, quality metal bracelet.

£7.65

Guaranteed same day despatch

Very slim, only 6mm thick.

POCKET CALCULATOR + ALARM CLOCK PLUS 3-WAY STOPWATCH



- ★ Calculator with %, √ & memory.
- ★ Continuous clock with
- ★ Hrs, mins, secs, day, month, day of week
- ★ Alarm
- ★ Stop-watch with 1/10 secs to 10 hours + lap and split-time modes, 1st and 2nd.
- ★ Batteries last 1 year continuous operation
- ★ Dimensions ¼" x 2¾" x 4⅛" in.
- ★ Complete with leatherette wallet.

LIST PRICE £24.95

METAC SPECIAL EXCLUSIVE PRICE

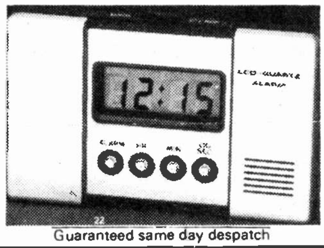
£18.50

Cannot be found cheaper anywhere else

' QUARTZ LCD ALARM '

Snooze + backlight. Batteries last 1 year approx. Includes batteries and travel pouch. Excellent value

£17.65



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THOUSANDS SOLD 11 FUNCTION SLIM CHRONO

6 digit 11 functions

- ° Hours, mins, secs.
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This same watch is being sold for £22.00 in newspaper and magazine special offer ads.

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World famous piercing alarm chronograph

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6 digit, 7 function watch with 4 alarms & volume control.

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SUPERIOR WATCHES

Full spec. calculator + 6 function watch.

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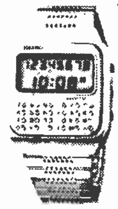


CALCULATOR WATCH

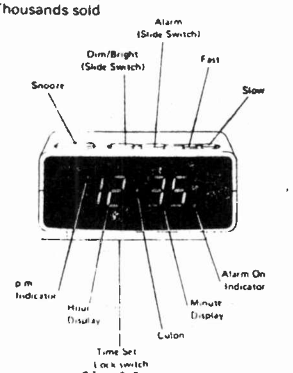
List price £165

METAC PRICE £127

HANIMEX Electronic LED Alarm Clock

Same as ETI offer

Thousands sold



Feature and Specification

- ★ Hour/minute display
- ★ Large LED display with p m and alarm on indicator
- ★ 24 Hours alarm with on-off control
- ★ Display flashing for power loss indication
- ★ Repeatable 9-minute snooze
- ★ Display bright/dim modes control

Size 5.15 x 3.93 x 2.36 (131mm x 100mm x 60mm).

Weight: 1 43 lbs (0 65 kg)

Guaranteed same day despatch

£8.65

GENUINE SOLAR

5 function LCD

- * Solar panel with battery back-up.
- * Back light + auto calendar.
- * Hours, mins, secs, day, date.
- * Quality metal bracelet.

£10.95

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LADIES LCD

Only 25 x 20 mm and 6 mm thick. 5 function: hours, mins, secs, day, date. + back light and auto cal. Elegant metal bracelet in silver or gold. State preference.

£9.95

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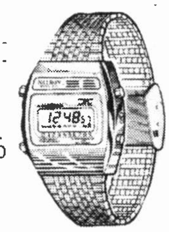
ALARM LCD

6 digit 7 functions + penetrating alarm. Hours Mins Secs Day Date Alpha Day Year. Back light + 200 year calendar.



ONLY

£21.95

THE METAC DIGITAL CLOCK ★ COMPLETE KIT ★

- ● Pleasant green display - 12/24 Hour readout
- ● Silent Synchronous Accuracy - Fully electronic
- ● Pulsating colon - Push-button setting
- ● Building time 1 Hr - Attractive acrylic case
- ● Easy-to-follow instructions - Size 10.5 x 5.7 x 8 cm
- ● Ready drilled PCB to accept components

PRICE £6.65

FLUORESCENT DISPLAY CLOCK RADIO

- ★ Mains operated
- ★ Soft glow green display
- ★ MW/FM & LW radio
- ★ Alarm with 9 min. snooze feature
- ★ Programmable play-to-sleep setting
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DIGITAL LED CLOCK

- ★ Automatic brightness control
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- ★ 9 minute snooze alarm

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ALARM CHRONOGRAPH WITH DUAL TIME ZONE FACILITY

- ●Constant LCD display of hours and minutes, **plus** optional seconds or date display, **plus** day of the week and am/pm indication.
- ●Perpetual calendar; day, date, month and year.
- ●24 hour alarm with on/off indication.
- ●1/10 second chronograph measuring net, lap and **first and second place** times.
- ●Dual time zone facility. Night light.

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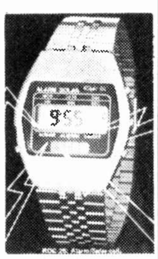
GENUINE SOLAR CHRONOGRAPH

£15.95

6 digit, 11 function. Hours Min Secs 1/100 1/10 Secs Mins Split & lap modes, Auto cal + back light. Powered from solar panel with battery back-up.



PLEASE NOTE

All our products carry full money back 10-day reassurance.

Watches are despatched by **FIRST-CLASS POST.** They are fitted with new batteries, and include guarantee and instructions.

Battery fitting service is available at our shops for no extra charge. We stock most watch batteries and this service is available to all.

Metac have been selling electronic watches probably longer than anyone else in the UK. We take care of your watch not just this year but next year and the years after that.

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24-hour phone service
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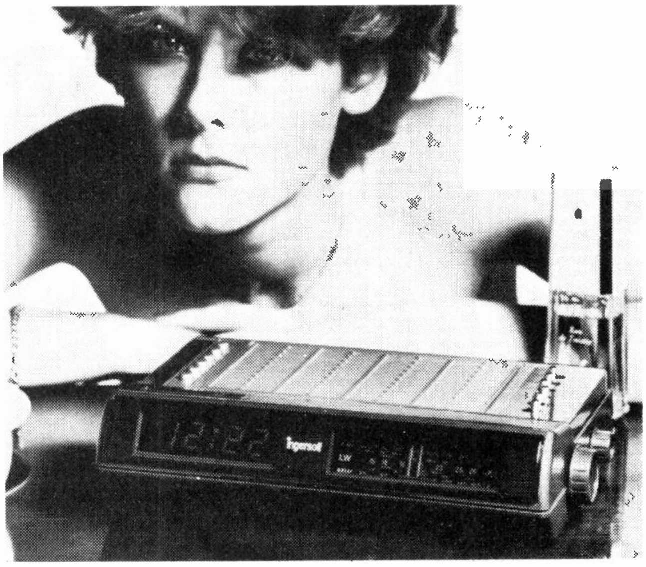
news digest................



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 incorporates 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 relevent 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 browing easy and the listings clearly and precisely done.

This tryly 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 permanrnt 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

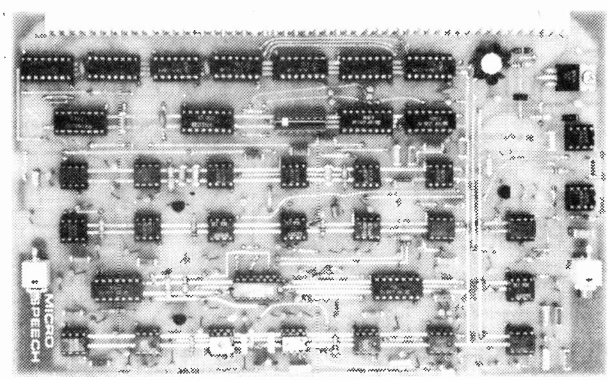
Computer Speech has come a long way since the Daleks first clanked their way across the TV screen. In the USA add-on devices for home systems (peripherals) can be purchased to make the small system talk in a reasonable — at least recognisable manner.

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) convertor 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 Pield Heath Avenue, Hillingdon, Middx.



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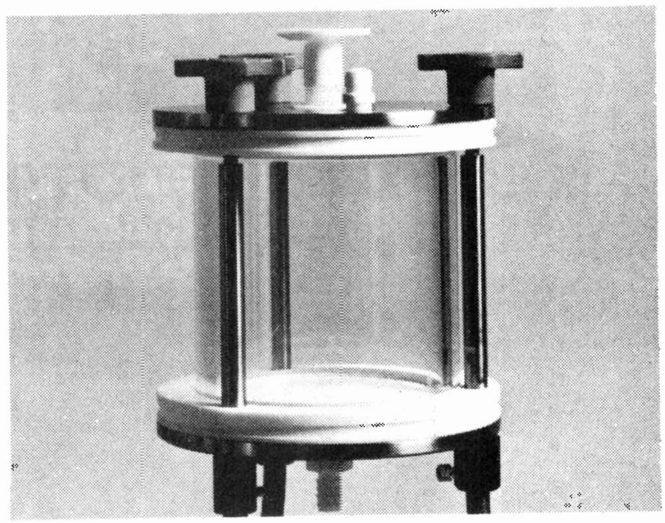
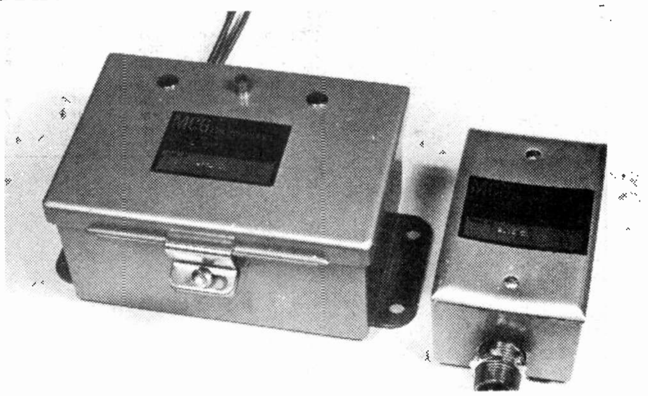


Technical Enquiry

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.

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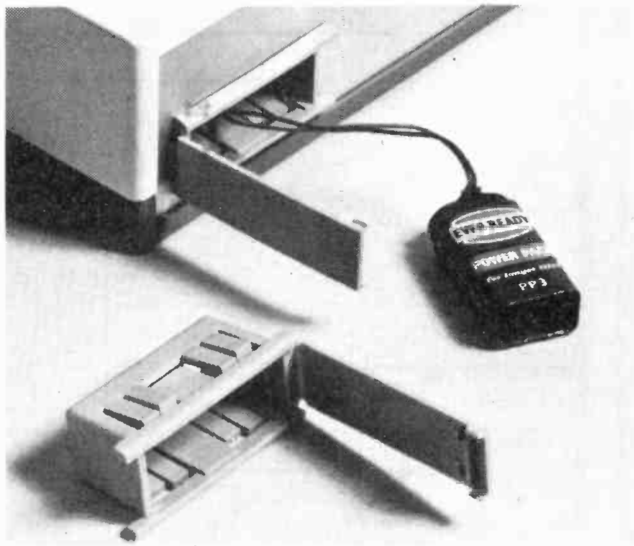

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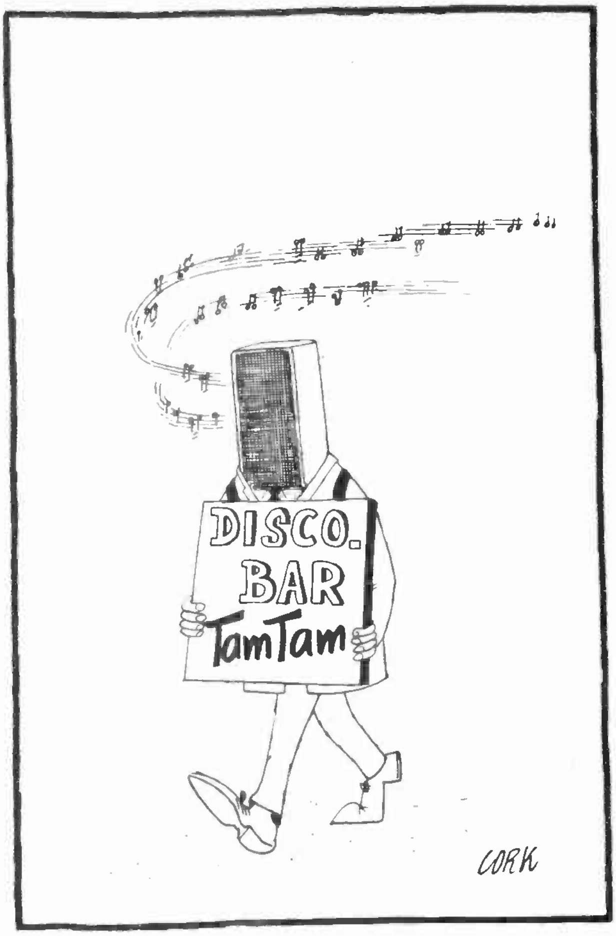
For further details contact: Michael Gouldsmith, OK Machine & Tool (UK) Ltd, 48a The Avenue, SOUTHAMPTON, Hants SO1 2SY.



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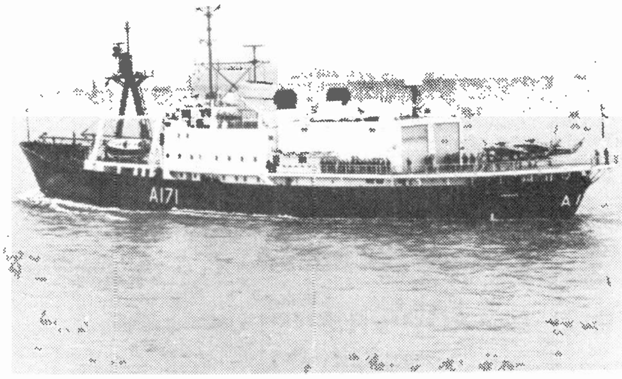


IMRC SATCOM For RN

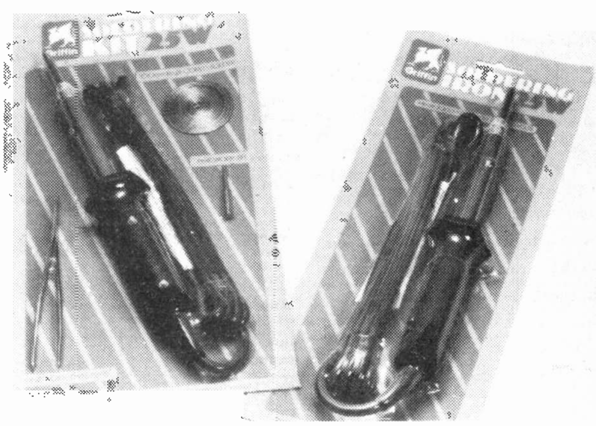
THE Royal Navy has had installed its first shipborne communications terminal for working via commercial maritime satellites. Supplied by International Marine Radio Company (IMRC) of Croydon, the terminal has been fitted into a Navy ice patrol vessel, HMS Endurance.

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.

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.

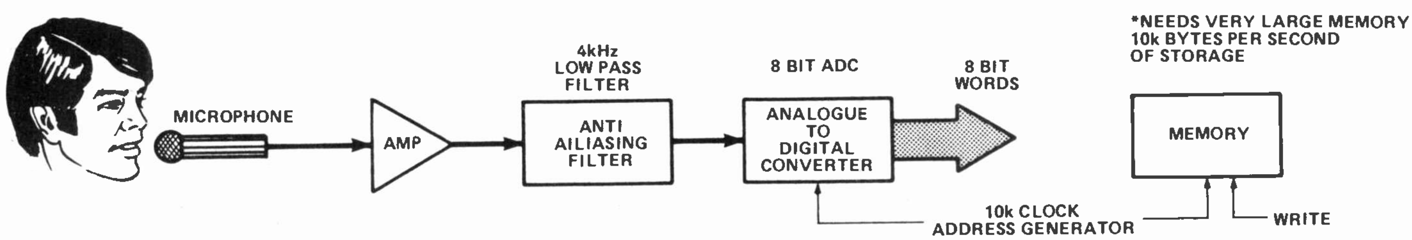
This technique is fine for some applications, where the set of phrases is small or where there will be no need to change them, because this means changing the disc. However, the unit is physically large and suffers from all the faults of any mechanical system.

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.

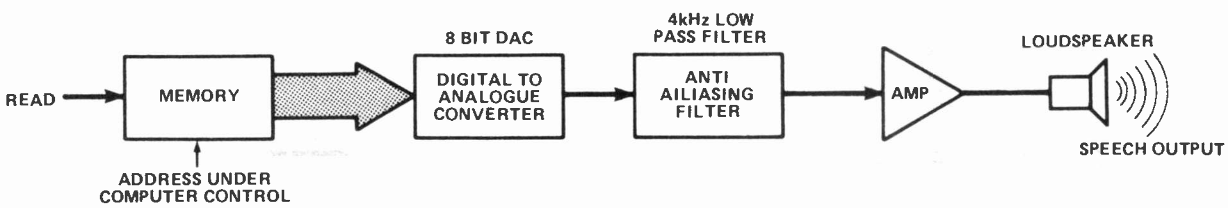
However, this type of storage would require enormous amounts of memory to generate short pieces of speech, because the unfortunate fact of life is that about 95% of the information stored by this method is redundant. The redundancy problem can be overcome by doing some special coding on the information. 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 undoubtably 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.

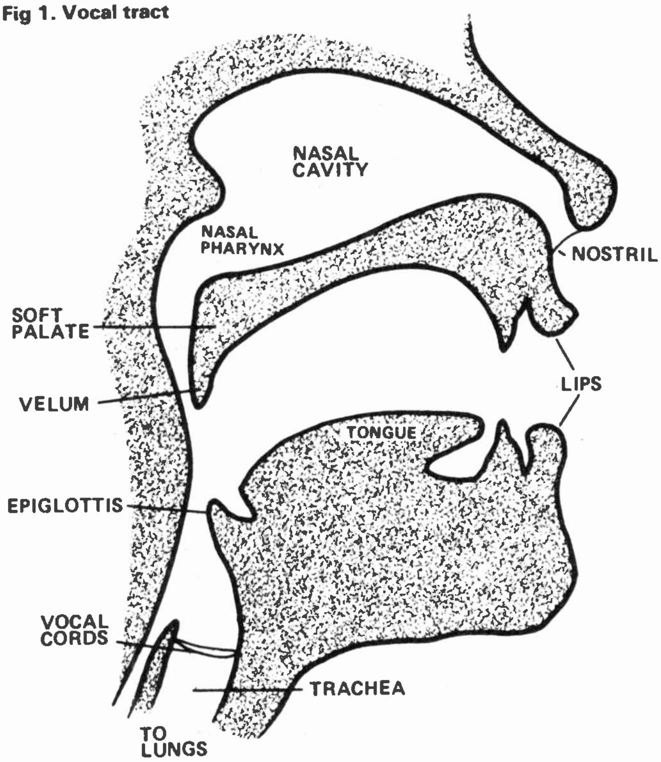
By opening and closing the mouth, by moving the tongue hump and by connecting or disconnecting the nasal cavity, the resonances of the tract can be manipulated so as to generate speech.

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 KAAN DOO WIHTH MEE'.

Fig 1. Vocal tract



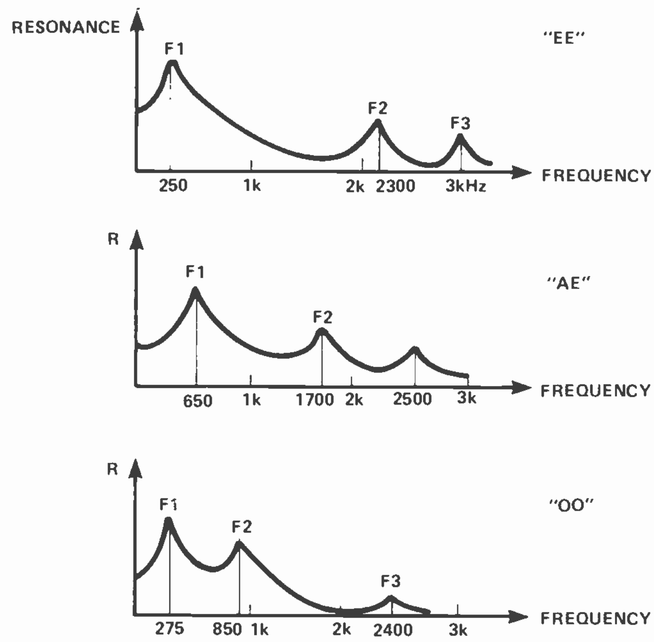


Fig 2. Acoustic response of some vowel sounds.

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

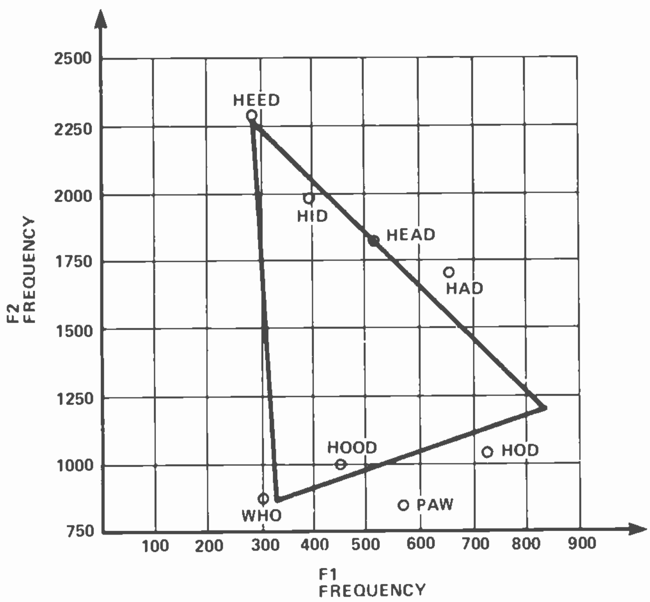


Fig 4. The vowel triangle!

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 dipthong 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, dipthongs 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 ▶

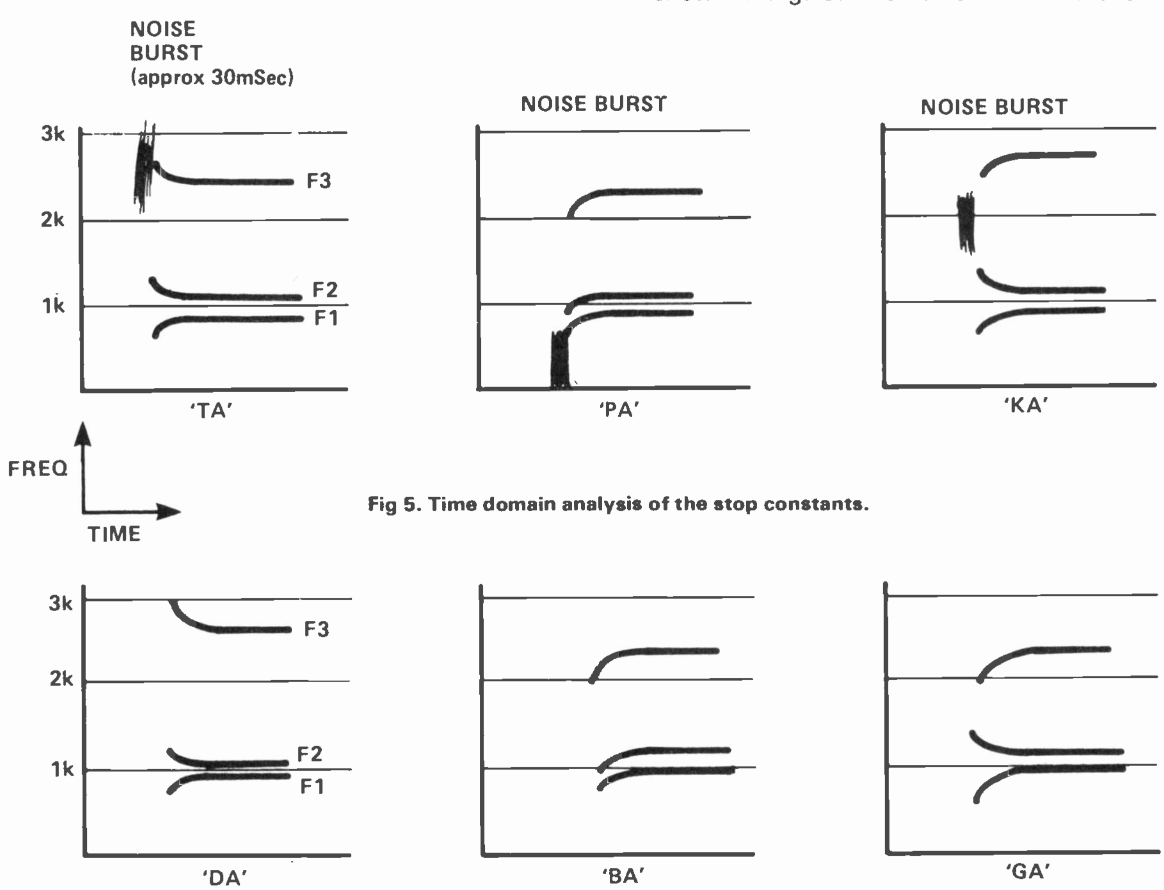


Fig 5. Time domain analysis of the stop constants.

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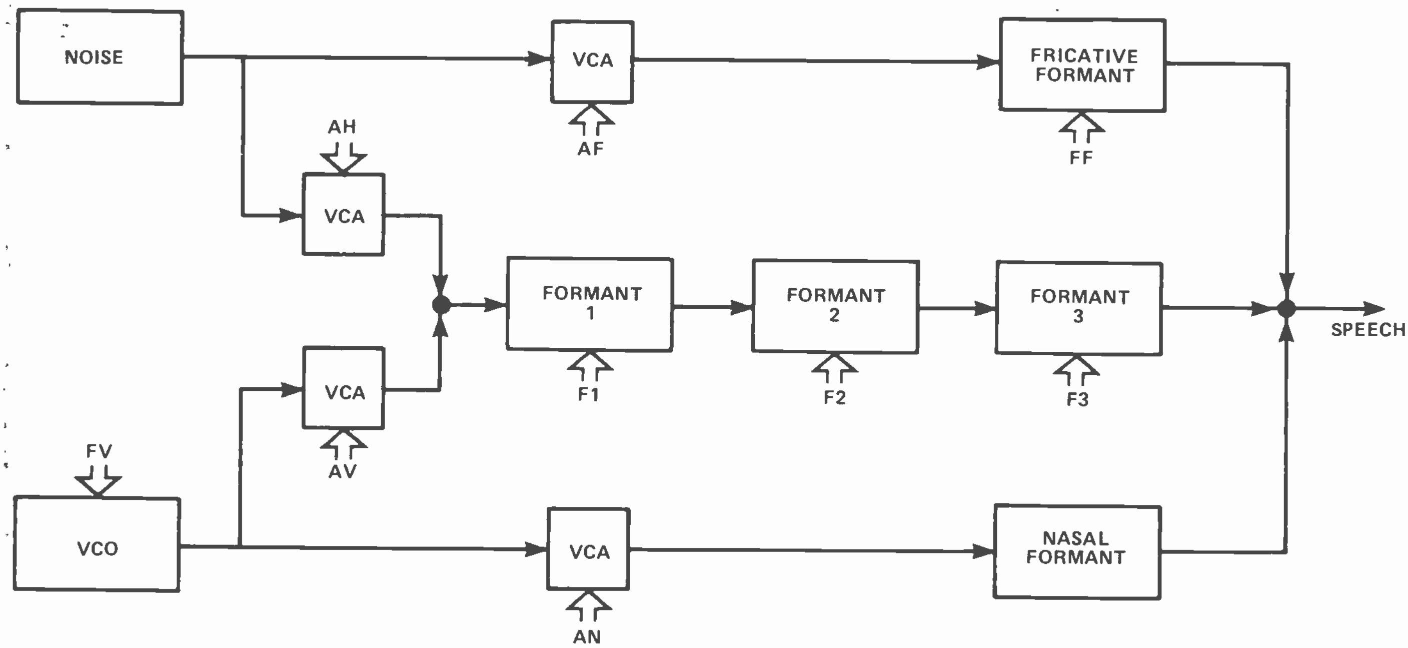
Fig 6. Block diagram of a three formant speech synthesiser.



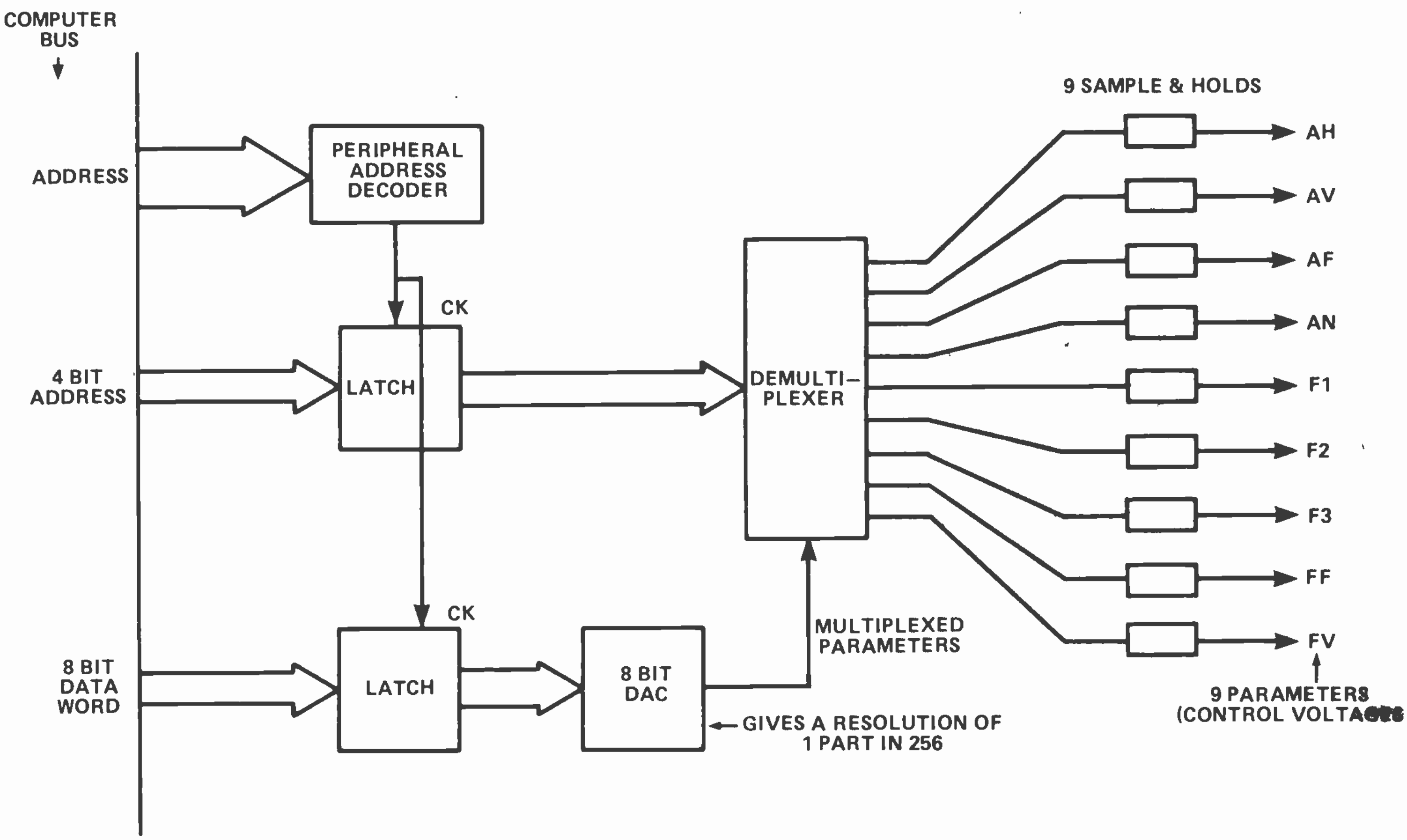


Fig 7. Block diagram of a parameter generator for a speech synthesis machine.

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 predecive 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.

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

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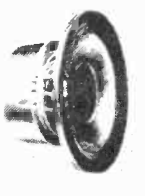

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ASY54	33p
ASY55	33p
BC107	7p
BC108	7p
BC109	7p
BC113	12p
BC117	15p
BC119	25p
BC140	27p
BC142	20p
BC143	24p
BC147	7p
BC149	7p
BC157	7p
BC158	7p
BC159	7p
BC168	7p
BC170	7p
BC171	7p
BC172	7p
BC173	7p
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BC186	19p
BC187	19p
BC207	10p
BC212	10p
BC213	10p
BC214	10p
BC237	12p
BC238	14p
BC301	30p
BC303	30p
BC328	13p
BC338	13p
BC547	11p
BC548	11p
BC549	11p
BC557	11p
BCY30	60p
BCY34	66p
BCY59	24p
BCY70	14p
BCY71	14p
BD115	30p
BD121	70p
BD123	60p
BD124	77p
BD131	35p
BD132	35p
BD135	30p
BD136	30p
BD137	30p
BD138	30p
BD139	30p
BD140	30p
BF115	25p
BF167	25p
BF173	20p
BF178	25p
BF179	25p
BF180	20p
BF181	20p
BF182	20p
BF183	20p
BF184	20p
BF185	20p
BF194	7p
BF196	7p
BF197	7p
BF198	7p
BF200	33p
BF224	16p
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BF259	28p
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BFR40	18p
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74107	25p
74109	30p
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74120	125p
74121	25p
74122	33p
74123	40p
74125	35p
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74132	50p
74136	79p
74141	56p
74142	200p
74145	58p
74147	110p
74148	90p
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74180	80p
74181	145p
74182	60p
74184	110p
74190	72p
74191	72p
74192	65p
74193	64p
74194	60p
74195	55p
74196	55p
74197	55p
74198	110p
74199	110p

CMOS

4000	15p
4001	15p
4002	15p
4006	68p
4007	15p
4008	64p
4009	35p
4010	35p
4011	15p
4012	15p
4013	35p
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4015	60p
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4081	16p
4082	16p
4086	59p
4501	19p
4507	40p
4510	70p
4516	64p
4518	70p
4519	60p
4520	65p
4528	55p
4578	27p
4583	82p
4585	105p

VOLTAGE REGULATORS

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7905	79p
7912	79p
7915	79p
7918	79p
7924	79p

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1A/400V	40p
3A/100V	36p
3A/200V	38p
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OA91	15p
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1N4148	4p
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1N4002	4p
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1N4004	6p
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1N4007	9p
1N5400	13p
1N5401	14p
1N5402	15p
1N5404	20p

BRIDGE RECTIFIERS

1A/50V	22p
1A/100V	24p
1A/200V	27p
1A/400V	30p
2A/50V	34p
2A/100V	36p
2A/200V	38p
2A/400V	40p

OPTO/DISPLAY

2N5777	50p
OCP71	70p
ORP12	70p
OL704	100p
OL707	100p
.125" & .2" LEDs	
Red	9p
Green	13p
Yellow	13p
Clip	3p

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8 pin	10p
14 pin	12p
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ZENER DIODES 400mW	
2.7V to 33V	8p
VERO BOARDS .1" copper	
2.5" × 5"	51p
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CERAMIC CAP 50V	
22pF to 50.000pF	3p
POLYESTER CAP 250V	
.01, .015, .022, .033, .047, .068, .1 uF	5p
.15, .22, .33 uF	6p
.47, .68 uF	12p
1 uF	15p
2.2 uF	25p
ELECTROLYTIC CAP 25V	
1 uF to 47 uF	6p
68 uF, 100 uF	7p
150 uF	8p
220 uF	9p
330 uF	11p
470 uF	14p
RESISTORS	
4.7 ohms to 1 Mohm	1p
POTENTIOMETERS	
1 Kohm to 2 Mohms log/linear	22p
5 Kohm to 1 Mohm log with switch	50p
PRESETS horizontal	
100 ohm to 1 Mohm	5p

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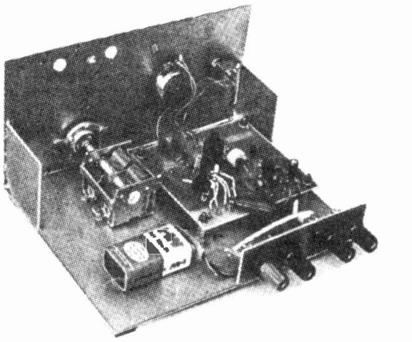
Hobby Electronics

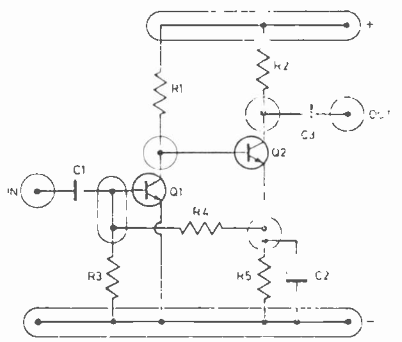
Next Month

Short Wave Receiver



Back in the bad-old-days when there were just valves, and they were expensive, you thought hard before adding another stage of amplification: first you tried to be clever. Our SW radio next month uses just two semiconductors yet will give surprisingly good performance over the range 5.5-25 MHz if used with a reasonable aerial.

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.

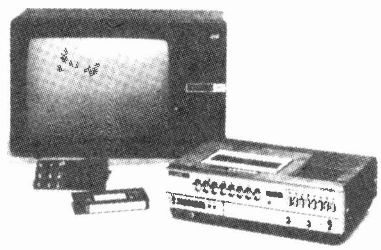
Scratch/rumble Filter

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

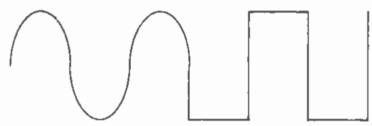


The age of the Video Cassette Recorder has arrived and soon they'll be common. However, they are the most complex, sophisticated, pieces of engineering that have ever crossed the doormat in reasonable numbers. Next month we explain how they work and take a look at the different systems being offered.

OST Rules, OK?

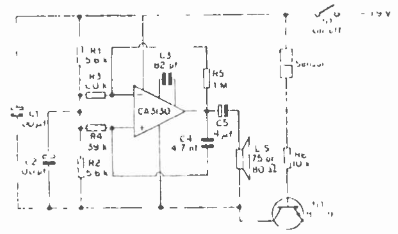
Got the hang of Ohms Law? No problem but the world isn't yours yet — have you ever found a problem it can't cope with? The chances are that you have. However, there are two other approaches to help you solve the nasty ones: Superposition and Thevenin's Theorem. They may sound complex but in reality they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

Sine/Square Wave Generator



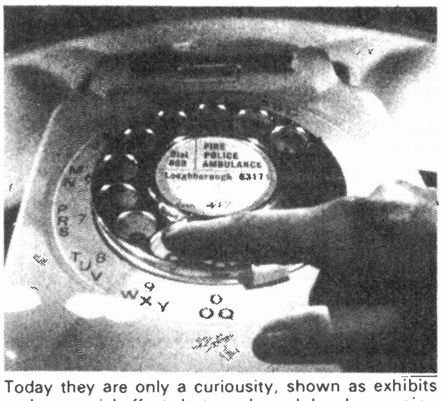
An essential part of anybody's test gear and our project next month enables you to add one to your workbench at low cost.

Projects Using The CA3130



We publish one chapter from R. A. Penfolds '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

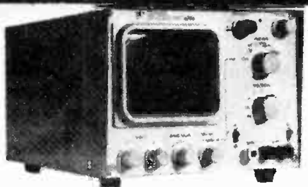


Today they are only a curiosity, shown as exhibits and as special effects but much work has been going on behind the scenes. Today's Holograms really make you wonder if you can believe your eyes.

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.

MORE SCOPE FOR YOUR MONEY



SPECIFICATIONS

ELMAC 4" SCOPE

ELECTRICAL DATA

VERTICAL AXIS (Y). Deflection Sensitivity — 100m V/division. Bandwidth (between 3 dB points) — DC — 5MHz. Input Attenuator — (calibrated) — 9 step 0.1, 0.2, 0.5, 1, 2, 5, 10, 20 50/div. Input Impedance — 1 Meg/40 pf in shunt. Input Voltage — Max — 600V P.P.

HORIZONTAL AXIS(X). Deflection Sensitivity — 0-400mV/division. Bandwidth (between 3 dB points — 1Hz-350KHz. Gain Control — Continuous when time bases in EXT position. Input Impedance — 1 Meg. Input Voltage — Max — 600V P.P.

TIME BASE. Sweep Range (calibrated) — 100msec/div to 1μ 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 — Continues from positive to negative.

POWER SUPPLY. Input voltage — 115/220V AC± 10% at 50/60Hz Power Dissipation — 18W.

CRT DATA — 4in. — flat face, single beam. — Maximum high voltage — 1.5kV. — Fitted with 8x10 division blue filter graticule.

PHYSICAL DATA Dimensions — 15cm(h)x20.5cm(w)x28cm(d). Weight — 4.3Kg(approx.). Stand — 2 position flat and inclined. Case — Steel, epoxy enamelled. Front panel — Aluminium, enamelled epoxy printing.

(As recommended by ETI)

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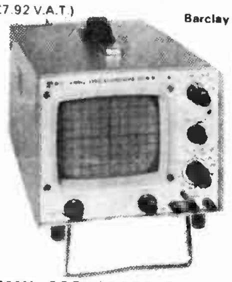

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6MHz OSCILLOSCOPE 3106B

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NEW 5" CRT MEG SCOPE (3106C) AVAILABLE @ £160 + VAT. SIZE AS 6-MEG SHOWN. 3" 5 MEG @ £83.25, VAT £6.66. CARRIAGE £1.50. SPEC. AS ELMAC 4".

Our 3106B with 1,600v acceleration voltage. 10 mv/cm sensitivity, auto trigger for the full bandwidth and X5 magnifier giving 1000NS/cm. Fastest sweep time (equivalent to 15 MHz oscilloscopes). SAE for brochure.

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Mag. issue	PROJECT	Ref.	PCB	Component Pack	Hardware Pack	Case *(Screened)	Total
	Graphic Equaliser	601	1.60	14.23	4.30	—	**20.13**
	Graphic Equaliser PSU	602	.55	1.29	—	—	**1.84**
TOR	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	**36.11**
	Stereo Simulator	607	.60	2.30	.53	2.24	**5.67**
	Freezer Alarm	608	.55	.92	3.85	1.65	**6.97**
NO	General Purpose Pre-Amp	609	.65	3.13	—	—	**3.78**
	G.S.R. Monitor	612	.70	4.70	7.10	3.95	**16.45**
	Burglar Alarm	613	.60	2.15	6.15	—	**8.90**
	Headlight Reminder	614	—	.55	1.65	—	**2.20**
6	Bench Amplifier	615	.70	3.40	2.93	3.95	**11.00**
	Audio Visual Metronome	616	—	1.31	1.62	—	**2.93**
	Compander	617	1.60	10.10	8.30	3.15	**23.15**
	50 watt High Power Amp	618	1.30	6.46	—	—	**7.76**
	100 watt High Power Amp	619	1.30	9.16	—	—	**10.46**
	High Power Amp PSU	620	1.10	5.66	7.89	—	**14.65**
	LED Dice	624	.50	2.92	.66	1.65	**5.73**
	Marker Generator	626	.80	3.68	1.49	.90	**6.87**
	Skeet	627	1.60	11.12	.97	4.53	**18.22**
	Flash Trigger	628	.65	3.48	.84	1.65	**6.62**
	Disco Lightshow	629	3.05	12.79	5.85	—	**21.69**
	Pink Noise Generator	630	.60	1.00	—	1.65	**3.25**
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 }			
Feb 78	Metal Locator Mk. II	T007	.92	5.91	8.76	3.38	**18.97**
Mar 78	Frequencer Shifter PSU	T008	.65	4.14	—	—	**4.79**
Mar 78	Frequencer Shifter	T009	1.50	16.99	—	2.40	**20.89**
Mar 78	LCD Meter	T010	1.00	24.62	—	—	**25.62**
Mar 78	Light Dimmer	T011	.55	3.40	3.12	—	**7.07**
Apr 78	Gas Monitor	T012	.80	10.11	1.10	1.35	**13.36**
May 78	Star Trek Radio	T013	.84	6.19	.83	—	**7.86**
Jun 78	Stars & Dots	T014	1.83	5.33	11.49	3.46	**22.11**
Jun 78	Spectrum Analyser	T015	8.32	35.76	16.02	5.00*	**65.10**
Jun 78	Wein Oscillator	T016	.89	6.36	4.80	2.40	**14.45**
Jul 78	UFO Detector	T017	1.45	10.80	.80	—	**13.05**
Jul 78	Torch Finder	T018	.45	1.27	—	—	**1.72**
Jul 78	Temperature Meter	T019	1.00	24.41	—	—	**25.41**
Aug 78	Etiwet	T020	.90	2.87	1.16	—	**4.93**
Sep 78	Cross Hatch Generator	T021	1.40	5.93	3.66	1.65	**12.64**
Sep 78	Stac Timer	T022	2.30	14.27	11.04	1.65	**29.26**
Sep 78	Wheel of Fortune	T023	1.35	4.34	.43	2.24	**8.36**
Oct 78	Complex Sound Generator	T024	2.95	10.15	8.78	—	**21.88**
Oct 78	R.F. Power Meter	T025	1.10	2.24	7.12	2.38	**12.84**
Oct 78	Power Bulge	T026	.60	.71	.78	.79	**2.88**
Oct 78	Telephone Bell Extension	T027	.95	3.48	3.02	2.15	**9.60**
Oct 78	Proximity Switch	T028	1.95	7.91	3.25	—	**13.11**
Feb 78	Ultra Sonic Receiver	T029	.60	3.38	4.95	—	**8.93**
Feb 78	Ultra Sonic Transmitter	T030	.45	.82	3.20	—	**4.47**
Nov 78	Cuts Cassette Interface	T031	2.80	26.12	.87	3.95	**12.66**
Nov 78	Audio Oscillator	T032	2.25	10.13	.38	—	**33.74**
Dec 78	Car Alarm	T033	1.80	2.80	.92	—	**5.52**
Dec 78	Wine Temp Meter	T034	1.10	1.31	1.31	.45	**5.79**
Dec 78	Curve Tracer	T035	1.00	3.04	2.60	2.67	**9.31**
Dec 78	Eprom Prog main board	T036	2.25	17.75	.21	—	**20.21**
Dec 78	Eprom Prog PSU	T037	1.30	3.79	—	—	**5.09**

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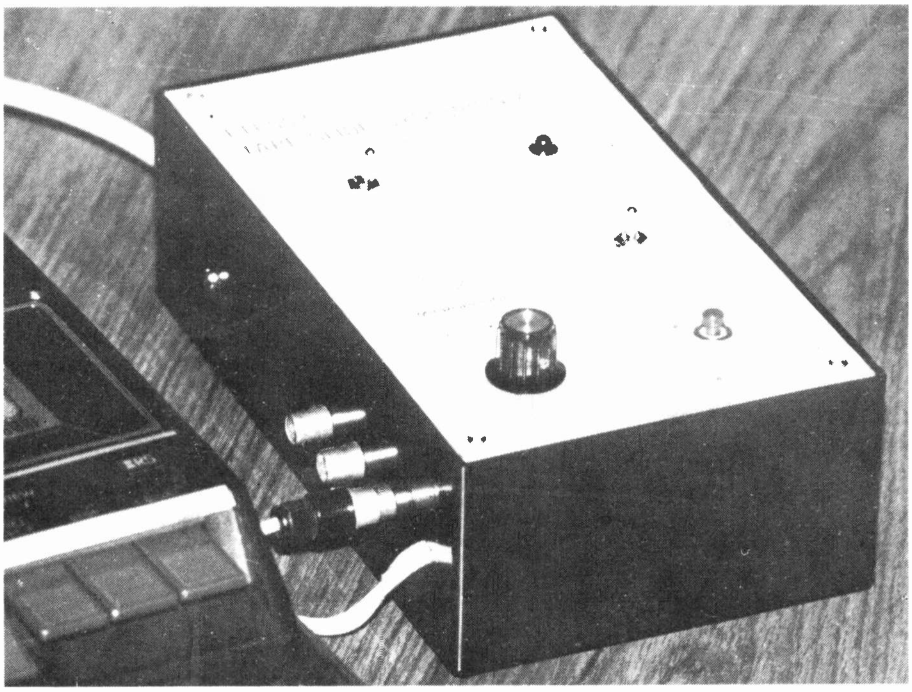


WHEN PUTTING on a slide show for your friends or a business meeting, it is usually necessary to have some commentary with it. If it is a one-time presentation this is no problem, but if the show is to be repeated or if you simply want to be able to recall good memories a couple of years later then a 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 activiate 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.

▶

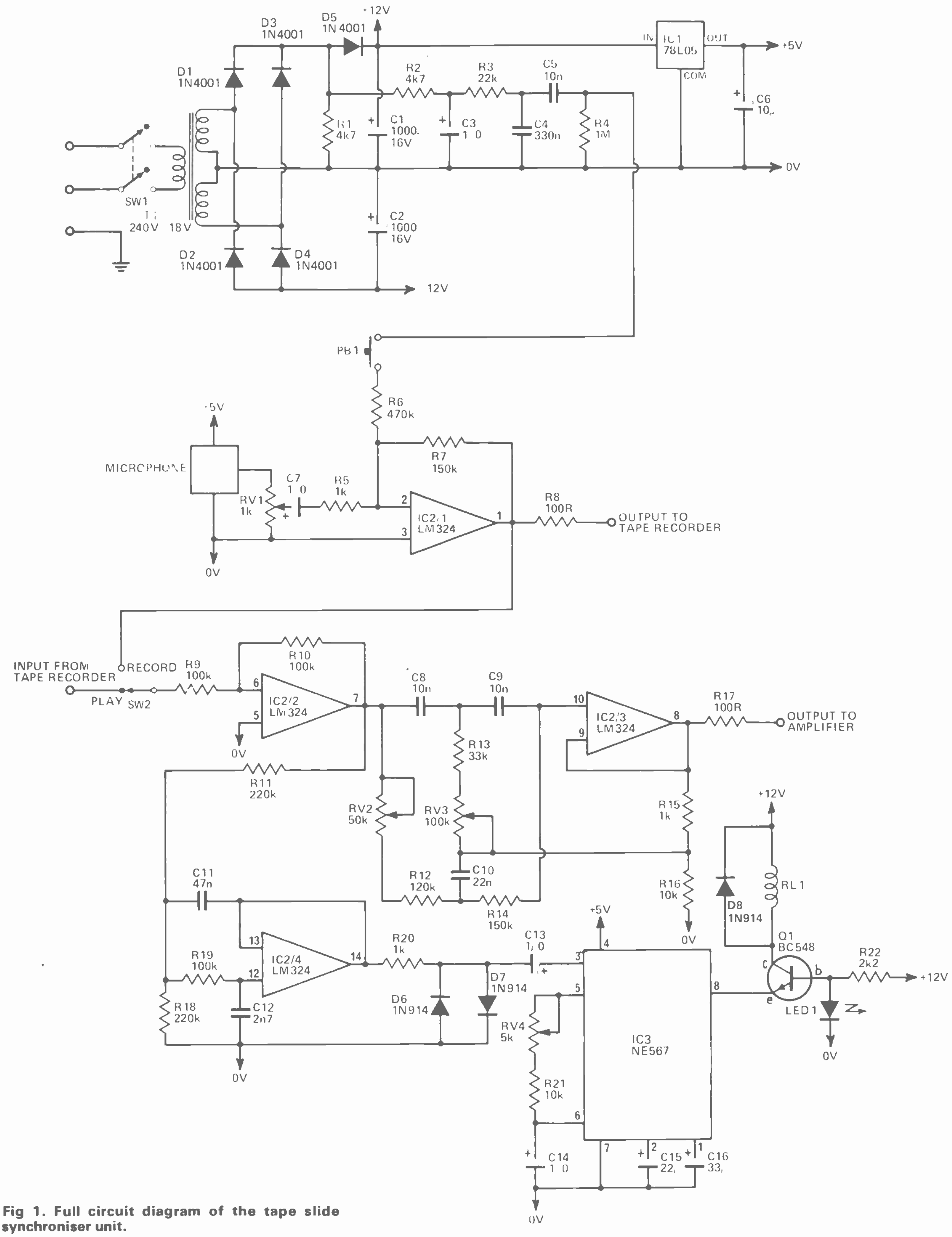


Fig 1. Full circuit diagram of the tape slide synchroniser unit.

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.

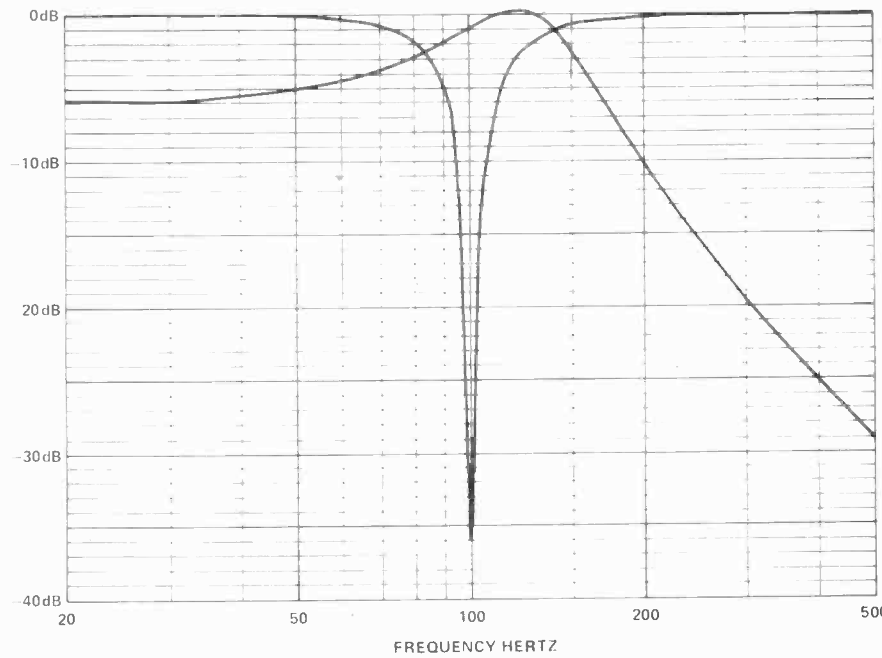


Fig 2. The frequency responses of the notch and low pass filter sections of the circuit.

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

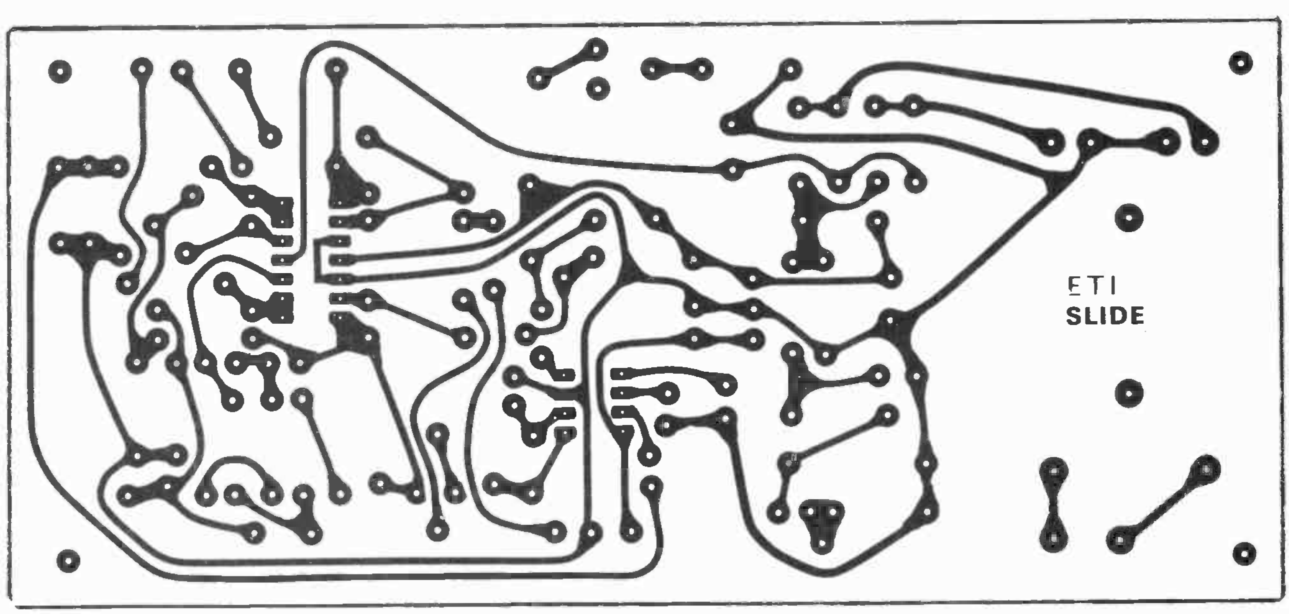
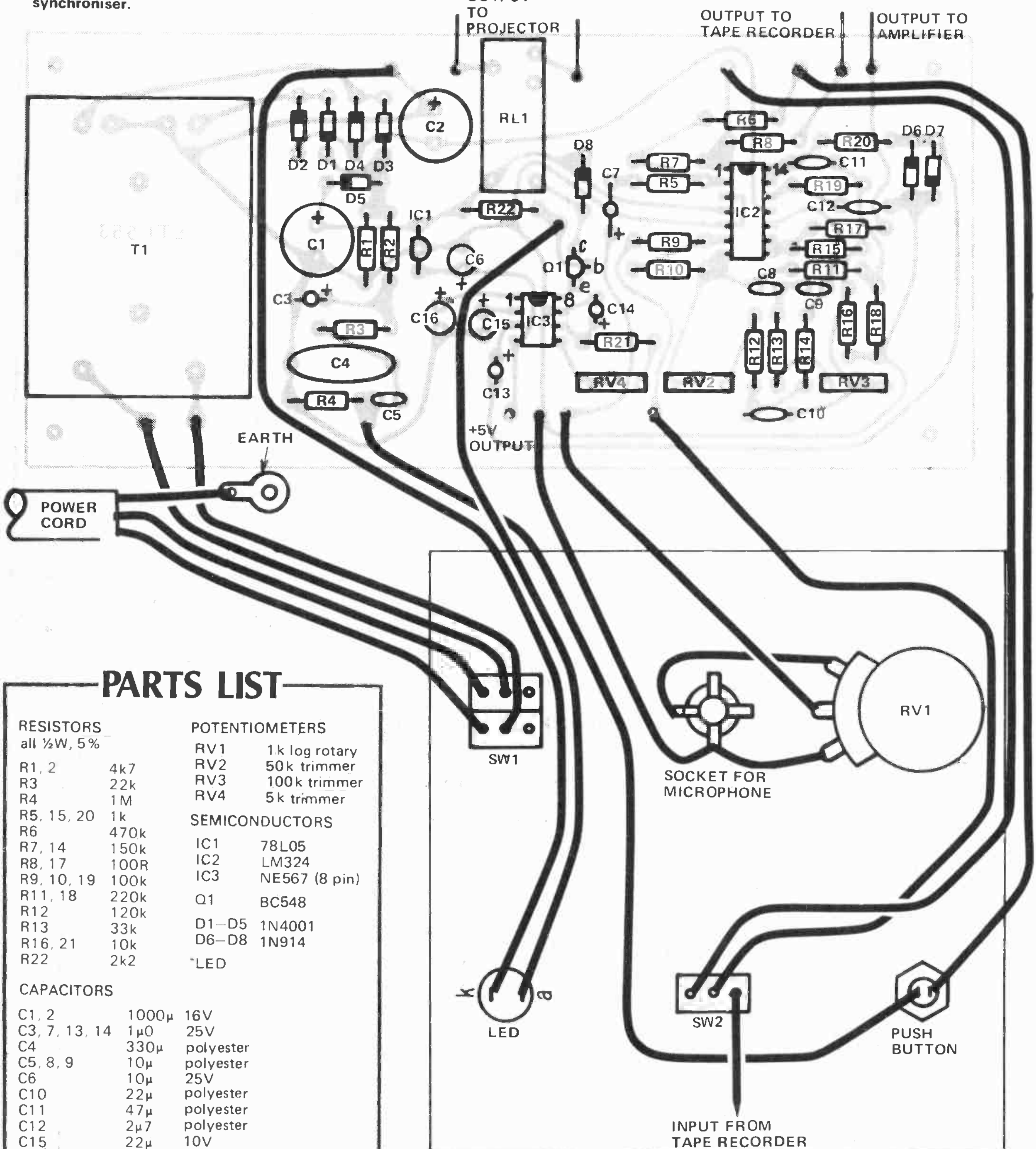


Fig. 3. Component overlay for the slide synchroniser.



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

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

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	

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 Marshalls, 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**. PDM35 **£27.25**. Mains adaptor **£3.24**. Case **£3.25**. 30kv probe **£18.95**. DM350 **£67.80**. DM450 **£96.50**. DM235 **£49.45**. Rechargeable batteries **£7.50**. 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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COMPONENTS

1N4148 **1.4p**. 1N4002 **2.9p**. 741 8 dil **15p**. 723 14 dil **29p**. NE555 8 dil **23p**. bc182b, bc183b bc184b, bc212b bc213b, bc214c, bc547, bc548, bc549, bc550 **4.5p**. tip31c, tip32c **34p**. tip41c, tip42c **45p**. bd131, bd132 **31p**. Plastic equivs bc107 bc109 **4.8p**. Fuses 20mm x 5mm cartridge 15, 25, 5 1, 2 3, 5Amp quickblow **1p**, anti-surge **3.4p**. Resistors 5% ¼W E12 10R to 10M **1p**, **0.8p** for 50+ for one value Polyester capacitors 250V 015, 068, 1mf **1.5p**, 01, 033, 33mf **2.7p**, 022 047mf **3.2p**, 22 47mf **4.8p**. Polystyrene capacitors E12 63v 10 to10000pf **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 (PC) **3.4p**, 10v 1000mf **5.1p**, 2200mf **6p**, 2mf (PC) **1.7p**. Zeners 400mW E24 2v7 to 33v **7p**. Preset pots sub-miniature 0 1 horiz or vert 100 to 4M7 **6.8p**. Potentiometers ½W 4K7 to 2M2 log or lin single **26p**, dual **76p**.

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0.9, 0.9	500 500	207	**2.35**	.55
0-8-9, 0-8-9	1A 1A	208	**3.50**	.55
0-15, 0-15	200 200	236	**1.95**	.40
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20-12-0-12-20	700(DC)	221	**3.10**	.70
0-15-20, 0-15-20	1A 1A	206	**4.20**	.85
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Amps	Ref. No.	Price £	P&P
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2.0	3	**4.80**	.85
3.0	20	**5.80**	1.00
4.0	21	**6.85**	1.00
5.0	51	**7.75**	1.00
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1.0	103	**4.20**	.85
2.0	104	**6.10**	1.00
3.0	105	**7.85**	1.00
4.0	106	**9.80**	1.10
6.0	107	**14.95**	1.30
8.0	118	**15.75**	1.50
10.0	119	**20.50**	2.00

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1.0	126	**4.65**	.85
2.0	127	**6.50**	1.00
3.0	125	**9.15**	1.10
4.0	123	**11.25**	1.30
5.0	40	**11.80**	1.30
6.0	120	**14.75**	1.40

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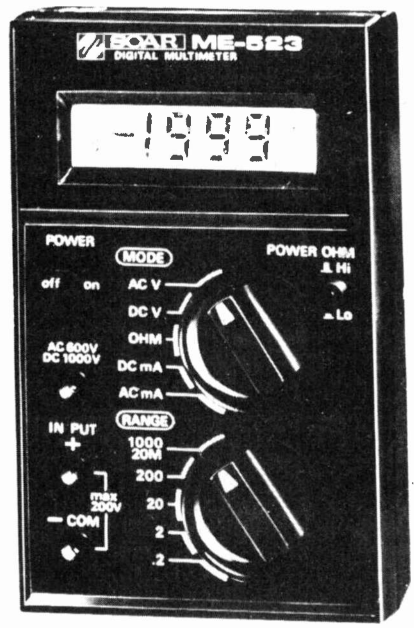

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BUILD A VCT

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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.

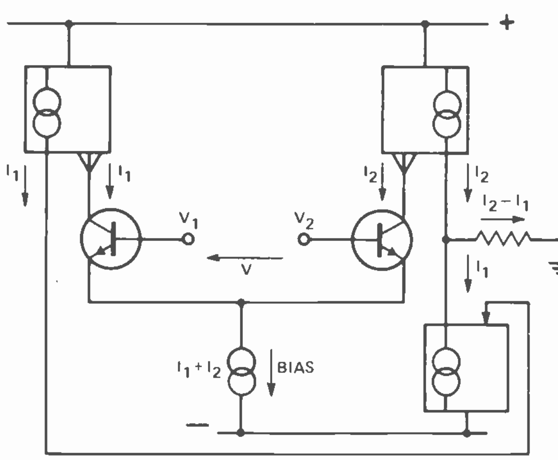


Fig. 2. Single-ended VCT (e.g. CA3080 operational transconductance amplifier.

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

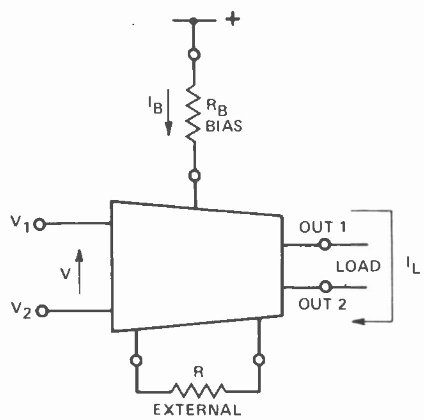


Fig. 1. VCT symbol and external connections.

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

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

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

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

$$I_L = I_1 - I_2$$

$$I_E = 3I_1 - I_B$$

$$I_E = I_B - 3I_2$$

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

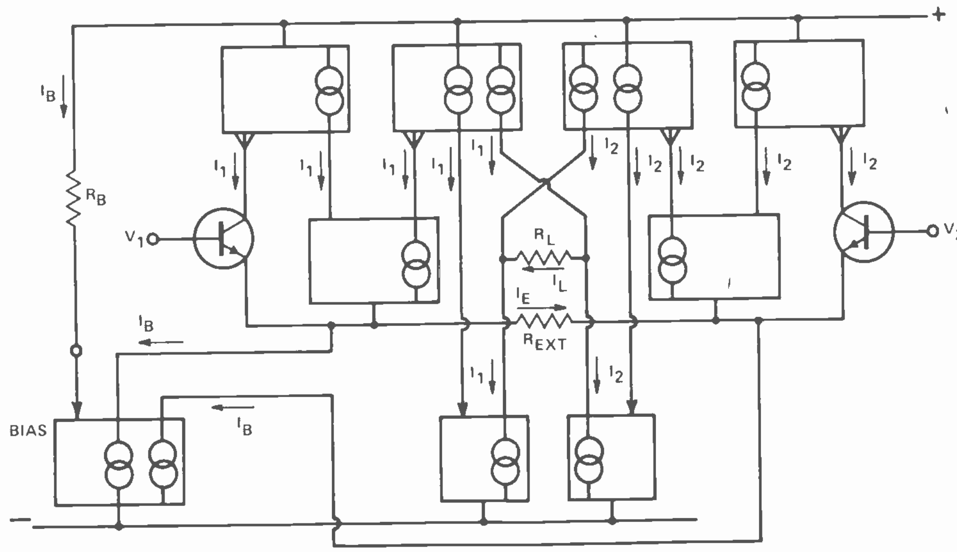


Fig. 3. VCT with floating input.

pair. The specifications on Q_1, Q_2 look impressive and those of Q_3, Q_4 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

$$I_E = I_{S1} \exp(eV_{EB}/kT)$$
$$= 1_{S2} \exp(eV_{EB}/kT \exp(e\ 10^{-3}/kT)$$

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

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

$$= I_{S1} \exp(-e\ 10^{-3}/kT) \exp(eV_{EB}/kT)$$
$$= I_{E1} \exp - (e\ 10^{-3}/kT)$$

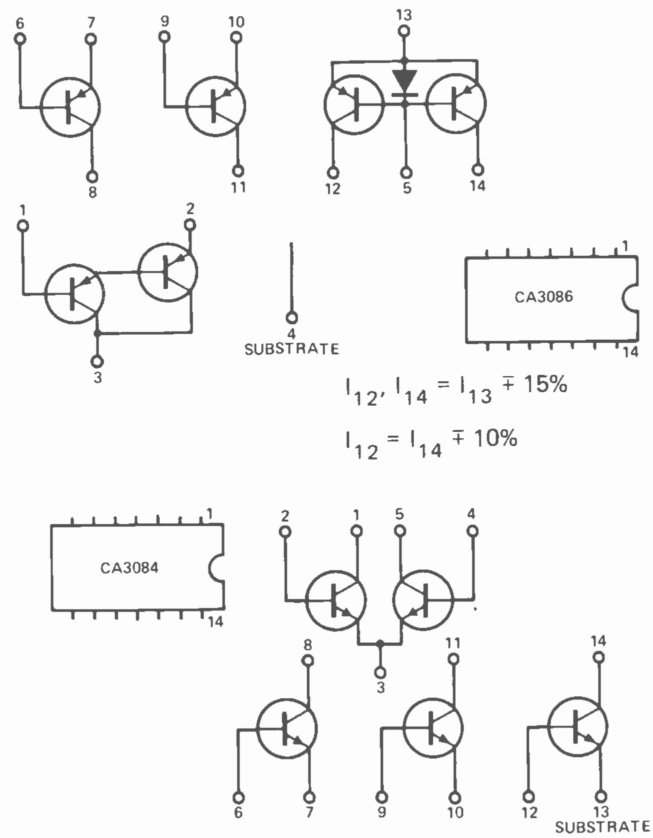
At room temperature, kT 1/40eV and I_{E2} 0.96 I_{E1}. So a ± 1 mV matching in V_{BE} leads to a 4-5% error in a current mirror application. In this light, Q_3 — Q_4 seem to be reasonably matched for the purpose and Q_1 — Q_2 less so.

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 Q_5 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 Q_1 and Q_2 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).



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

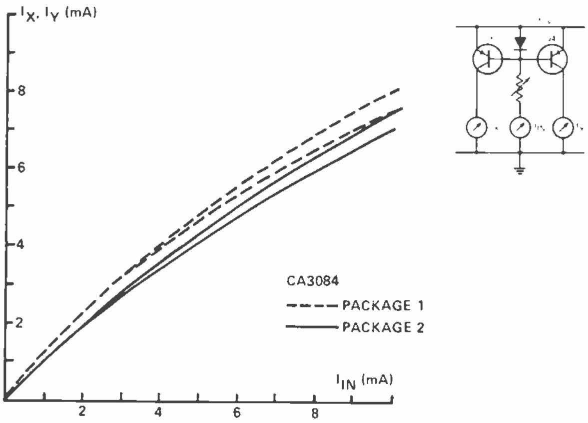


Fig. 5. Elementary current mirror — output matching test.

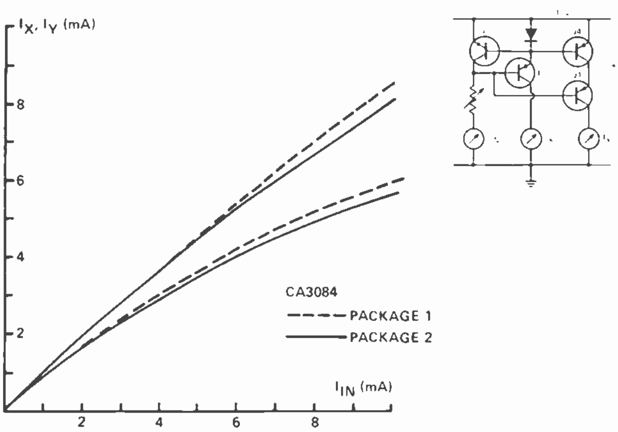


Fig. 6. Complex current mirror output matching test.

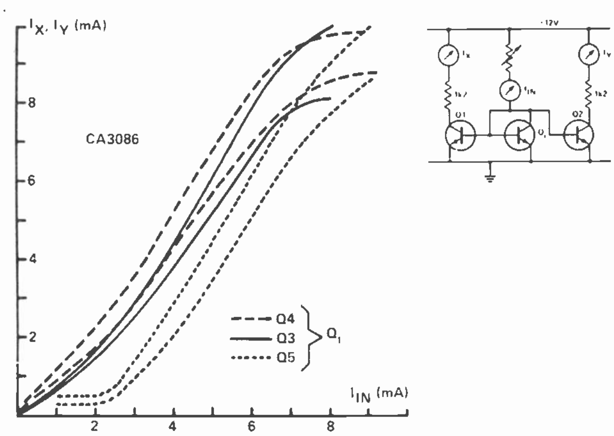


Fig. 7. Elementary current mirror — transistor matching.

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 necessary cause, the bias circuit has been split into two independent sources. In effect, this provides both bias and offset capabilities. Usually one would employ Darlingtons 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

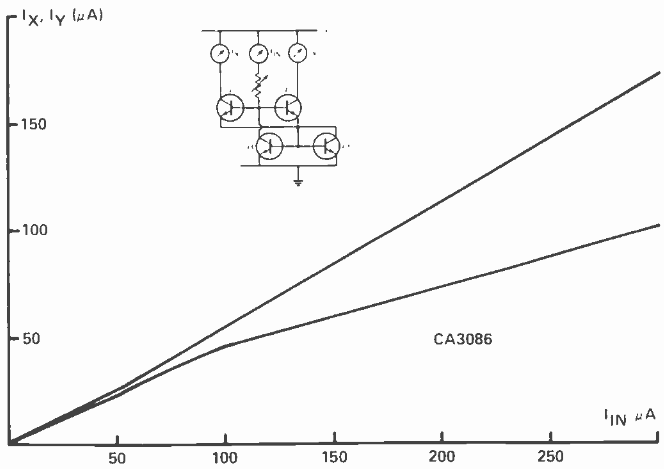


Fig. 8. Complex current mirror — output matching.

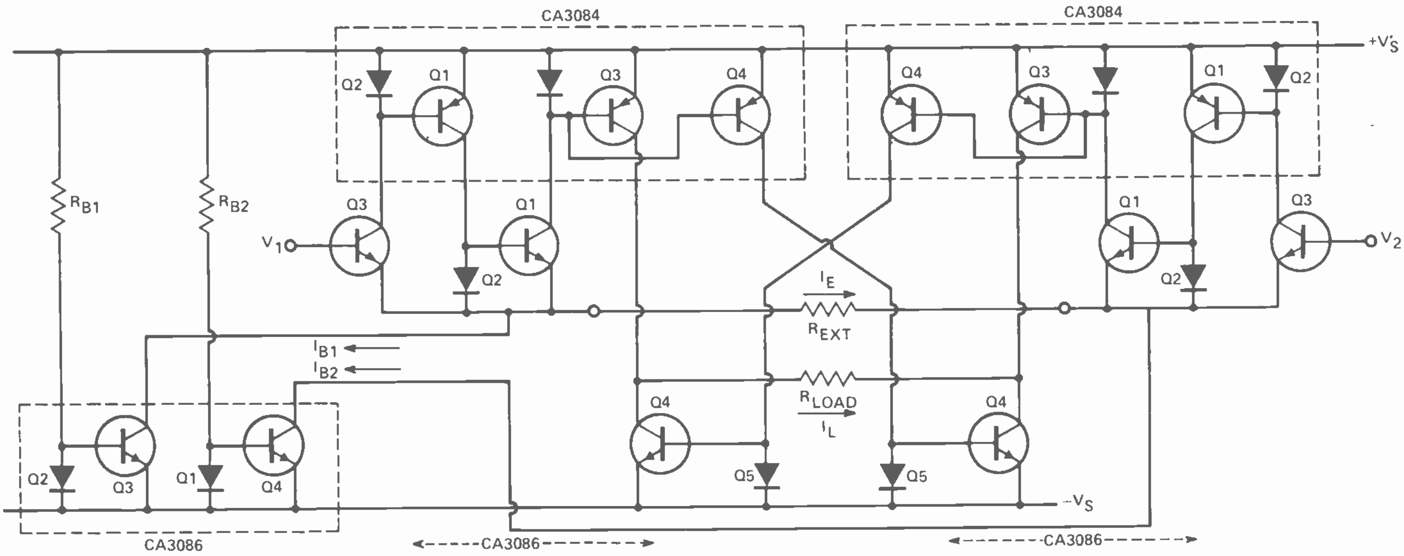


Fig. 9. Simplified VCT design employing IC transistor arrays.

(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. ▶

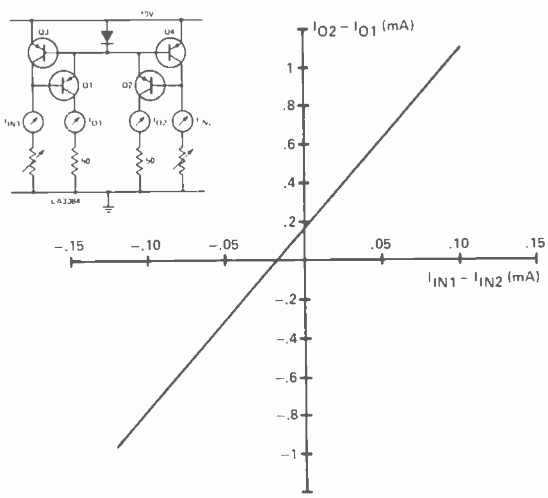
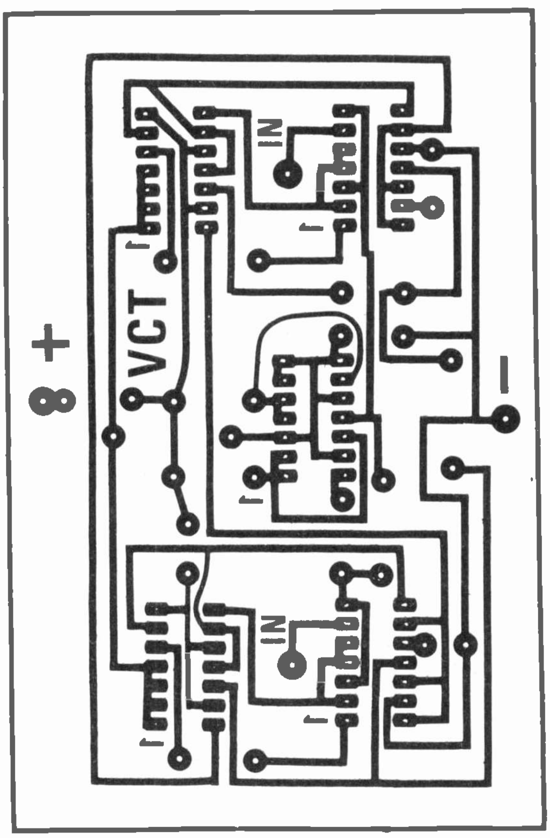


Fig. 10. Effect of linking current mirrors within the VCT.



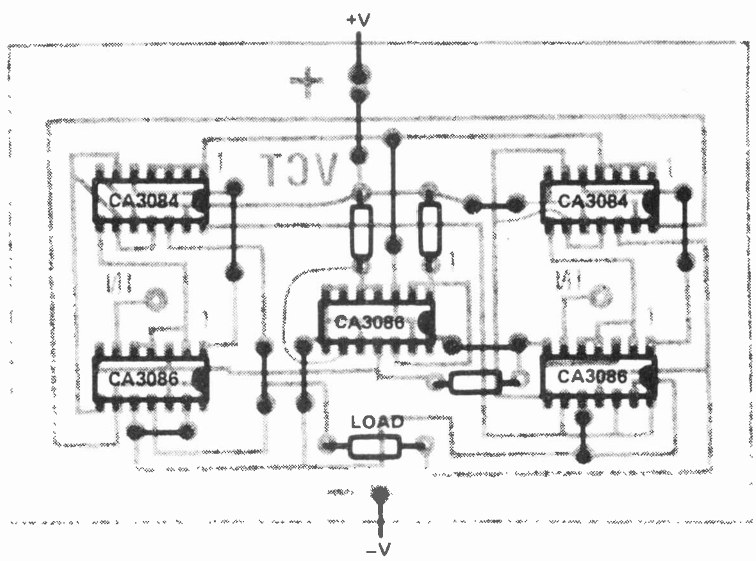


Fig. 11. PCB layout, showing external components, wire links, etc. — view from component side.

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 μA for VCTa and 40 μA 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

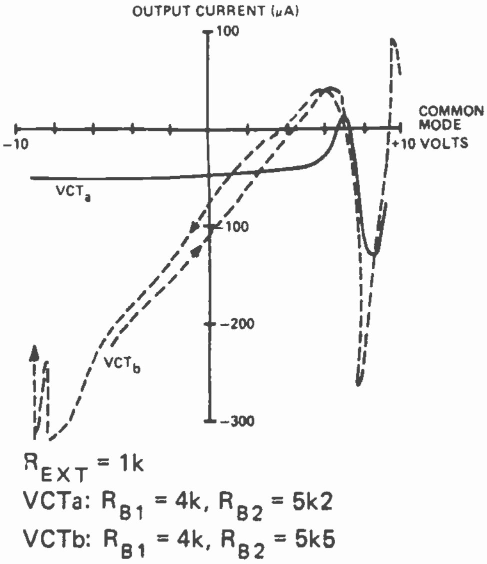


Fig. 12. Common mode signal transfer (V1 = V2).

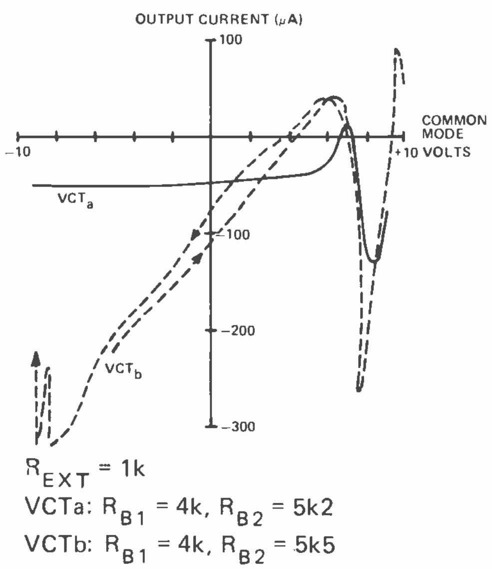


Fig. 13. Transfer characteristics.

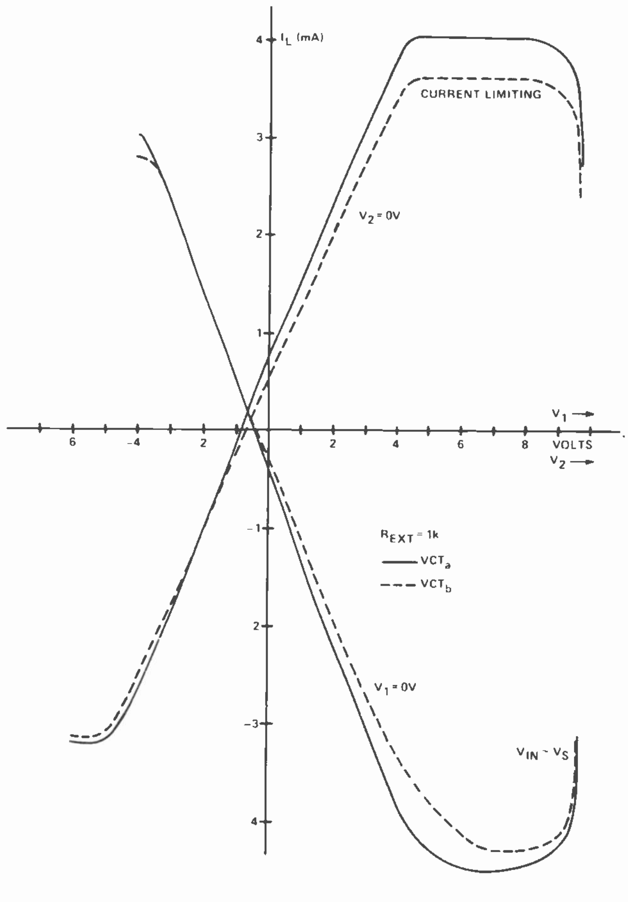


Fig. 14. Transfer characteristics with one end of the load grounded and with corresponding input grounded.

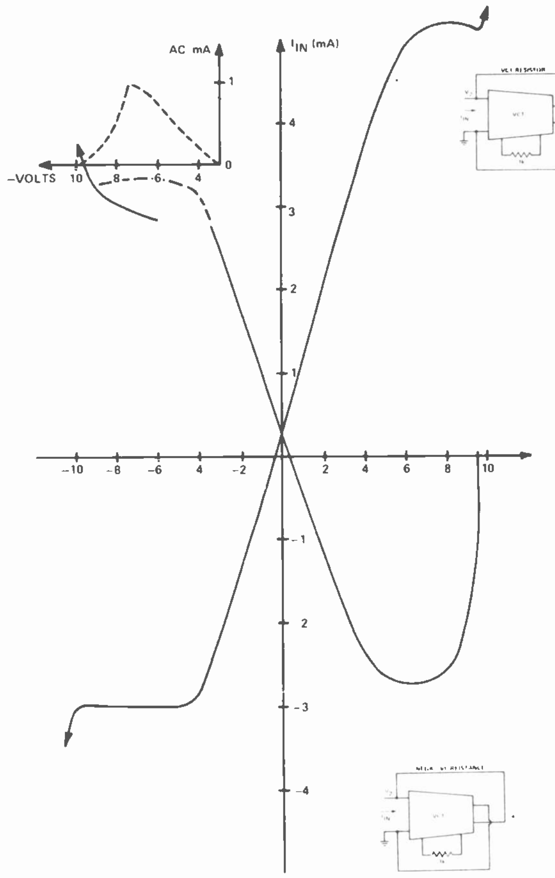


Fig. 16. VCT 'resistors' — positive and negative.

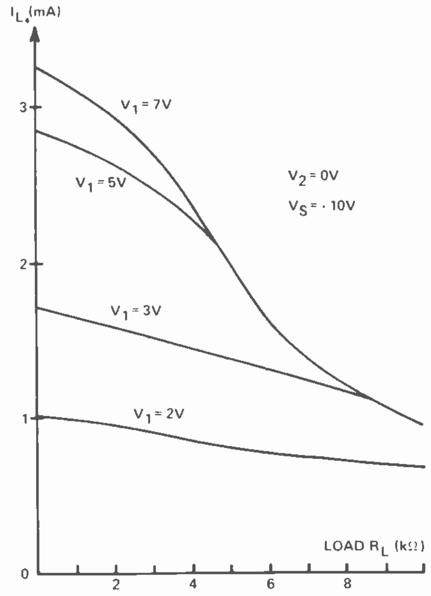


Fig. 15. Effect of output load resistance.

and the measured values (VCTa: 1mA / 12V and 6mA / 7.75V for R_{EXT} ¨10k, 1k exceed expectation slightly (c.f. 1mA / 15V, 6mA / 9V) due to a small current gain cuased by transistor mismatching. This effect also leads to small discrepancies from the expected current limit levels (e.g. ⅔ x 20V / 4k and ⅔ x 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 rezeroed if either end of the load is to be tied to a fixed potential as in Fig. 14.

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 aggrevates 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 substiantially 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 immittance conversion principle so it is instructive to consider the resistance applications of the VCT in Fig. 16 where the terminal resistances are expect to be $\pm\ ^2/_3\ R_{EXT}$. 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. ETI

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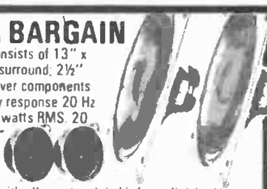

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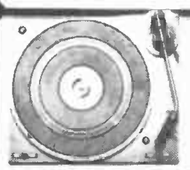

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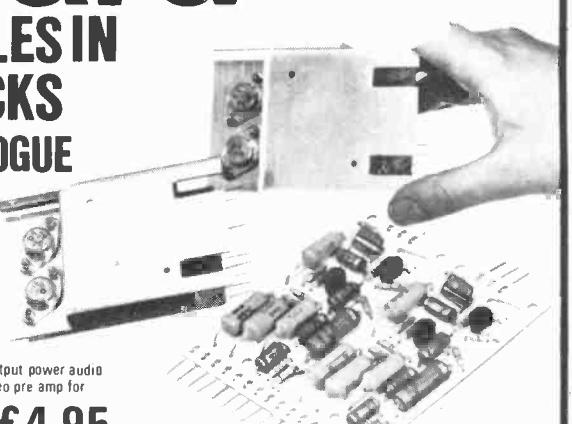

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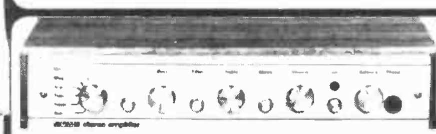

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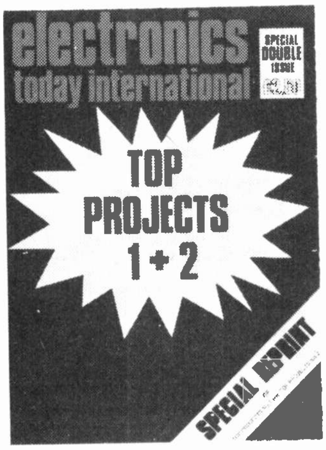

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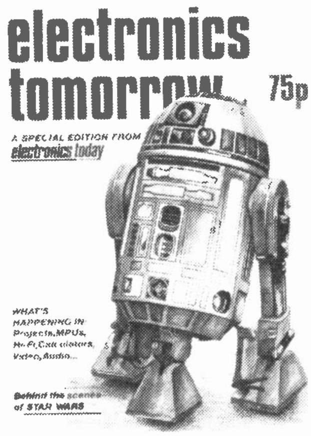

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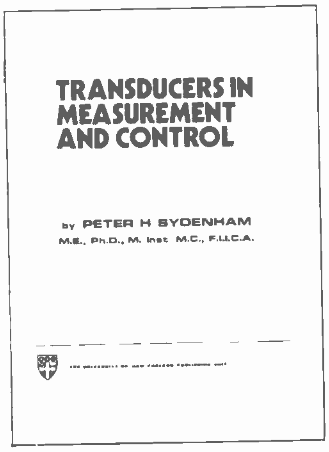

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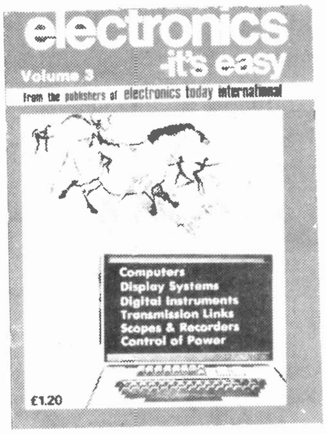

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TAPE NOISE LIMITER

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.

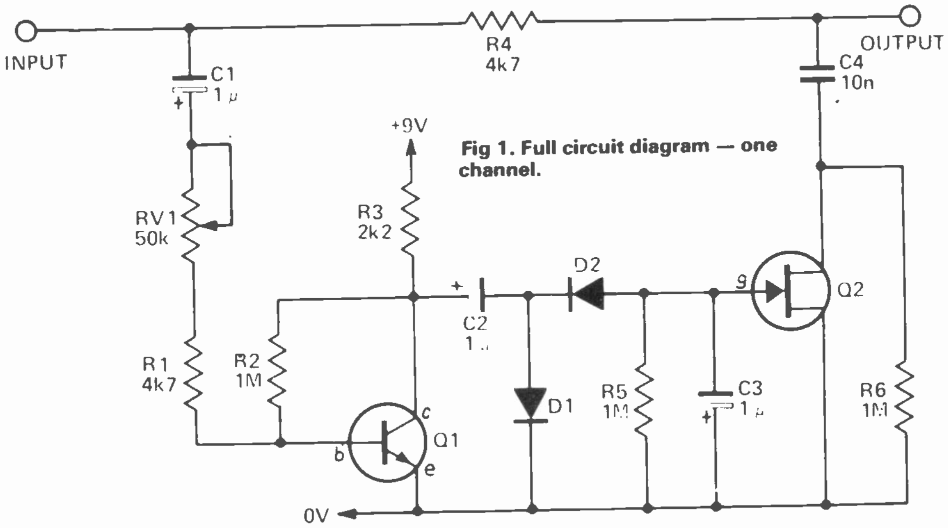


Fig 1. Full circuit diagram — one channel.

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.

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 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

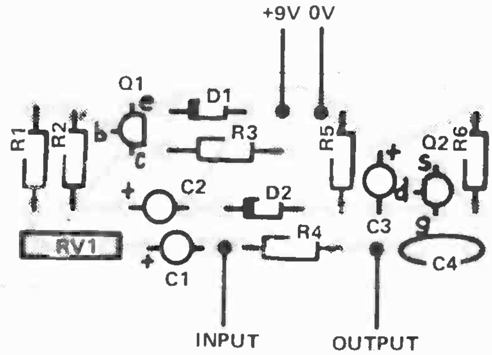
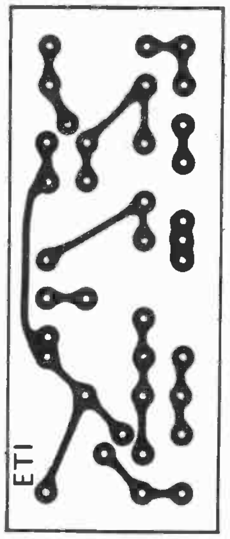


Fig 2. Above: Component overlay.



Foil pattern shown full size

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 uF 25 V
C4	10n polyester
TRANSISTORS	
Q1	BC548
Q2	2N5459
DIODE	
D1-D2	1N914
MISCELLANEOUS	
Nine volt battery and clip, PCB case.	

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 ususal 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 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.

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. Perhap's that's what encouraged the development of steam cars for 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

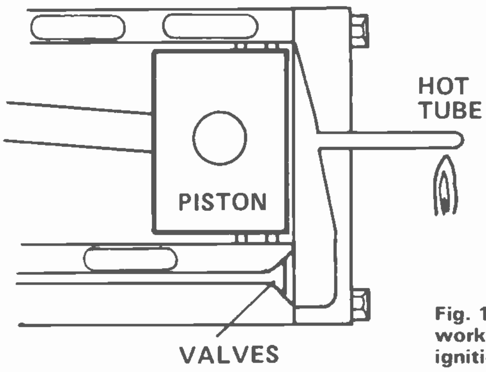


Fig. 1. Diagram of the workings of hot tube ignition.

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 ▶

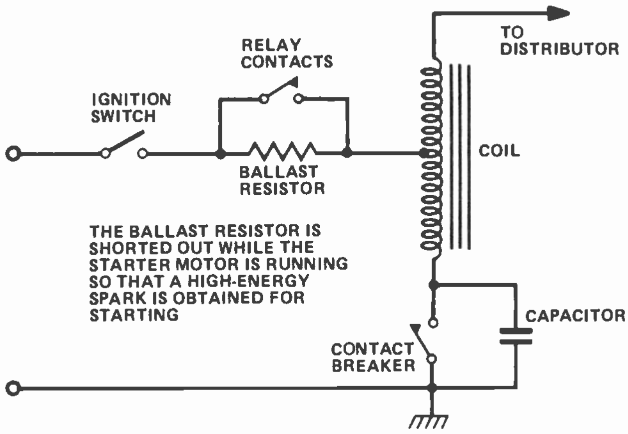


Fig 2. Simple electrical ignition

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

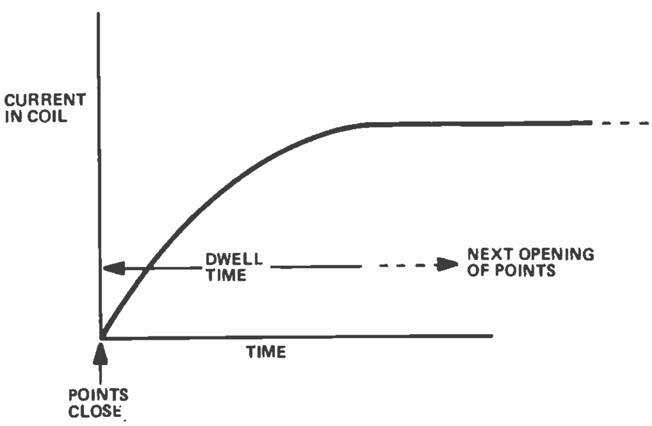
Make A Point Of It

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 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.

Fig 3. Graph of current through coil.



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

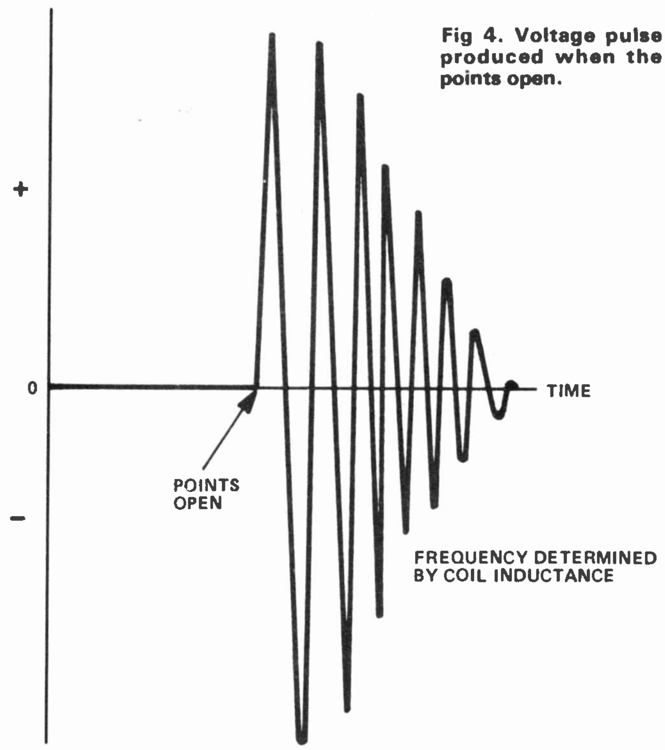


Fig 4. Voltage pulse produced when the points open.

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

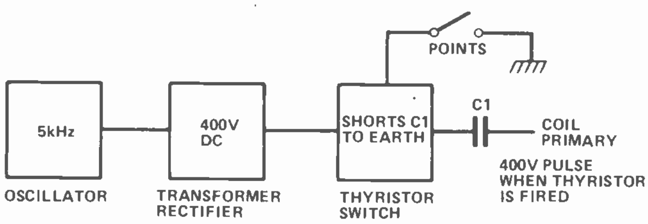


Fig 5. Typical modern system.

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 persuade 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

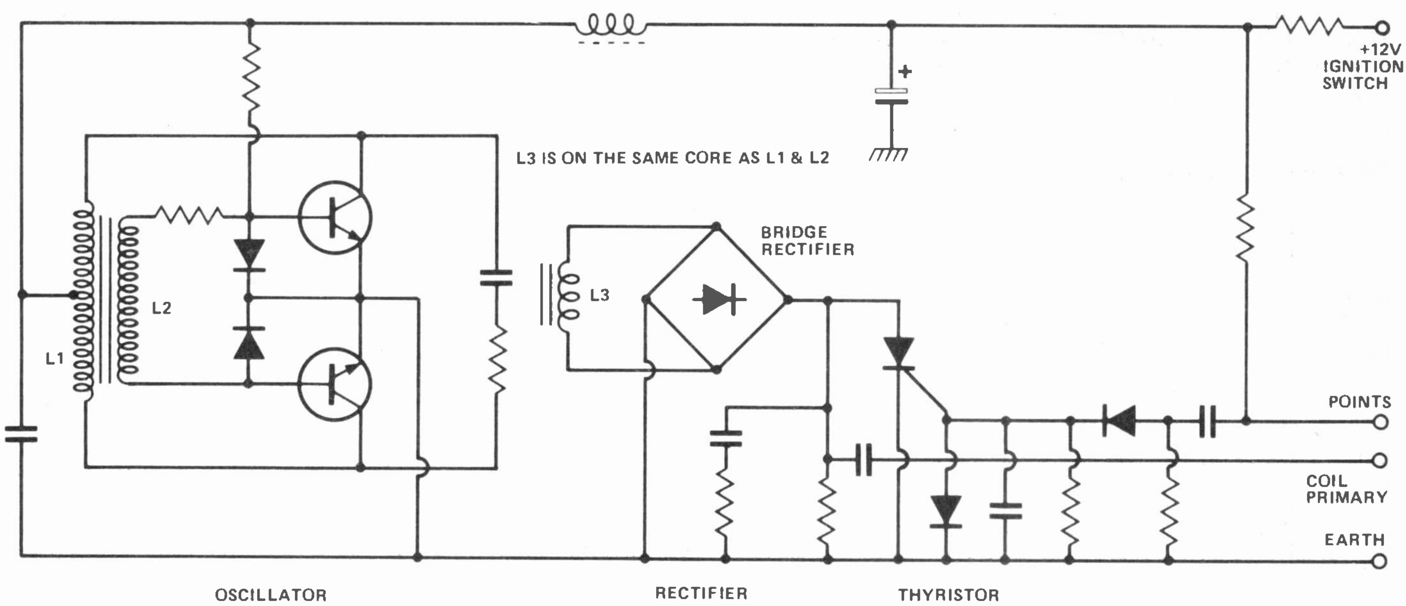
Many exaggerated claims are made for electronic ignition system, but the hard facts are that the main advantage is a longer time between ignition setting, particularly if the infra-red beam system is used. Cold starting can be better but only if the inverter uses a voltage regulator, which is rather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



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 tacho would be many times the power of such a motor. Also on some machines there is no convenient place a normal tacho can be fitted.

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

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.

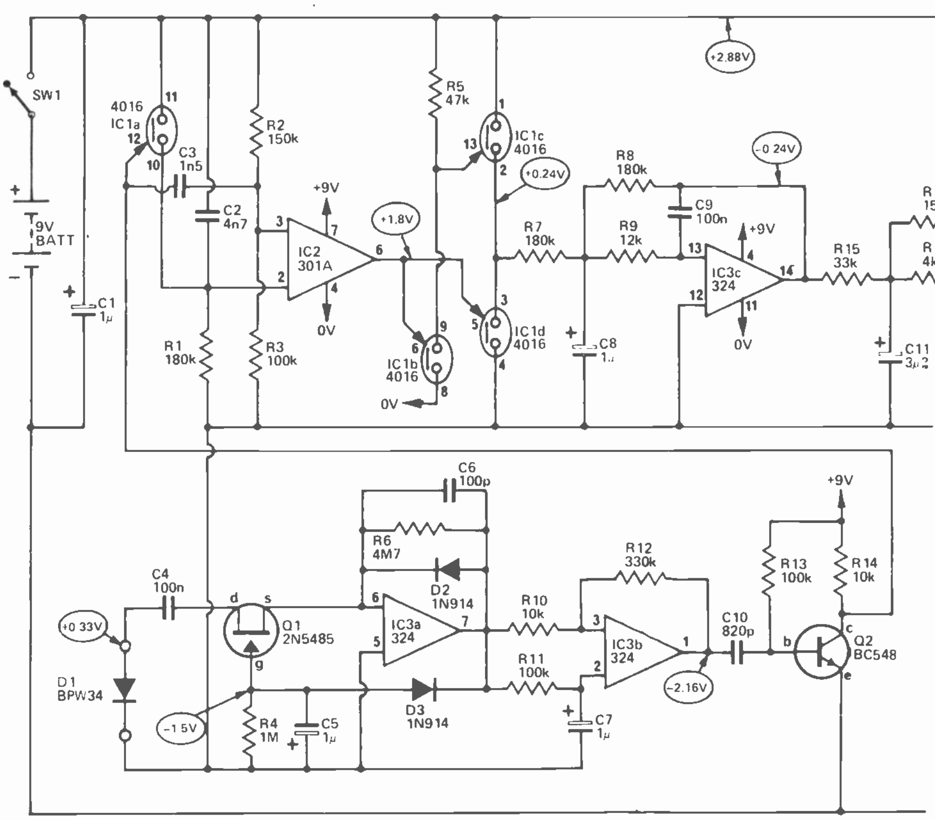
However the Intersil Evaluation kit which we have used in the past is fairly easy to get hold of, and so we based the design around this unit. This meant converting the pulses from the sensor into a voltage. This however has another benefit in that a greater resolution can be obtained more quickly. To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

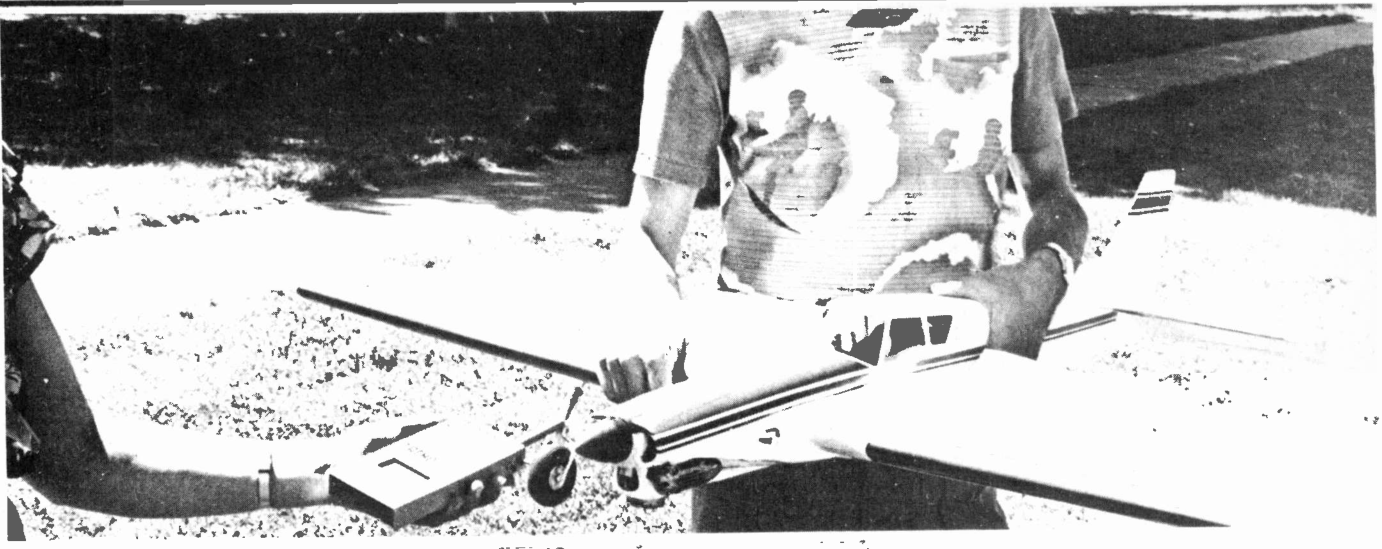
The use of the BPW34 photodiode in the photovoltaic mode, ie actually generating a voltage, simplifies the biasing otherwise needed.

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





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 Vref. 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 Vref. 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 Vref. 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.

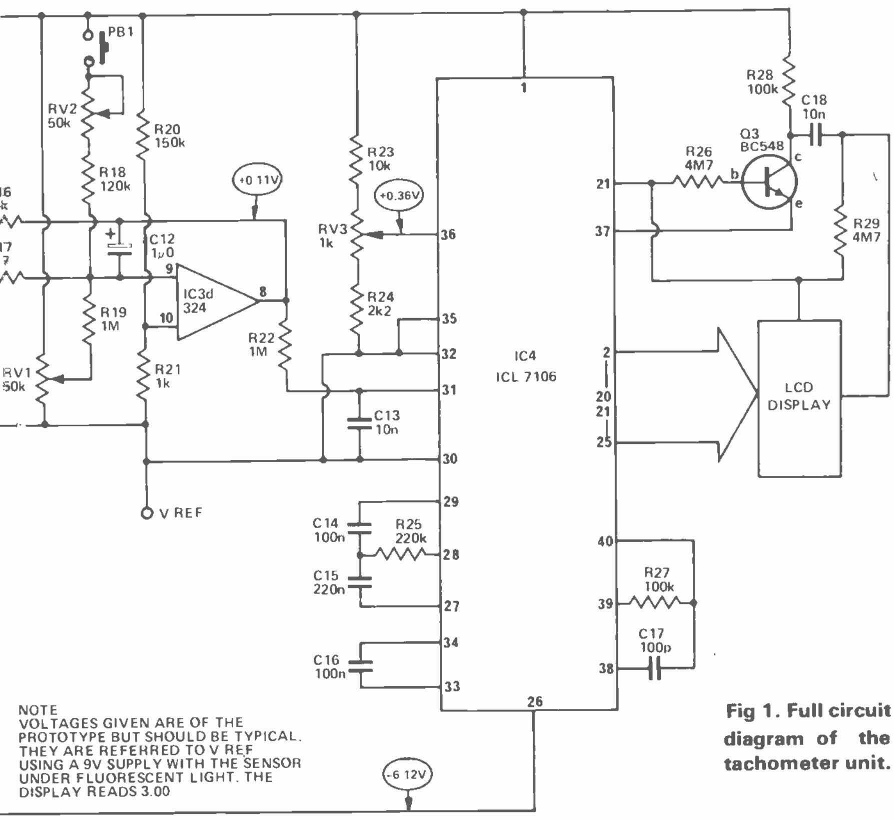


Fig 1. Full circuit diagram of the tachometer unit.

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 ¼ 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 Polystryene
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

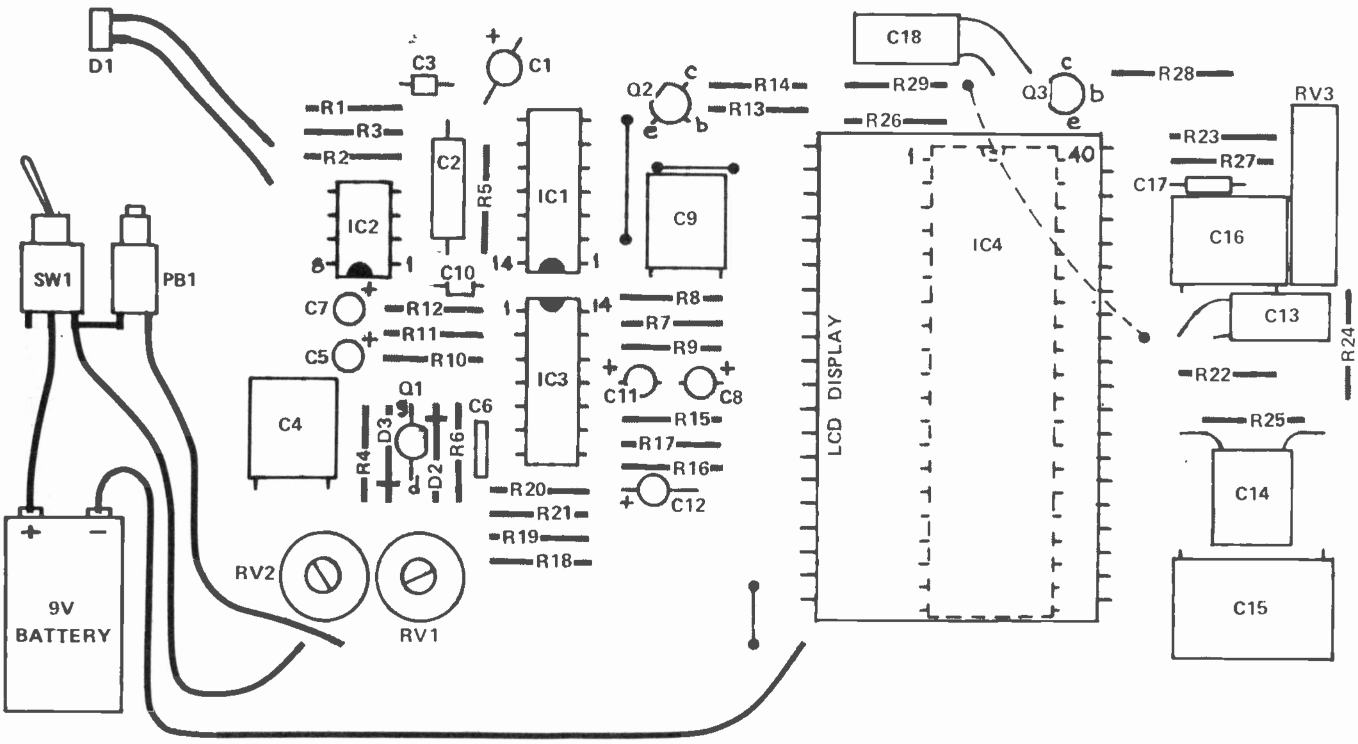
SEMICONDUCTORS

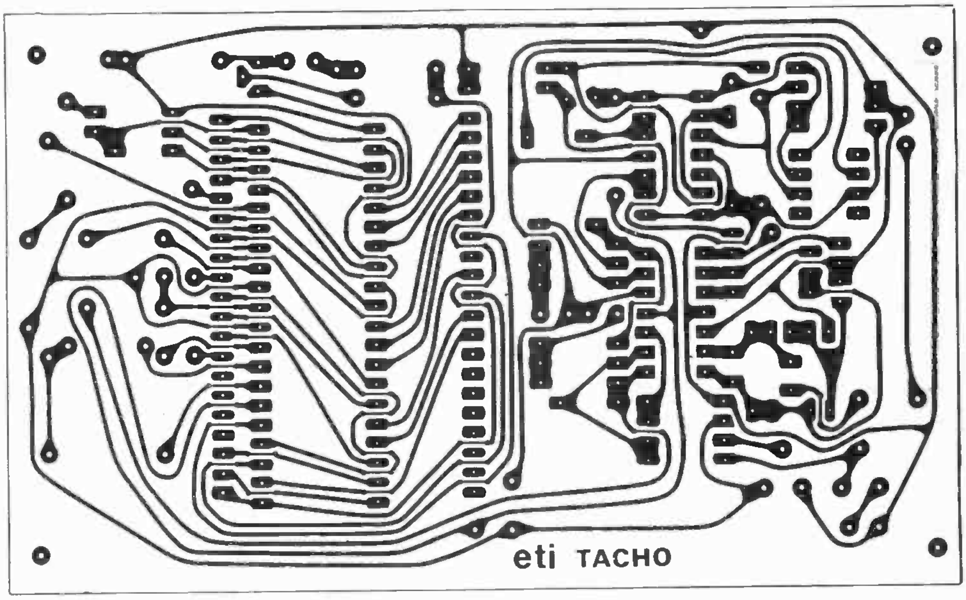
IC1	4016
IC2	301A
IC3	324
IC4	ICL 7106
Q1	2N5485
Q2, 3	BC548
D1	BPW34
D2, 3	1N914

MISCELLANEOUS

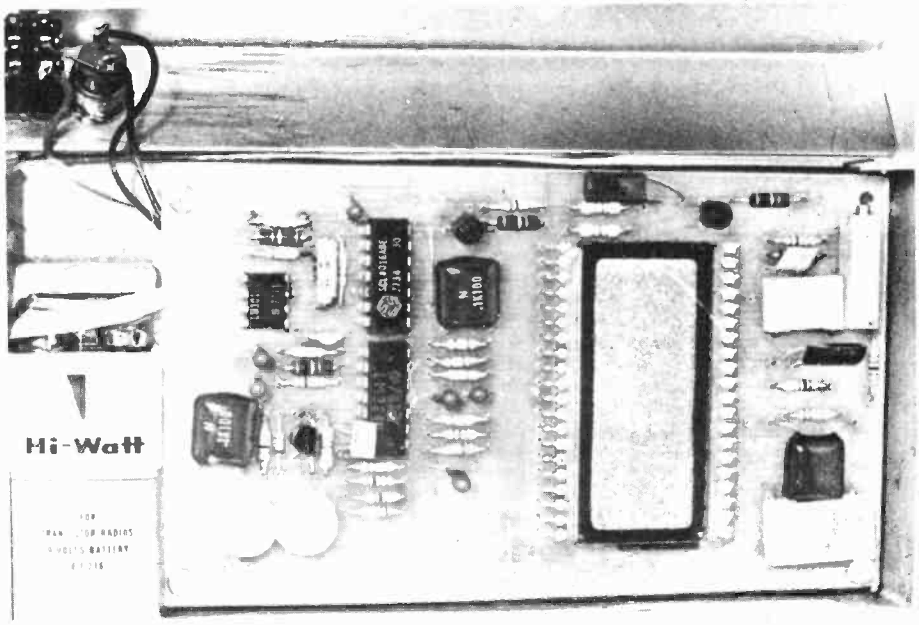
PCB, toggle switch, pushbutton, LCD display (evaluation kit?) case, battery clip.

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.





Above: full size foil pattern for the tacho unit.
Below: An assembled pCB. Comparing this with the overlay shown opposite should help with construction.



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 posible 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 propellors 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 input pulses is to be used, e.g. a three or four bladed propeller, the value of R1 can be changed. ($R1 \approx 360k$ / 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

data sheet

AY-5-1317A CHORD GENERATOR — NATIONAL

FEATURES

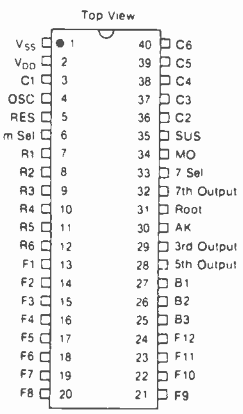
- ROOT, 3rd, 5th, 7th Chird Elements
- Additional output for special effects
- Sustain capability
- Top key priority
- Self-contained oscillator circuit
- Operated with single pole, single throw switch matrix

DESCRIPTION

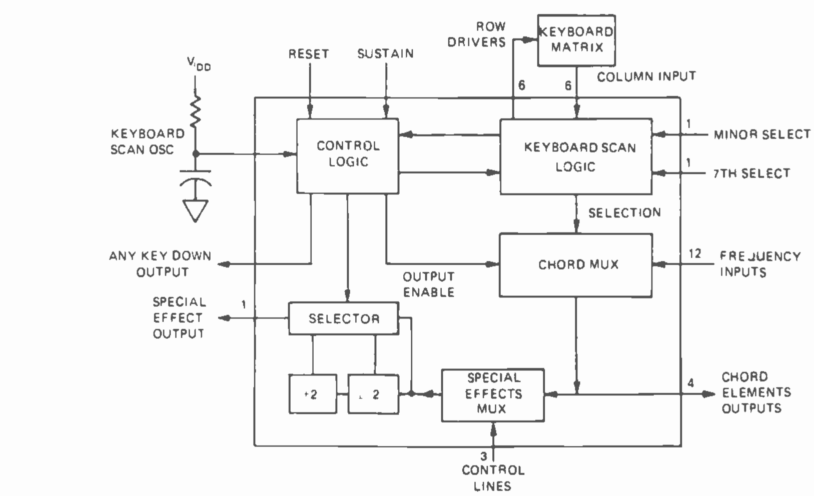
The AY-5-1317A is a P-Channel MOS IC which accepts twelve basic frequencies (one full octave) and outputs the notes necessary to form Major, Minor and Seventh chords. This is the only known standard chord generator IC that performs these functions. The chord elements (ROOT, 3rd, 4th, 5th, 6th and 7th) can be multiplexed internally to perform special effects such as walking bass, rhythm arpegio, laternating 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.

PIN CONFIGURATION

40 LEAD DUAL IN LINE



BLOCK DIAGRAM



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	VIL	V_{DD}	—	−8.5	
Logic 1	VIH	−1.0V	—	+0.3V	
Input Capacitance	CIN	—	—	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)	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.

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

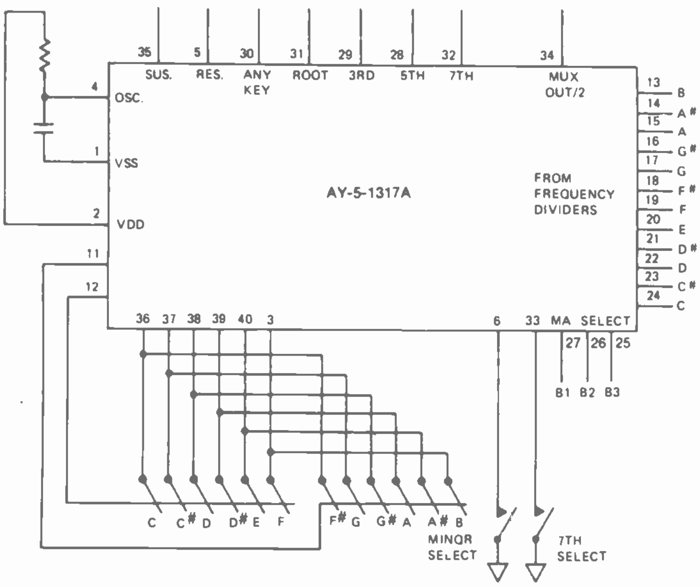
Pin No.	Name (Symbol)	Function
28	5th Output (5th)	This line will output the 5th frequency element of the selected chord.
29	3rd Output (3rd)	This line will output the 3rd frequency element of the selected chord. Minor 3rd will be provided if a Minor chord is selected. Major 3rd will be provided if a 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

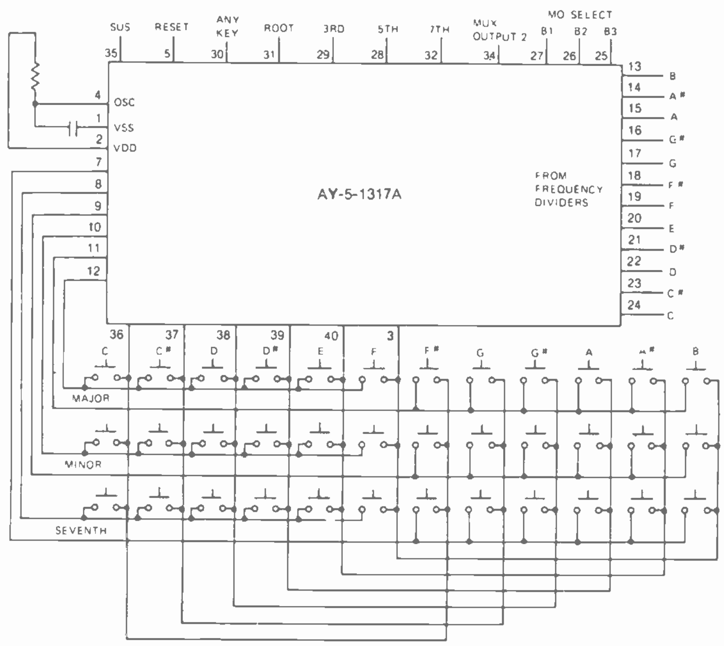
	FREQUENCY OUTPUTS						
Chord Selection	Root	3rd Minor	3rd Major	4th	5th	6th	7th
C	C (÷2)	D# (÷2)	E (÷2)	F (÷2)	G (÷2)	A (÷2)	A# (÷2)
C#	C# (÷2)	E (÷2)	F (÷2)	F# (÷2)	G# (÷2)	A# (÷2)	B (: 2)
D	D (÷2)	F (÷2)	F# (÷2)	G (÷2)	A (÷2)	B (÷2)	C (÷1)
D#	D# (÷2)	F# (÷2)	G (÷2)	G# (÷2)	A# (÷2)	C (÷1)	C# (÷1)
E	E (÷2)	G (÷2)	G# (÷2)	A (÷2)	B (÷2)	C# (÷1)	D (÷1)
F	F (÷2)	G# (÷2)	A (÷2)	A# (÷2)	C (÷1)	D (÷1)	D# (÷1)
F#	F# (÷4)	A (÷4)	A# (÷4)	B (÷4)	C# (÷2)	D# (÷2)	E (÷2)
G	G (÷4)	A# (÷4)	B (÷4)	C (÷2)	D (÷2)	E (÷2)	F (÷2)
G#	G# (÷4)	B (÷4)	C (÷2)	C# (÷2)	D# (÷2)	F (÷2)	F# (÷2)
A	A (÷4)	C (÷2)	C# (÷2)	D (÷2)	E (÷2)	F# (÷2)	G (÷2)
A#	A# (÷4)	C# (÷2)	D (÷2)	D# (÷2)	F (÷2)	G (÷2)	G# (÷2)
B	B (÷4)	D (÷2)	D# (÷2)	E (÷2)	F# (÷2)	G# (÷2)	A (÷2)

NATIONAL

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



STANDARD INTERCONNECTION FOR A 3×12 KEY MATRIX



Marshall's Electronics

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Glasgow: 85 West Regent Street, G2 2QD. Tel: 041-332 4133. Bristol: 1 Straits Parade, Fishponds Road, B516 2LX. Tel: 0272 654201.

TRANSISTORS

				2N3393	0.17
2N696	0.39	2N2218	0.35	2N3394	0.17
2N697	0.31	2N2218A	0.38	2N3395	0.19
2N698	0.49	2N2219	0.38	2N3396	0.19
2N699	0.58	2N2219A	0.39	2N3397	0.19
2N706	0.30	2N2220	0.39	2N3438	0.85
2N706A	0.30	2N2221	0.25	2N3440	0.75
2N708	0.30	2N2221A	0.25	2N3441	0.92
2N718	0.30	2N2222	0.25	2N3442	1.45
2N718A	0.54	2N2222A	0.25	2N3638	0.17
2N720A	0.85	2N2369	0.27	2N3638A	0.17
2N722	0.45	2N2369A	0.27	2N3702	0.14
2N727	0.50	2N2646	0.80	2N3703	0.14
2N914	0.38	2N2647	1.55	2N3704	0.14
2N916	0.33	2N2903	1.60	2N3705	0.14
2N917	0.38	2N2904	0.31	2N3706	0.14
2N918	0.45	2N2904A	0.31	2N3707	0.14
2N929	0.37	2N2905	0.31	2N3708	0.12
2N929A	0.37	2N2905A	0.31	2N3709	0.12
2N930	0.37	2N2906	0.25	2N3771	2.16
2N930A	0.95	2N2906A	0.25	2N3772	2.20
2N1711	0.30	2N2907	0.25	2N3773	3.15
2N1889	0.30	2N2907A	0.25	2N3819	0.36
2N1890	0.30	2N2923	0.17	2N3820	0.39
2N1893	0.30	2N2924	0.17	2N3821	0.96
2N2102	0.50	2N2925	0.19	2N3900	0.28
2N2192	0.58	2N2926	0.17	2N3901	0.30
2N2193	0.50	2N3053	0.25	2N3903	0.20
2N2193A	0.52	2N3054	0.72	2N3904	0.18
2N2194	0.42	2N3055	0.75	2N3905	0.18
2N2194A	0.45	2N3390	0.50	2N3906	0.18
2N2195	0.40	2N3391	0.40	2N4031	0.55
2N2195A	0.40	2N3391A	0.45	2N4032	0.65
2N2217	0.55	2N3392	0.17	2N4036	0.72

2N4037	0.60	2N5192	0.80	2N6124	0.45
2N4058	0.22	2N5193	0.75	2N6125	0.47
2N4059	0.17	2N5194	0.80	40361	0.55
2N4060	0.22	2N5195	0.97	40362	0.55
2N4061	0.19	2N5245	0.37	40363	1.45
2N4062	0.20	2N5246	0.38	40408	0.82
2N4064	1.35	2N5247	0.44	40409	0.82
2N4074	2.65	2N5248	0.44	40410	0.82
2N4121	0.27	2N5294	0.44	40411	3.10
2N4122	0.27	2N5295	0.44	40594	0.87
2N4123	0.19	2N5296	0.44	40595	0.98
2N4124	0.19	2N5298	0.44	40673	0.80
2N4125	0.19	2N5447	0.16	40669	1.30
2N4126	0.19	2N5448	0.16	AC126	0.48
2N4284	0.38	2N5449	0.20	AC127	0.48
2N4286	0.22	2N5457	0.38	AC128	0.48
2N4287	0.22	2N5458	0.35	AC151	0.43
2N4288	0.22	2N5459	0.32	AC152	0.54
2N4289	0.22	2N5460	0.65	AC153	0.59
2N4347	2.20	2N5484	0.37	AC153K	0.59
2N4348	2.65	2N5485	0.40	AC176K	0.70
2N4918	0.65	2N5486	0.40	AC176	0.54
2N4919	0.70	2N5490	0.64	AC187	0.59
2N4920	0.83	2N5492	0.64	AC187K	0.65
2N4921	0.54	2N5494	0.65	AC188	0.54
2N4922	0.60	2N5496	0.67	AC188K	0.65
2N4923	0.75	2N6027	0.64	AD161	1.00
2N4924	1.15	2N6107	0.45	AD162	1.00
2N5086	0.30	2N6108	0.55	AF106	0.60
2N5087	0.30	2N6109	0.55	AF109	0.52
2N5088	0.30	2N6111	0.49	BC107	0.16
2N5069	0.30	2N6121	0.41	BC107A	0.16
2N5190	0.65	2N6122	0.44	BC107B	0.16
2N5191	0.75	2N6123	0.48	BC108	0.16

BC108A	0.16	BC178B	0.35		
BC108B	0.16	BC179	0.25	BC213L	0.17
BC108C	0.17	BC179A	0.25	BC213LA	0.17
BC109	0.16	BC179B	0.25	BC213LB	0.17
BC109B	0.17	BC179C	0.26	BC213LC	0.17
BC109C	0.18	BC182	0.12	BC214	0.17
BC140	0.30	BC182A	0.12	BC214B	0.17
BC141	0.32	BC182B	0.13	BC214C	0.17
BC147	0.13	BC182L	0.15	BC214L	0.18
BC147B	0.13	BC182LA	0.15	BC214LB	0.18
BC148	0.13	BC182LB	0.15	BC214LC	0.18
BC148B	0.13	BC183	0.12	BC237B	0.15
BC148C	0.13	BC183A	0.12	BC238A	0.13
BC149	0.15	BC183B	0.13	BC238B	0.13
BC149C	0.15	BC183C	0.13	BC238C	0.13
BC157A	0.15	BC183L	0.15	BC239B	0.16
BC158A	0.15	BC183LA	0.15	BC239C	0.17
BC158B	0.15	BC183LB	0.15	BC257A	0.18
BC159A	0.17	BC183LC	0.15	BC258B	0.19
BC159B	0.17	BC184	0.12	BC259B	0.19
BC160	0.38	BC184B	0.13	BC300	0.43
BC161	0.38	BC184C	0.13	BC301	0.43
BC167	0.13	BC184L	0.15	BC302	0.37
BC167B	0.13	BC184LB	0.15	BC303	0.54
BC168A	0.13	BC184LC	0.15	BC307	0.16
BC168B	0.13	BC212	0.15	BC307A	0.16
BC168C	0.13	BC212A	0.15	BC307B	0.16
BC169B	0.13	BC212B	0.15	BC308	0.16
BC169C	0.13	BC212L	0.18	BC308B	0.16
BC177	0.22	BC212LA	0.18	BC309A	0.16
BC177A	0.22	BC212LB	0.18	BC309B	0.16
BC177B	0.25	BC213	0.15	BC309C	0.16
BC178	0.22	BC213A	0.15	BC327	0.22
BC178A	0.25	BC213B	0.15	BC328	0.20

BC337	0.20	BD240A	0.49	BF160	0.33
BC338	0.23	BD240C	0.59	BF161	0.65
BC547	0.13	BD241A	0.49	BF167	0.37
BC547A	0.13	BD241C	0.65	BF173	0.37
BC547B	0.13	BD242A	0.55	BF177	0.27
BC548	0.13	BD242C	0.62	BF178	0.27
BC549	0.14	BD243A	0.65	BF179	0.33
BC549B	0.14	BD243C	0.87	BF180	0.37
BC549C	0.15	BD244A	0.70	BF181	0.37
BC557	0.14	BD244C	0.87	BF182	0.37
BC558	0.13	BD245A	0.69	BF183	0.44
BC559	0.15	BD245C	0.85	BF184	0.41
BCY70	0.21	BD246A	0.72	BF185	0.37
BCY71	0.26	BD246C	0.93	BF194	0.16
BCY72	0.18	BD433	0.44	BF195	0.16
BD115	0.88	BD434	0.46	BF196	0.16
BD131	0.55	BD435	0.46	BF197	0.18
BD132	0.75	BD436	0.46	BF198	0.19
BD135	0.40	BD437	0.55	BF199	0.19
BD136	0.40	BD438	0.55	BF224J	0.22
BD137	0.41	BD529	0.49	BF225J	0.27
BD138	0.41	BD530	0.55	BF244A	0.38
BD139	0.43	BD535	0.70	BF244B	0.33
BD140	0.43	BD536	0.70	BF245A	0.44
BD181	1.90	BD537	0.74	BF245B	0.44
BD182	2.20	BD538	0.77	BF257	0.35
BD183	2.35	BD539	0.60	BF258	0.35
BD187	0.95	BD540	0.60	BF259	0.35
BD235	0.46	BDX14	1.32	BF336	0.42
BD236	0.44	BDX18	1.90	BF337	0.49
BD237	0.44	BDY20	1.10	BF338	0.52
BD238	0.44	BDY55	1.90	BFR39	0.30
BD239A	0.44	BDY56	2.10	BF240	0.29
BD239C	0.59	BF115	0.39	BFR41	0.30

BFR79	0.30	ME4001	0.16	TIP30C	0.70
BFR80	0.30	ME4002	0.16	TIP31A	0.54
BFR81	0.30	ME4003	0.16	TIP31C	0.72
BFX29	0.34	ME4101	0.11	TIP32A	0.59
BFX30	0.34	ME4102	0.11	TIP32C	0.82
BFX84	0.30	ME4103	0.11	TIP41A	0.76
BFX85	0.38	ME4104	0.11	TIP41C	0.97
BFX86	0.30	ME6101	0.22	TIP42A	0.86
BFX87	0.35	ME6102	0.22	TIP42C	1.08
BFX88	0.30	MJ2955	1.35	TIP2955	0.70
BFX89	1.37	MJE340	0.62	TIP3055	0.59
BFY50	0.27	MJE370	0.62	TIS34	1.05
BFY51	0.27	MJE371	0.86	TIS42	0.50
BFY52	0.27	MJE520	0.50	TIS43	0.47
BFY90	1.35	MJE521	0.70	TIS90	0.22
BR101	0.55	MJE2955	1.65	TIS91	0.27
BRY39	0.55	MPF3055	1.05	TIS92	0.33
BSX19	0.35	MPF102	0.33	TIS93	0.36
BSX20	0.35	MPF103	0.44	ZTX300	0.17
BSX21	0.35	MPF104	0.44	ZTX301	0.17
BU104	1.80	MPSA05	0.44	ZTX302	0.27
BU105	1.55	MPSA05	0.27	ZTX303	0.27
BU126	1.08	MPSA06	0.27	ZTX304	0.27
BU204	2.20	MPSA12	0.44	ZTX330	0.22
BU205	2.40	MPSA14	0.33	ZTX500	0.16
BU206	2.70	MPSA55	0.27	ZTX530	0.25
BU208	2.70	MPSA56	0.27		
ME0401	0.22	R2008B	2.45		
ME0402	0.22	R2010B	2.15		
ME0404	0.17	TIP29A	0.49		
ME0412	0.22	TIP29C	0.65		
ME0414	0.22	TIP30A	0.54		

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LINEAR CIRCUITS

CA3018	0.75	LM379S	4.25	LM7815K	1.75	TBA530	2.35
CA3018A	1.10	LM380N8	0.96	LM7824K	1.75	TBA530Q	2.45
CA3020	2.20	LM380N14	1.08	LM78L05CZ	0.30	TBA540	2.60
CA3020A	2.50	LM381AN	2.70	LM78L12CZ	0.30	TBA540Q	2.70
CA3028A	0.90	LM381N	1.69	LM78L15CZ	0.30	TBA550	3.60
CA3028B	1.25	LM382N	1.32	MM5314	4.60	TBA550Q	3.80
CA3030	1.50	LM384N	1.55	MM5316	4.60	TBA5600Q	3.00
CA3030A	2.20	LM386N	0.88	NE555	0.33	TBA570	2.10
CA3038	2.90	LM387N	1.10	NE556	0.85	TBA570Q	2.20
CA3038A	4.10	LM388N	1.00	NE558N	1.98	TBA700Q	2.20
CA3045	1.55	LM389N	1.00	NE560	4.50	TBA720AQ	2.06
CA3046	0.77	LM702C	0.81	NE561	4.50	TBA750	2.36
CA3048	2.45	LM709	0.70	NE562	4.50	TBA750Q	2.45
CA3052	1.78	LM709B	0.50	NE565	1.39	TBA800	1.30
CA3080	0.85	LM70914	0.49	NE566	1.75	TBA810S	1.30
CA3080A	2.10	LM710	0.67	NE567	1.90	TBA820	0.80
CA3086	0.50	LM71014	0.64	NE571N	4.95	TBA920	2.99
CA3088B	1.87	LM711CN	0.72	SAS560	2.70	TCA160C	2.36
CA3089B	2.90	LM723C	0.75	SAS570	2.70	TCA160B	2.55
CA3090Q	4.40	LM723C14	0.45	SAJ110	2.10	TCA270	2.99
CA3130	1.06			S041P	1.35	TCA730	4.50
CA3140	1.04	LM741C	0.70	S042P	1.35	TCA740	4.50
LM301	0.30	LM741C8	0.30	SN76001N	1.30	TCA750	3.00
LM307N	0.50	LM741C14	0.30	SN76003N	2.38	TCA760	2.00
LM308N	0.95	LM747CN	0.99	SN76013N	1.50	TCA105	1.49
LM309KC	1.95	LM7488	0.50	SN76023N	1.50	TCA440	1.65
LM317K	3.35	LM74814	0.90	SN76033N	2.35	TDA1022	7.50
LM318N	2.45	LM1303N	1.15	TAA263	1.35	TDA1024	1.24
LM320T5	2.15	LM1304N	1.52	TAA300	3.70	TDA1034	4.75
LM320T12	2.15	LM1305N	1.52	TAA320A	1.15	TDA2020A0	4.50
LM320T15	2.15	LM1307N	1.22	TAA350A	3.00	UAA170	2.15
LM320T24	2.15	LM1310N	2.10	TAA521	1.10	UAA180	2.15
LM320P5	1.15	LM1351N	1.30	TAA522	2.10	TL080CP	1.25
LM320P12	1.15	LM1458N	0.45	TAA550	0.48	TL081CP	0.90
LM320P15	1.15	LM1496N	0.97	TA560	2.10	TL082CP	1.10
LM320P24	1.15	LM1808N	2.10	TAA570	2.20	TL083CN	1.40
LM323K	6.95	LM1812N	6.20	TAA370A	5.45	TL084CN	1.45
LM339N	0.60	LM1820N	1.16	TAA630	2.40	LF355N	0.80
LM340T5	0.88	LM1828N	1.90	TAA960	3.90	LF356N	0.80
LM340T15	0.88	LM1830N	1.90	TAA970	4.20	LF357N	0.80
LM340T24	0.88	LM1841N	1.90	TAA611B	2.50	LF13201N	3.00
LM341P5	0.80	LM1845N	1.50	TAA621	2.50	LF13331N	3.00
LM341P12	0.80	LM1848N	1.98	TAA661A	1.65	LF13741H	0.80
LM341P15	0.80	LM1850N	1.90	TAA661B	1.45	LF13741N	0.55
LM341P24	0.80	LM1889N	4.90	TAA700	4.50		
LM348N	0.95	LM3301N	0.60	TAA930A	1.45		
LM358N	0.60	LM3302N	0.55	TAA930B	1.45		
LM360N	3.00	LM3401N	0.55	TAD100	2.00		
LM370N	3.30	LM3900N	0.68	TBA120	0.80		
LM371H	2.35	LM3905N	1.15	TBA500	2.24		
LM350K	6.45	LM3909N	0.78	TBA500Q	2.34		
LM373N	3.35	LM3911N	1.10	TBA510	2.35		
LM374N	3.36	LM7805K	1.75	TBA510Q	2.48		
LM377N	1.80	LM7812K	1.75	TBA520	2.60		
LM378N	2.40	LM324	0.75	TBA520Q	2.70		

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		4022B	1.00	4051B	0.85	4078	0.27
4000	0.22	4023B	0.22	4052B	0.86	4081B	0.24
4001B	0.22	4024B	0.76	4053B	0.98	4082	0.27
4002	0.22	4025B	0.22	4054	1.48	4085	0.89
4006	1.25	4027B	0.55	4055	1.65	4086	0.89
4007	0.22	4028B	0.92	4056	1.65	4089B	2.10
4008B	0.99	4029B	1.10	4059	6.00	4093B	1.00
4009	0.58	4030	0.84	4060B	1.15	4094	2.30
4010	0.58	4031B	2.25	4063	1.35	4095	1.30
4011B	0.22	4035B	1.30	4066B	0.75	4096	1.30
4012	0.22	4037	1.20	4067	4.85	4097	4.65
4013B	0.52	4041B	0.85	4068	0.27	4098	1.00
4014	1.00	4042B	0.86	4069B	0.24	4510B	1.20
4015	1.05	4043	1.05	4070B	0.85	4511	1.75
4016	0.52	4044	1.00	4071B	0.24	4516	2.10
4017B	105	4045	1.76	4072	0.27	4518B	1.20
4018B	1.05	4046B	1.50	4073B	0.24		
4019B	0.52	4047B	0.96	4075B	0.24		
4020B	1.15	4049	0.96	4076B	0.99		

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74LS00N	0.26	74LS168N	2.43	7404N	0.17	7496N	0.70
74LS01N	0.26	74LS169N	2.43	7405N	0.22	7497N	1.95
74LS02N	0.26	74LS174N	1.33	7406N	0.56	74100N	1.40
74LS03N	0.26	74LS175N	1.26	7407N	0.55	74107N	0.35
74LS04N	0.29	74LS181N	3.95	7408N	0.22	74118N	0.95
74LS10N	0.26	74LS189N	3.74	7409N	0.22	74119N	1.40
74LS12N	0.26	74LS190N	1.00	7410N	0.20	74121N	0.28
74LS13N	0.58	74LS191N	1.00	7411N	0.26	74122N	0.55
74LS14N	1.43	74LS192N	1.98	7412N	0.20	74123N	0.55
74LS20N	0.26	74LS193N	1.98	7413N	0.36	74125N	0.45
74LS26N	0.39	74LS196N	1.28	7414N	0.80	74141N	0.86
74LS27N	0.50	74C00N	0.24	7416N	0.36	74148N	1.35
74LS28N	0.42	74C02N	0.24	7417N	0.36	74145N	0.86
74LS30N	0.26	74C04N	0.24	7420N	0.22	74150N	1.20
74LS37N	0.32	74C08N	0.24	7423N	0.32	74151N	0.76
74LS38N	0.32	74C10N	0.24	7425N	0.32	74153N	0.76
74LS40N	0.29	74C14N	1.41	7427N	0.32	74154N	1.20
74LS42N	1.07	74C20N	0.24	7430N	0.22	74155N	0.70
74LS47N	1.09	74C30N	0.24	7432N	0.30	74157N	0.78
74LS48N	1.09	74C32N	0.24	7437N	0.35	74160AN	1.10
74LS49N	1.09	74C42N	0.92	7438N	0.32	74161AN	1.10
74LS51N	0.28	74C48N	1.38	7440N	0.20	74162AN	1.10
74LS54N	0.26	74C73N	0.54	7441AN	0.84	74163AN	1.10
74LS73N	0.42	74C74N	0.56	7442N	0.76	74164N	1.36
74LS76N	0.42	74C76N	0.54	7445N	1.40	74165N	1.36
74LS78N	0.42	74C83N	1.30	7446AN	0.90	74167N	2.50
74LS83AN	1.20	74C85N	1.30	7447AN	0.80	74174N	1.60
74LS85N	1.10	74C86N	0.64	7448N	0.80	74175N	1.00
74LS90N	1.10	74C89N	4.39	7450N	0.22	74176N	0.90
74LS91N	1.20	74C90N	0.85	7451N	0.22	74177N	0.80
74LS92N	0.86	74C93N	0.85	7453N	0.22	74180N	1.00
74LS93N	1.10	74C95N	1.04	7454N	0.22	74181N	2.00
74LS95AN	1.10	74C107N	1.22	7460N	0.22	74182N	0.80
74LS96N	1.35	74C150N	4.14	7470N	0.46	74184N	1.50
74LS107N	0.42	74C151N	2.47	7472N	0.30	74185N	1.50
74LS109N	0.42	74C154N	3.68	7473N	0.44	74188N	3.25
74LS122N	0.80	74C157N	2.21	7474N	0.32	74189N	2.60
74LS123N	0.83	74C160N	1.11	7475N	0.80	74190N	1.40
74LS124N	2.70	74C161N	1.11	7476N	0.45	74191N	1.20
74LS125N	0.50	74C162N	1.11	7480N	0.60	74192N	1.20
74LS126N	0.50	74C163N	1.11	7481N	1.00	74193N	1.20
74LS136N	0.44	74C164N	1.04	7482N	0.90	74196N	1.20
74LS156N	1.20	74C193N	1.11	7483N	1.05	74197N	1.00
74LS158N	0.65	74C195N	1.04	7484N	1.20	74198N	2.00
74LS160N	1.43	7400N	0.17	7492N	0.45	74199N	2.00
74LS161N	0.85	7401N	0.17	7493N	0.45		
74LS162N	1.43	7402N	0.17	7494N	0.90		
74LS164N	1.43	7403N	0.17	7495N	0.76		

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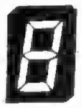

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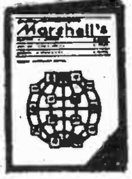

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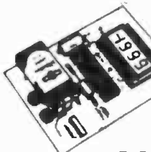

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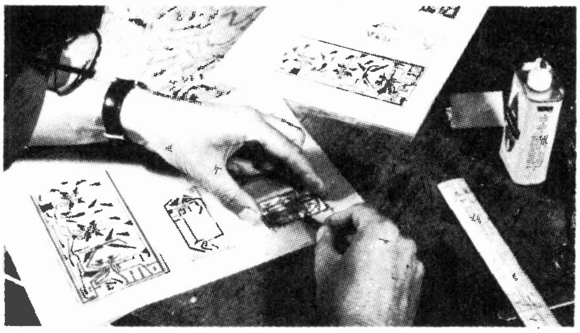
ETIPRINTS are a fast new aid for producing high quality printed circuit boards. Each ETIPRINTS sheet contains a set of etch resistant rub down transfers of the printed circuit board designs for several of our projects. ETIPRINTS are made from our original artwork ensuring a neat and accurate board. We 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!

PARTS LIST

Shown below is the listing for the last years ETIPRINTS. Earlier sheets are available, ring Tim Salmon for details.

003	Race Track Game	Jan 78
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	5 Watt Stereo Amp (modified)	Jan 77
	Metronome	Feb 78
	Shutter Time	Feb 78
005	Op-Amp Supply Frequency Shifter LCD Panelmeter Light Dimmer (3 times)	Mar 78
006	CMOS Switched Preamp From Experimenters P.S.U. 555 Boards (twice	"Electronics Tomorrow"
007	Star Trek Radio	May 78
	CD Ignition	May 78
	CCD Phaser	May 78
	White Line Follower	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 Compander 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	July 78
	Torch Finder (twice)	July 78
	Etiwet (twice)	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	Oct 78
	Proximity Switch	Oct 78
	Audio Oscillator (2)	Nov 78
019	Car Alarm (2)	Dec 78
	Wine Temp (2)	Dec 78
	Curve Tracer	Dec 78
020	Digital Tacho	Jan 79
	Module	Jan 79
	Digital Dial	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 descripton 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.

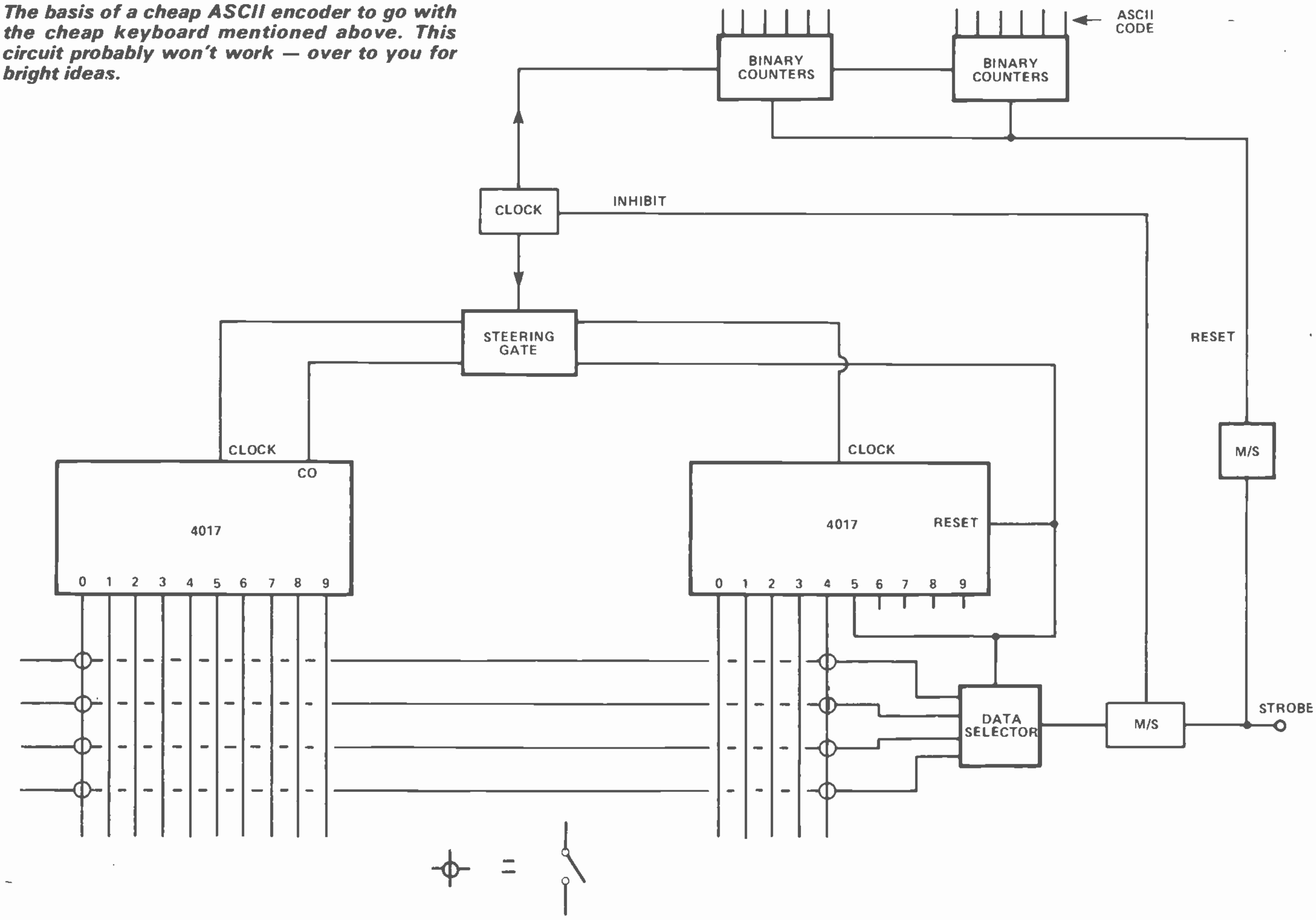
This was of very simple construction a formed A 60 station (15 × 4 matrix) input terminal at a cost of about £5.00.

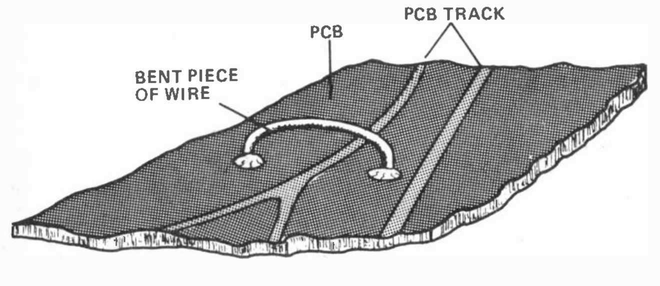
Construction of the keyboard was kept as simple and straightforward as possible by forming the keys from a piece of bent wire as shown in the diagram. Although this sounds like a recipe for trouble, the design has proven itself over the past few months. To make the keyboard more attractive a layer of 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 feds 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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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 incudes 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

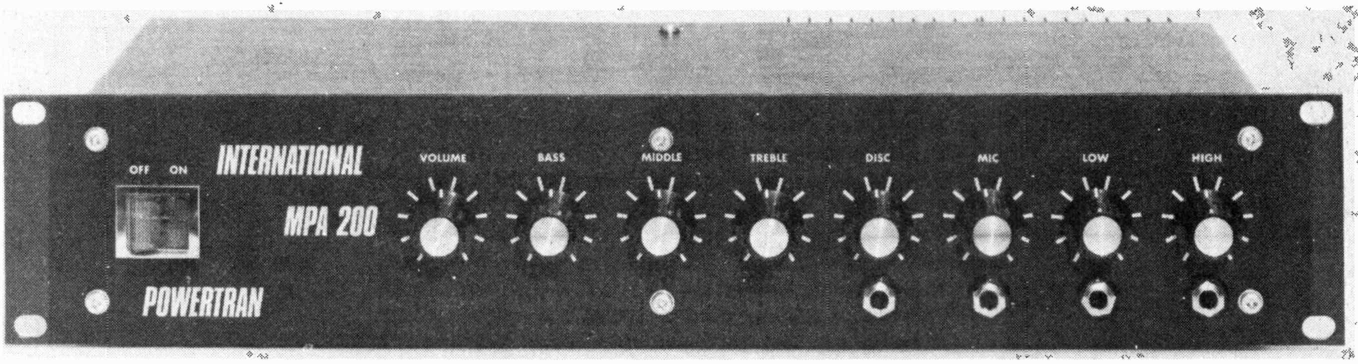
Even when there is no signal, Q105 is dissipating over 500 mW so get rid of the heat from this with a cooling clip pressed onto it. Wind L1 onto R128 with 10 turns of 25g wire before fitting to the board. The wire supplied in the kits is self fluxing polyurethane covered and can be soldered directly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

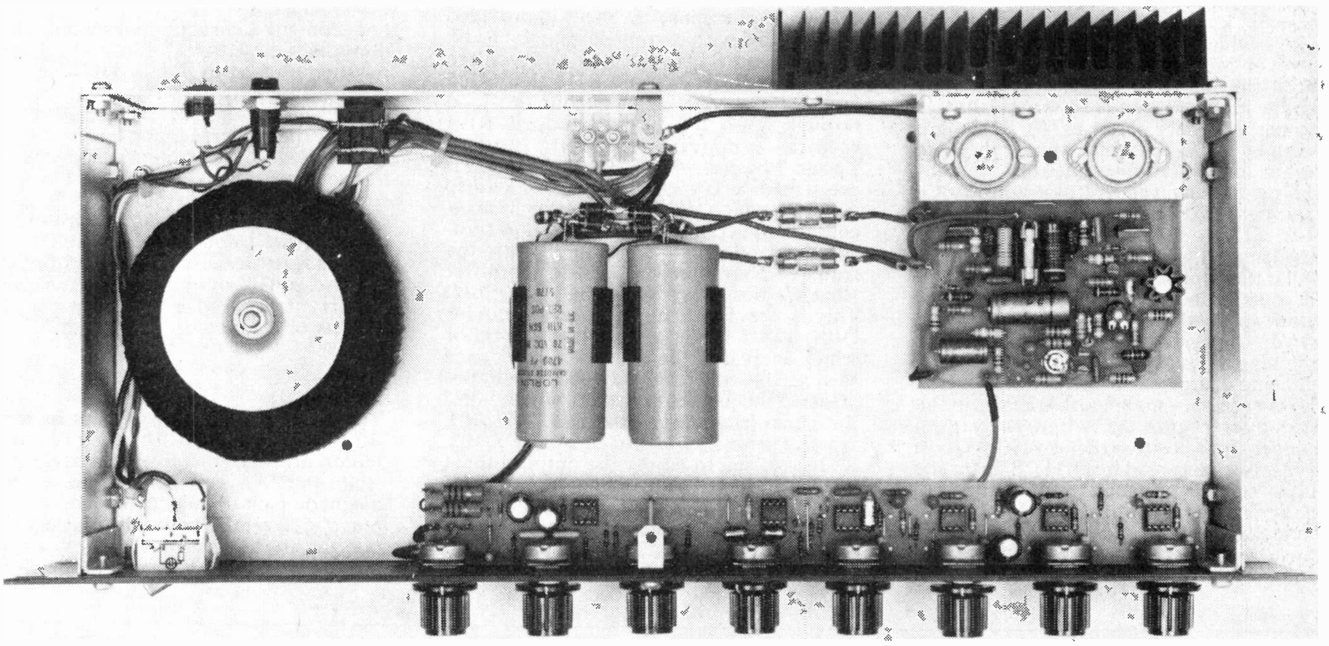
By simple component changes all four inputs can have flat response for any sensitivity between 1mV and 100mV

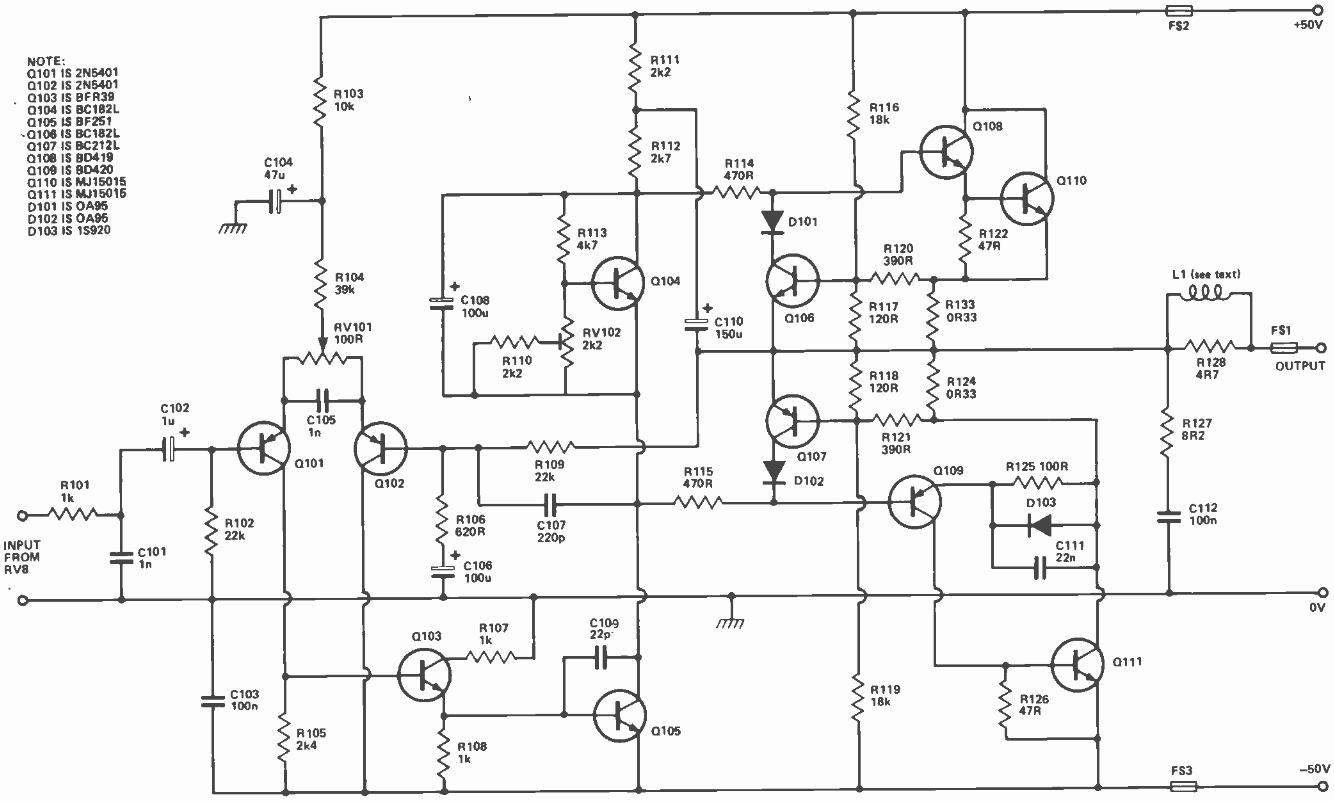
current of 100mA in the output stage. Adjust RV101 for zero off-set voltage at the output terminal. Make re-measurements of these voltages for about 10 minutes or until they stop changing whilst the amplifier is becoming thermally stabilized.

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.

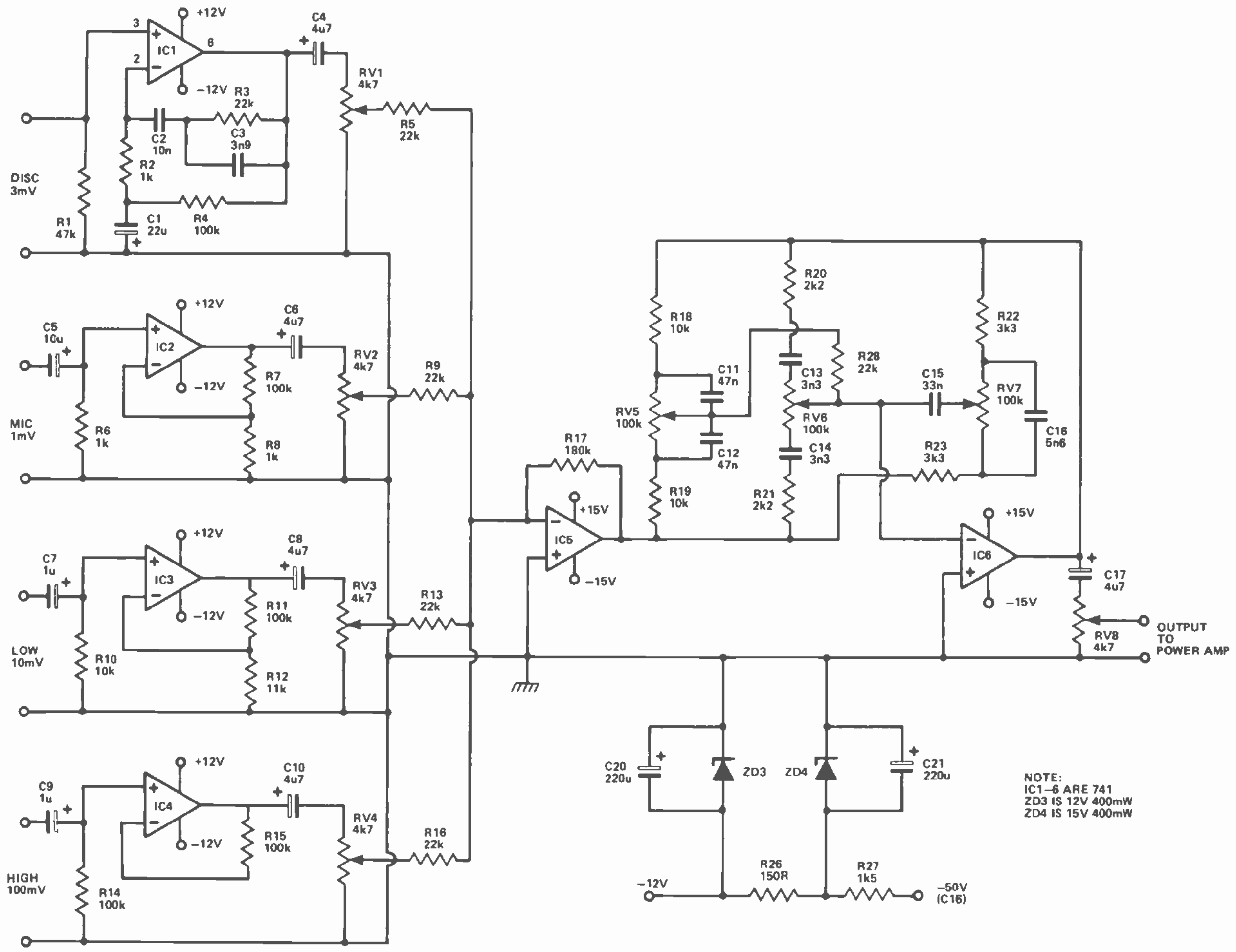
Protection against overload is provided by Q106, 107 with current sensing by R117, 120, 123 and R118, 121, 124 and voltage sensing by R116, 117 and R118, 119. R115 limits the current drawn from the load through Q107, 105 during overload. R114 restores symmetry for positive going signals. However, the 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 emmiter 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

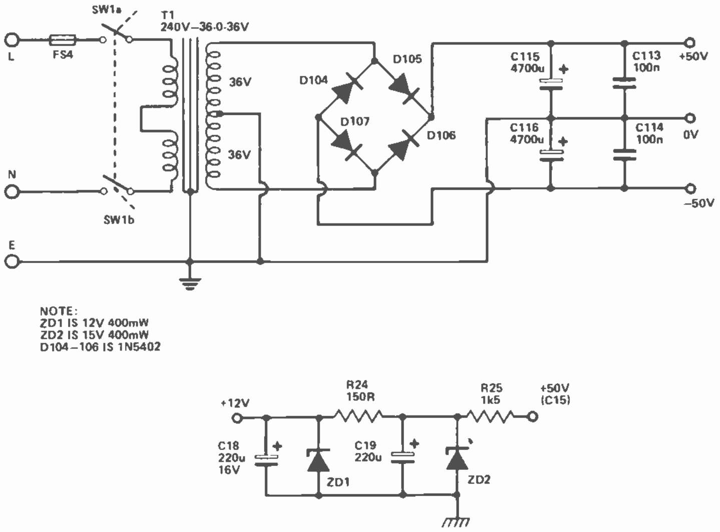
For economy the supply to the amplifier is unregulated. D104-107 form a full wave rectifier filtered by C115, 116. C113, 114 remove high frequency transients from the power rails. A toroidal transformer is used because the stray magnetic field is very low thereby reducing the hum introduced into the 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

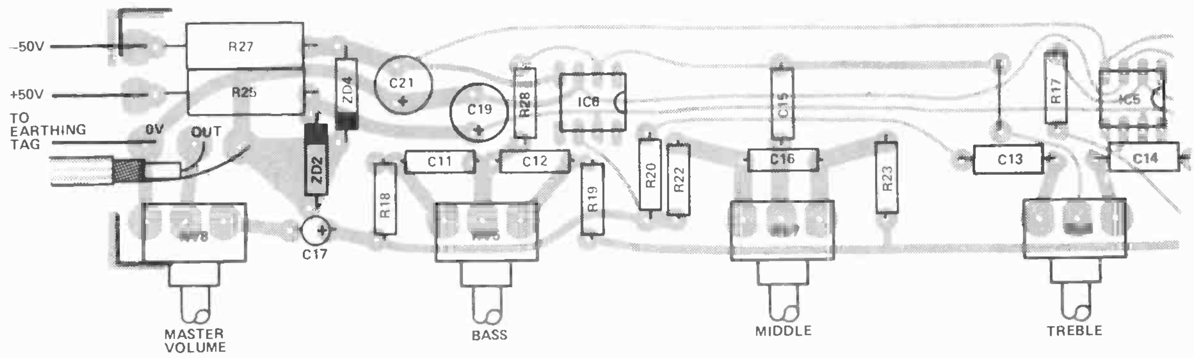
The actual mixing is carried out by RV1-4, R5, 9, 13, 16, 16 and IC5 but before that the inputs are buffered by IC1-4 stages. IC1 stage is RIAA equalized for use with a magnetic pick-up but if this facility is not required it can be built with flat equalization for another purpose such as a guitar pick-up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



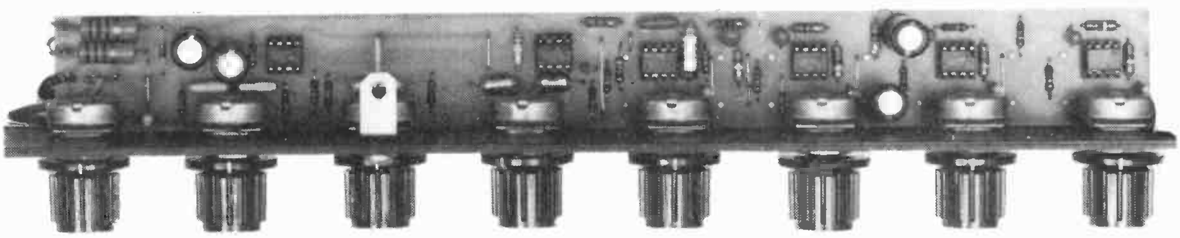
Above left: the full circuit for the power amplifier section of the mixer amp. This builds onto its own PCB and can be employed to good advantage in other systems. Above right: the mixer circuit itself. Note the provision of a third-mid-tone control circuit which will be found to be useful in disco applications.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

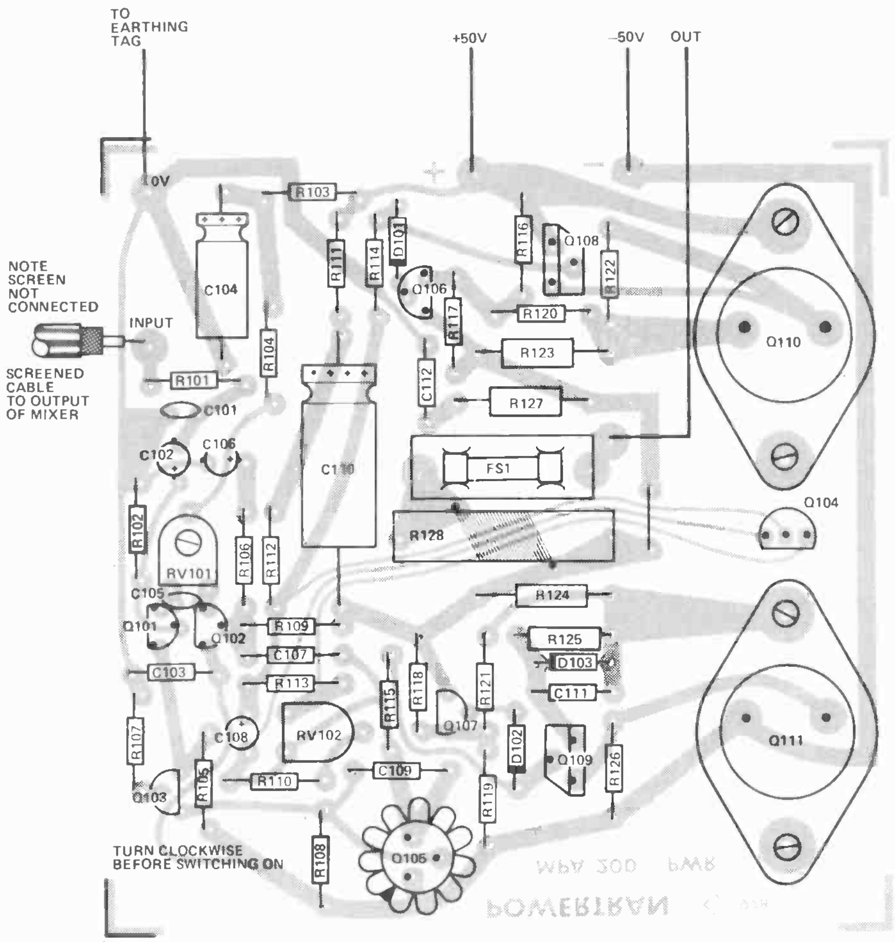


able for most pick-ups). For 15 mV sensitivity omit C3, R4, use wire links in place of C1, 2, use 15K, 18K, 100K for R1, 2, 3 respectively and replace link A with a 1u tantalum capacitor. All the buffer stages produce an output of 100mV for their rated input. Changing the resistor values alters the sensitivity 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.



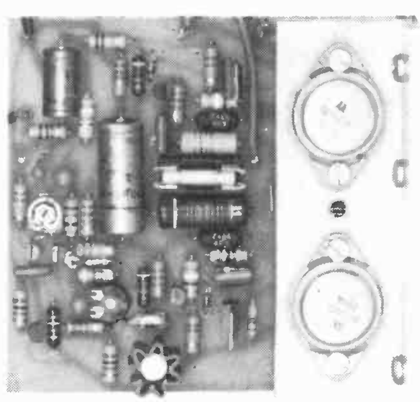
Above: the somewhat protracted overlay for the mixer board of the amplifier unit. This fixes onto the back of the controls to make construction easier. Below: the main power amplifier overlay. Read the setting-up procedures carefully before turning this on!

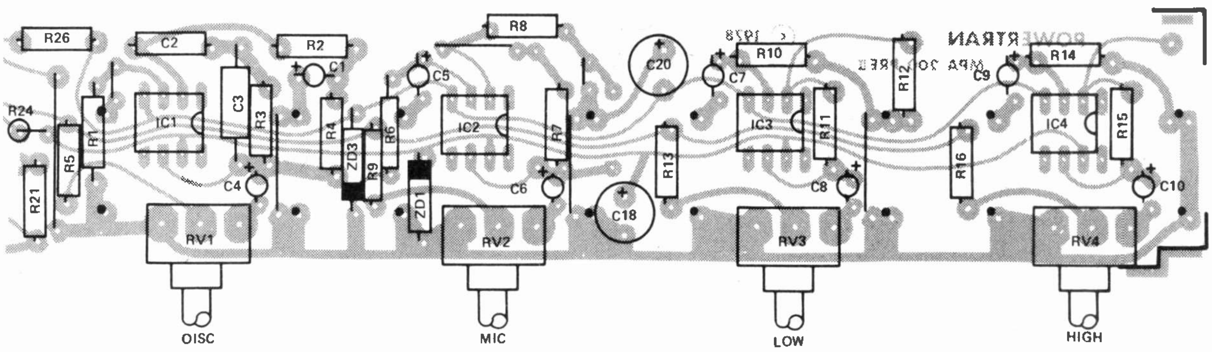


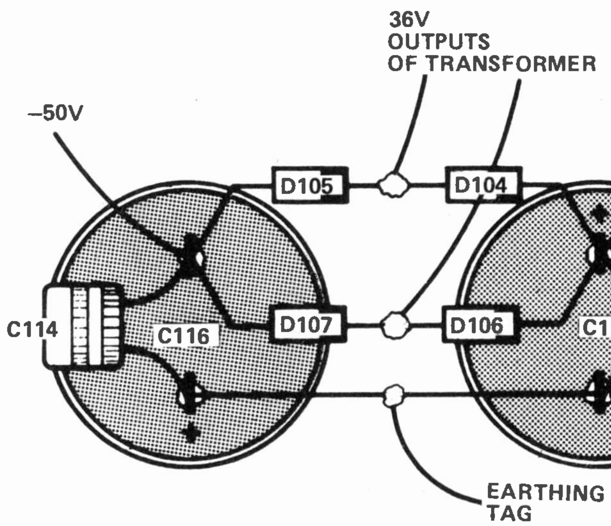


Component overlays for the boards within the unit. The mixer board is shown above — unfortunately in two pieces—(we're not fond of that kind of centre fold-out!) to make the components clear.

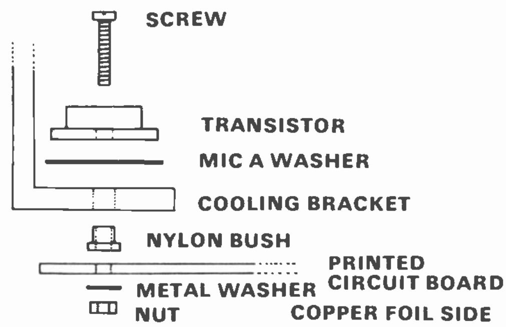
Below left is the 100W amplifier board. Take care when fitting the power transistors to their heatsinks, follow the diagram opposite. Note that RV102 should be set fully clockwise before switch on.







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	4µ7 16V tantalum
C5	10µ 16V tantalum
C7,9	1µ 16V tantalum
C11,12	47n polyester
C13,14	3n3 polystyrene
C15	33n polyester
C16	5n6 polystyrene
C18,19,20,21	220µ 16V electrolytic
C101, 105	1n ceramic
C102	1µ 16V tantalum
C103,112, 114	100n polyester
C104	47µ 63V electrolytic
C106, 108	100µ 3V tantalum
C107	220p polystyrene
C109	22p 100V polystyrene
C110	150µ 63V electrolytic
C111	22n polyester
C115,116,	4700µ 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 lin
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.

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.

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 . . . ▶

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

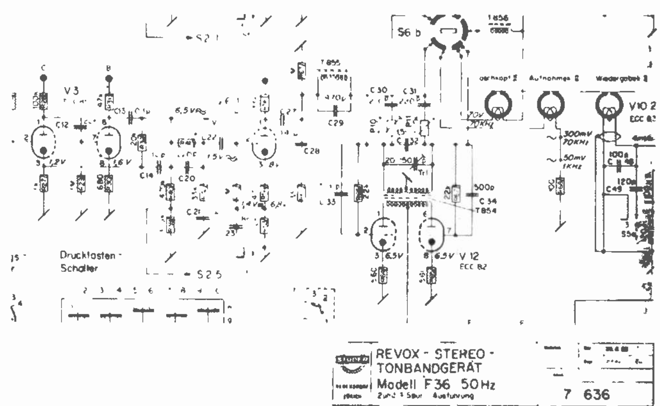


Fig. 1
Transconductance converter with filter coupling in valve technique. Recording amplifier of the REVOX F36 magnetic tape recorder. Circuit diagram drawn 26.2.62.

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 partenting, 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.

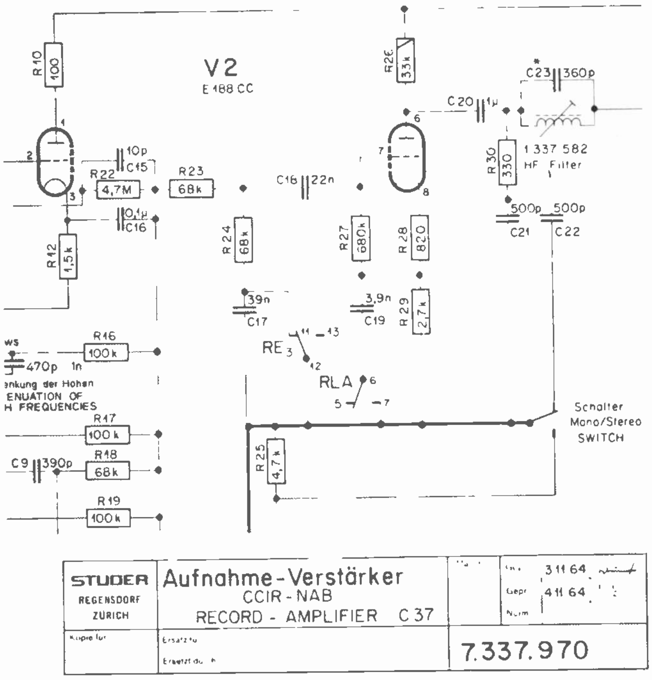


Fig. 2
Transconductance converter with filter coupling in valve technique. Recording amplifier of STUDER C37 magnetic recorder. Circuit diagram drawn on 3.11.64.

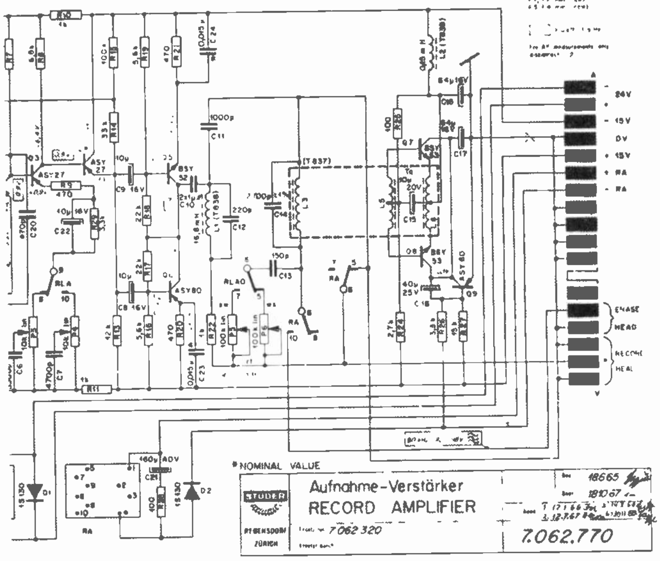


Fig. 3
Transconductance converter with symmetrical output stage, driven active generator and filter coupling in transistorised technique. Recording amplifier of the STUDER A62 magnetic tape recorder. Circuit diagram drawn on 18.6.65.

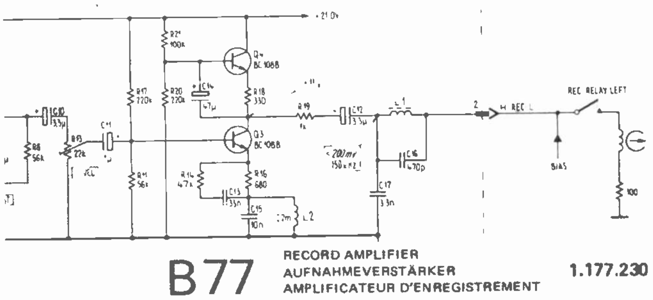


Fig. 4
Transconductance converter with free active generator and filter coupling. Recording amplifier of magnetic tape recorder B77.

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 imcomplete 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 measureably 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 feed back 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 Actiliner 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 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 disucssing 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

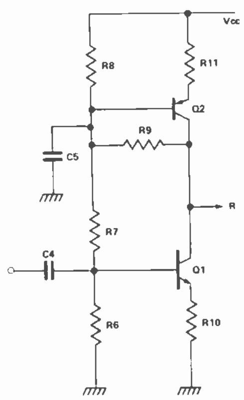


Fig. 2. Actilinear

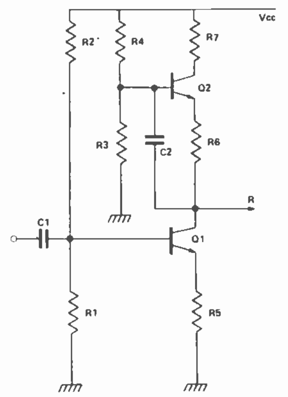


Fig. 3. Transconductance module by a different manufacturer.

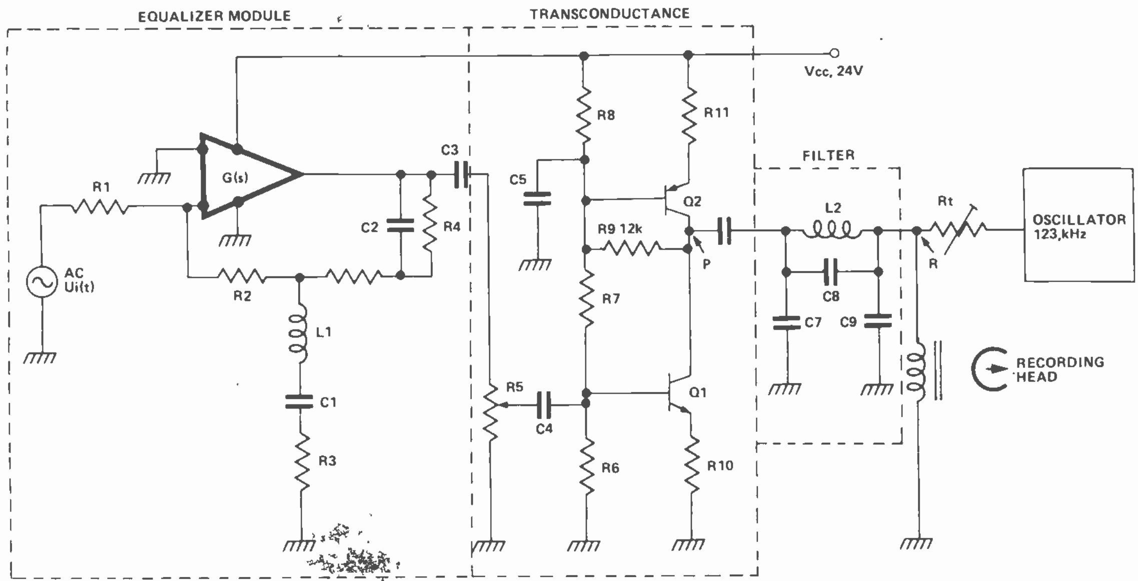


Fig. 1. Circuit diagram of Tandberg recording amp employing Actilinear circuitry.

MARKET PLACE

Digital Alarm

Size: 105mm wide 115mm deep x 55 mm high.

THIS IS THE THIRD digital alarm clock that we are offering (we regret the earlier versions are no longer available). We have sold thousands and thousands of these and our buying power enables us to offer a first rate branded product at a really excellent price.

The Hanimex HC-1100 is designed for mains operation only (240V/50Hz) with a 12 hour display, AM/PM and Alarm Set indicators incorporated in the large display. A switch on the top controls a Dim/Bright display function.

Setting up both the time and alarm is simplicity itself as buttons are provided for both fast and slow setting and there's no problem about knocking these accidentally as a 'locking' switch is provided under the clock. A 9-minute 'snooze' switch is located at the top.

£8·95

Inclusive of VAT and Postage

An example of this clock can be seen and examined in our reception at our Oxford Street offices.

DIGITAL ALARM

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London W1R 1RF

Please find enclosed my cheque PO for £8.95 (payable to ETI Magazine) for a Hanimex Digital Alarm Clock.

Name ....

Adress ....

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....

Please allow 28 days for delivery

LCD Watch

New low price!

The enormous numbers involved in ETI offers has enabled us to arrange a real bargain — a full spec LCD watch with adjustable metal bracelet for under half the going rate.

This watch gives continuous display of hours and minutes press the button once and you'll get the date (American style). After a couple of seconds the display automatically reverts to time but if you press again you'll get a continuous seconds display.

Press another button and you get a back light, enabling you to see the display in the dark. Setting, or resetting is simplicity itself and a 'hold' facility allows you to set the watch spot on. The accuracy is magnificent, as with all the current range of digital watches and battery life is well in excess of a year.

£8·95

(Inclusive of VAT and Postage)

An example of this watch can be seen and examined in our reception at our Oxford Street offices.

LCD WATCH

To:
LCD Watch Offer
ETI Magazine
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London W1R 1RF

Please find enclosed my cheque/PO for £8.95 (made payable to ETI Magazine) for my LCD Digital Watch.

Name ....

Address ....

....

....

Please allow 14 days for delivery

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

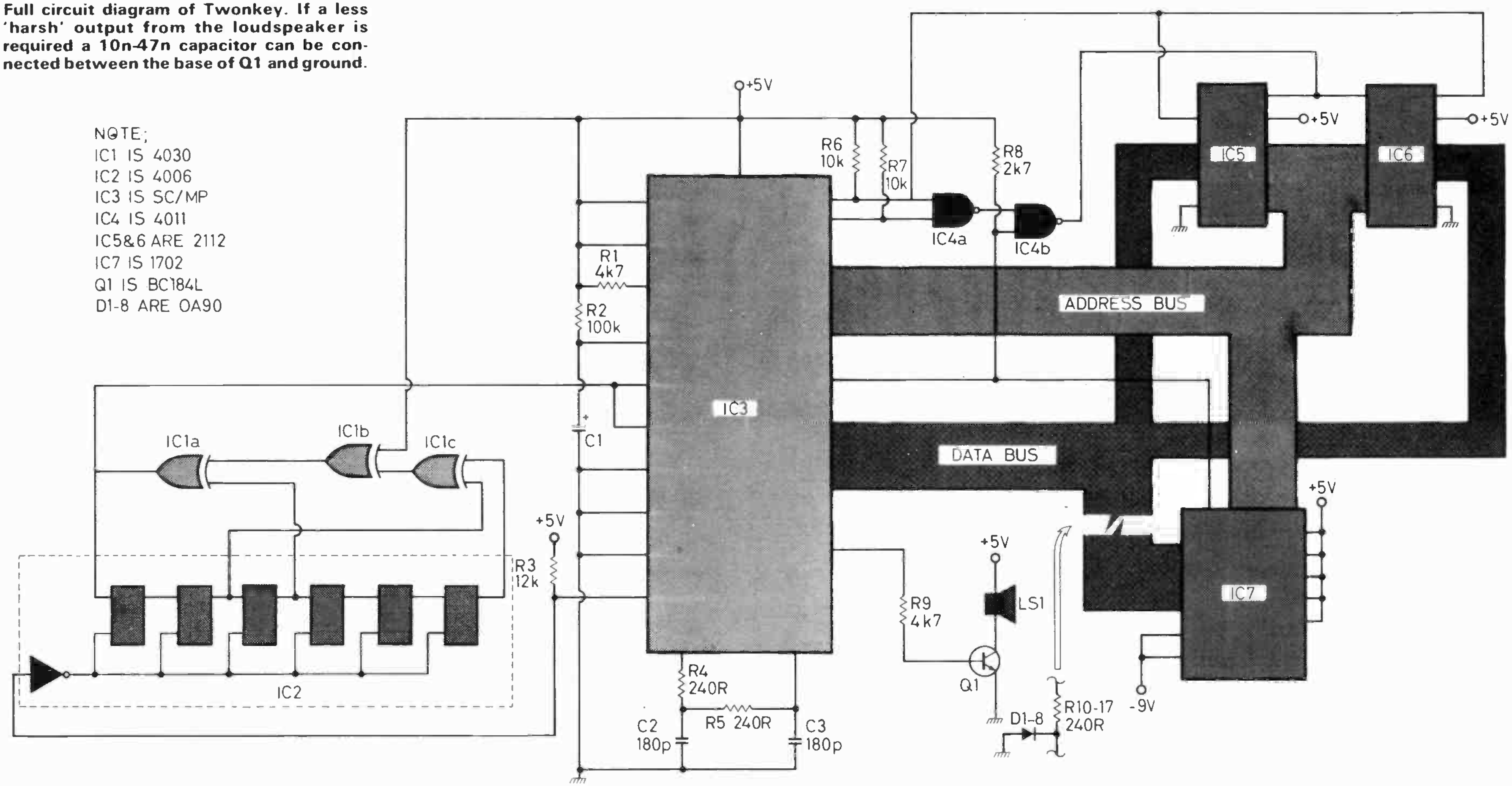
By this time, the original aim, which was to test the compositional rules in question, had become secondary to the fun of using the computer to generate new music.

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



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 OOIH.

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 OOOH to OFFH. 256 bytes of RAM in the shape of 2, 2112-A4 256 x 4 bit static chips are provided at addresses 1OOH to 1FFH. Address lines AO 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 O.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 dame sequence of pseudo-random bits (and hence tunes) occuring 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-OO1B (!) may be consulted.

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

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.

PROGRAM LISTING

```
00  08            NOP               Dummy instruction — not executed
01  C4  01  START LDI    1          Store 1 in location 510
03  36            XPAH   PTR 1
04  C4  FE        LDI    FEH
06  32            XPAL   PTR 2
07  C4  01        LDI    1
09  OA  00        STO    PTR 2+0
0B  C4  00        LDI    0          Clear cycle counter (No. of levels down
0D  36            XPAH   PTR 2      decision tree)
0E  C4  00        LDI    0          Each location in top half of memory is
10  32            XPAL   PTR 2      written to two locations starting at
                                    bottom of RAM with random incre-
                                    ment. Repeated 7 times
11  C6  01  OUTLOOP LD   PTR 2+1    Increment cycle counter
13  C4  80        LDI    80H        Set PTR 1=180H=384 (bottom of top
15  31            XPAL   PTR 1      half of RAM)
16  C4  80        LDI    —128       Extension register=—128
18  01            XAE               PTR 1 points to location being read, and
19  C4  01        LDI    1          is stepped upwards. EXT contains
1B  35            XPAH   PTR 1      displacemtn to location being written
1C  C1  00  INLOOP LD    PTR 1+0
1E  C9  80        STO    PTR 1-128  Take contents of (PTR 1) and store 1 in
20  01            XAE               (PTR 1 + EXT) and in (PTR 1+EXT+2)
21  F4  02        ADI    2
23  02            CCL
24  01            XAE
25  C9  80        STO    PTR 1-128
27  06            CSA               Input random bit and either:
28  D4  20        ANI    00100000B=32
2A  98  0A        JZ     INCLOW
2C  C1  80        LD     PTR 1-128  Increment (PTR 1+EXT+2) or:
2E  F4  01        ADI    1
30  02            CCL
31  C9  80        STO    PTR 1-128
33  01            XAE
34  90  10        JMP    EXTEST
36  01      INCLOW XAE              Increment (PTR 1+EXT)
37  F4  FE        ADI    —2
39  02            CCL
3A  01            XAE
3B  C1  80        LD     PTR 1-128
3D  F4  01        ADI    1
3F  02            CCL
40  C9  80        STO    PTR 1-128
42  01            XAE
43  F4  02        ADI    2          Add 2 to EXT for next pass
45  02            CCL
46  98  05  EXTEST JZ    PTEST      If EXT=0 go to PTEST; 1 pass through
48  01            XAE               memory completed, else add 2 to PTR 1
49  C5  02        LD@    PTR 1+2    and loop back to INLOOP
4B  90  CF        JMP    INLOOP
4D  C4  00  PTEST LDI    0          If cycle counter (PTR 2)=7 then go to
4F  32            XPAL   PTR 2      note (PTR 2=0)
50  F4  F9        ADI    —7
52  02            CCL
53  98  06        JZ     NOTE
55  F4  07        ADI    7          else go to OUTLOOP
57  02            CCL
58  32            XPAL   PTR 2
59  90  B6        JMP    OUTLOOP
5B  C4  EF  NOTE  LDI    EFH        PTR 2 points to pitch table
5D  32            XPAL   PTR 2      (PTR was zero)
5E  35            XPAH   PTR 1      Clear high byte of PTR 1 (return address
```

```
83  06      SECPART CSA             Input random bit and either:
84  D4  20        ANI    00100000B
86  9C  06        JNZ    RHYTH3
88  C4  9B        LDI    9BH        Write middle sized note by subroutine
8A  31            XPAL   PTR 1      at 9BH, on return go to NXNOTE
8B  3D            XPPC   PTR 1
8C  90  D7        JMP    NXNOTE
8E  C4  9F  RHYTH3 LDI   9FH        or write 2 short notes by 2 calls to
90  31            XPAL   PTR 1      subroutine at 9FH
91  3D            XPPC   PTR 1
92  C4  9F        LDI    9FH
94  31            XPAL   PTR 1
95  3D            XPPC   PTR 1      Go to NXNOTE for next note from RAM
96  90  CD        JMP    NXNOTE
98  C4  01  WRNOTE LDI   1          Subroutine WRNOTE. Entry point de-
9A  90  06        JMP    GO         termines note length divisor. This is
9C  C4  02        LDI    2          loaded to high byte of pointer con-
9E  90  02        JMP    GO         taining return address (as this is always
                                    zero)
AO  C4  03        LDI    3
A2  35      GO    XPAH   PTR 1      Load pitch code from RAM, use as index
A3  C7  FF        LD@    PTR 3-1    for table of pitches. Replace code with
A5  01            XAE               actual pitch from table. Pitch code stays
A6  C2  80        LD     PTR 2-128  in extension register
A8  CB  00        STO    PTR 3+0
AA  01            XAE               Add 8 to pitch code and use as index to
AB  F4  08        ADI    8          duration table (contains number of
AD  02            CCL               cycles for 0.362 secs at each pitch)
AE  01            XAE
AF  C2  80        LD     PTR 2-128
B1  01            XAE               Note length to EXT ready for division
B2  C4  00        LDI    0          divisor is fetched from pointer 1 high
B4  35            XPAH   PTR 1      byte which is zeroed at the same time
B5  19      S101  S10
B6  F4  FF        ADI    —1         Number of cycles divided by 2, 4, or 8
B8  02            CCL               depending on subroutine entry point to
B9  9C  FA        JNZ    S101       give the 3 different note lengths
BB  01            XAE
BC  CB  01        STO    PTR 3+1    Note length is stored in RAM location
BE  33            XPAL   PTR 3      immediately above corresponding pitch
BF  98  04        JZ     PLAY       if end of RAM (100H) has been reached,
C1  33            XPAL   PTR 3      go to play else decrement PTR and
C2  C7  FF        LD@    PTR 3-1    return
C4  3D            XPPC   PTR 1
C5  33      PLAY  XPAL   PTR 3      Load note length (PTR points to low
C6  C3  01        LD     PTR 3+1    byte of current note) and store in PTR 1
C8  31      POS   XPAL   PTR 1
C9  C4  07        LDI    00000111B  Load bit pattern to set flag bits in stat
CB  07            CAS               reg. Output high delay to make half
CC  C4  OF        LDI    15         cycles of audio waveform same length
CE  8F  00        DLY    0
D0  C3  00        LD     PTR 3+0    Load pitch from RAM (number of times
D2  F4  FF  ADI1  ADI    —1         round this delay loop for a half cycle at
D4  02            CCL               desired frequency)
D5  9C  FB        JNZ    ADI1
D7  C4  00        LDI    00000000B  Clear flag bits
D9  07            CAS               Takes audio output low
DA  C3  00        LD     PTR 3+0    Load pitch from RAM
DC  F4  FF  ADI2  ADI    —1         Delay loop for negative half cycle
DE  02            CCL
DF  9C  FB        JNZ    AD12       Decrement cycle counter. If not zero, go
E1  31            XPAL   PTR 1      to POS for another cycle
E2  F4  FF        ADI    —1
E4  02            CCL
```

```
5F  C4  01           LDI    1            will be stored here)
61  37               XPAH   PTR 3
62  C4  FF           LDI    FFH          Set PTR 3= 511 = 1FFH · top of RAM)
64  33               XPAL   PTR 3
65  06      NXNOTE   CSA                 Start of note length writing loop
66  D4  20           ANI    00100000B    input random bit and either:
68  9C  06           JNZ    RHYTH1
6A  C4  97           LDI    97H          Write long note by subroutine at 97H,
6C  31               XPAL   PTR 1        on return, jump back to NXNOTE
6D  3D               XPPC   PTR 1
6E  90  F5           JMP    NXNOTE
70  06      RHYTH1   CSA                 or input random bit and either:
71  D4  20           ANI    00100000B
73  9C  06           JNZ    RHYTH2       Write middle sized note by subroutine
75  C4  9B           LDI    9BH          at 9BH, on return go to SECPART
77  31               XPAL   PTR 1
78  3D               XPPC   PTR 1
79  90  08           JMP    SECPART
7B  C4  9F  RHYTH2   LDI    9FH          or write 2 short notes by 2 calls to
7D  31               XPAL   PTR 1        subroutine at 9FH
7E  3D               XPPC   PTR 1
7F  C4  9F           LDI    9FH
81  31               XPAL   PTR 1
82  3D               XPPC   PTR 1
```

```
E5  9C  E1   JNZ    POS       Inter note gap
E7  8F  3A   DLY    58        Move note counter to next note
E9  C7  02   LD@    PTR 3+2   If PTR 3/200H go to play · next note)
EB  33       XPAL   PTR 3
EC  9C  D7   JNZ    PLAY
EE  35       XPAH   PTR 1     Else go back to start for another tune!
EF  3D       XPPC   PTR 1
F0  32       DEFB   50        F   350.875 HZ    Pitches at 4MHZ
F1  35       DEFB   53        E   332.005 HZ
F2  3C       DEFB   60        D   294.985 HZ
F3  44       DEFB   68        C   261.645s HZ
F4  48       DEFB   72        B   247.645 HZ
F5  51       DEFB   81        A   221.045 HZ
F6  5B       DEFB   91        G   197.47  HZ
F7  67       DEFB   103       F   175.07  HZ

F8  FE       DEFB   254       0.362 SECS    Length of long note at
F9  F0       DEFB   240       0.361 SECS
FA  D6       DEFB   214       0.363 SECS
FB  BD       DEFB   189       0.361 SECS
FC  B3       DEFB   179       0.361 SECS
FD  A0       DEFB   160       0.362 SECS
FE  8F       DEFB   143       0.362 SECS
FF  71       DEFB   127       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 readibility, 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 instruction 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 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 lenghts 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 tio NOTE, otherwise control passes to PLAY.

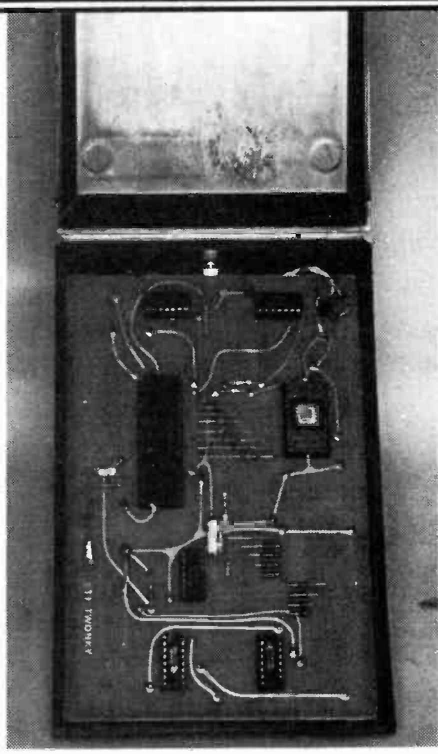
PLAY

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 quality 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 × 160 mm) and will fit in one of the larger size veroboxes, which are designed for this standard. Batteries, either 4 × 1.5V + 1 × 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.

BUYLINES

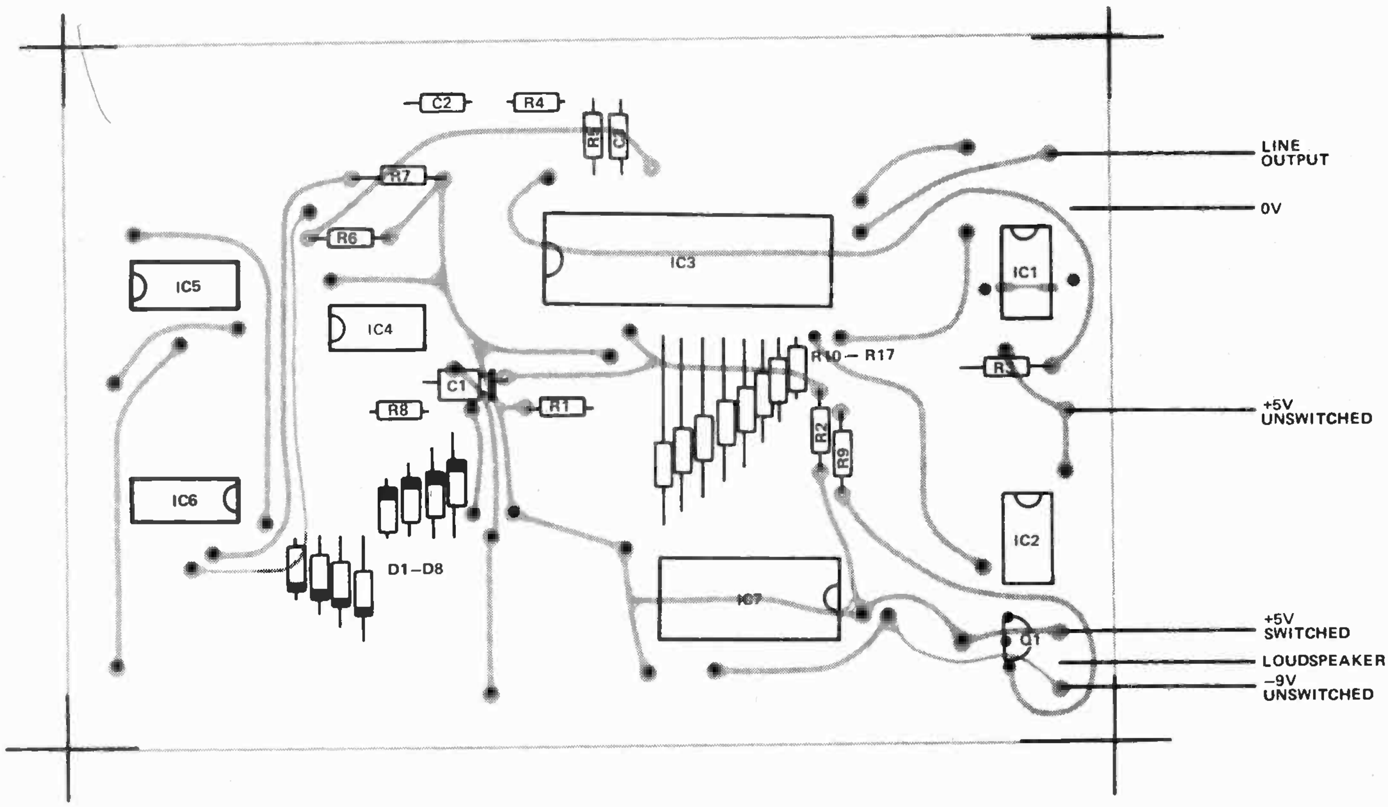
Marshalls, see their advert in this issue for addresses, will be supplying an EPROM with the Twonky program burned in. They will also be able to supply all the other parts for this project except the PCB which will be available from Tamtronix, Ramar, Crofton etc.

PARTS LIST

RESISTORS	all ½W, 5%
R1, 9	4k7
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	OA90

MISCELLANEOUS

PCB, loudspeaker, case batteries and clips.



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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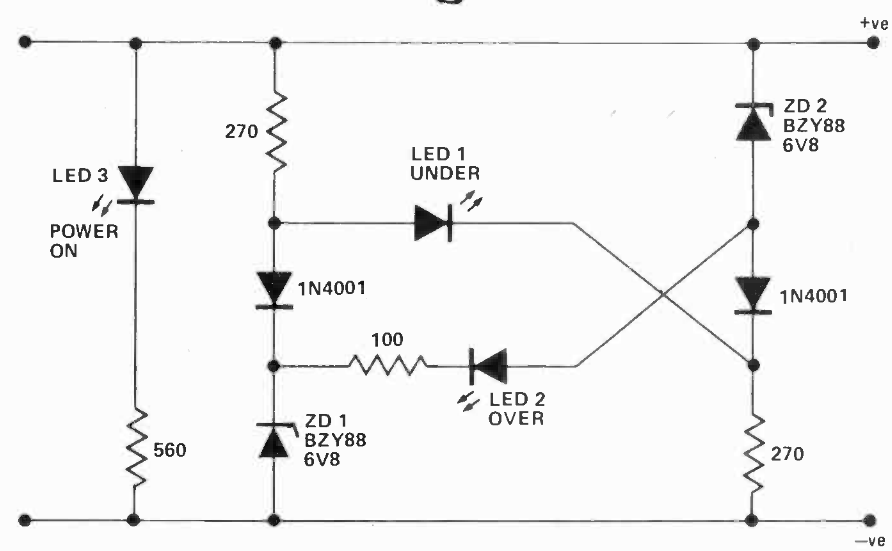
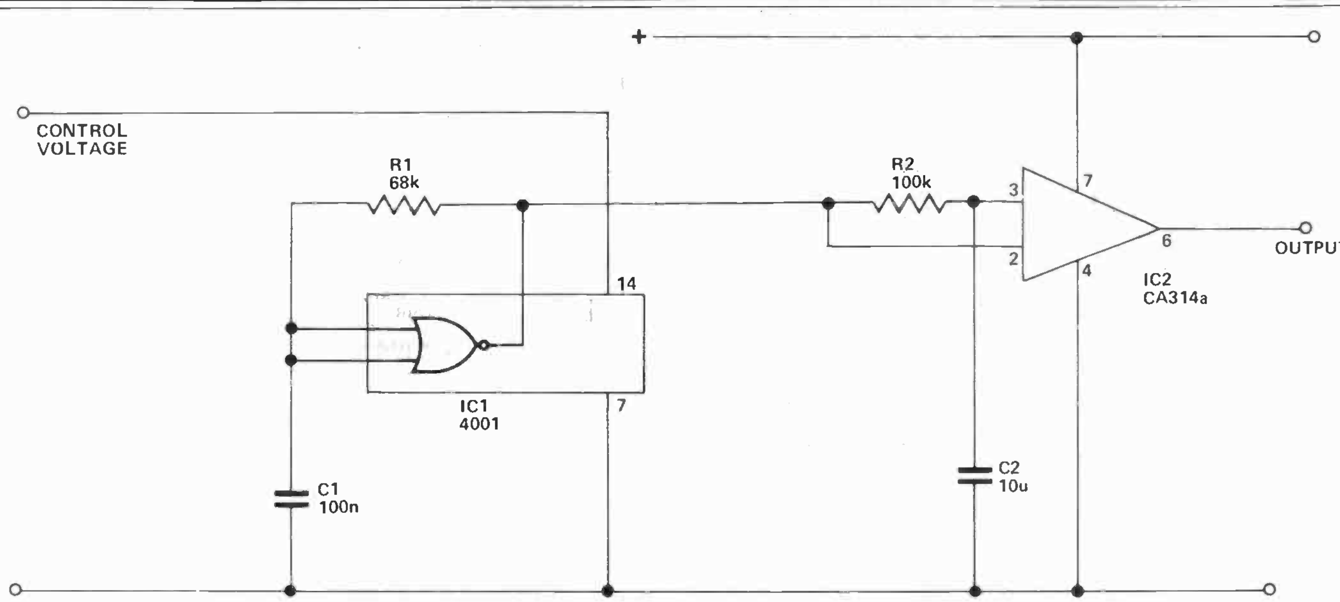


Here is an idea for supply voltage monitoring, in the form of a voltage monitor for 12V supplies, indicating both over or under tolerance voltages. Using three LED's the user can see at a glance whether power is on, over-voltage or under-voltage.

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 x 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 ICI 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 ICI. IC2 is used to square up and buffer the output of ICI 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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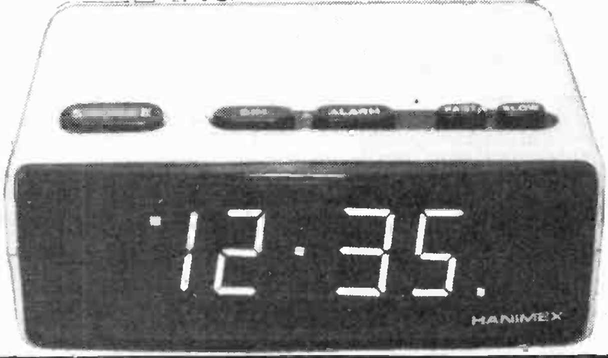

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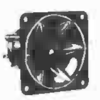

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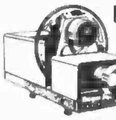

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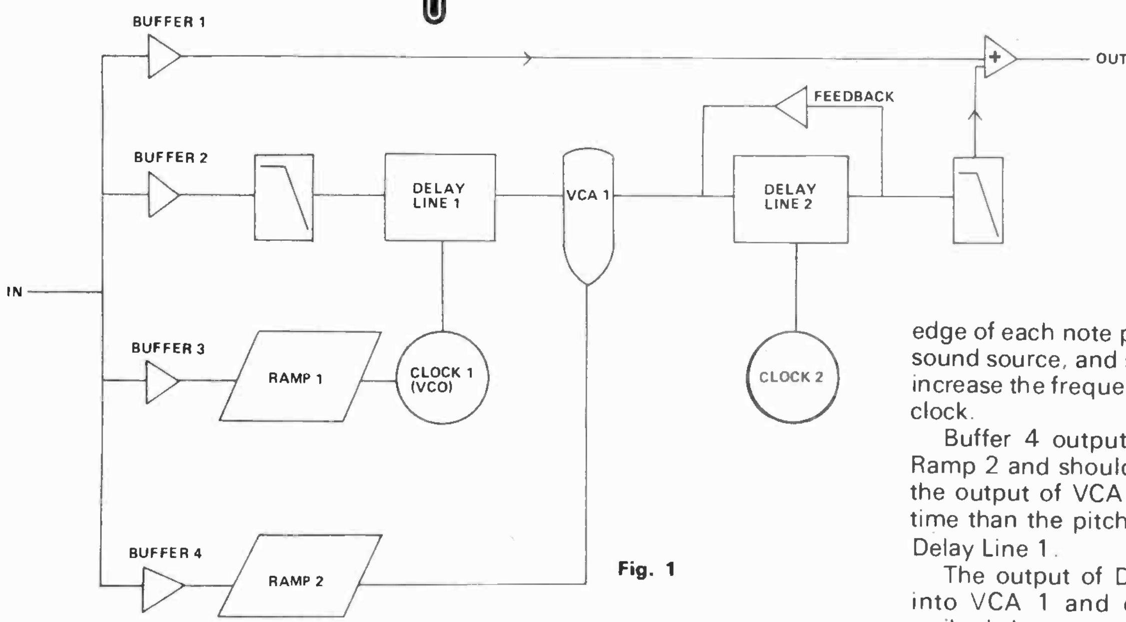


Fig. 1

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 apear 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.

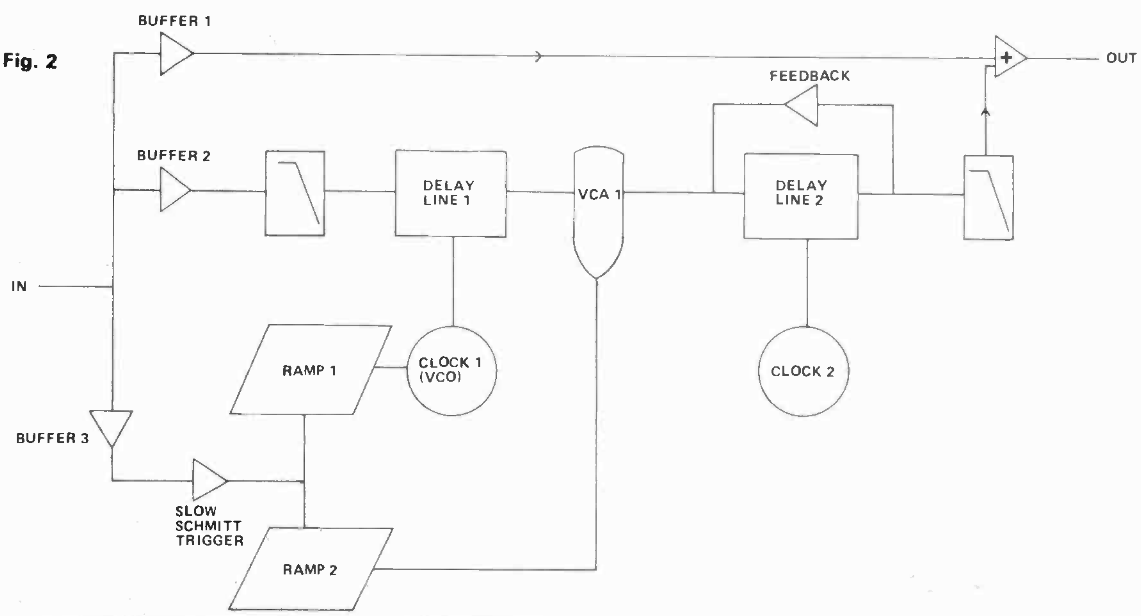
The output of VCA 1 is fed into Delay Line 2 which is wired as a reverberator with it's feedback set very high, but not over-loading.

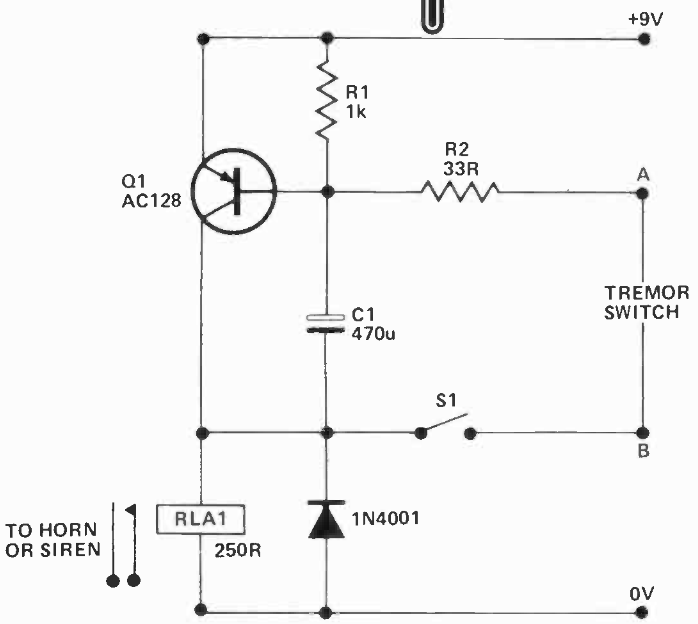
The output of Delay Line 2 is low pass filtered and mixed with the original unprocessed input from Buffer 1 in the required proportions.

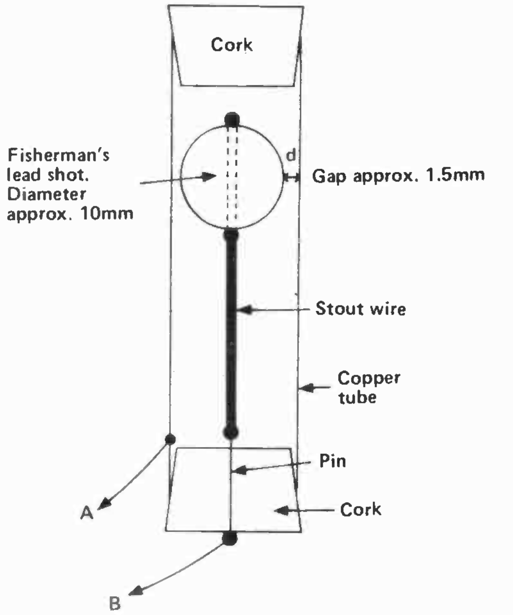
Alternative Approach (fig. 2)

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







TREMOR SWITCH

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 20-30μA, so low that no on-off switch has been incorporated. SW1 isolates the tremor switch 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 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).

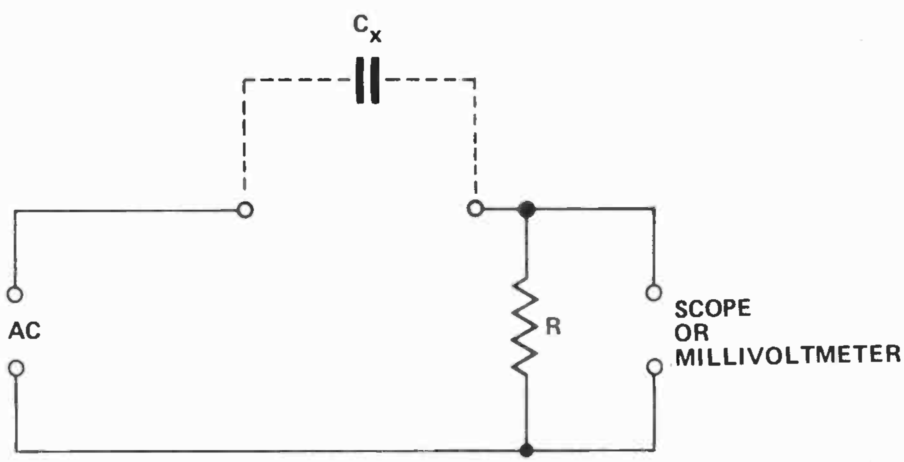
My siren consists of a NE555 design from ETI Jan '77 and an LM380 power amp.

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.



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 μF	1 kHz	100 R	0.001 mV per p

The input wave form should be 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.

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Section 3

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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	27p
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7491	71p
7492	46p
7493	40p
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4021	88p
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4050	48p
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4071	19p
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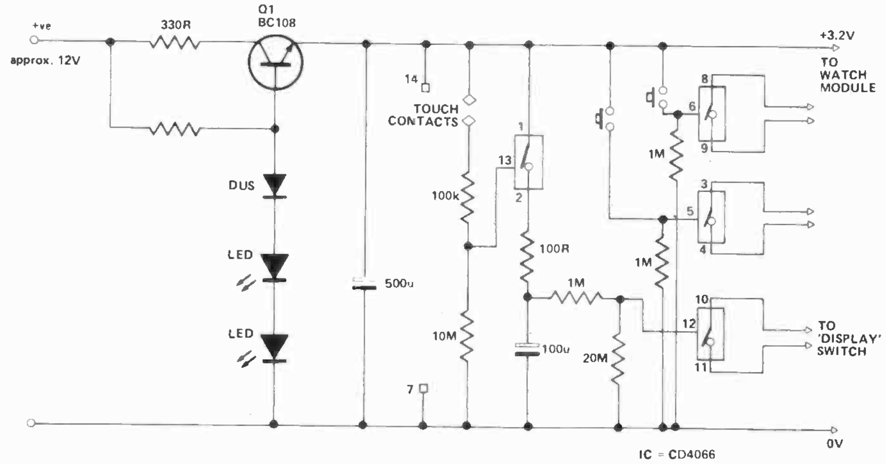


With the availability of economical LCD wristwatches has come a surplus of very cheap LED types which, with a little ingenuity, are eminently suitable for a permanent display installation; one obvious use is a cheap digital car clock.

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.

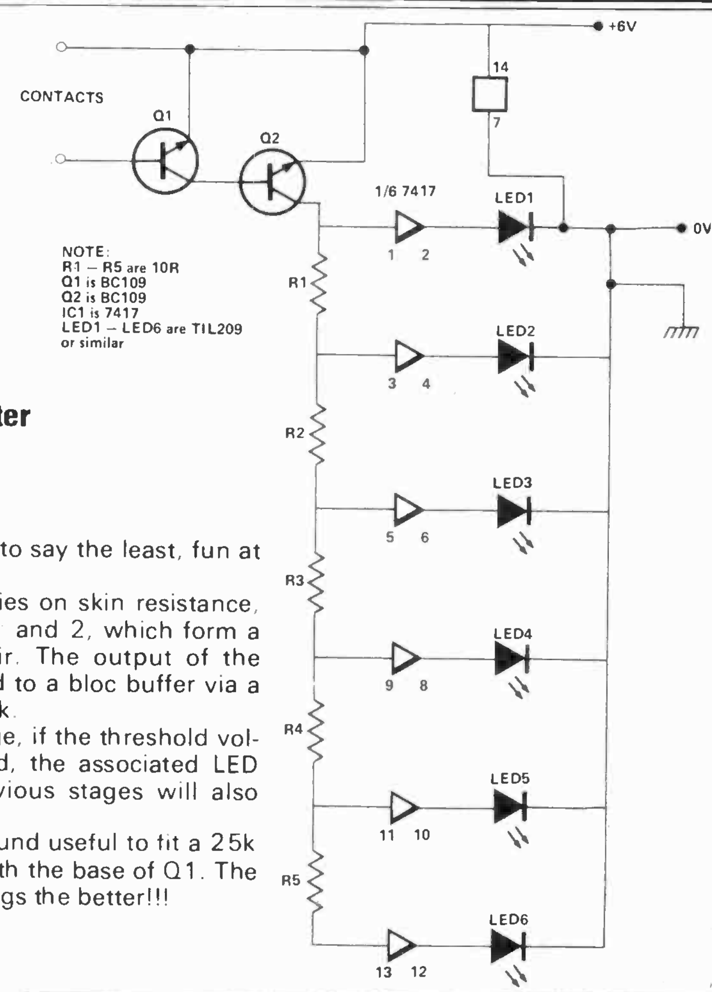
Remove the back of the watch-case and discard the cells; the contacts of one cell holder are shorted together and the 3V2 supply soldered, noting polarity, to the two remaining contacts: with the 'display on' switch shorted out the result is a highly accurate mini-clock with negligable current drain 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!!!

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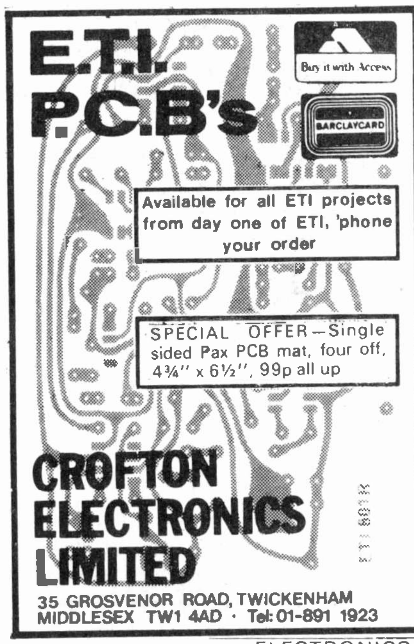

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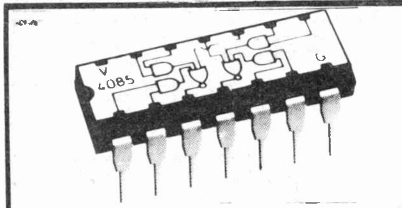

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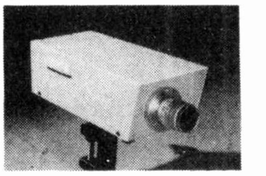

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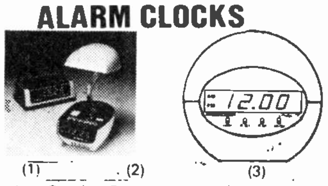

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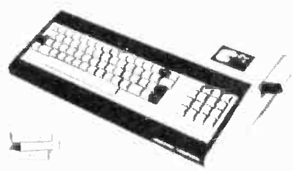

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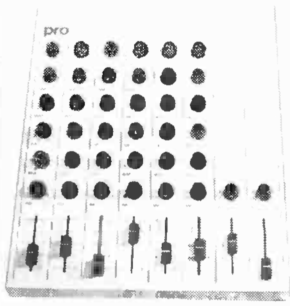

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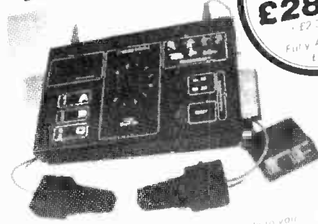

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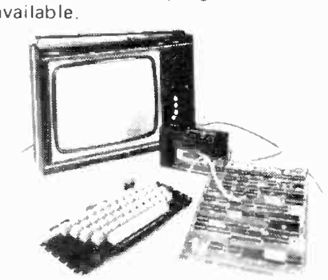

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