ISSN. 0142-7229

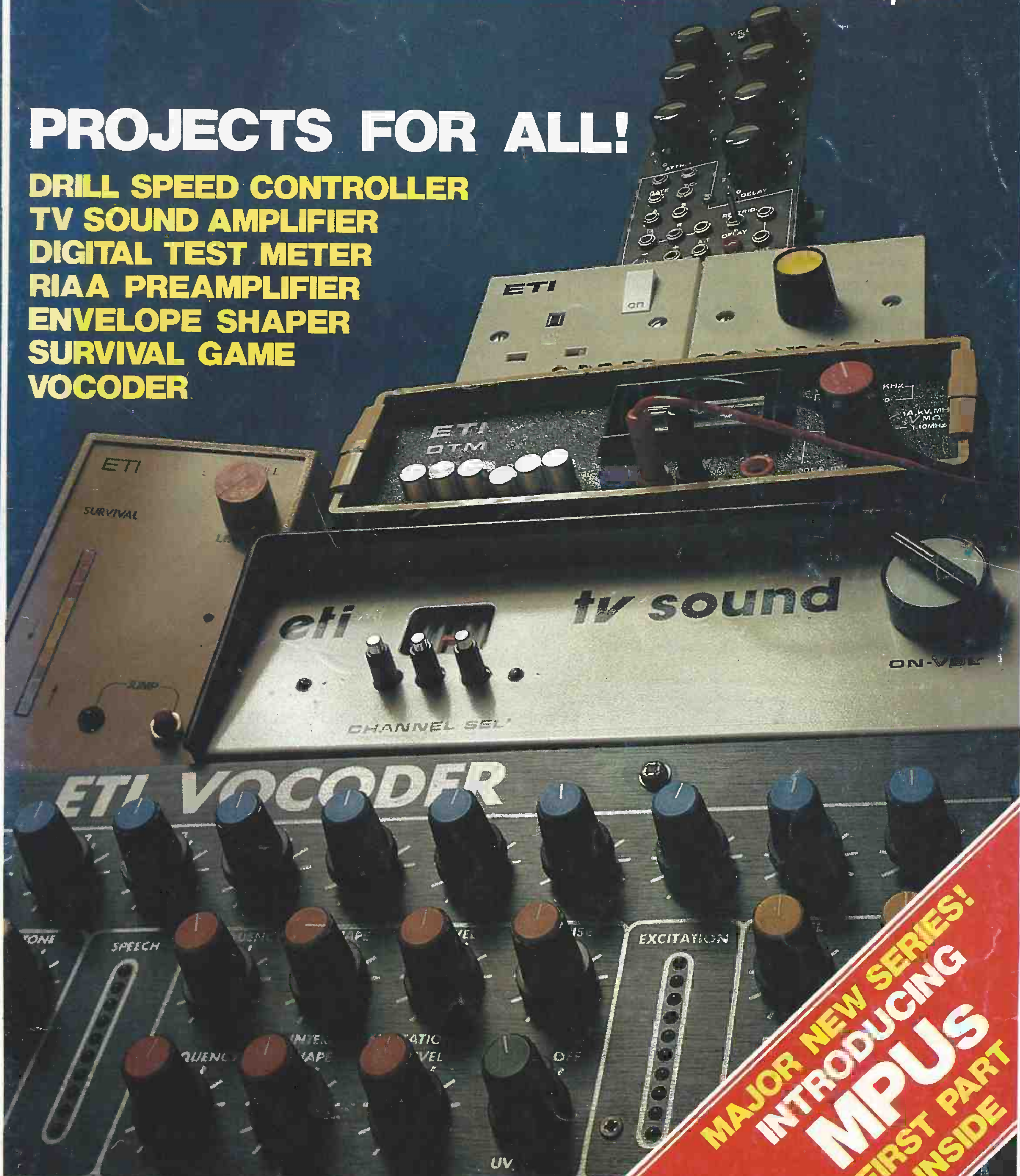
electronics today

INTERNATIONAL

SEPTEMBER 1980 60p

PROJECTS FOR ALL!

DRILL SPEED CONTROLLER
TV SOUND AMPLIFIER
DIGITAL TEST METER
RIAA PREAMPLIFIER
ENVELOPE SHAPER
SURVIVAL GAME
VOCODER



MAJOR NEW SERIES! INTRODUCING MPUs FIRST PART INSIDE

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

8K ON BOARD MEMORY!
5K RAM. 3K ROM or 4K RAM. 4K ROM (link selectable). Kit supplied with 3K RAM, 3K ROM. System expandable for up to 32K memory.

2 KEYBOARDS!
56 Key alphanumeric keyboard for entering high level language plus 16 key Hex pad for easy entry of machine code.

GRAPHICS!
64 character graphics option — includes transistor symbols! Only £18.20 extra!

MEMORY MAPPED
high resolution VDU circuitry using discrete TTL for extra flexibility. Has its own 2K memory to give 32 lines for 64 characters.

KANSAS CITY
low error rate tape interface.

2 MICROPROCESSORS
Z80 the powerful CPU with 158 instruction, including all 78 of the 8080, controls the MM57109 number cruncher. Functions include +, —, *, /, squares, roots, logs, exponentials, trig functions, inverses etc. Range 10^{-99} to 9×19^{99} to 8 figures plus 2 exponent digits.

EFFICIENT OPERATION
Why waste valuable memory on sub routines for numeric processing? The number cruncher handles everything internally!

RESIDENT BASIC
with extended mathematical capability. Only 2K memory used but more powerful than most 8K Basics!

1K MONITOR
resident in EPROM.

SINGLE BOARD DESIGN
Even keyboards and power supply circuitry on the superb quality double sided plated through-hole PCB.

PSI COMP 80
Z80 Based powerful scientific computer design as published in WIRELESS WORLD

Cabinet size 19.0" × 15.7" × 3.3". Television not included in price

COMPLETE KIT NOW ONLY £225 + VAT

The kit for this outstandingly practical design by John Adams published in a series of articles in Wireless World really is complete. Included in the PSICOMP 80 scientific computer kit is a professionally finished cabinet, fibre-glass double sided, plated-through-hole printed circuit board. 2 keyboards PCB mounted for ease of construction, IC sockets, high reliability metal oxide resistors, power supply using custom designed toroidal transformer. 2K Basic and 1K monitor in EPROMS and, of course, wire, nuts, bolts, etc.

KIT ALSO AVAILABLE AS SEPARATE PACKS

For those customers who wish to spread their purchase or build a personalised system the kit is available as separate packs eg. PCB (16" × 12.5") £43.20. Pair of keyboards £34.80. Firmware in EPROMS £30.00. Toroidal transformer and power supply components £17.60. Cabinet (very rugged, made from steel, really beautifully finished) £26.50. P.S. Will greatly enhance any other single board computer including OHIO SUPERBOARD for which it can be readily modified. Other packs listed in our FREE CATALOGUE.

PSI COMP 80 Memory Expansion System

Expansion up to 32K all inside the computer's own cabinet!

By carefully thought out engineering a mother board with buffers and its own power supply (powered by the computer's transformer) enables up to 3 8K RAM or 8K ROM boards to be fitted neatly inside the computer cabinet. Connections to the mother board from the main board expansion socket is made via a ribbon cable.

Mother board:	Fibre glass double sided plated through hole P.C.B. 8.7" x 3.0" set of all components including all brackets, fixing parts and ribbon cable with socket to connect to expansion plug **£39.90**
8K Static RAM board	Fibre glass double sided plated through hole P.C.B. 5.6" x 4.8" .... **£12.50** Set of components including IC sockets, plug and socket but excluding RAMs .... **£11.20** 2114L RAM (16 required) .... **£5.00** Complete set of board, components, 16 RAMS **£89.50**
8K ROM board	Fibre glass double sided plated through hole P.C.B. 5.6" x 4.8" .... **£12.40** Set of components including IC sockets, plug and socket but excluding ROMs .... **£10.70** 2708 ROM (8 required) .... **£8.00** Complete set of board, components, 8 ROMs **£78.50**

THIS MONTH'S FRONT COVER FEATURE!
★ ETI VOCODER ★

Panel size 19.0" x 5.25". Depth 12.2".

14 CHANNELS!
NOISE GENERATOR!
SLEW RATE CONTROL!
2 OSCILLATORS!
VOICED/UNVOICED DETECTOR!
LED PPM METERS!

COMPLETE KIT ONLY £195 + VAT
Kit includes FREE foot control and test oscillator!

Like all our kits the ETI VOCODER really is complete — fully finished metal work, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc. — even a 13A plug!

MANY MORE KITS ON PAGE 8

POWERTRAN

OUR CATALOGUE IS FREE! WRITE OR PHONE NOW!

POWERTRAN ELECTRONICS

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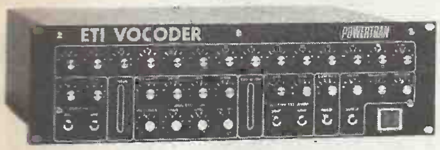
SECURICOR DELIVERY: For this optional service (U.K. mainland only) add £2.50(VAT inclusive) per kit.
SALES COUNTER: If you prefer to collect kit from the factory, call at Sales Counter. Open 9 a.m.-12 noon, 1-4.30 p.m. Monday-Thursday.



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Testing Time p.79

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INFORMATION

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Britain's first complete computer kit.

The Sinclair ZX80.

£79.95

Price breakdown
ZX80 and manual: £69.52
VAT: £10.43
Post and packing FREE

Please note: many kit makers quote VAT-exclusive prices.

You've seen the reviews...you've heard the excitement...now make the kit!

This is the ZX80. 'Personal Computer World' gave it 5 stars for 'excellent value.' Benchmark tests say it's faster than all previous personal computers. And the response from kit enthusiasts has been tremendous.

To help you appreciate its value, the price is shown above with and without VAT. This is so you can compare the ZX80 with competitive kits that don't appear with inclusive prices.

'Excellent value' indeed!

For just £79.95 (*including* VAT and p&p) you get everything you need to build a personal computer at home...PCB, with IC sockets for all ICs; case; leads for direct connection to a cassette recorder and television (black and white or colour): *everything!*

Yet the ZX80 really is a complete, powerful, full-facility computer, matching or surpassing other personal computers at several times the price.

The ZX80 is programmed in BASIC, and you can use it to do quite literally anything from playing chess to managing a business.

The ZX80 is pleasantly straightforward to assemble, using a fine-tipped soldering iron. It immediately proves what a good job you've done; connect it to your TV...link it to an appropriate power source*...and you're ready to go.

Your ZX80 kit contains...

- Printed circuit board, with IC sockets for all ICs.
- Complete components set, including all ICs–all manufactured by selected world-leading suppliers.
- New rugged Sinclair keyboard, touch-sensitive, wipe-clean.
- Ready-moulded case.
- Leads and plugs for connection to domestic TV and cassette recorder. (Programs can be SAVEd and LOADed on to a portable cassette recorder.)
- FREE course in BASIC programming and user manual.

Optional extras

- Mains adaptor of 600 mA at 9 V DC nominal unregulated (available separately–see coupon).
- Additional memory expansion boards allowing up to 16K bytes RAM. (Extra RAM chips also available–see coupon).

*Use a 600 mA at 9 V DC nominal unregulated mains adaptor. Available from Sinclair if desired (see coupon).

The unique and valuable components of the Sinclair ZX80.

The Sinclair ZX80 is not just another personal computer. Quite apart from its exceptionally low price, the ZX80 has two uniquely advanced components: the Sinclair BASIC interpreter; and the Sinclair teach-yourself BASIC manual.

The unique Sinclair BASIC interpreter offers remarkable programming advantages:

- **Unique 'one-touch' key word entry: the ZX80 eliminates a great deal of tiresome typing. Key words (RUN, PRINT, LIST, etc.) have their own single-key entry.**
- Unique syntax check. Only lines with correct syntax are accepted into programs. A cursor identifies errors immediately. This prevents entry of long and complicated programs with faults only discovered when you try to run them.
- Excellent string-handling capability–takes up to 26 string variables of any length. All strings can undergo all relational tests (e.g. comparison). The ZX80 also has string input–to request a line of text when necessary. Strings do *not* need to be dimensioned.
- Up to 26 single dimension arrays.
- FOR/NEXT loops nested up to 26.
- Variable names of any length.
- BASIC language also handles full Boolean arithmetic, conditional expressions, etc.
- Exceptionally powerful edit facilities, allows modification of existing program lines.
- Randomise function, useful for games and secret codes, as well as more serious applications.
- Timer under program control.
- PEEK and POKE enable entry of machine code instructions. USR causes jump to a user's machine language sub-routine.
- High-resolution graphics with 22 standard graphic symbols.
- All characters printable in reverse under program control.
- Lines of unlimited length.

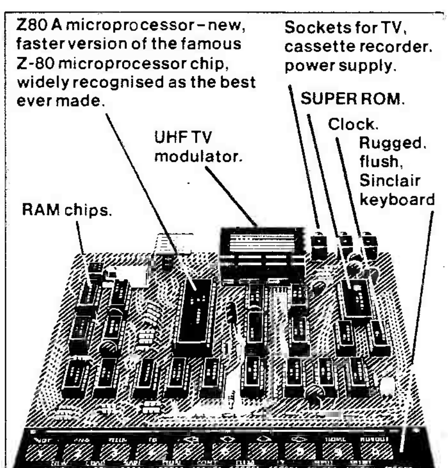
Fewer chips, compact design, volume production–more power per pound!

The ZX80 owes its remarkable low price to its remarkable design: the whole system is packed on to fewer, newer, more powerful and advanced LSI chips. A single SUPER ROM, for instance, contains the BASIC interpreter, the character set, operating system, and monitor. And the ZX80's 1K byte RAM is roughly equivalent to 4K bytes in a conventional computer–typically storing 100 lines of BASIC. (Key words occupy only a single byte.)

The display shows 32 characters by 24 lines.

And Benchmark tests show that the ZX80 is faster than all other personal computers.

No other personal computer offers this unique combination of high capability and low price.



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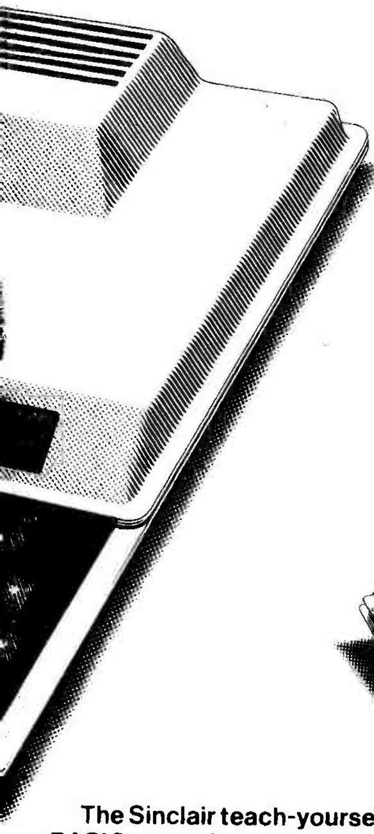
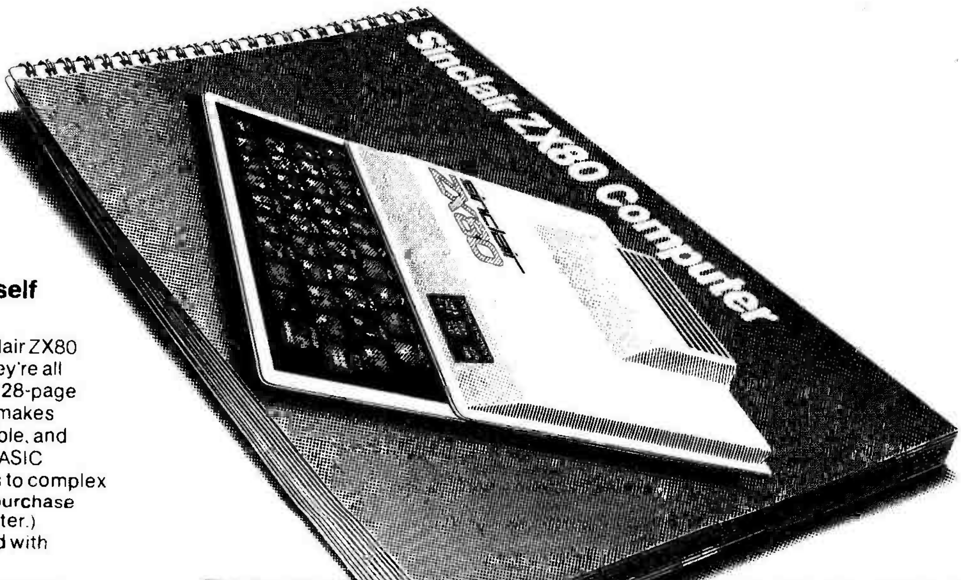


ZX80 software – now available!

See advertisements in Personal Computer World, Electronics Today International, and other journals.

New dedicated software – developed independently of Science of Cambridge – reflects the enormous interest in the ZX80. More software available soon – from leading consultancies and software houses.



The Sinclair teach-yourself BASIC manual.

If the specifications of the Sinclair ZX80 mean little to you – don't worry. They're all explained in the specially-written 128-page book *free* with every kit! The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming – from first principles to complex programs. (Available separately – purchase price refunded if you buy a ZX80 later.) A hardware manual is also included with every kit.

The Sinclair ZX80. Kit: £79.95. Assembled: £99.95. Complete!

The ZX80 kit costs a mere £79.95. Can't wait to have a ZX80 up and running? No problem! It's also available, ready assembled and complete with mains adaptor, for only £99.95.

Demand for the ZX80 is very high: use the coupon to order today for the earliest possible delivery. All orders will be despatched in strict rotation. We'll acknowledge each order by return, and tell you exactly when your ZX80 will be delivered. If you choose not to wait, you can cancel your order immediately, and your money will be refunded at once. Again, of course, you may return your ZX80 as received within 14 days for a full refund. We want you to be satisfied beyond all doubt – and we have no doubt that you will be.

sinclair ZX80

Science of Cambridge Ltd
6 Kings Parade, Cambridge, Cambs., CB2 1SN.
Tel: 0223 311488.

ORDER FORM

To: Science of Cambridge Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN.
Remember: all prices shown include VAT, postage and packing. No hidden extras.
Please send me:

Quantity	Item	Item price £	Total £
	Sinclair ZX80 Personal Computer kit(s). Price includes ZX80 BASIC manual, excludes mains adaptor	£79.95	
	Ready-assembled Sinclair ZX80 Personal Computer(s). Price includes ZX80 BASIC manual and mains adaptor	£99.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	8.95	
	Memory Expansion Board(s) (each one takes up to 3K bytes).	12.00	
	RAM Memory chips – standard 1K bytes capacity	16.00	
	Sinclair ZX80 Manual(s) (manual free with every ZX80 kit or ready-made computer).	5.00	

NB. Your Sinclair ZX80 may qualify as a business expense. **TOTAL** £

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7421	40p
7422	22p
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7426	40p
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7454	17p
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7470	36p
7472	30p
7473	34p
7474	30p
7475	38p
7476	32p
7480	50p
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74LS257	90p
74LS258	180p
74LS259	180p
74LS266	100p
74LS273	170p
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75324	375p
75325	375p
75361	300p
75363	400p
T5365	350p
75451	72p
75491/2	96p
8T26	200p
8T28	250p
8T95	200p
8T97	160p
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9368	250p
9370	300p
9374	200p

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AY5-4007D	520p
CA3019	80p
CA3046	70p
CA3048	225p
CA3080E	72p
CA3086	48p
CA3089E	225p
CA309—AQ	375p
CA3130E	90p
CA3140E	50p
CA3160E	100p
CA3161E	140p
CA3162E	450p
CA3189E	300p
CA3280	100p
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ICL7106	850p
ICL8038	340p
ICM7555	80p
LF356P	95p
LM10C	425p
LM301A	30p
LM311	70p
LM318	200p
LM319	225p
LM324	45p
LM339	75p
LM348	95p
LM377	175p
LM380	75p
LM381AN	180p
LM393	100p
LM709	36p
LM710	50p
LM725	350p
LM733	100p
LM741	18p
LM747	70p
LM748	35p
LM2917	250p
LM3900	70p
LM3909	70p
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LM3915	250p
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MC1310P	150p
MC1458	48p
MC1495L	350p
MC1496	100p
MC3340P	120p
MC3360P	120p
MK50398	750p
ML920	775p
MM57160	620p
NE531	150p
NE555	22p
NE556	70p
NE561B	425p
NE562B	425p
NE564	520p
NE565	130p
NE566	155p
NE567	175p
NE571	425p
NE5534A	260p
RC4151	400p
S566B	270
SAB3209	POA
SAD1024A	1250p
SFF96364	1100p
SL490	400p
SN76003N	250p
SN76013N	140p
SN76013ND	120p
SN76477	200p
SP8515	750p
TAA621	275p
TBA641B11	225p
TBA651	200p
TBA800	90p
TBA810	100p
TBA820	90p
TBA950	300p
TCA210	250p
TCA220	350p
TCA940	175p
TDA1004	300p
TDA1008	320p
TDA1010	225p
TDA1022	570p
TDA1024	120p
TDA1034B	250p
TDA1170	250p
TDA2002V	325p
TDA2020	320p
TL071	45p
TL072	85p
TL074	130p
TL081	45p
TI082	70p
TL084	110p
TL170	50p
UAA170	200p
UDN6118	320p
UDN6184	320p
ULN2003	100p
XR2206	350p
XR2207	400p
XR2240	400p
ZN414	90p
ZN419C	225p
ZN424E	135p
ZN425E	400p

VOLTAGE REGULATORS

Fixed Plastic TO-220

1A	+ve		—ve	
5V	7805	60p	7905	65p
12V	7812	60p	7912	65p
15V	7815	60p	7915	70p
18V	7818	60p	7918	70p
24V	7824	60p	7924	70p
100mA	TO92			
5V	78L05	30p	79L05	70p
12V	78L12	30p	79L12	70p
15V	78L15	30p	79L15	70p

OTHER REGULATORS

LM309K	135p	78HGKC	600p
LM317T	200p	78HO5KC	600p
LM323K	550p	78MGT2C	135p
LM723	37p	78P05	900p
		79HGKC	700p

OPTO-ELECTRONICS

2N5777	45p	ORP60	120p
OCP71	130p	ORP61	120p
ORP12	120p	TIL78	55p

OPTO-ISOLATORS

ILD74	130p	TIL111	90p
MCT26	100p	TIL112	90p
MCS2400	190p	TIL116	90p

LEDS

0.125"		0.2"	
TIL32	55p	TIL220 Red	16p
TIL209 Red	13p	TIL222 Gr	18p
TIL211 Gr	20p	TIL228 Red	22p
TIL212 Ye	25p	Rectangular	
TIL216 Red	18p	LEDs (R, G, Y)	30p

DISPLAYS

3015F	200p	NSB5881	570p
DL704	140p	TIL311	600p
DL707 Red	140p	TIL312/3	110p
707 Gr	140p	TIL321/2	130p
DL747 Red	225p	TIL330	140p
747 Gr	225p	7750/60	200p
FND357	120p	**DRIVERS**	
FND500	120p	9638	250p
FND507	120p	9370	300p
MAN3640	175p	UDN6118	320p
MAN4640	200p	UDN6184	320p

TRANSISTORS

AC126	25p
AC127/8	20p
AC176	25p
AC187/8	25p
AF116	50p
AD149	70p
AD161/2	45p
AU107	200p
BC107/8	11p
BC109	11p
BC117	20p
BC147/8	9p
BC149	10p
BC157/8	10p
BC159	11p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	16p
BC461	36p
BC477/8	30p
BC516/7	50p
BC547B	16p
BC548C	9p
BC549C	18p
BC557B	16p
BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD135/6	54p
BD⅛ ⅛& ⅛ ¼ P	
BD140	60p
BD189	60p
BD232	95p
BD233	75p
BD235	85p
BD241	70p
BD242	70p
BDY56	200p
BF200	32p
BF244B	35p
BF256B	70p
BF257/8	32p
BF259	36p
BFR39	25p
BFR40	25p
BFR41	25p
BFR79	25p
BFR80	25p
BFR81	25p
BFX29	30p
BFX30	34p
BFX84/5	40p
BFX86/7	30p
BFX88	30p
BFW10	90p
BFY50	30p
BFY51/2	30p
BFY56	33p
BFY90	90p
BRY39	45p
BSX19/20	20p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU205	200p
BU208	200p
BU406	145p
E300	50p
E308	50p
E310	50p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJE340	50p
MJE2955	100p
MJE3055	70p
MPF102	45p
MPF103/4	40p
MPF105/6	40p
MPS6531	50p
MPS6534	50p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSU06	63p
MPSU07	90p
MPSU45	90p
MPSU65	78p
OC28	130p
OC35	130p
TIP29A	40p
TIP29C	55p
TIP30A	48p
TIP30C	60p
TIP31A	58p
TIP31C	62p
TIP32A	68p
TIP32C	82p
TIP33A	90p
TIP33C	114p
TIP34A	115p
TIP34C	160p
TIP35A	225p
TIP35C	290p
TIP36A	270p
TIP36C	340p
TIP41A	65p
TIP41C	78p
TIP42A	70p
TIP42C	82p
TIP54	160p
TIP120	120p
TIP122	130p
TIP142	130p
TIP147	130p
TIP2955	78p
TIP4055	70p
TIS43	34p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX500	15p
ZTX502	18p
ZTX504	30p
2N457A	250p
2N696	35p
2N697	25p
2N698	45p
2N706A	20p
2N708A	20p
2N918	45p
2N930	18p
2N1131/2	20p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	30p
2N2222A	30p
2N2369A	25p
2N2484	30p
2N2646	45p
2N2904/5	30p
2N2906A	30p
2N2907A	30p
2N2926	9p
2N3053	30p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3565	30p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	300p
2N3819	25p
2N3820	50p
2N3823	70p
2N3866	90p
2N3902	700p
2N3903/4	18p
2N3905/6	20p
2N4037	65p
2N4058/9	12p
2N4060	12p
2N4061/2	18p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	60p
2N5087	27p
2N5089	27p
2N5172	27p
2N5179	90p
2N5191	90p
2N5194	90p
2N5245	40p
2N5296	)5p
2N5401	50p
2N5457/8	40p
2N5459	40p
2N5460	60p
2N5485	44p
2N5875	250p
2N6027	48p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2N6292	65p
2SC1172	150p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	100p
40290	250p
40360	40p
40361/2	75p
40364	120p
40408	70p
40409	85p
40410	85p
40411	300p
40594	120p
40595	120p
40673	75p
40841	90p
40871/2	90p

DIODES

BY127	12p
BYX36-300	20p
OA47	9p
OA81	15p
OA85	15p
OA90	9p
OA91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
IS920	9p

HEAT SINKS

For TO220 Voltage Regs. and Transistors 22p
For TO5 12p

BRIDGE RECTIFIERS

1A	50V	19p
1A	100V	20p
1A	400V	25p
1A	600V	30p
2A	50V	30p
2A	100V	35p
2A	400V	45p
3A	200V	60p
3A	600V	72p
4A	100V	95p
4A	400V	100p
6A	50V	80p
6A	100V	100p
6A	400V	120p
10A	400V	200p
25A	400V	400p

ZENERS

2.7V-33V

400mW	9p
1W	15p

TRIACS PLASTIC

3A 400V	60p
3A 500V	65p
6A 400V	70p
6A 500V	88p
8A 400V	75p
8A 500V	95p
12A 400V	85p
12A 500V	105p
16A 400V	110p
16A 500V	130p
T2800D	130p

THYRISTORS

1A 50V	40p
1A 400V	65p
3A 400V	90p
8A 600V	140p
12A 400V	160p
16A 100V	160p
16A 400V	180p
16A 600V	220p
BT106	110p
C106D	45p
MCR101	36p
2N3525	130p
2N4444	140p
2N5060	34p
2N5064	40p

LOUDSPEAKERS

Size		
2½	64R	80p
2½	8R	80p
2	8R	90p
1½	8R	100p

MEMORIES

2102-2L	120p
2107B	500p
2111-2	250p
2112-2	300p
2114	300p
2114-2L	500p
4027-3	375p
4044	900p
4116	400p
5101	510p
6810	325p
74S201	350p
82516	325p

ROM/PROMs

71301	700p
74S188	225p
74S287	350p
74S387	350p
74S470	650p
74S471	650p
74S571	650p
82S137	750p
93427	400p
93436	650p
93446	650p
93448	900p

CPUs

1600	1200p
1802CE	650p
2650A	2000p
6502	1000p
6800	650p
6802	1250p
6809	2500p
8080A	450p
8085A	1200p
1NS8060	1000p
Z80	£10
Z80A	1150p

EPROMs

1702A	600p
2708	450p
2716 (+5V)	£10

SUPPORT DEVICES

3242	800p
3245	450p
6532	1000p
6820	500p
6821	375p
6845	2500p
6850	300p
8205	320p
8212	225p
8216	225p
8224	275p
8228	525p
8251	550p
8253	1000p
8255	550p
8257	950p
8259	1200p
Z80P10	650p
Z80AP10	800p
Z80CTC	650p
MC14411	1100p
MC14412	1100p

UART

AY-3-1015P	500p
AY-5-1013P	400p
IM6402	500p
TMS6011NC	400p

CHARACTER GENERATORS

3257ADC	990p
MCM6576	£12
RO-3-2513 U.C.	600p
RO-3-2513 L.C.	700p
SN74S262AN	£10

KEYBOARD ENCODER

AY-5-2376	700p

TRANSFORMERS

(prim 220/240V)

6-0-6	100mA	88p
9-0-9	75mA	92p
0-120	12500mA	280p
0-25V (VA)		250p
9-0-9 1A		270p*
12V 2A		350p*
0-12-15		
20-24-30 1A		340p*
15-0-15 1A		265p*

(Please add 50p p&p charge to all marked * above our normal p&p charge).

RESISTORS High

Stab 5% E12
Carbon Film

¼W 10R-1M one value	7p/5pcs
½W 10R-10M one value	5p/3pcs

Miniature Presets

Hor/Vert 100R-1M	12p
Carbon Track Pots 5K-1M Log or Lin	
Single	30p
Single with Switch	60p
Dual	72p
SLIDER POTS 60mm Track LIN 5K, 10K, 50K, 100K	60p
LOG 10K	60p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	20p	28 pin	30p
16 pin	11p	22 pin	22p	40 pin	40p

WIRE WRAP SOCKETS BY TEXAS

8 pin	25p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

SUBMINIATURE SWITCHES

Toggle	
SPST	60p
SPDT	65p
DPDT	70p
DPDT (centre off)	85p
Push to make	15p
Break	25p
Push latching SPCO	60p
SLIDE DPDT	18p
ROCKER SPST	28p
WAFER	
1P/12W	45p
3P/4W	45p
4P/3W	45p
2P/6W	45p

CRYSTALS

100KHz	300p
1MHz	370p
1.008MHz	370p
3.2768MHz	350p
3.579545MHz	200p
4MHz	350p
8.867237MHz	400p
10.7MHz	350p
18MHz	300p
26.690MHz	210p
27.145MHz	210p

ANTEX SOLDERING IRONS

C-15W	415p
CX-17W	425p
CCN-15W	425p
X25	440p

SPARE BITS

C/CX/CCN	50p
X25	50p

SPARE ELEMENTS

C/CX/X25	180p
CCN	200p

ADCOLA IRONS

K1000	550p
K2000	550p

VEROBOARDS

0IP Breadboar 4.15 × 6.15 (Suitable for 20 × 14 pin or 16 × 16 pin DIL ICs)	325p
DIP Breadboard as above with tracks for 31 way connector	375p
V-Q Boards for ICs (No track cutting)	130p

CONNECTOR PLUGS

31 way Plug	120p
31 way Socket	120p
S-100 Busboar	1500p

EDGEBOARD CONNECTORS 0.156" PITCH

2 x 10 way	85p	2 x 22 way	135p
2 x 15 way	100p	2 x 25 way	160p
2 x 18 way	120p		

COUNTERS

74C925	475p
74C928	600p
ICM7216B	2000p
ICM7217A	850p
ZN1040E	700p

TTL & ECL

MC4024	325p
MC4044	325p
10116	70p
10231	350p

SPECIAL OFFERS (subject to stocks)

555	£18/100	7805	£5/10
741	£16/100	7812	£5/10
2114L-3	£4.00	7905	£6/10
2708 (450 ns)	£4.50	7912	£6/10
2708 (650 ns)	£4.00	2114L 450 ns	£24/8
2716 (plus 5V only)	£9.00		
4116 (200 ns)	£28/8		

P&P + VAT Extra

BREADBOARDS

EXP350 3.6 x 2.1 (Up to 3 x 14 pin ICs)	£3.15
EXP650 3.6 x 2.4 (Up to 1 x 40 pin IC)	£3.60
EXP300 6 x 2.1 (Up to 6 x 14 pin ICs)	£5.75
EXP600 6 x 2.4 (Up to 1 x 40 pin DCs)	£6.30

PROTOBOARD (R) SOLDERLESS BREADBOARDS

Socket Strips/Bus Strips/Binding Posts mounted on sturdy base plate.

PB6	6 x 14 DIL ICs	£9.20
PB100	10 x 14 DIL ICs	£11.80
PB102	12 x 14 DIL ICs	£22.95
PB103	24 x 14 DIL ICs	£34.45
PB104	32 x 14 DIL ICs	£45.95

(The above boards are suitable for all DIL ICs.)

16 KEY KEYPAD (Reed Switches)	450p
UHF Modulator 6MHz	£3.75
UHF Modulator 8MHz	450p
Reed Switches (12VA)	£0.25
LOGIC PROBE	£18.00
SUPERTESTER 680R	£33.00
MICROTEST 80R	£17.00
TMK500	£22.00
Pocket multimeter	£4.75

VEROBOARDS

0.1 (copper clad)

2.5×3.75	65p
2.5×5	75p
3.75×3.75	75p
3.75×5	80p
3.75×17	290p
4.75×17.9	380p

Pkt of 100 pins	50p
Spot face cutter	86p
Pin insertion tool	118p
Vero Wiring Pen + 2 wire spools + combs	370p
Combs	7p

IC TEST CLIPS

14 pin	£2.60	24 pin	£4.90
16 pin	£2.75	40 pin	£7.90

We carry a large stock of 74 and 74LS TTLs, CMOS, Linears, Memories, etc. and can normally offer ex-stock deliveries. We welcome inquiries for volume quantities both from local and overseas buyers.

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DIGEST

Booking Up

Bernard Babani (Publishing) Ltd of The Grampians, Shepherds Bush Road, London W6 7NF have brought out a brand new catalogue of Radio and Electronics books which they publish. They cover such subjects as Electronics, Semiconductors, Computers, Television, Radio, Hi-fi, etc. Whether you are a hobbyist, engineer, designer or student, they have something for you. The catalogue is free, just send them a reasonably large stamped addressed envelope and you will recieve your copy by return.

Power Cuts On The Way

In 1968 your 20 inch colour telly using 90° deflection would have consumed over 200 W. Now, the figure is around 65 W. A new development from Finland will further reduce that to about 40 W.

The system, which results in a reduction of about 40% in power consumption, has been incorporated in the Salora G Series of portable colour sets. The design is basically a 90% efficient couple between the power supply and picture tube using an induction transfer system. The resultant cool running improves reliability and extends operational life.

The G Series, with its 16, 20 and 22 inch models, will operate from a standard 60A/hour 12 V battery for 15 hours, or from mains for as long as you pay your bills.

All the models feature automatic electronic tuning, fine tuning and memory plus add-on options for remoted control, 12 V battery and video frequency interface unit.

Salora products are available in the UK from Salora (UK) Ltd, 25A Techno Trading Estate, Swindon SN2 6EZ.

Computer Aided Yacht Race

This year the 1980 Observer Single Handed Transatlantic Yacht Race is being aided by a computer-based system. Known as the Argos system, each of the yachts involved in the race has an on-board transmitter which emits a signal picked up by two satellites regularly crossing the Atlantic. These signals are then rebounded to earth for decoding and processing. The information is fed via Toulouse in France to a CII Honeywell Bull computer in Paris and then is further processed by a Micral Computer in the Paris offices of Europe 1 radio station. A Benson drafting machine on line to this computer is then able to give a graphic representation of the yachts' positions. This information is used by the radio station for its coverage of the race and also allows the race organisers to keep a constant eye on the progress of each yacht. This means increased safety for the race, as Coastguards can be immediately notified if they are in difficulty. After the disasters which occurred during last year's Fastnet race, this system will hopefully increase the safety factor in open sea racing.

EMP — The Govt. Speaks

Your Ref.

Our Ref.

HOME OFFICE,
QUEEN ANNE'S GATE,
LONDON, SW1H 9AT

2 . 7 . 1980

The Under Secretary of State desires to acknowledge the receipt of your letter of the 27. 6. 80 *which is receiving attention.*

This is the entire text of the replies we have received to date from the vast machinery of the British government. Receiving attention? We shall keep plugging away though, and report any sensible answers we do manage to obtain. Meanwhile what are your views on the subject of EMP? Let's hear about them.

Powering Down

Every piece of electrical and electronic equipment needs a power supply of some sort. Larsen Sweeney's latest forecast of the use of power supplies in Europe up to 1986 reports a general downtrend. Not only is the general power supply business slowing down, but, in particular, newer supply systems, eg switching regulated and switched mode, are also feeling the pinch. This is largely a result of a slowdown in new product design and development.

The report warns that British power supply designers are at a distinct disadvantage in this marketplace and many will not survive the recession. Their competitors in West Germany, France, Sweden and Japan are supported financially by their respective governments, but the British companies are on their own.

The 243 page Larsen Sweeney report covers 16 European countries and 34 power supply product groups, including sections on marketing, the industry, the end user and distributors. Every home should have one. You'll have to raid the piggy bank, though. 'Power Supply In Europe To 1986' will set you back £695. Beat the rush . . . send your life savings now to Larsen Sweeney Publications Ltd, P O Box 36, Maidstone, Kent.

Vetting VDUs

If your work involves reading data from a telly screen (operating a computer terminal, for instance) you may occasionally wonder if it affects your eyesight, especially if you go home every night with a splitting headache.

The twin evils of radiation and eyestrain have attracted some attention with respect to VDU usage. For this reason the VDU Eye Test (VET) Advisory Group was set up to devise a test package for VDU users. Their final report has now been published as a 12 page booklet.

The Group found 'that no significant hazard from X-ray, ultra-violet, visible or RF radiation has been detected' in modern VDU design. Moreover, the Group found no evidence that VDU use could cause eyestrain. We consulted a practising Ophthalmic Optician who told us that normal use of the eyes cannot cause damage.

The report did, however, list several factors that could cause discomfort, which the layman might call eyestrain. These included the posture of the VDU user and the working environment.

The Group concluded that VDUs can be used safely, if designed and intalled with proper attention to the user's ergonomic requirements. Where there is intensive use of VDUs, the user's eyesight should be checked with the test recommended in the report.

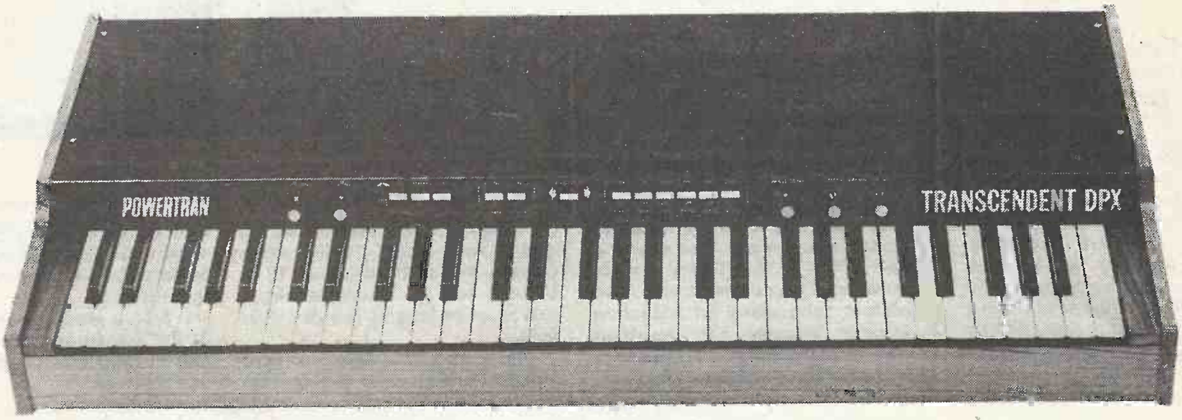
If you would like a copy of the VET Advisory Group's report, write to Tom Stewart, Butler Cox & Partners Ltd, Morley House, 26-30 Holborn Viaduct, London EC1A 2BF.

TRANSCENDENT DPX

DIGITALLY CONTROLLED, TOUCH SENSITIVE, POLYPHONIC, MULTI-VOICE SYNTHESIZER

Another superb design by synthesizer expert Tim Orr — published in Electronics Today International

The Transcendent DPX is a really versatile new 5 octave keyboard instrument. There are two audio outputs which can be used simultaneously. On the first there is a beautiful harpsichord or reed sound — fully polyphonic, i.e. you can play chords with as many notes as you like. On the second output there is a wide range of different voices, still fully polyphonic. It can be a straightforward piano or a honky tonk piano or even a mixture of the two! Alternatively you can play strings over the whole range of the keyboard or brass over the whole range of the keyboard or should you prefer — strings on the top of the keyboard and brass at the lower end (the keyboard is electronically split after the first two octaves) or vice versa or even a combination of strings and brass sounds simultaneously. And on all voices you can switch in circuitry to make the keyboard touch sensitive! The harder you press down a key the louder it sounds — just like an acoustic piano. The digitally controlled multiplexed system makes practical touch sensitivity with the complex dynamics law necessary for a high degree of realism. There is a master volume and tone control, a separate control for the brass sounds and also a vibrato circuit with variable depth control together with a variable delay control so that the vibrato comes in only after waiting a short time after the note is struck for even more realistic strong sounds.



Cabinet size 36.3"×15.0"×5.0" (rear) 3.3" (front)

COMPLETE KIT ONLY £299 +VAT

To add interest to the sounds and make them more natural there is a chorus/ensemble unit which is a complex phasing system using CCD (charge coupled device) analogue delay lines. The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble circuitry can be switched in with either strong or mild effects.
As the system is based on digital circuitry digital data can be easily taken to and from a computer (for storing and playing back accompaniments with or without pitch or key change, computer composing, etc., etc.)
Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophisticated, the kit is mechanically extremely simple with excellent access to all the circuit boards which interconnect with multiway connectors, just four of which are removed to separate the keyboard circuitry and the panel circuitry from the main circuitry in the cabinet.
The kit includes fully finished metalwork, solid teak cabinet, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc., even a 13A plug!

POWERTRAN

MANY MORE KITS ON PAGE 110 MORE KITS AND ORDERING INFORMATION ON INSIDE FRONT COVER

TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

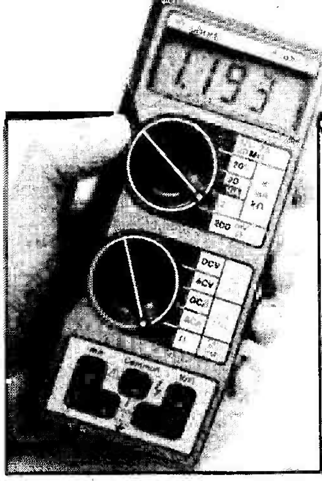
LIVE PERFORMANCE SYNTHESIZER DESIGNED BY CONSULTANT TIM ORR (FORMERLY SYNTHESIZER DESIGNER FOR EMS LIMITED) AND FEATURED AS A CONSTRUCTIONAL ARTICLE IN ELECTRONICS TODAY INTERNATIONAL.

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 noice 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 ½% metal film) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibreglass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready-built units selling for many times the price.

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

COMPLETE KIT ONLY £168.50+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!



Metering Your Multis

The Alpha V is the latest and smallest hand-held digital multimeter from Gould Instruments. It has a 3½-digit liquid crystal display with 25 measuring ranges covering the five basic functions of DC voltage, AC voltage, DC current, AC current and resistance. It has a maximum reading of 1999 and maximum resolution of 100 uV. Range and function selection is by two rotary switches on the clearly coded front panel. The multimeter is powered by a 9 V carbon zinc or alkaline battery (PP3 or equivalent), the latter giving a typical life of 200 hours. There is a battery low indicator provided by the display, which shows 'BAT' when less than 10% of useful battery life remains. The case is of high-impact ABS plastic and the display is shock mounted behind a polycarbonate plastic window. Accessories supplied with the basic instrument include standard red and black test leads, battery and handbook. The cost is £85.00 (plus VAT) from Gould Instruments Division, Roebuck Road, Haina

Anti Car Theft

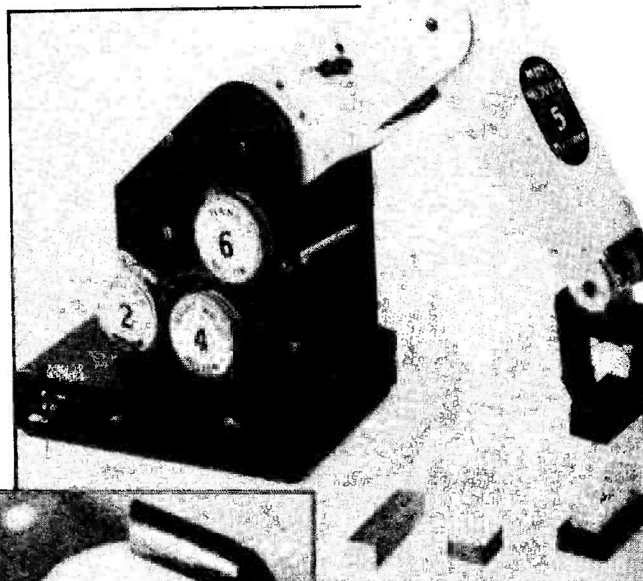
Maywood Security Services Ltd.is marketing a method of deterring vehicle thieves. A mobile service is offered which involves abrading the vehicle registration number on every window of a car, caravan, commercial vehicle or boat. This means that in order to mask the identity of a stolen car the thieves must replace all of its windows. The abrading process takes about five minutes at a cost of about £5 per vehicle (quantity discounts may be given). Maywood Security Services Ltd are operating as a franchise for Safecar and they will quite happily call at your place of work or home. This method has received the support of police crime prevention officers thoughout the country who have to deal with some 350,000 vehicle thefts a year. The address is Maywood Security Services Ltd, Peake House, 232 High Street, Harlington, Hayes, Middlesex, UB3 5DS. They cover North West, West and South West London.

Status Symbols

Raindirk of Downham Market Norfolk are now supplying the Status range of audio equipment. Their Status 500 power amplifier delivers 250 W per channel into 8R, using power MOSFET output stages. Ths Status 20 Stereo Control Unit is a rack-mounting system with a modular disc replay amplifier that can be remotely located, three band equaliser with continously variable turn-over frequencies, built-in headphone amplifiers and external mains power supply. The range will soon also include a parametric equaliser. You can get more information on the Status 500 and the rest of the Status range from Raindirk Ltd, Downham Market, Norfolk.

Sharp Shapes

Sharp Corporation are now marketing an alternative to conventional tubular LEDs. They are designed for flush fitting to front panels and are currently offered in the form of round 'point' indicators, equilateral and isosceles triangles, square and flat sections, all in three different sizes, (3, 4, and 5 mm) and three different colours — red, yellow and green. The shapes make good function indicators and the 'squares and flats' can be stacked to form bar graphs. For 1,000 pieces the price is between 5p and 10p each depending on the size, shape and colour. They are available from CRP Electronics Ltd, 13 Hazelbury Crescent, Luton, LU1 1DF.



Robot School

Integrated Computer Systems Inc. have announced details of their new courses in 'ADA' and 'Computerised Robots'. 'ADA', a new high level computer language, has been developed by the US Department of Defence in co-ordination with European Defence Ministries and may become an industry standard.

Aimed at managers, engineers and programmers, ICS's 'Computerised Robots' course will pinpoint where the new breed of 'intelligent' robots can be used to increase productivity and streamline production.

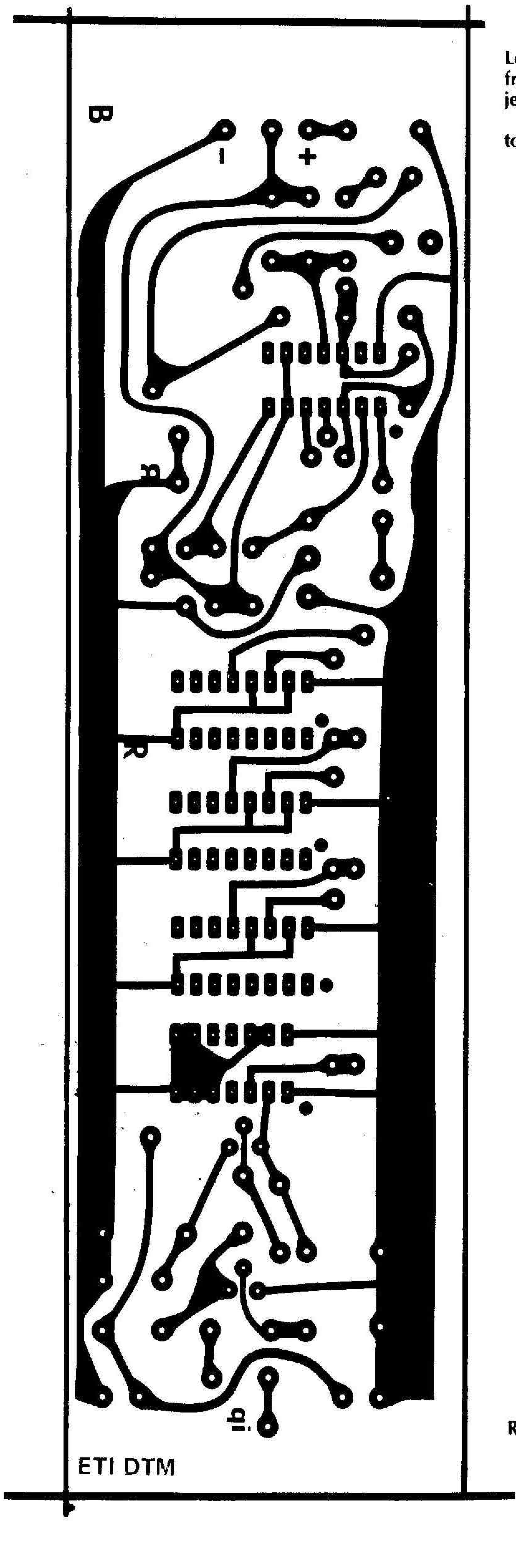
Japan is currently the major employer of robot labour with 6,000 in use (40,000 if you include the simplest automata). The USA has 3,500 while Europe has only 2,000. If computer companies enter the robotics market, it is estimated that there could be 200,000 robots in use by 1990 in the USA alone with over 35% of all production in robot 'hands' by the turn of the century. As the increasing use of robot labour changes the face of society, all we will need is a machine that enjoys living in it.

You can get more information on the course programme from Dr David C Collins, ICS Publishing Co Ltd, Pebblecoombe, Tadworth, Surrey.

Small is Beautiful

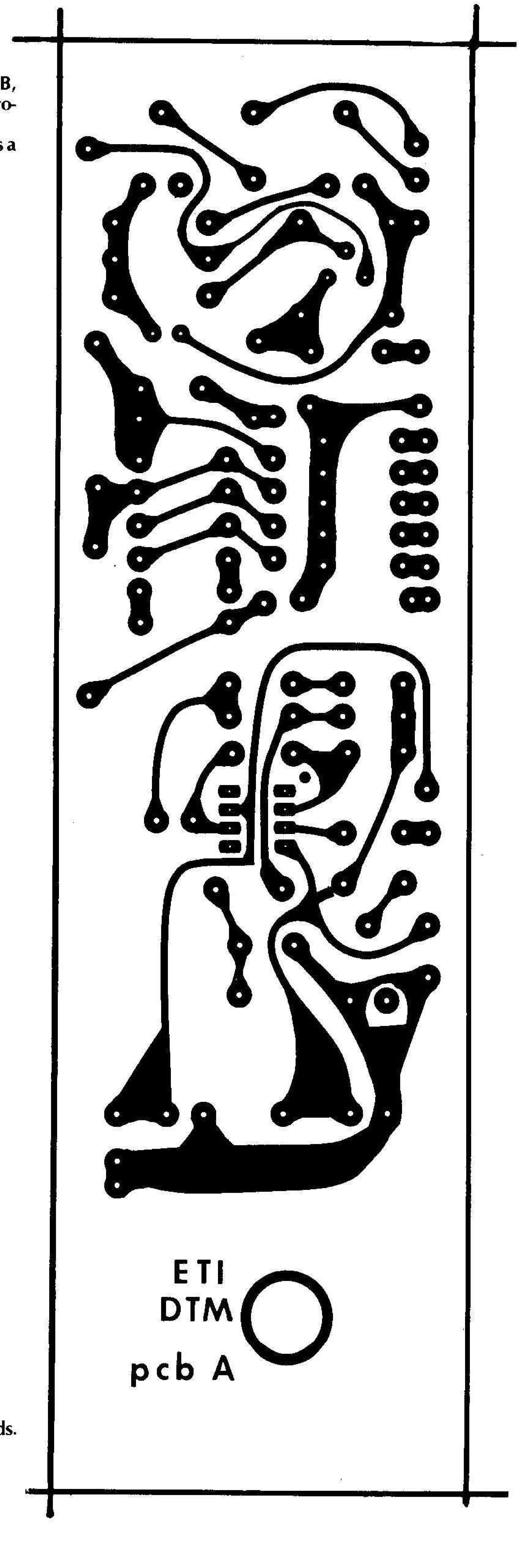
A miniature hi-fi system is now available from Misubishi Electric, called 'System 4'. It delivers 50 W per channel, both channels driven into 8R and it measures 27W × 42.4H × 27cmD. The four units consist of the M-A04 Power-amp, M-P04 pre-amplifier, M-F04 AM/FM Tuner and the M-T04 front-loading Cassette Deck which is metal tape compatible. Their latest speaker system is also available. A 50 W 8R two way infinite baffle speaker, the SS 630E, retails at £115.00 for the pair. Frequency response is 60 Hz to 22 kHz and dimensions are 305W × 544H × 257mmD.

PCB FOIL PATTERNS

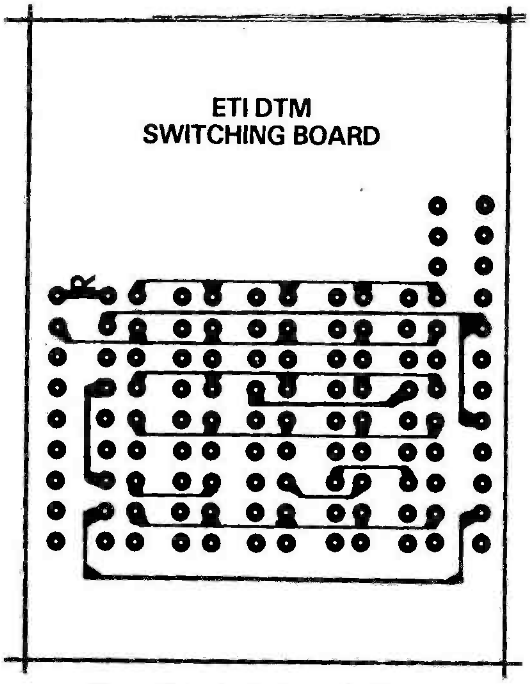


Left: Foil pattern for PCB board B, from the ETI Digital Test Meter project.

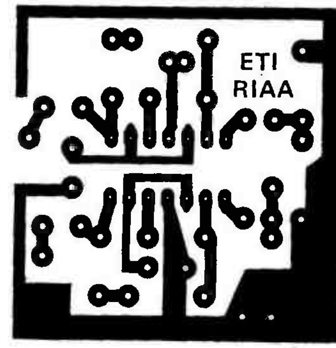
Note that this project comprises a total of three boards.



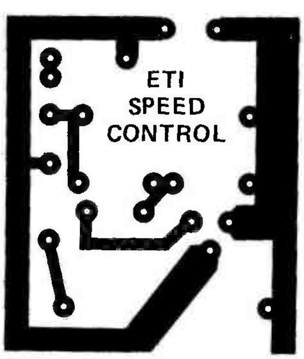
Right: The second of the DTM boards.



Above: The switching board for the DTM project.

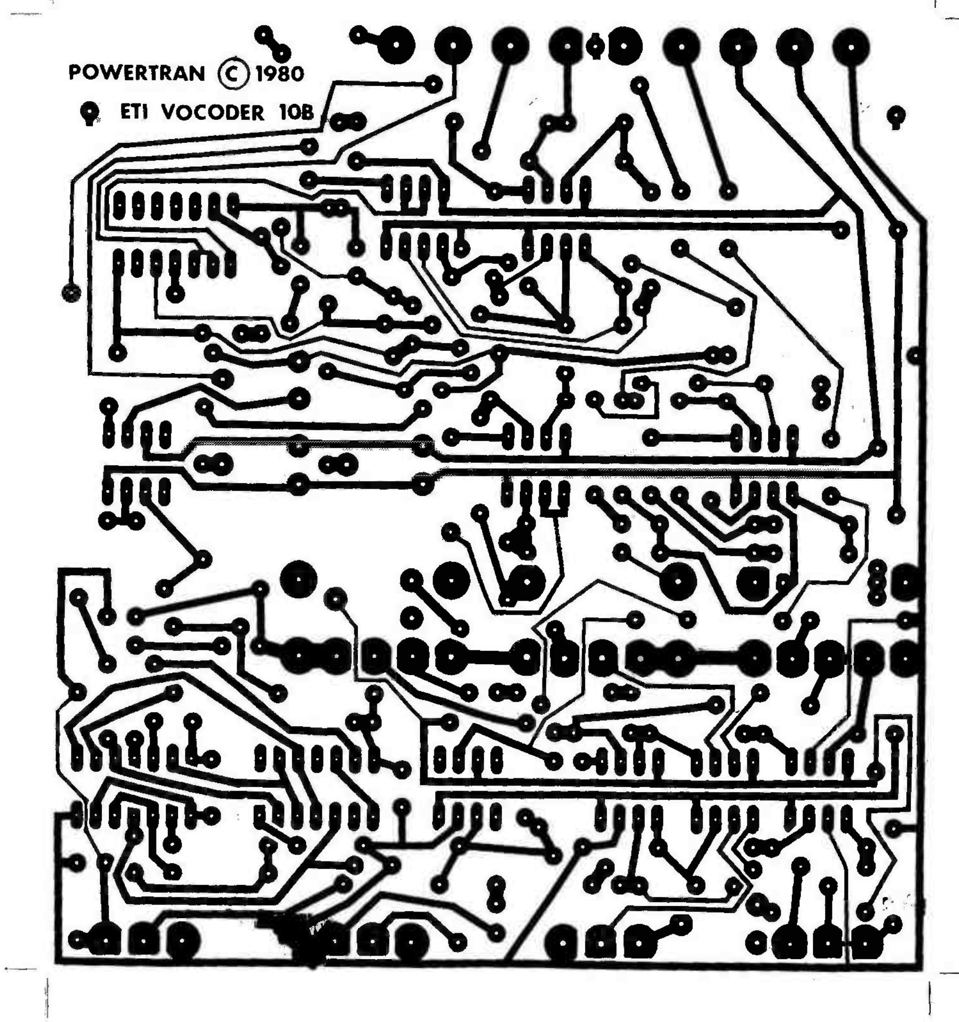


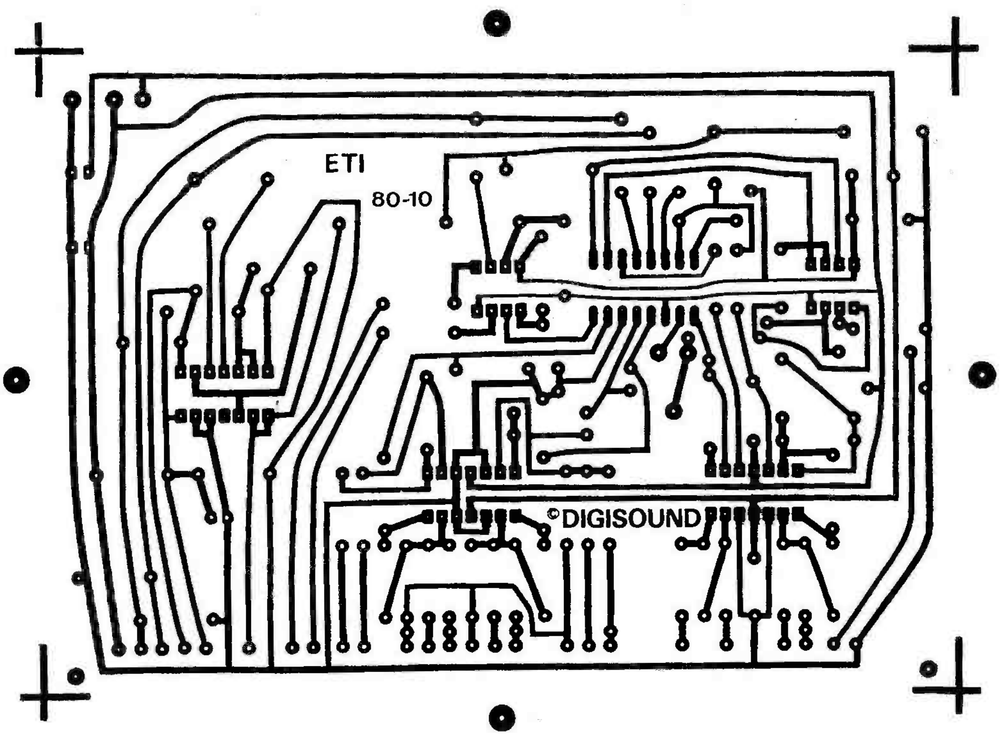
Above: The RIAA preamp foil pattern. The board is intended to be mounted inside existing equipment and space maybe left for fixing.



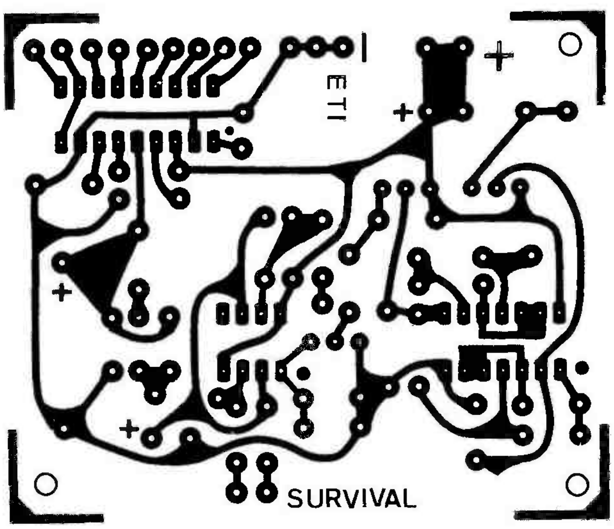
Above: The Drill Speed Controller PCB. Construction is not critical here and other methods may be employed. Take care with the PCB as mains voltage will be present.

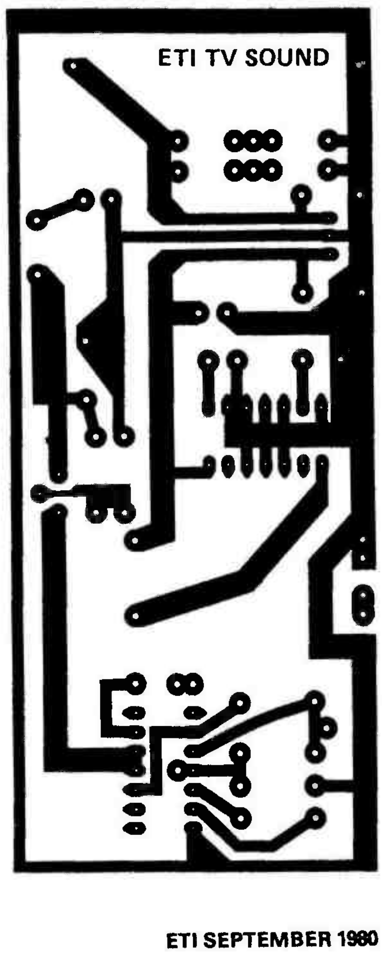
Below: Vocoder board B. The large PCB is not shown here as it is *too* large to go on the page. An SAE to Modmags will secure a copy.





Above: Project 80 board for this month's module. Note that copyright exists on the board and firms may not reproduce the PCBs for sale.





Above: Foil pattern for the SURVIVAL game. This has been designed to fit the specified case.
Right: The monitor amplifier board for the TV Sound Tuner. This circuit is an optical extra to aid tuning and setting up.

ETIPRINTS

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).

PARTS LIST

Shown below is the listing for the last year's ETIPRINTS.

Earlier sheets are available, ring Tim Salmon for details.

038	Buffer Moving Coil Preamp Process Controller	Jan 80
039A	Hum Filter Logic Probe	Dec 79
039B	Long Period Timer Rain Alarm Touch Switch Flash Trigger Pseudo Random Noise Gen	Dec 79
039C	Function Generator	Dec 79
040A	ETI 80 – VCO and VCLFO	Feb 80
040B	ETI 80 – PSU Tuning Fork Filter Coin Toss	Feb 80
041A	ETI Audiophile ETI VCA Signal Trace ETI HC Electromyogram	Mar 80
041B	VCM Heater Controller	Mar 80
042A	300W Amp Module	Apr 80
033	Fuel Level Monitor, Alarm, Screen Controller Dynamic Noise Reducer	Sep 79
042B	Touch Dimmer, Battery Charger RC Guardian (Top,Bottom) 1&2	Apr 80
043	IR60 preamp, Receiver, PSU, Servo Tester, VU–PPM	May 80
044A	IR60 Function Board (Top & underside) Control Circuit, Line Transmitter, Tape Response Meter Ohmmeter	June 80
044B	FM receiver PSU & Monitor Amp Drum Synth (function board)	June 80

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!

ETIPRINTS

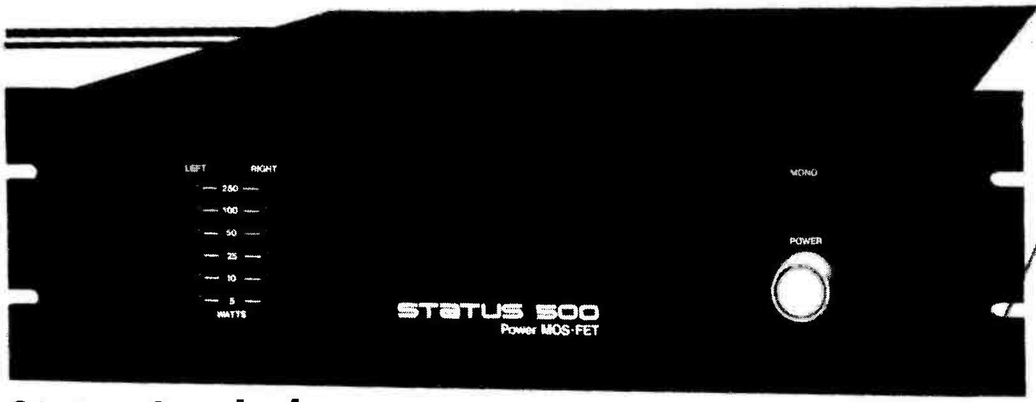
BUY LINES

ORDER TODAY

Send a cheque or PO (payable to ETI Magazine) to

ETI PRINT, ETI MAGAZINE 145 Charing Cross Road, London WC2H 0EE.

Price £1.20p.



Status Symbols

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100 W Power Amp (August)

In Fig.7 on page 67, C1, 2 and 4 are shown the wrong way round. However, they are shown correctly on the component overlay.

In the Power Amplifier Board Parts List on page 68, R15 should be 10R 1W and R16 should be 10R 2W. In the DC Sensing Board Parts List on the same page R7 should be 4k7, R20, 23 are 82k, R18 is 1k0, R26 is 91k and R27 is 5k6. C1,2 and 11 should be 22u 16 V electrolytic and C9, 10 should be carbonate types.

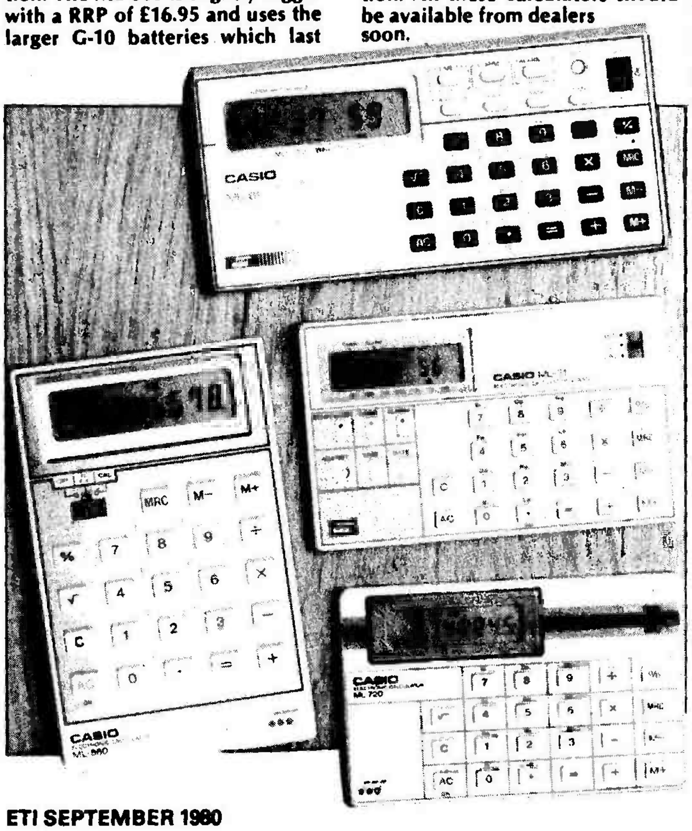
The component overlays on page 69 are correct.

Music To Your Ears

Casio have brought out four new calculators to follow in the footsteps of their Melody Card M-80. They all have eight digits calculating capacity in four functions, with full percent and independent memory. Sliding the mode switch to 'music' converts them to an 11 note instrument for the user to play tunes on the numerals (0-9) and decimal keys.

The ML-720 is credit-card sized and is priced at £17.95. It is powered by two G-8 size batteries which last for 700 hours continuous calculating use. This is extended by an automatic power off function with full memory retention. The ML-860 is slightly bigger with a RRP of £16.95 and uses the larger G-10 batteries which last almost twice as long as the G-8 type.

For £25.95 you have the choice of the ML-71 and the ML-81 which both tell the time as well. The ML-71 is credit-card size and keeps continuous track of time, with running second display and date and includes a one-tenth second stopwatch feature. It also has an alarm for any preset time of day as well as a countdown timer. The G-10 batteries last about a year. The ML-81 is larger again with the same facilities as the ML-71 plus an independent alarm. The two G-12 batteries last for 14 months continuous operation. All these calculators should be available from dealers soon.



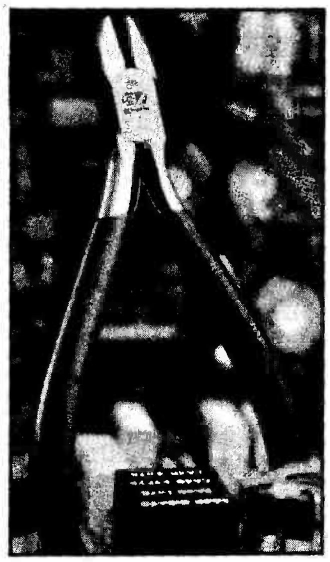
Black Hole (May 1980)

R21, R83 and C10 should be 1k0, 18k and 10nF respectively. A 39k resistor should be connected in series with C40. Cut the appropriate PCB track and solder the resistor across the break. A 1N4148 diode should be connected across each SAD512D input (soldered to the underside of the PCB). Later issue PCBs from Powertran will be suitably modified.

Kit News

TK Electronics' contribution to making legs obsolete should be available in September. It's a touch-controlled light dimmer with single alternate action touch plate. Nothing strange in that, you say. Well, TK have married their touch dimmer with an infra-red remote control system. So, you needn't leave your water bed, with infra-red light controller in one hand and ultrasonic TV controller in the other (and the two will not interfere with each other). TK's TDR300K 300 W Remote Controlled Lightdimmer will probably cost around £10. Watch their adverts in ETI for latest details. Meanwhile TK can supply an infra-red on/off light controller for £12 plus VAT (order model RC500K). A multi-channel infra-red remote control system for models, hi-fi, etc is also available separately.

Aura Sounds, who pioneered the introduction of Wersi organ kits in the UK, have been appointed marketing agents for Heathkit Electronics. Both companies *and* you and I come out on top — Heathkit broadens its sales representation, Aura Sounds expands its kit business and Heathkit products are a little more widely avaiable to the likes of you and me.

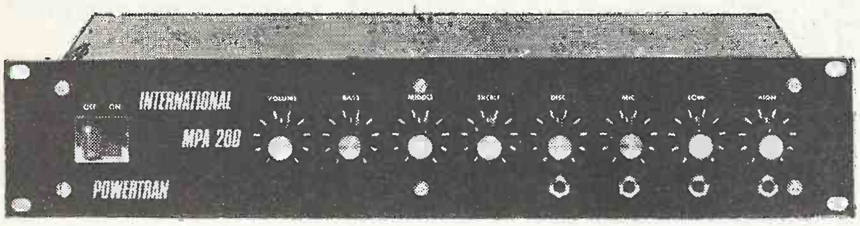


Hard Wire Side Cutter

A new specialist side cutter for use in the electronics and electrical industries is now available from CeKa. Its hard wearing tungsten carbide tipped cutting edges provide the tool with long working life and cutting capacities of, for example, 0.6 mm on piano wire and 1.6 mm on hard electrode wire. The cutter is 4½" in size and is box jointed for exact location, flush cutting and the prevention of cutting edge overlap. A smooth and controlled action while cutting in sensitive or confined situations is achieved by double leaf return springs. The cutter handles are covered by moulded black PVC grips. In addition to cutting hard wires, CeKa states that use of the side cutters continually on ordinary soft wire will make its working life almost indefinite. The RRP of the CK Precision Side Cutter is £19.40 plus VAT. The address is CeKa Works Ltd, Pwllheli, Gwynedd, North Wales.

MPA 200 100 WATT (rms into 8Ω) MIXER/AMPLIFIER

Featured as a constructional article in ETI, the MPA 200 is an exceptionally low priced — but professionally finished — general purpose high power amplifier. It features an adaptable input mixer which accepts a wide range of sources such as a microphone, guitar, etc. There are wide range tone controls and a master volume control. Mechanically the MPA 200 is simplicity itself with minimal wiring needed making construction very straightforward.
The kit includes fully finished metalwork, fibreglass PCBs, controls, wire, etc. — complete down to the last nut and bolt.



Panel size 19.0"×3.5". Depth 7.3"

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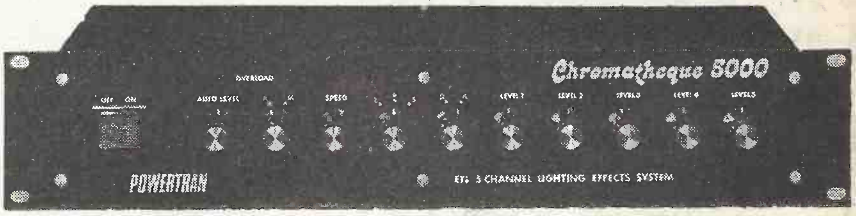
CHROMATHEQUE 5000 5 CHANNEL LIGHTING EFFECTS SYSTEM

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!

COMPLETE KIT ONLY £49.50 + VAT!

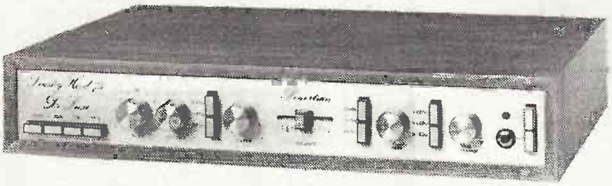


Panel size 19.0"×3.5". Depth 7.3"

POWERTRAN

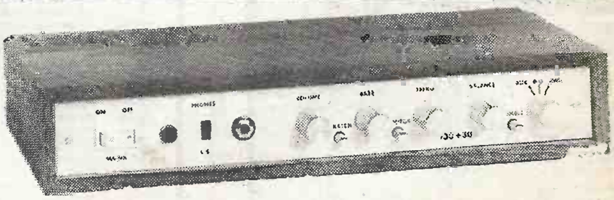
SYNTHESIZER KITS ON PAGE 8. MORE KITS AND ORDERING INFORMATION ON INSIDE FRONT COVER.

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



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

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



T20 + 20 20W STEREO AMPLIFIER £33.10 + VAT

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

Above 2 kits are supplied with fully finished metalwork, ready assembled high quality teak veneer cabinet, cable, nuts, bolts, etc. and full instructions — in fact everything!

BLACK HOLE

MUSIC EFFECTS DEVICE — AS FEATURED IN ELECTRONICS TODAY INTERNATIONAL!

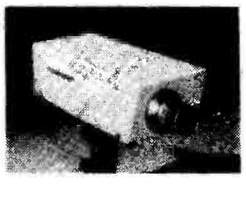
The BLACK HOLE designed by Tim Orr, is a powerful new musical effects device for processing both natural and electronic instruments, offering genuine VIBRATO (pitch modulation) and a CHORUS mode which gives a "spacey" feel to the sound achieved by delaying the input signal and mixing it back with the original. Notches (HOLES), introduced in the frequency response, move up and down as the time delay is modulated by the chorus sweep generator. An optional double chorus mode allows exciting antiphase effects to be added. The device is floor standing with foot switch controls, LED effect selection indicators, has variable sensitivity, has high signal/noise ratio obtained by an audio compander and is mains powered — no batteries to change! Like all our kits everything is provided including a highly superior, rugged steel, beautifully finished enclosure.

COMPLETE KIT ONLY £49.80 + VAT (single delay line system)
De Luxe version (dual delay line system) also available for **£59.80** + VAT

Cabinet size 10.0" x 8.5" x 2.5" (rear) 1.8" (front)

REMOTE CONTROL. 32-channel ultrasonic infra-red transmitter I.C. (SL490) £2.85 each. 32 channel receiver IC.s (ML928+ML929) £3.60 pair. Complete data/projects booklet add 50p. P&P 25p. Dataplus Developments, 81 Cholmeley Road, Reading, Berks.

POWERTRAN TRANSCENDENT DPX built to high professional standards available for only £350. Package includes swell pedal, handbook and "Anchor" tuition course. Phone High Wycombe (0494) 36923 (office hours).



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TRANSCENDENT 2000. Synthesizer. Fully set up and in perfect working order. Must sell, hence £200 only. Phone Worcester 354450 (evenings or weekends).

BOOKS BOOKS BOOKS — Large range of electronics books in stock. Send s.a.e. for list. Servio Radio, Dept ETI 10, 156-8 Merton Road, Wimbledon SW19 1EG.

A SUPERB VALUE STEREO POWER AMPLIFIER OFFER ● Stabilised PSU: 2N 3055 output ● Stereo 60 watt RMS; IC Preamp. Case includes, controls volume, selector etc., din output/inputs for magnetic pick-up/microphone (3.mv) + Tuner + Tape/Aux. 26 transistors — 2 IC Screened Douglas Transformer, 240 V AC mains lead. NEW—TESTED—DATA £19.95 (inclusive), KLIFCO ELECTRONICS, 1 REGENT ROAD, ILKLEY, W. YORKSHIRE LS29 9EA.

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MSF CLOCK is ALWAYS CORRECT — never gains or loses, self-setting at switch-on, 8 digits show Date, Hours, Minutes and Seconds, larger digit Hours and Minutes for easy QUICK-GLANCE time, auto, GMT/BST and leap year, also parallel BCD output and can record when an event occurs, receives Rugby time signals, 1000Km range, ACCURACY, £54.80.
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40508	44p
4066	50p
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7420	15p
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7422	26p
7427	20p
7428	28p
7430	16p
7432	20p
7437	14p
7438	18p
7440	13p
7441	52p
7442	32p
7443	60p
7444	100p
7445	64p
7446	65p
7447A	45p
7448	52p
7450	10p
7451/3	13p
7454	10p
7460	13p
7470	20p
7472	19p
7473	★16p
7474	★17p
7475	26p
7476	20p
7480	32p
7485	80p
7486	18p
7490	★22p
7491	57p
7492	30p
7493	★20p
7494	50p
7495	40p
7496	37p
7497	200p
74100	60p
74107	22p
74109	34p
74118	84p
74121	22p
74122	30p
74123	50p
74125/6	42p
74132	60p
74141/5	46p
74150	55p
74151	47p
74153	43p
74154	66p
74155	46p
74156	42p
74157	38p
74160	70p
74161	55p
74162	60p
74163	45p
74164/5	56p
74166	95p
74173	70p
74174/5	55p
74177	70p
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BC147/8	10p
BC149	10p
BC157/8	12p
BC159	12p
BC167	14p
BC169C	13p
BC171	10p
BC173	8p
BC177/8	16p
BC179	16p
BC182B	10p
BC182L	★7p
BC183B	10p
BC184	10p
BC186	25p
BC207/9	13p
BC212	10p
BC212L	★7p
BC213L	10p
BC214	10p
BC214L	★8p
BC238	18p
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BC338	17p
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BC478	23p
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BC557/8	14p
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ZTX503	17p
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2N918	35p
2N1131	20p
2N1302/3	35p
2N1304	35p
2N1306	30p
2N1613	25p
2N1711	13p
2N1893	25p
2N2217	18p
2N2219	23p
2N2222A	23p
2N2369	17p
2N2484	25p
2N2646	46p
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2N2906/7	21p
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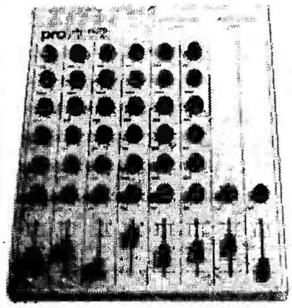

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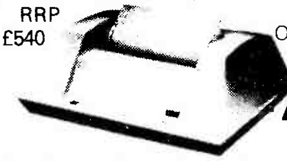

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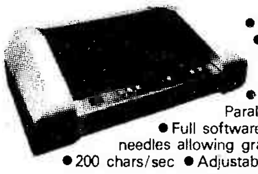

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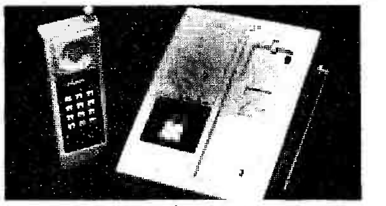

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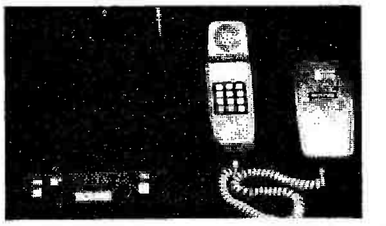

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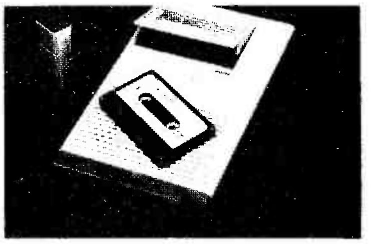

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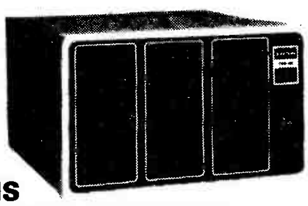

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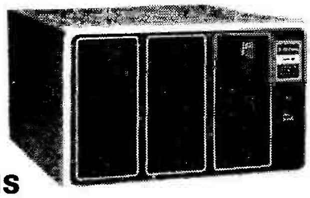

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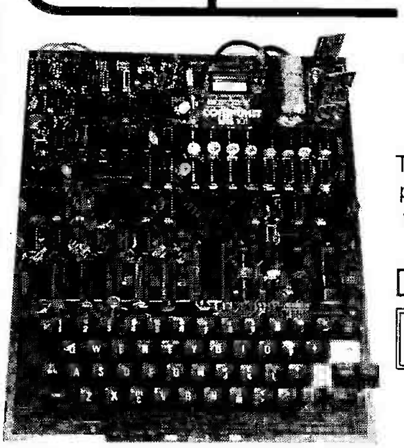

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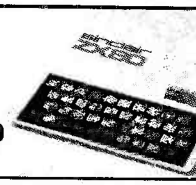

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ELECTRONIC CAPACITORS: (Values are in μF) **500V**: 10 **50p**; 47 **78p**; **250V**: 100 **65p**; **63V**: 0.47, 1.0, 1.5, 2.2, 3.3, 4.7, 6.8, **8p**; 10, 15, 22, **11p**; 32, 47, 50, **12p**; 63, 100, **27p**; **50V**: 50, 100, 220, **25p**; 470, **32p**; 1000, **60p**; **40V**: 2, 33, **8p**; 100, **12p**; 2200, 3300, **85p**; 4700, **98p**; **35V**: 10, 33, **7p**; 330, 470, **32p**; **25V**: 10, 22, 47, 100 **8p**; 160, 220, 250, **15p**; 470 **25p**; 640, 1000, **35p**; 1500, **40p**; 2200, **45p**; 3300, **77p**; 4700 **85p**; **16V**: 10, 47, **7p**; 100, 125, **8p**; 220, 330, **14p**; 470, **20p**; 1000, 1500, **30p**; 2200 **36p**; **10V**: 100, **7p**; 640, **12p**; 1000, **16p**.
TAG-END TYPE: **450V**: 100μF **180p**; **70V**: 4700, **165p**; **64V**: 3300 **150p**; 2500 **110p**; **50V**: 4700, **150p**; 3300 **135p**; 2200 **99p**; **40V**: 4700 **130p**; 4000 **92p**; 3300 **98p**; 2500 **90p**; **30V**: 4700 **110p**; **25V**: 15000 **195p**; 6400 **120p**; 4700 **100p**; 3300 **85p**; 2200 **60p**.

POLYESTER CAPACITORS: Axial lead type. **400V**: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 10n, 15n **9p**; 18n **10p**; 22n, 33n **11p**; 47n, 68n **14p**; 100n **17p**; 150n, 220n **24p**; 330n, 470n **41p**; 680n **48p**; 1μF **64p**; 2μ2 **82p**. **160V**: 10nF, 12n, 39n, 100n, 150n, 220n **11p**; 330n, 470n **19p**; 680n, 1μF **22p**; 2.2μF **32p**; 4.7μF **36p**. **1000V**: 10n, 15n **20p**; 22n **22p**; 47n **26p**; 100n **38p**; 470n **53p**; 1μF **175p**.

POLYESTER RADIAL LEAD CAPACITORS: 250V: 10n, 15n, 22n, 27n **5p**; 33n, 47n, 68n, 100n **7p**; 150n **10p**; 220n, 330n 13p; 470n **17p**; 680n **19p**; 1μ **22p**; 1μ5 **30p**; 2μ2 **34p**.

TANTALUM BEAD CAPACITORS 35V: 0.1μF, 0.22, 0.33, 0.47, 0.68, 1.0μ, 2.2μF, 3.3, 4.7, **25V**: 10, **20V**: 6μ8, **16V**: 2μ2, 4μ7, 10 **15p**. **16V**: 22μ **28p**, 47, 100 **50p**, 220 **80p**; **10V**: 15μ, 22μ, 33, **24p**; 100μ **35p**; **6V**: 47μ, 68, 100 **28p**; **3V**: 100 **20p**.

POTENTIOMETERS: Rotary, Carbon, Track, 0.25W Log & 0.5W Lin. 470Ω, 680Ω, 1KΩ & 2KΩ (Linear only) Single Gang **29p**
5KΩ-2MΩ Single Gang Log & Lin **29p**
5KΩ-2MΩ Single Gang D/P Switch **69p**
5KΩ-2MΩ Double Gang Log & Lin **88p**
Wire Wound Single Turn 1 Watt 20Ω 20KΩ **105p**

MYLAR FILM CAPACITORS
100V: 0.001, 0.002, 0.005, 0.01μF **6p**
0.015, 0.02, 0.04, 0.05, 0.056μF **7p**
0.1μF, **8p**. **50V**: 0.47μF **12p**

SLIDER POTENTIOMETERS
0-25W log and linear values 60mm
5KΩ-500KΩ single gang **60p**
10KΩ-500KΩ dual gang **80p**
Self Stick Graduated Bezels **33p**

CERAMIC CAPACITORS 50V
Range: 0.5pF to 10,000pF **4p**
0.015μF, 0.022μF, 0.033μF **5p**
0.047μF **5p**; 0.1μF, 0.2μF **7p**

PRESET POTENTIOMETERS
0.1W 50Ω–5MΩ Miniature Vertical & Horizontal **7p**
0-25W 100Ω–3.3MΩ horiz. larger **10p**
0-25W 200Ω–4.7MΩ Vert. **10p**
Cermet, Precision, multiturn, 0.75W ¾in 100Ω-100KΩ **90p**

SILVER MICA (Values in pF) 3.3, 4.7, 6.8, 10, 12, 18, 22, 33, 47, 50, 68, 75, 82, 85, 100, 120, 150, 220 **11p** each
250, 270, 300, 330, 360, 390, 470, 600, 800, 820 **18p** each
1000, 1200, 1800, 2000 **26p** each

RESISTORS — Erie make 5% Carbon Miniature High Stability, Low noise

	RANGE	VAL	1-99	100+
¼W	2.2Ω-4.7M	E24	2p	1p
½W	2.2Ω-4.7M	E12	2p	1p
1W	2.2Ω-10M	E12	5p	4p
2%Metal Film 10Ω-1MΩ			5p	4p
1%0.5W 51Ω-1M		E24	8p	6p

100+ price applies to Resistors of each type not mixed values.

POLYSTYRENE CAPACITORS:
10pF to 1nF **8p**; 1.5nF to 47nF **10p**

MINIATURE TYPE TRIMMERS
2.5-6pF; 3-10pF; 10-40pF **22p**
5-25pF; 5-45pF; 60pF; 88pF **30p**

COMPRESSION TRIMMERS
3-40pF; 10-80pF; 25-190pF **30p**
100-500pF **45p** 400-1250pF **58p**

GAS & SMOKE DETECTORS
TGS 812 & 813 **415p**; Socket **30p**

JACKSONS VARIABLE CAPACITORS
OILICON 100/300pF **205p**
500pF **250p**
6:1 Ball Drive 4511/DAF **145p**
Dial Drive 4103 6:1/36:1 **775p**
Drum 54mm **55p**
0-1-365pF **325p**
00 2 365pF **395p**
0 2 365pF with slow motion Drive **450p**
0 0 208/176 **360p**
.. .. with slow motion drive **410p**
C804-5pF: 10, 15: 25: 50pF **250p**
100, 150pF **335p**
'L' 3x310pF **725p**
00-3x25pF **550p**

RF CHOKES
1μH, 4.7, 10, 22, 33, 47, 100, 200, 470, 750, 1mH, 2.5, 5, 10 **30p each**
43mH, 100 **60p each**

VEROBOARD

	0.1 (copper clad)	0.15	0.1 (plain)
2½ x 3¼"	58p	51p	42p
2½ x 5"	68p	62p	—
3¾ x 3¾"	68p	—	—
3¾ x 5"	77p	86p	65p
2½ x 17"	204p	—	—
3¾ x 17"	264p	229p	—
4¾ x 17"	345p	—	210p

Pkt. of 36 pins **22p**. 'VQ' Board **120p**
Pin insertion tool **140p** DIP Board **290p**
Spot face cutter **105p**. Veroblock **324p**

VERO WIRING PEN
Plus Spool **325p**
Spare spool (wire) **80p** Combs **7p** each

FERRIC CHLORIDE
1lb bag Anhydrous **195p** + 35p P&P

DALO ETCH RESIST PEN + spare tip **75p**

COPPER CLAD BOARDS

Fibre Glass	Single-sided	Double-sided	SRBP 9.5"×8.5"
6" x 6"	90p	110p	95p
6" x 12"	150p	195p	

OIL PLUGS (Headers)
14 pin **35p**; 16 pin **40p**
24 pin **85p**; 40 pin **295p**.

Soldercon pins 100 **60p**; 500 **275p**.

DIL SOCKETS (TEXAS)

	Low Prof.	Wire Wrap
8pin	10p	25p
14pin	12p	35p
16pin	13p	46p
18pin	16p	52p
20pin	22p	65p
22pin	25p	70p
24pin	30p	78p
28pin	35p	85p
36pin	—	105p
40pin	40p	109p

EDGE CONNECTORS: (Double type

	.1	.156
2x10 way	—	85p
2x15 way	—	99p
2x18 way	115p	120p
2x22 way	130p	135p
2x25 way	149p	160p
2x30 way	170p	—
2x36 way	194p	—
2x40 way	210	—
2x43 way	232p	—

DIODES

BA102	25
AA119	18
AAZ15	15
BY100	24
BY126	12
BY127	12
CRO33	157
OA9	50
OA47	12
OA70	12
OA79	15
OA81	15
OA85	15
OA90	8
OA91	8
OA95	8
OA200	9
OA202	9
IN914	4
IN916	5
IN4001/2	5
IN4003	6
IN4004/5	6
IN4006/7	7
IN4148	4
IN5404	17
IS44	20
IN5401	13
IN5402	14
IN5406	18
IN5408	30

NOISE
Z5J 180

VARICAPS

BA102	25
BB105B	40
BB106	40
MVAM2	165
MVAM115	140

TRIACS

3A200V	49
3A400V	50
8A100V	54
8A400V	64
8A800V	108
12A100V	60
12A400V	70
12A800V	115
16A100V	110
16A400V	105
16A800V	195
25A500V	235
25A800V	195
T2800D	120

BRIDGE RECTIFIERS (plastic case)

	p
1A/50V	20
1A/100V	22
1A/200V	25
1A/400V	29
1A/600V	34
2A/50V	35
2A/100V	44
2A/200V	46
2A/400V	53
2A/600V	65
4A/100V	72
4A/400V	79
6A/100V	73
6A/200V	78
6A/400V	85
BY164	56
VM18 DIL	50

ZENERS
Range: 2V7 to 39V 400mW **8p each**
Range: 3V3 to 33V, 1.3W **15p each**

Thyristors

IA/50V	37
IA/100V	42
IA/200V	47
IA/400V	55
5A400V	39
5A600V	43
8A300V	48
8A500V	58
8A600V	85
12A100V	42
12A300V	59
12A500V	92
12A800V	120
BT106	150
BT116	150
C106D	38
TIC44	22
TIC45	25
2N4444	140
2N5064	35

DIAC

ST2	25
75108	350
75150	140
75154	150
75450	80
75451	75
75454	224
75491	89
75492	94

COMPUTER ICs

2102	125
2102-2	225
2112-2	250
2114-450n	299
2114-300n	399
2708	585
27L08	995
4116	495
4047	750
6502	995
6503	850
6504	785
6505	850
6520	525
6522	825
6532	1050
6551	1150
6800	800
6810	360
6821	500
6850	485
6852	485
8080A	595
8085A	1220
81LS95	135
81LS96	135
81LS97	140
8251	700
8253	1275
8T26A	235
8T28A	280
8T95N	160
8T97N	150
AY-3-1015	550p
AY-5-1013	395
AY-5-2376	920
DMB123	195
MC1488	90
MC1489	90
MC14411	1020
MC14412	1520
MK4027-2	470
MK4027-3	445
MK4027-4	350
MM5208D	TBA
MMB116N	TBA
MK4116-4	2099
RO-3-2513L	690
RO-3-2513U	650
SFF96364E	1050
SFC71301	820
SFS80102	205
TMS2516	950
TMS2716	1150
TMS4027	325
TMS4035	250
TMS4039	250
TMS4045	720
TNS4047	1083
TMS6011	365
Z80 CPU 2.5M	990
Z80A CPU4M	1099
Z80 CTC	595
Z80A CTC	720
Z80 P10	660
Z80A P10	720

LINEAR ICs

702	75
709 14 pin	38
709C 8 pin	35
710	67
733	99
741 8 pin	17
747C 14 pin	78
748C 8 pin	36
753 8 pin	185
810	159
9400CJ	390
AY-1-0212	595
AY-1-1313A	660
AY-1-1320	315
AY-1-5050	190
AY-1-5051	160
AY-1-5721/6	210
AY-3-1270	840
AY-3-1350	795
AY-3-8500	390
AY-3-8910	850
AY-5-1224A	235
AY-5-1230	450
AY-5-1315	595
AY-5-1317A	630
AS-5-3500	510
AY-5-3507	415
AY-5-3600	1090
AY-5-40070	650
AY-5-8100	735
CA3011	110
CA3012	150
CA3014	157
CA3018	68
CA3019	70
CA3020	186
CA3023	191
CA3028A	80
CA3035	235
CA3036	115
CA3043	275
CA3045	365
CA3046	71
CA3048	214
CA3059	176
CA3075	213
CA3080E	71
CA3081	190
CA3085	80
CA3089E	215
CA3090AQ	375
CA3123E	150
CA3130	90
CA3140	48
CA3160	95
ICL7106	795
ICL7107	975
ICL8038CC	340
ICL8211A	150
ICM7205	1150
ICM7215	1050
ICM7216AJ	1950
ICM7216B	1950
ICM7216C	1950
ICM7217A	790
ICM7224	785
ICM7227A	885
ICM7555	89
LD130	452
LF356	90
LM10	395
LM301AP	23
LM308T	70
LM311	80
LM318S	195
LM324A	45
LM339	70
LM348	90
LM349	125
LM379	375
LM380	80
LM381N	145
LM382	125
LM384	110
LM386	99
LM387	150
LM389	93
LM1458	40
LM3900	60
LM3909N	70
LM3911	125
LM3914	240
LM3915	240
LM13600	135
M252AA	625
M253AA	1150
MC1204	250
MC1301	79
MC1303	88
MC1304P	260
MC1310P	175
MC1312PQ	195
MC1458	45
MC1495	350
MC1496L	92
MC1596	226
MC3302	150
MC3340P	120
MC3360P	120
MC3401	52
MC3403	135
MC3405	150
MEM780	205
MFC6040	97
MK50398	635
MM5303	835
MM5307	1275
MM57160	620
MSM55	890
NE515	80
NE518	210
NE543K	210
NE544	185
NE555	22
NE556	55
NE560	325
NE561	395
NE562B	410
NE564	425
NE565A	120
NE566	160
NE567V	170
NE570	375
NE571	420
RC4136D	110
S556B	275
SAB3209	425
SAB3210	275
SG3402	295
SAS560	150
SAS570	150
SL414A	150
SN76003N	240
SN76013	170
SN76013ND	130
SN76018	148
SN76023	170
SN76023ND	130
SN76033N	195
SN76115N	215
SN76131	110
SN76227N	95
SN76477	175
SN76660	120
SP8629	299
TAA621AX1	250
TAA661A	155
TAA700	353
TAA960	320
TA0100	159
TBA120S	70
TBA540Q	220
TBA550Q	330
TBA641-A12 BX or BX11	250
TBA651	190
TBA800	90
TBA810	95
TBA820	70
TBA920Q	280
TBA990Q	270
TCA270Q	220
TCA965	120
TDA1004	290
TDA1008	310
TDA1022	575
TDA1024	105
TDA1490	280
TDA2020	320
TDA2030	300
TL061CP	54
TL062CP	129
TL064CN	159
TL071	45
TL072CP	90
TL074CN	140
TL081CP	42
TL082CP	96
TL083CP	95
TL084CN	120
UAA170	150
UAA180	150
XR2266	750
ZN414	90
ZN423	195
ZN424E	130
ZN425E	415
ZN1034E	200
ZN1040E	685

TTL 74 (TEXAS)

7400	11	7442	71	74157	75
7401	12	7443	120	74159	185
7402	12	7444	116	74160	99
7403	14	7445	116	74161	98
7404	14	7446	132	74162	99
7405	18	7447	88	74163	99
7406	48	7448	99	74164	120
7407	48	7450	20	74165	120
7408	22	7451	20	74166	155
7409	22	7453	20	74167	240
7410	9	7454	20	74170	230
7411	25	7460	20	74172	420
7412	20	7470	41	74173	120
7413	33	7472	31	74174	105
7414	52	7473	40	74175	82
7416	31	7474	34	74176	90
7417	31	7475	56	74177	90
7420	19	7476	41	74178	149
7421	38	7480	55	74179	155
7422	26	7481	120	74180	90
7423	32	7482	75	74181	290
7425	30	7483	94	74182	88
7426	44	7484	113	74184	145
7427	32	7485	121	74185	145
7428	35	7486	33	74188	299
7430	20	7489	215	74190	135
7432	28	7490	57	74191	135
7433	38	7491	85	74192	135
7437	35	7492	59	74193	135
7438	30	7493	59	74194	105
7440	20	7494	95	74195	198
7441	74	7495	75	74196	130
		7496	95	74197	90
		7497	180	74198	195
		74100	130	74199	198
		74104	62	74221	140
		74105	62	74246	195
		74107	35	74247	195
		74109	60	74248	195
		74110	54	74249	195
		74111	68	74251	120
		74112	150	74265	63
		74116	198	74273	270
		74118	99	74278	220
		74119	125	74279	99
		74120	105	74283	150
		74121	42	74284	385
		74122	55	74285	385
		74123	95	74290	125
		74125	45	74293	125
		74126	55	74297	236
		74128	74	74298	185
		74132	70	74365	95
		74136	65	74366	95
		74141	85	74367	95
		74142	195	74368	95
		74143	350	74390	185
		74144	350	74393	185
		74145	90	74490	150
		74147	180		
		74148	145		
		74150	150		
		74151	75		
		74153	75		
		74154	140		
		74155	75		
		74156	80		

74L

74L00	78
L30	80
L47	395
L75	220
L85	360
L121	195
L123	340

74S

74S00	60
S04	73
S132	350
S138	250
S158	524
S188	210
S189	158
S194	195
S195	795
S241	195
S262	895
S287	325
S288	210
S470	325
S472	1150
S475	825

74LS

LS00	13	LS91	125	LS166	175
LS01	13	LS92	75	LS168	210
LS02	15	LS93	75	LS169	210
LS03	15	LS95	115	LS170	288
LS04	20	LS96	180	LS173	105
LS05	23	LS107	45	LS174	147
LS08	23	LS109	75	LS175	110
LS09	23	LS112	80	LS181	295
LS10	20	LS113	55	LS183	298
LS11	32	LS114	49	LS189	120
LS12	32	LS122	70	LS190	120
LS13	40	LS123	95	LS191	120
LS14	75	LS124	180	LS192	125
LS15	40	LS125	60	LS193	125
LS20	21	LS126	60	LS194	125
LS21	32	LS132	95	LS195	125
LS22	40	LS136	55	LS196	120
LS26	48	LS138	70	LS197	120
LS27	45	LS139	90	LS199	
LS28	48	LS145	120	LS200	345
LS30	24	LS147	210	LS202	345
LS32	30	LS148	175	LS221	120
LS33	39	LS151	96	LS240	225
LS37	39	LS153	85	LS241	225
LS38	39	LS155	98	LS242	232
LS40	28	LS156	96	LS243	232
LS42	80	LS157	78	LS244	225
LS47	85	LS158	85	LS245	270
LS48	120	LS160	120	LS247	135
LS49	120	LS161	98	LS248	135
LS51	25	LS162	110	LS249	135
LS54	30	LS163	100	LS251	130
LS55	70	LS164	115	LS253	130
LS63	150	LS165	155		
LS73	40				
LS74	40				
LS75	48				
LS76	45				
LS78	45				
LS83	105				
LS85	105				
LS86	45				
LS90	50				

TRANSISTORS

	p												
AC125	35	BC182L	10	BF179	38	MPF103	38	TIS45	45	2N2221A	23	2N4921	40
AC126	25	BC183L	10	BF180	38	MPF104	36	TIS46	45	2N2222A	20	2N4922	55
AC127	22	BC184L	10	BF184	25	MPF105	36	TIS59	50	2N2297	48	2N5102	125
AC128	20	BC187	25	BF185	25	MPF106	40	TIS74	47	2N2303	45	2N5135	21
AC141	27	BC212	9	BF194	11	MPSA05	22	TIS88	50	2N2368	21	2N5136	21
AC142	28	BC212L	9	BF195	12	MPSA06	24	TIS90	30	2N2369A	15	2N5138	20
AC176	25	BC213	9	BF196	12	MPSA12	29	TIS91	32	2N2476	120	2N5172	25
AC187	26	BC213L	9	BF197	12	MPSA55	29	UC734	50	2N2483	28	2N5179	60
AC188	28	BC214	9	BF198	16	MPSA56	29	ZTX107	11	2N2484	30	2N5180	38
ACY17	60	BC214L	10	BF199	29	MPSU02	58	ZTX108	11	2N2492	50	2N5191	70
ACY18	60	BC237	14	BF200	40	MPSU05	50	ZTX109	11	2N2497	50	2N5305	20
ACY19	60	BC238	15	BF224A	24	MPSU06	50	ZTX300	13	2N2646	48	2N5308	20
ACY20	53	BC307B	14	BF244B	60	MPSU52	65	ZTX301	16	2N2784	55	2N5457	32
ACY21	60	BC308	16	BF245	30	MPSU55	55	ZTX302	20	2N2904	24	2N5458	32
ACY22	60	BC327	12	BF256A	50	MPSU56	60	ZTX303	25	2N2905A	22	2N5459	32
ACY28	60	BC328	15	BF256B	45	MPU131	45	ZTX304	17	2N2906	22	2N5485	35
ACY39	80	BC337	12	BF257	35	OC26	170	ZTX314	24	2N2907	22	2N5777	45
ACY41	39	BC338	12	BF258	35	OC28	120	ZTX326	45	2N2907A	22	2N6388	128
AD149	75	BC441	30	BF259	35	OC35	125	ZTX341	28	2N2926G	10	2N6027	40
AD161	42	BC461	30	BF274	42	OC36	130	ZTX500	15	2N3011	20	2N6109	50
AD162	42	BC477	35	BF451	35	OC41	125	ZTX501	15	2N3020	33	2N5879	140
AF114	75	BC516	38	BF336	35	OC42	48	ZTX502	17	2N3053	19	2SD234	50
AF115	60	BC517	35	BF337	32	OC43	55	ZTX503	15	2N3054	55	3N128	112
AF116	75	BC547	10	BF594	40	OC44	55	ZTX504	25	2N3055	48	3N140	112
AF117	95	BC548	10	BF595	40	OC45	40	ZTX531	25	2N3108	32		
AF118	95	BC549C	15	BFR39	25	OC70	40	ZTX550	25	2N3252	38		
AF139	40	BC556	15	BFR40	25	OC71	35	40311	60	2N3302	26		
AF178	75	BC557	10	BFR41	24	OC72	40	40313	125	2N3441	140		
AF186	50	BC558	15	BFR79	24	OC74	50	40315	68	2N3442	140		
AF239	42	BC559	15	BFR80	24	OC75	45	40316	85	2N3663	14		
ASZ21	60	BCY30	80	BFR81	24	OC76	36	40317	65	2N3702	10		
BC107	10	BCY34	75	BFR98	105	OC77	76	40320	70	2N3703	10		
BC107B	12	BCY35	50	BFX29	26	OC81	35	40324	91	2N3704	10		
BC108	10	BCY39	78	BFX81	45	OC82	50	40326	52	2N3705	10		
BC108B	12	BCY40	48	BFX84	25	OC83	48	40327	62	2N3706	10		
BC108C	12	BCY42	14	BFX85	28	OC84	45	40347	80	2N3707	10		
BC109	10	BCY45	50	BFX86	28	OC140	110	40348	105	2N3708	11		
BC109B	12	BCY70	14	BFX87	28	OC170	85	40368	43	2N3709	11		
BC109C	12	BCY71	18	BFX88	28	OC171	45	40361	50	2N3710	10		
BC114	20	BCY72	20	BFY50	21	OC200	48	40362	50	2N3711	10		
BC115	20	BCY78	19	BFY51	21	TIP29	36	40467A	95	2N3713	140		
BC117	20	BD112	95	BFY52	21	TIP29A	36	40468	60	2N3771	179		
BC118	18	BD124	115	BFY53	28	TIP29B	56	40468A	70	2N3772	195		
BC119	28	BD131	42	BFY55	38	TIP29C	60	40408	95	2N3773	288		
BC237	10	BD132	42	BFY56	32	TIP30	48	40411	280	2N3819	20		
BC238	10	BD133	50	BFY64	40	TIP30A	48	40594	98	2N3820	45		
BC140	28	BD135	40	BFY71	20	TIP30B	50	40595	90	2N3822	130		
BC142	28	BD136	40	BFY81	99	TIP30C	58	40603	67	2N3823	70		
BC143	28	BD137	40	BRY39	39			40636	130	2N3824	70		
BC147	9	BD138	40	BSX20	20	TIP31A	45	40673	95	2N3866	90		
BC147B	10	BD139	40	BSX26	75	TIP31B	43	2N697	25	2N3879	150		
bc148	8	BD140	40	BSX29	45	TIP31C	55	2N698	40	2N3903	20		
BC148B	10	BD144	198	BSX78	75	TIP32A	48	2N699	30	2N3904	16		
BC149	9	BD145	175	BSY26	40	TIP32C	60	2N706A	19	2N3905	18		
BC149C	10	BD158	60	BSY95A	18	TIP33A	65	2N708	33	2N3906	17		
BC153	20	BD205	110	BU105	170	TIP33C	78	2N918	33	2N4037	52		
BC154	13	BD206	110	BU205	170	TIP34A	74	2N1131	22	2N4041	40		
BC157	10	BD222	65	BU208	215	TIP34C	88	2N1132	24	2N4058	17		
BC158	10	BD245	50	E421	250	TIP35A	160	2N1302	35	2N4061	17		
BC159	11	BD378	70	MD8001	225	TIP35C	185	2N1303	50	2N4062	17		
BC160	28	BD434	32	MJ490	90	TIP36A	170	2N1304	50	2N4064	115		
BC167A	11	BD517	70	MJ491	175	TIP36C	199	2N1305	35	2N4220	60		
BC168C	10	BD695A	85	MJ2955	105	TIP41A	55	2N1306	40	2N4234	36		
BC169C	10	BD696A	85	MJE170	130	TIP41B	60	2N1307	45	2N4236	45		
BC170	15	BDY56	170	MJE180	130	TIP42A	64	2N1308	50	2N4264	24		
BC172	11	BDY60	140	MJE340	54	TIP42B	82	2N1613	23	2N4286	15		
BC177	15	BF115	26	MJE370	70	TIP120	80	2N1670	150	2N4289	15		
BC178	14	BF154	28	MJE371	70	TIP121	99	2N1671B	120	2N4314	61		
BC179	15	BF158	30	MJ490	90	TIP142	125	2N2160	350	2N4400	20		
BC182	10	BF167	25	MJE520	65	TIP147	145	2N2217	43	2N4427	75		
BC183	10	BF173	24	MJE521	74	TIP2955	60	2N2218A	34	2N4859	65		
BC184	10	BF177	25	MJE2955	90	TIP3055	60	2N2219A	22	2N4871	50		
		BF178	30	MJE3055	70	TIS43	30	2N2220A	23	2N4898	135		
				MPF102	66	TIS44	45			2N4901	160		

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ETI NEXT MONTH

October issue on sale September 6th - Don't miss out order your copy today.

FM Radio Control

In the course of the past year you've seen all the others produce radio control projects. You've also seen them make a right mess of the idea!

Next month ETI presents the definitive FM, easy-to-build, every-home-should-have-one, radio control. We won't spin it out over 10000 issues either, our circuit is sufficiently refined for us to be able to present full details in one issue!

If you're at all intrigued by controlling things at a distance ETI October is *the* place to be.

Fuzz Sustain

Brilliantly innovative project to please all of the guitarists, all of the time. This nifty little box can provide a really rich fuzz sound and/or a *true* sustain. We stress the 'true' because there have been some attempts to pass off things which are decidedly second-rate before now. As usual ETI gets it right! Inexpensive, ingenious and simply magnificent are words which could well apply to this our latest musicians project!

Don't miss it lest your plectrum gets lonely!

Circuits Circuits And More Circuits

Spot Designs is our new 'tried and tested' circuits features. All the ideas presented have been built and proven — so it is not surprising that this is already a popular new addition to ETI. Next month we're presenting six pages of this top-class ideas material, in response to the many requests to increase the size of the feature.

This is a 'special' one-time only offer so don't get left out circuitless!

Universal Cassette Interface

Into micros? Then ETI has something a little bit special for you next month — a tape interface with switchable baud rate and flexible I/O. It can be run with any system and any tape machine (within reason) and offers all the benefits of being able to save programs on tape at a ridiculous price! Miss this and your fingers will undoubtedly drop off typing!

Einstein Relatives

Yep. The feature you said we would *never* do. A clear easily understood explanation of the Special Theory of Relativity. This is the topic that those smug little physicists are always telling us humans we can never hope to comprehend. Well we can. Just read ETI next month and see for yourself.

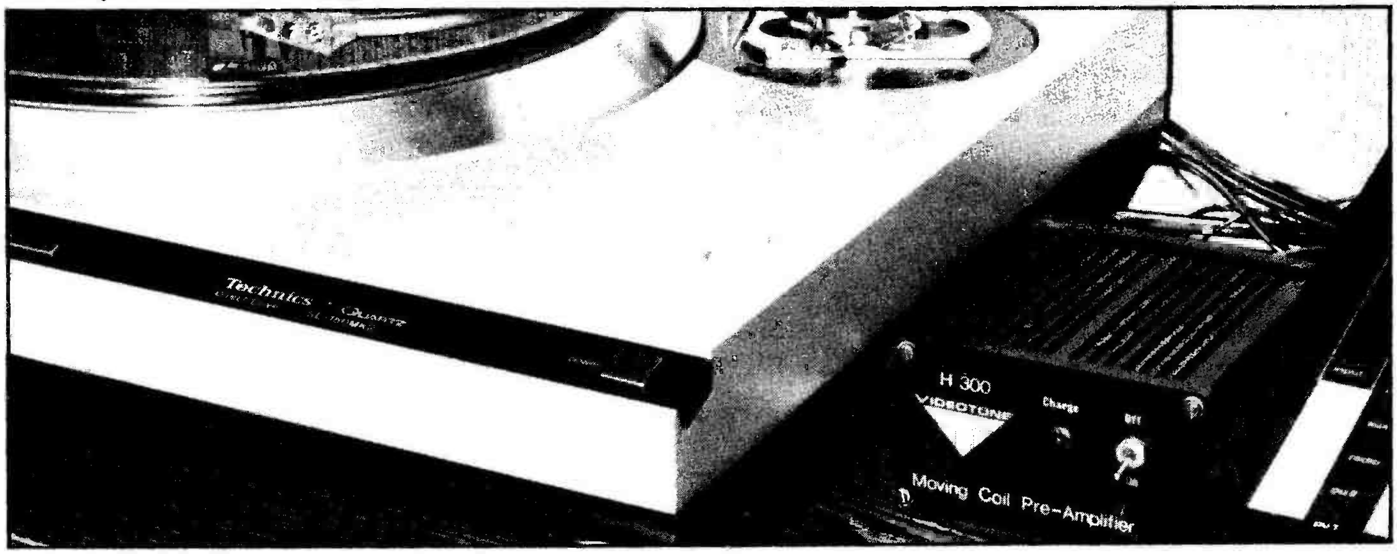
Also Appearing . . . .

Taking part in next month's production we also have: a Bench Amp for the experimenter; a review for the HP-41C alpha-numeric calculator; an audio signal generator; a flash trigger for quick-off-the-mark photographers plus, of course, all our usual brilliant regulars. It's got to be worth the mere 60p we ask in exchange!

Articles mentioned herein are in an advanced state of preparation. However, circumstances may dictate changes to the final contents.

HEAD AMPLIFIER DESIGN

If you've taken the plunge into moving coil cartridges and you're looking around for a head amplifier, Andy Sykes of Videotone explains how you can design your own.



For those of you not yet smitten by the all consuming Hi-Fi bug, a 'Head Amplifier' is *not* the latest tool for psychologists. The term is borrowed from the telecommunications industry where a preamplifier sited at the mast head is sometimes used to boost the received RF signal in areas of poor signal strength.

Over the past five years there has been a tremendous upsurge of interest in new methods of extracting the musical information from the depths of the record groove. Along with this has come a re-appraisal of the relative merits of the moving coil and moving magnet pickup cartridges. Each has a great deal to recommend it and we should start by comparing the two, albeit briefly.

The principle of operation is the same, ie a current is induced in a coil by a (relatively) moving magnetic field. In the moving magnet type it is, as the name suggests, the magnet that moves because it is mounted on the opposite end of the cantilever to the stylus.

Mass Tendencies

This system works well, but the mass of the magnet/stylus assembly has a nasty tendency to resonate within or just above the audio band. With careful design this effect can be minimised, but some colouration of the sound still occurs. Another problem is that the high impedence of the cartridge, due to the high number of turns required to achieve a usable output, also causes matching problems, lending to high frequency losses in the signal lead capacitance.

Despite all this, excellent results are achievable for a moderate cost and it worth noting that the most competitive area for moving magnet cartridges is between £15 and £25.

Role Playing

Recent developments in technology, however, have made possible an effective reversal of the roles of magnet and coil, neatly overcoming the problems just mentioned, as it is now the coil which moves, inside a static magnetic field. (it is only fair to mention at this point that Ortofon have been producing very underated moving coil cartridges for many years and are generally considered to be the pioneers of the field). The coil can be made very light, reducing the resonance problem and the output impedance is low due to the small number of turns used, which cures the lead losses.

All is not quite sweetness and light, however, as the system brings its own set of problems, which can be summarised as:

1. Low output — 150uV nominal
2. Very low source impedance
3. Expensive to manufacture

These problems *can* be overcome at a price, however, and if it is perfection for which you strive, the moving coil cartridge can be considered the best method of transferring data from the record to your ears at present. It is interesting to note that most of the current batch of professional Hi-Fi reviewers use a moving coil cartridge against which others are judged. ➔

Coming Up in the World

A step up device is required to match the low output impedance of the cartridge and to raise its meagre output to a point comparable with the universal moving magnet input or amplifier at approximately 5 mV. One way to achieve this is by the use of a matching transformer similar to those used with low impedance microphones. This solution, however, brings in problems such as secondary load matching, third harmonic distortion, frequency response limitations and hum pickup, all of which require careful and thus expensive design to overcome successfully. An active amplifer is a more cost effective (the watchword of the eighties) solution and has the added advantage of being within the design capabilities of the home constructor.

Design Criteria

The criteria to be considered in the design of such a preamplifier are primarily noise, frequency response and distortion.

If we consider a general MC (Moving Coil) cartridge with an output of 150 mV, source impedance of 10 R, and frequency response of 20 Hz to 25 kHz, a matching head amp would have to have at least the following characteristics to achieve Hi-Fi standards:

1. Gain x30 for nominal 4.5 mV output into 47k
2. Signal to noise ratio better than 60 dB
3. Distortion less than 0.05%
4. Overload factor better than 40 dB
5. Frequency bandwidth better than 20 Hz to 20 kHz

The input impedance should theoretically be the same as the cartridge source impedance for maximum power transfer, but it has been argued that MC cartridges work best into loads somewhat higher than this, as it reduces the power dissipation in the (cartridge) coil. Manufacturers differ widely in their recommendations for input impedance, but values between 100R and 470R are most commonly quoted. These values are normally determined by audition, but in my experience strict adherence to the recommended value is by no means as important as one is lead to believe, the differences in sound being more likely due to circuit variation than to mismatch. A good general purpose design *should,* therefore, be suitable for all MC cartridges.

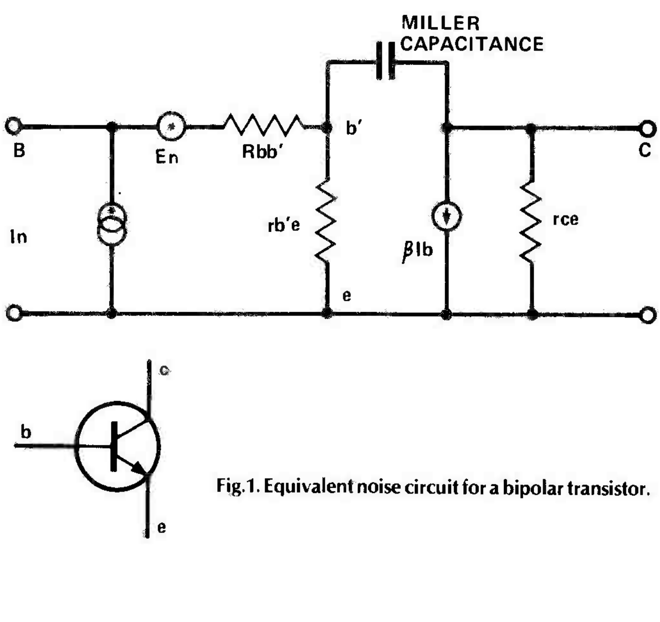


Fig.1. Equivalent noise circuit for a bipolar transistor.

Noise Model

Noise can be thought of as an additional voltage appearing at the input of an amplifier, the ratio between this voltage and the input signal voltage being the measured signal to noise ratio. It is assumed in this model that all noise introduced by the amplifier is added to this input noise voltage and that subsequent amplification of both signal and noise takes place equally and noiselessly. If we wish to achieve a signal to noise ratio of better than 60 dB, this implies an equivalent input noise voltage of around 150 nV. As a comparison, a moving magnet input stage with a signal to noise ratio of 80 dB would have an input noise level of 450 nV and only the very best amplifiers ever achieve anything like this kind of noise figure.

There are three main sources of noise in a transistor amplifier; thermal noise, flicker noise and shot noise. The first two are common to all electronic components, both active and passive, whereas the last is produced in active devices only. Without getting too bogged down in semiconductor physics, shot noise is caused by random fluctuations in the diffusion of minority carriers at the base/emitter junction of the transistor and also by recombination effects within the base region.

Suffice it to say that this type of noise is proportional to the emitter current flowing through the transistor (or diode) and is broadband. Flicker noise is present in semiconductors, resistors and thin metal films, and is produced by skin effects in the surface of the conducting regions of the device. The noise level depends upon the material, but is typically proportional to I2/F, where I is the current flowing, and is thus often called I/f noise. Thermal noise is, as the name suggests, produced by thermal agitation within the component material and is again broadband in character and proportional to the temperature of the device. The level of noise can be calculated from the equation

$$e^2 = / \, 4KTBR$$

where e = generated noise voltage
K = Boltzman's constant
B = frequency bandwidth over which to noise is measured
T = temperature in degrees Kelvin
R = the resistance value

Armed with this knowledge, the potential noise generated by any component used in our proposed head amp can be measured and steps taken to reduce its contribution to the total noise produced by the circuit.

In general there are four ground rules which should be followed to help achieve good performance.

1. Choose low noise components
2. Pay careful attention to transistor biasing arrangements
3. Keep resistor values as low as possible
4. Pay careful attention to avoid the pickup of external noise sources

Couldn't be simpler could it?

Low noise types of resistors are metal oxide, close tolerance metal glaze, or thick film. Avoid the use of large electrolytics as the (inevitable) leakage currents generate noise. Tantalum or polycarbonate types are best for the higher capacitance values and polystyrene or silver mica the best cost/size/noise level compromise for lower values. PTFE is the best of all, however, but tends to be on the expensive side. The noise levels produced by transistors are normally obtained from the manufacturer's data and there are several factors to be considered.

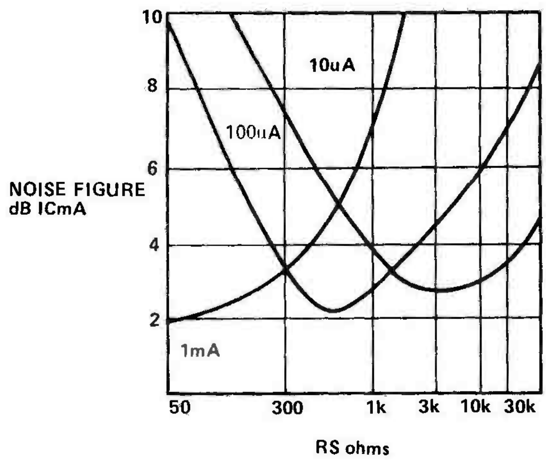


Fig.2. Noise curves for the BC413.

Equivalent Thinking

If we refer to the equivalent circuit for a transistor in common emitter configuration shown in Fig.1, and then consider the various noise sources contained within this circuit, a mathematical expression for the total noise generated can be derived. The exact form of this equation requires far too much deep thought for us to deal with it in detail here, but note that both noise voltage and noise current terms would be involved. It is also immaterial because transistor manufacturers are kind enough to measure it for us and provide noise versus frequency, and noise versus source resistance plots which take the general form shown in Fig.2.

The overall noise level is dependent upon the collector current flowing and for the lowest noise there is an optimum source resistance.

For use in our head amplifier this should ideally be the same as the source impedance of a moving coil cartridge, about 10 R, but due to the need to optimise other parameters it is more likely to be between 1k and 10k for a typical audio low noise transistor. This is because the vast majority of uses for these devices involve higher source impedances, ie 47k and the manufacturers do not see sufficient market to justify the production of a special low noise, low source resistance type, except, that is, for the ever-industrious Japanese.

A Nipponese semiconductor firm recently introduced the answer to the head amp designers dreams with a range of low noise transistors with optimum source resistances as low as 2R!

This ability to cobble up a special device to order, where no standard model is adequate, is one reason why the Japanese rule the audio kingdom.

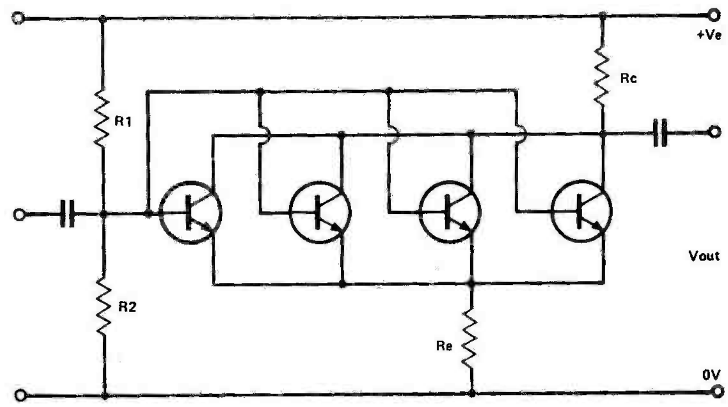
Phenomenal

All is not yet lost, however, as there are two phenomena which may be used to advantage when designing a low noise amplifier with standard components. The first is that some medium power transistors exhibit better noise figures when driven from a low source resistance than normal low noise, low level types. This is mainly due to the need to keep r_{bb} low (see Fig.1) in order to obtain good h_{fe} figures when operating at relatively high collector currents (values between 1 mA and 10 mA are common), which tends to rule out battery operation.

This brings the additional problem of the mains supply, of which more later. Suitable transistors for this type of use are 2N4405 or BC361, both of which have been successfully used in commercial designs.

The second possible answer is the use of a parallel transistor stage. This is where several transistors are wired in parallel, obvious really isn't it? The main advantage of which lies in the fact that in common emitter mode the base/emitter junctions are in parallel and thus the noise currents and voltages produced by each transistor are summed together, see Fig.3. The basic rule for Communications Engineers considering the noise levels of their systems is that noise signals from several separate sources, feeding into a common input, *add* by power.

Therefore, the total noise voltage for our parallel stage will be given by the equation $E_{nt} = E_n/N$ where N is the number of transistors. Similarly the total noise current will be given by $I_{nt} = NI_n$. Now the best noise course resistance for a transistor is given by $R_o = E_n/I_n$ and so for our parallel stage this is $R_{ot} = E_{nt}/I_{nt} = R_o/N$. R_{ot} is thus dependent upon the number of transistors used in parallel, the greater the number used the lower the best source resistance becomes.



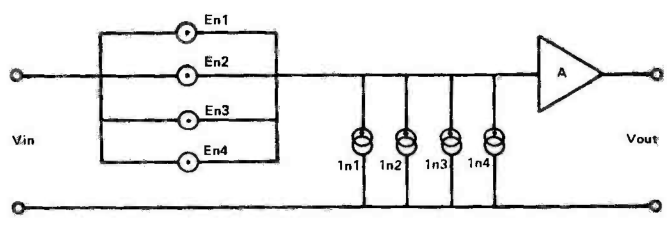


Fig.3. Noise model of parallel stage.

Let us now consider a typical low noise transistor with a best source resistance of 2k to be used with an MC of source impedance 10R. The number of parallel transistors required for the best match is given by 2000/10 = 200. This is clearly impractical for reasons of cost, the physical space required and, more important, the high value of Miller capacitance that would result. As can be seen from Fig.1, the Miller capacitance introduces feedback between the collector and base of the transistor and is the factor which limits the high frequency response. It would be a major problem if this many transistors were used. In practice eight transistors seems to be the best compromise and is the number most commonly used. Even so it is important to choose a transistor with both a low best source resistance and a good F_t if good results are to be obtained. The F_t of a transistor is the frequency at which the gain becomes unity and should be in the region of 200 MHz. Suitable types for this type of use are BC413, BC415, BC337, 2N4148.

Circuit Options

So much for the theory, we come now to consider the options open to us, in terms of the circuit configurations, which may achieve the required specifications for our Head Amplifier. Something to remember here is that any biasing components used will also add to the noise. Take a standard common emitter circuit, for example, with feedback to counteract thermal changes as shown in Fig.4. The noise voltages produced by R1, R2 and R3 all contribute to the overall noise of the stage. The base bias resistors are particularly important as their noise voltages are effectively in parallel with the input signal and will be amplified by such. The contributions of these biasing components can be reduced by decoupling as shown in Fig.5. The biasing under DC conditions remains the same, but the equivalent noise circuit is as shown.

Note that only the noise associated with R3 will contribute to the input noise and this may be made low in value reducing the thermal noise from this component.

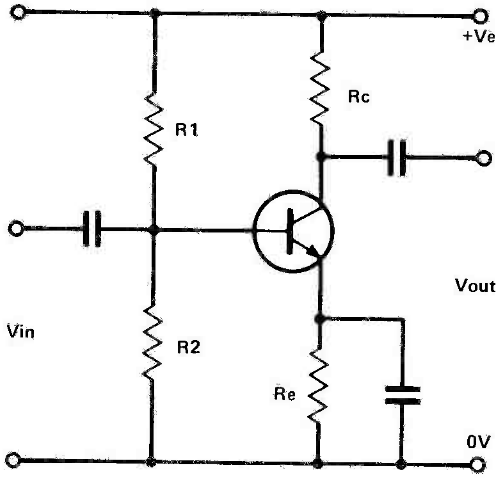


Fig.4. A standard common emitter circuit.

These examples serve to illustrate the principle because a single stage circuit is unsuitable for use as a high quality Head Amp. The main reasons for this are the variations in gain due to the spread of H_{fe} values in any transistor type and the relatively high values of distortion which are produced. Some form of feedback is required to stabilise and reduce both these parameters and, in general, at least a two stage circuit must be used to produce an acceptable performance.

Controversial Distortion

There is no "best" circuit but there are, as always, some points to bear in mind. In order to reduce the distortion to an acceptably low level, a fair amount of feedback is required and care should be taken to avoid Transient Intermodulation Distortion (TID). This particular form of distortion has proved to be somewhat difficult to define rigorously and there is not an inconsiderable amount of controversy as to exactly what it is and how to avoid it.

Nevertheless it is generally accepted that TID is reduced by ensuring that any amplification stage has a greater gain bandwidth than the stage preceeding it. TID also depends on the amount of overall feedback applied around the circuit and careful design of each individual stage to control the amount of harmonic distortion produced will reduce the amount of overall feedback required and hence reduce the circuit susceptability to TID.

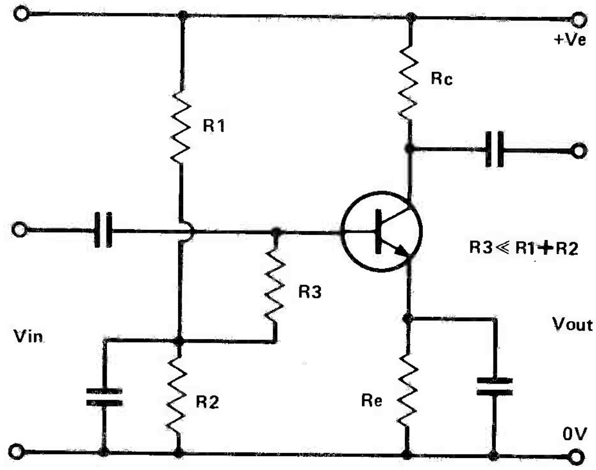


Fig.5. Low noise base bias circuit.

Breakthrough

The frequency response of the design is also important for two reasons. Apart from the obvious need to keep it wide enough to encompass the whole audio band (traditionally 20 Hz to 20 kHz), it also plays a part in the circuit's susceptability to Radio Breakthrough. This is a problem because of the high sensitivity of the front end coupled as it is to what is in effect a tuned circuit made up of the cartridge inductance and the input capacitance. My extensive, but completely unintentional, researches into this subject have shown that the two most popular sources of RF interference are Radio 4 at 200 kHz and the local Police/Fire/Ambulance/Taxi Services at anything between 90 and 120 MHz, though the latter is normally only a problem if the offending transmitter is passing close to your Hi-Fi. So, don't put your new moving coil set-up in the front room, folks, if you live on a busy road. The installation of a Mu metal garden gate and front door might also help (for explanation of Mu metal see Hums). Another potential source of RF comes from Citizen's Band transmitters on 27 MHz. But as we all know these are illegal in this country and so nobody really uses them, they just install them in their cars for show.

The offending RF signal is normally received by the first stage acting as a simple diode detector and can be tackled by careful attention to earthing and by the provision of RF filters in the input and supply lines. The input loading capacitor provides good RF decoupling only if a type with good high frequency characteristics is used. Ferrite beads on the input connecting leads can also be used to increase their inductance.

Breakthrough occuring from supply line pickup requires further decoupling to eliminate it. Large electrolytics have a substantial impedance at high frequencies and so should be shunted by a capacitor with better characteristics. A 100n ceramic is suitable here and a small inductor in the supply line is also good practice.

Passing the Buck

Another method of avoiding breakthrough is to make the bandwidth of the head amp wide enough to include any potentially troublesome frequencies. A bandwidth of, say 10 MHz, would include most national AM stations and any signal picked up would simply be amplified without being detected and passed into the main amplifier. This is known as "passing the buck" in the trade and relies upon the better RF rejections characteristics of the RIAA equalisation stage.

And so to Details

A typical two stage amplifer is shown in Figs. 6 and 7. These are of the common emitter/emitter follower and common emitter/common emitter types respectively and serve as good examples of typical designs. Both circuits are direct coupled and have overall negative feedback to set the required gain and reduce distortion.

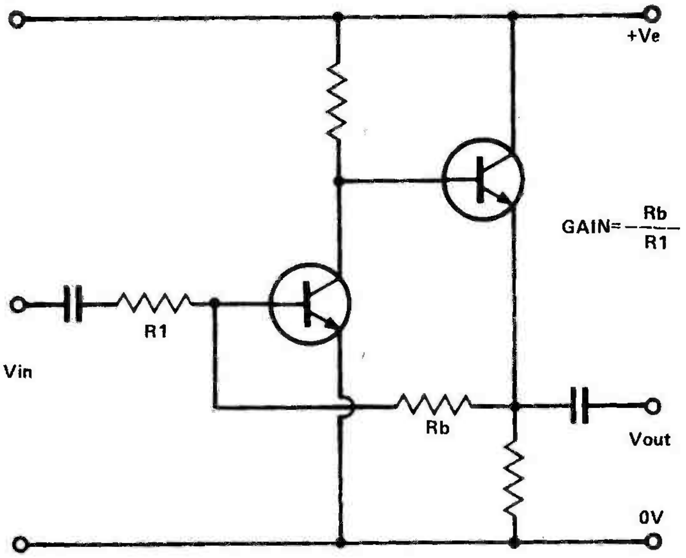


Fig.6. Common emitter/emitter follower amplifier configuration.

The effect of temperature on biasing is also minimised and note that the low noise method of biasing is used in Fig.7. To reduce noise to a minimum the feedback components should be kept as low in value as possible, preferably around the 1-10R mark, though this is only practicable in the latter circuit as R1 in Fig.6 is also the input impedance presented to the cartridge and thus should be somewhere near 100R.

This resistor is in series with the base of the first transistor, however, and as this is probably near to the best source resistance for this stage, assuming the use of parallel transistors, can provide a trade-off with the noise contributed by the relatively high values of the feedback components.

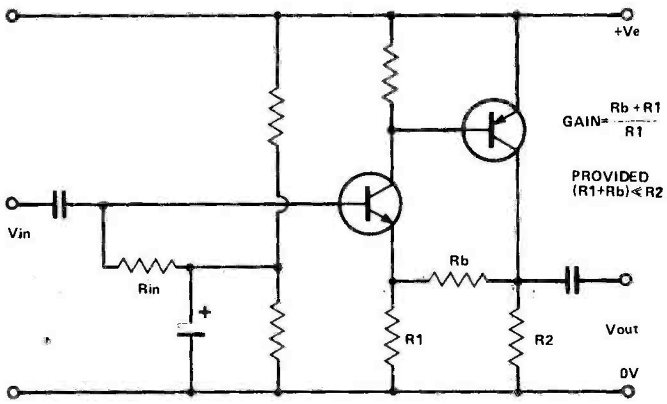


Fig.7. Common emitter/common emitter amplifier configuration.

When using low feedback resistor values make sure that there is sufficient drive capability in the circuit. A feedback resistance of 10R in Fig.7, for example, will require a drive of 100 mA for a 1V swing and would, therefore, require the use of a medium power transistor in the second stage.

This component may also contribute its fair share of noise and some degree of experimentation will be required to reach the best compromise.

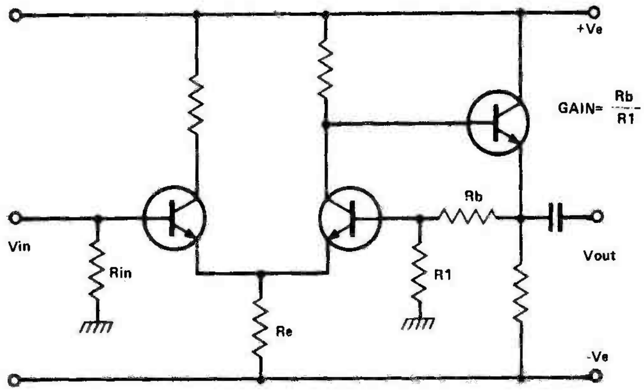


Fig.8. Differential input circuit.

Redundant Capacitor

A differential input stage as show in Fig.8 may be used to great effect. The input is referenced to signal earth, eliminating the need for an input capacitor. The resistance to supply-borne interference and hum is also greater with this kind of configuration and can be further improved by replacing Re with a constant current generator.

This is just as well because the need for a differential supply makes battery operation expensive and somewhat impractical.

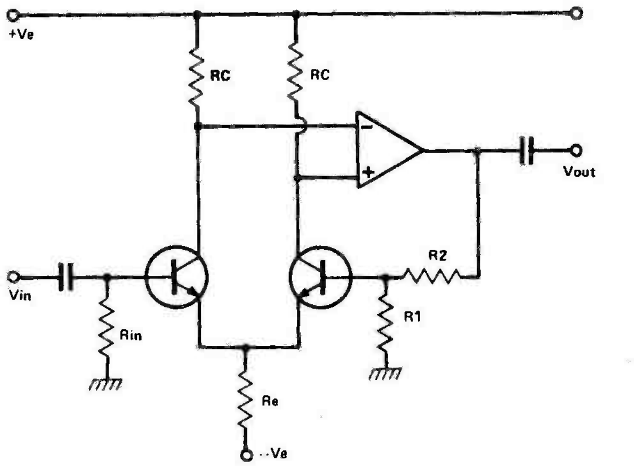


Fig.9. Differential input with op amp.

A second gain stage may be added to increase the amount of feedback applied and so reduce distortion. This may be another differential stage or even an operational amplifier (Fig.9).

This latter option may suffer a noise penalty due to the inherent noise output of the op amp but there are some good low noise types now available, such as the TDA1034N and TL071.

Next month we bring Andy Sykes' dissertation to a close with Part 2 of all you need to know about head amplifier design.

ETI

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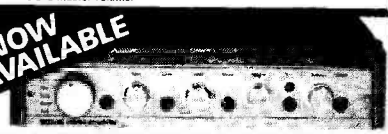

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CURRENT AFFAIRS

We seem to take for granted that circuits work, but why is it that conductors, semi-conductors and insulators do just what their names imply? A.S. Lipson takes us step by step through the whys and wherefores of atomic structure.

Most of us are reasonably familiar with what electricity is — the movement of electrons through a conductor. But there are some things that we tend to take for granted. For instance, why is it that some materials, like metals, conduct easily, whereas others — insulators — don't, and still others — semiconductors — seem to be somewhere in the middle; conducting, but not as well as metals? In order to find out why, we'll first have to learn something about atomic structure......

First Theory

Essentially, the atom consists of a central, very small positively-charged lump called the nucleus, surrounded by negatively charged electrons. Many books — particularly old ones — tend to give the impression that the electrons are just like little planets orbiting a sun (the nucleus) and that the atom is like a miniature solar system. This is *wrong*. Electrons do not behave just like little billiard balls, or little solid lumps. It is in fact more accurate (although not quite so simple) to visualise the electrons in an atom as being spread out 'charge clouds' around the nucleus, with most of this charge being concentrated at specific distances from the nucleus. The comparison between the two points of view is made in Fig.1.

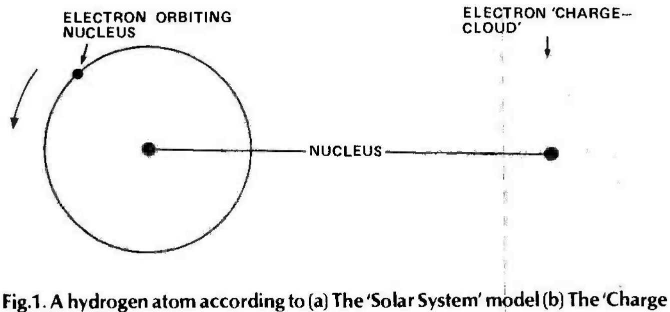


Fig.1. A hydrogen atom according to (a) The 'Solar System' model (b) The 'Charge Cloud' model.

The electrons within an atom can have different energies. If they obtain more than a specified amount of energy (for any particular type of atom), then they can actually break free from the atom. It is clear that the more energy a particular electron has within an atom, the less energy that electron will need to have added to it in order for it to break away from the atom; in other words, the easier it will be for that electron to escape.

Conduction and Insulation

But what has all this to do with conduction of electricity? In metals, some of the outer electrons present have quite high energies within their atoms and, in a solid lump of metal, one or two electrons from each atom are more or less free of their own atoms, although they are held into the metal as a whole. The positively charged ions left when electrons are removed from atoms are packed closely together and, in between them, the free electrons move about at random, (acting as a sort of 'atomic glue'). This negative charge attracts the remaining positive charge on the ions, and holds the whole thing together. (See Fig. 2.) The charge-clouds of all the free electrons join together, and form what is often known as an 'electron sea'. Because of this structure — the way that they are held together — metals can conduct electricity. Why?

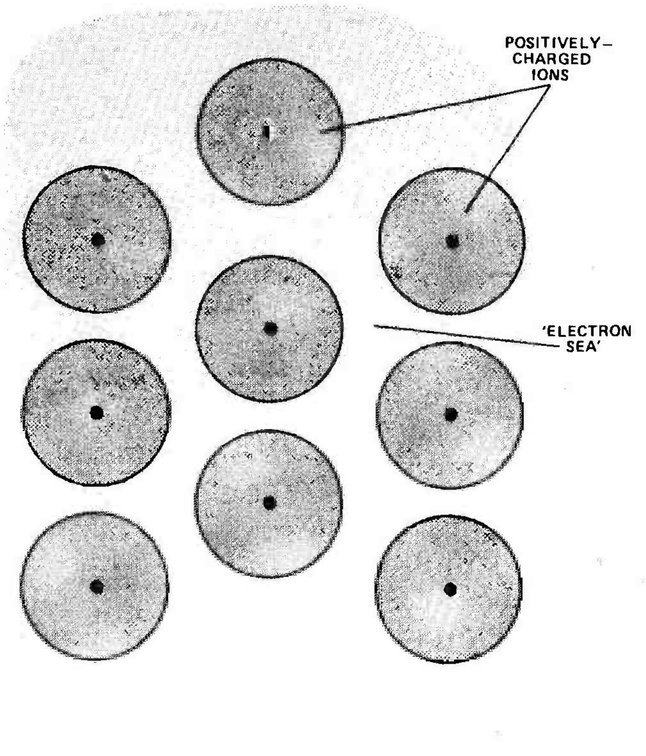


Fig.2. The structure of a metal. Positively charged ions are surrounded by an electron 'Charge Cloud'.

Because of all those free electrons, which aren't held by any particular atom, only by the metal as a whole. They are so loosely attached that if you apply a potential difference across the metal, they can drift along under its influence, and so cause a current to flow. In insulators, on the other hand, the electrons are held much more tightly by the atoms, there is no 'electron sea', and the atoms are bonded together by other means. Consequently, if a potential difference is applied, the electrons are unable to break free from their atoms, and so no current can flow. Our problem is thus solved — we now know how electrical current is conducted in metals, and why it isn't in insulators. Or do we? This theory was widely accepted for some time, and in fact it's still accepted as being broadly true, but there are just one or two things it doesn't explain. Semiconductors, for instance? And why should metals hold their electrons less tightly than non-metals? Our theory is obviously incomplete . . .

The New Approach

It was the physicists (naturally . . .) to the rescue. So we must once again return to the atom . . .

In the first decades of this century, a startling new branch of physics — Quantum Mechanics — made its debut. This was the work of several men, including Einstein, Heisenberg and Schrodinger. One of the first results Quantum Mechanics produced was embodied in a conclusion that Niels Bohr published in 1913. This was that, contrary to what had previously been assumed, the electrons within an atom could not have just *any* energy level, but could only exist at certain *set* energy levels. (See Fig. 3a.) This was a radical departure from what had been believed up until then, but it has been proved and is now unquestioned by physicists.

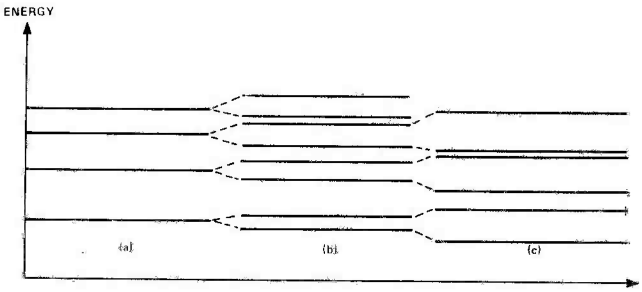


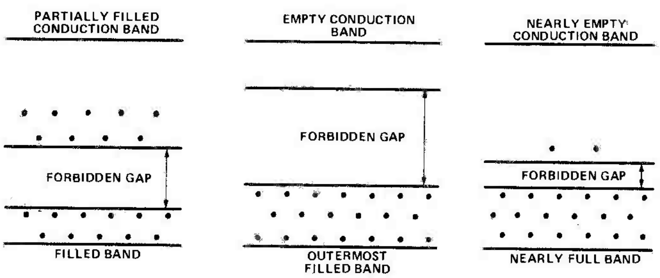
Fig.3a. The electrons within atoms can exist only at set levels. b) When two atoms interact with each other, their energy levels are split. c) In a solid, millions of atoms all interact with each other, and the energy levels are split into so many 'sub-levels' that they behave like continuous bands.

So electrons in atoms can only exist at certain set energy levels. But if you get more than one atom together, the situation changes again — energy levels are split. If, for example, you put two atoms close together, and then look at what has happened to a particular energy level in each atom, you will find that, in one atom, it has shifted up fractionally, in the other atom, it has shifted down slightly. The two atoms act as though the single energy level has been split into two (See Fig. 3b), one very slightly higher than the other. In a solid, where there are millions of atoms all together, the energy levels are split into so many 'sub-levels', all very close in energy, that they act like continuous bands. (Fig. 3c.) In a solid, instead of there being several separate energy levels at which the electrons can exist there are, instead, several energy 'bands', within which electrons can have a whole range of energy levels. Between these bands however — and this is the important bit — there are still 'forbidden gaps'; energy ranges in which electrons cannot exist because there are no allowable energy levels present. So how does all this help us to understand electrical conduction? Patience . . . We're just coming to that . . .

Electron Distribution

The way a material behaves electrically, whether it acts as a conductor or an insulator or whatever, depends on the arrangements of its energy bands, and the way that the electrons are distributed within them. The energy bands of a) a conductor, b) an insulator and c) a semiconductor are shown in Fig. 4. Firstly we will deal with the conductor. The energy bands shown in Fig. 4a are fairly typical of a material like copper. As in any material, the lower energy bands tend to fill up with electrons more easily than the higher energy bands, and consequently, they contain all the electrons that they can possibly hold. There is then a 'forbidden gap' of energies, and above this is another band — known as the conduction band. This band, unlike those below it, is not full, but is capable of holding more electrons than it in fact does. An electron in this band is relatively loosely held by this atom and so it requires only a very small amount of energy, which can be obtained from an applied potential difference to raise it to a higher energy *but still within the conduction band.*

It can now drift along within the metal under the influence of the potential difference. Thus, in a metal, which has either a partially-filled conduction band (eg. copper) or an empty conduction band which overlaps a full energy band, (as in magnesium) it is possible for current to flow quite easily. So far, so good. What about insulators? The energy-band theory can also explain the behaviour of non-conducting materials (Fig. 4b). In such substances, there are still full energy bands at the lower energy levels, but the conduction band is empty. In other words in insulators, electrons do not normally exist with enough energy to be in the conduction band. And it is only in this conduction band that electrons are free enough to take part in a flow of electrical current. If it were possible to get the electrons out of the lower energy bands into the conduction band then these materials could conduct electricity, but in order for that to happen electrons would have to cross the forbidden gap, and the energy required to make them do this is much more than can be supplied by a normal potential difference. In terms of eV (the eV, or 'electron-volt', is a measure of energy which atomic physicists find it convenient to work with, 1 eV being the energy picked up by an electron in passing through a potential difference of 1 volt), the forbidden gap in insulators in normally about 5 eV, hence, under normal circumstances, insulators do not carry electricity.



What About Semiconductors?

Semiconductors are really an 'in-between' case. Like insulators, very pure semiconductors such as silicon or germanium have empty conduction bands when the temperature is 'absolute zero' (about minus 273°C), separated from the other energy bands by a forbidden gap. At normal temperatures the conduction bands are not completely empty. Why? Because in semiconductors the forbidden gap is much smaller than in insulators — about 1 eV. It is so much smaller, in fact, that at normal termperatures, the vibration of the atoms in the semiconductor is sufficient to give enough energy to a few electrons to reach the conduction band. Eventually they fall back to the lower energy bands — but more electrons are entering the conduction band all the time, so eventually a balance is struck, with the number of electrons entering the conduction band in any period of time being equal to the number falling back. At normal temperatures, therefore, there are always just a few electrons in the conduction band of a semiconductor, and so it is able to conduct electricity. Though it conducts less well than a metal, since there are far fewer electrons in the conduction band.

But That's Not All.....

There is, however, another means by which a semiconductor can carry electricity. Every time an electron leaves a lower energy band for the conduction band, it leaves an electrically neutral space where there was previously some negative charge. These neutral spaces, surrounded by negatively-charged electrons, can behave almost like a positively charged particle, and when a potential difference is applied, this 'hole' as it is called travels in the opposite direction to that of the electrons. To understand how this happens, imagine a row of chairs, with someone sitting in each of them except the one at the end. (Fig.5) If the first person in the row moves into the empty chair, the next person moves into the chair left empty by the first person, and so on, the 'space' where no one was sitting appears to move in the opposite direction to the people, and that's exactly how it works with 'holes' in semiconductors. While it appears that the hole is moving in one direction, carrying positive charge, what is really happening is that the electrons in the lower energy bands are travelling in the other direction, carrying negative charge, and are moving into the spaces left by electrons which have gone into the conduction band.

Conclusion

Therefore, in a semiconductor, there are two types of charge carriers involved in the conduction of electricity; electrons and 'holes'. Various experiments indicate that in germanium, for example, about one third of all the current is carried by the 'holes'!

Fig. 4. Comparison of the forbidden gap position and magnitude in the three basic types of material. Far left: a conducting substance. The lower energy bands are full of electrons and the forbidden gap is easily bridged by sufficiently energetic electrons which then enter the conduction band. Center: insulators. Note the empty conduction band and the wide forbidden gap in which there are no permissable energy levels. On the right: semiconductor materials in which the energy gap is around 1 eV and at room temperature sufficient energy is imparted by heat action to allow some electrons to cross the gap into the conduction band.

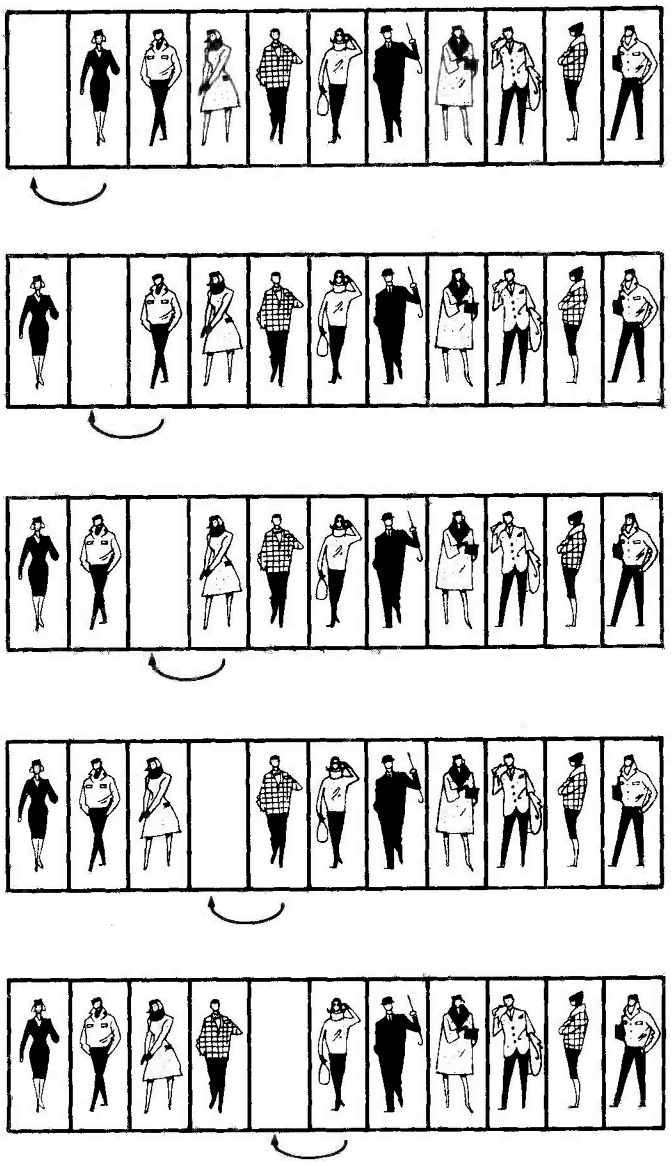


Fig.5. As each person moves into the space next to them, it appears that the gap moves in the other direction. In the conduction band this is an electrically neutral space where there was previously a negative charge. These 'holes' can behave almost like a positively charged particle when a potential difference is applied this 'hole' moves in the opposite direction to the electrons.

You will remember that, in semiconductors, electrons reach the conduction band because of the vibration of the atoms. This fact is quite important. At higher temperatures the atoms vibrate more, and so more electrons (and 'holes') are available for conduction purposes. To the extent that above about 100°C for germanium, and 150°C for silicon, the conduction is no longer really under control, and so devices like transistors, which use semiconductors, have to be kept below these temperatures, if they are to remain reliable during operation. The fact that silicon is useful as a semiconductor at higher temperatures than germanium, was the major reason for the increased use of silicon rather than germanium devices!

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MICROBASICS

Since the demise of Microfile, we felt it was time to initiate another on-going publishing situation computingwise. Henry Budgett kicks off the first instalment of this great new hardware series with a potted history of the technology

Almost without fail we read in some publication or other that the age of computers is upon us. Whilst this statement is unquestionably true it is well worth looking back at the developments that have resulted in this proliferation of computers and computer-based systems. There is a popular temptation to attempt to baffle readers with science and technical terms in articles like this and this has led to an almost 'cult' image being foisted upon the industry, whereas, in reality, we should be trying to do exactly the opposite. It is to this end that I will attempt to define and explain each piece of terminology as it is reached. It is also the reason that I have chosen to begin the series at the beginning rather than to look at just the current darling of the media, the microprocessor.

Three Wise Men

In taking a look over our shoulders at the names associated with the very early computers we find that three stand out as veritable beacons. Taking them in chronological order, for no better reason than simplicity, we first meet Blaise Pascal. Born in the seventeenth century in France he made a considerable impact on the field of mathematics at that time. His father was a tax collector and the sight of him spending many hours adding figures stimulated Blaise to produce a mechanical engine that would remove the drudgery. The basic design worked, no mean feat in itself, and enjoyed a limited commercial success. Its main drawbacks were that it could only add or subtract (and only one of those at a time). The Pascaline, as it was called, is still in use today recording the mileage travelled in your car and its improved successor which was capable of multiplication survived until the first electronic calculator sent it to the scrap heap. If you are fortunate enough to have one lying in a corner it is worth the trouble to take its lid off and reveal the guts. Remember as you look that this was invented when the Industrial Revolution was still in the future and there were no facilities for making accurate mechanical parts, a problem that was to cause our next innovator to fail.

Inventor With A Difference

Charles Babbage began in a similar manner to Pascal. He was also a child prodigy in the field of mathematics and soon began to find fault with the tables of logarithms being published. It was to the end of producing a machine for calculating these tables that Babbage began his life's work. It was fortunate that he was a wealthy man because despite a Government grant of some £17,000 and eleven years work he finally abandoned his Difference Engine. Despite this failure his thoughts on automated mathematical machines were still active and he conceived the Analytical Engine that was to eventually ruin him. This idea was to incorporate all the essentials of the Difference Engine but with the magic ingredient of being programmable'. The original specification of the machine was that it could perform mathematical operations to order on data provided.

At this instant the concept of computers as we know them today was born. The 'Engine' even incorporated most of the elements found in modern electronic machines. However the theory was not matched by the practice. The inability to make precision parts once again spelled doom and Babbage died aged 80 with not much left to his name except a pile of cogs and wheels. His son did manage to put together a working model, which can today be seen in the Science Museum, London.

Herman The Wise

Less than twenty years later our third individual, Herman Hollerith, forged the final link in the chain of events with his Tabulator. Designed as an entry in a competition to find a system that could analyse the results of the 1890 American census it harnessed the newly developed power source, electricity. Hollerith's machine completed the census in record time and made its inventor a very rich man. Indeed, the company he founded, IBM, is probably the largest mainframe computer producer in the world.

This combination of electricity and advanced mechanics was by no means an ideal solution. In the case of the 'Tabulator', it was designed for one specific job and could not be easily changed. This was not the programmable tool conceived by Babbage. It is interesting to note that, just as Babbage had looked toward the punched cards used by weavers to control their looms, so Hollerith used similar cards to record the census information on. These cards are still in use today in many computer rooms (some things never change!).

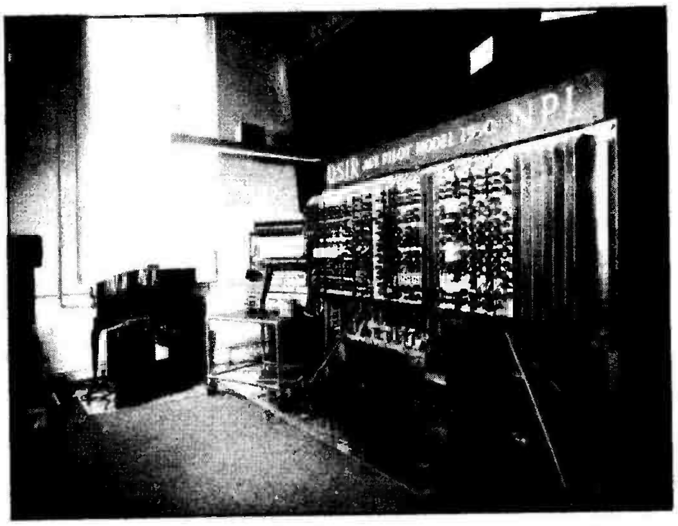
The Electronic Age

Just as the application of electrical energy brought Hollerith's 'Tabulator' the success it did, so it spurred on the development of the wide variety of electronic circuits based around the thermionic valve. By the time of the second World War there were many potential challengers for the title of the first computer but they all shared one common characteristic. The development of electronic switching had resulted in the universal adoption of the binary number system. The reason is simple, you can easily turn something on or off and hence create a binary code, but it is obviously much harder to turn something off or on in nine discrete steps. If Pascal or Babbage had designed their systems around binary mathematics instead of the conventional decimal they would have simplified their problems ninefold and the world may even have been introduced to the steam powered computer. Having taken the step to binary, computers never looked back and giants such as Collosus, ENIAC and ACE were born. Each of these was the descendent of the 'Analytical Engine' in that it could be programmed to do any logical task, within reason, and consisted of a number of basic elements, as in today's computers.

In much the same way as the transition from mechanical to electrical occurred, these early computers were replaced by pure electronic devices based on the newly invented transistor. The thermionic valve was an unreliable object, slow in operation and costly in terms of power consumption and space. Indeed, the processing capabilities of most of today's microprocessors greatly exceed the facilities offered even thirty years ago. The advent of the transistor produced the 'second generation' of computers. A 'generation' in computer terms is generally defined as a tenfold decrease in size with a tenfold increase in processing throughput at a tenth of the original cost. As the transistor became the descendent of the valve, so the chip or integrated circuit became the descendent of the transistor. In those days, some ten to twelve years ago, the first integrated devices consisted of perhaps a half dozen transistors on a single chip of silicon. Rapid advances were made and soon a new kind of computer was born.

The Minis

Just as the Mini car revolutionised the way the world looked at motoring so the minicomputer changed the face of computers. Up till the advent of the integrated circuit there had been only 'computers', now there were 'mainframes' and 'minis'. These two were rigidly divided into sectors of operation, the mainframes were used for serious purposes, the minis were 'toys' used in research. Among the names of companies who were to make their fortunes producing minis was DEC, probably still the world leader. Soon the mini was to be found everywhere from research labs to classrooms and their spread was due simply to the fact that they were small, cheap and relatively easy to use. They were even built into pieces of equipment like machine tools. Indeed it is fair to say that the mini paved the way for the micro, although the actual distinctions between them have been rapidly eroded.



The pilot model of the National Physical Laboratory's ACE, one of the first computer giants (Crown copyright).

Firms involved in the business of integrated circuit production tend to follow a natural progression in the devices that they make. First off the production line come the standard logic elements, the AND OR type gates, and once the production of these is running at a profitable level they attempt to squeeze a little more onto the slab of silicon. As soon as this stage is proved they take another leap forward and so on. In the terminology this is a progression from SSI (Small Scale Integration) with about 10-20 actual devices on the 'chip' through MSI (Medium Scale Integration) which has a dozen or so gates (rather than discrete elements) up to LSI (Large Scale Integration) which is taken as being greater than 100 gates on the chip. At this stage of the game we are still talking about complex TTL type packages, the next jump is to VLSI which, believe it or not, stands for Very Large Scale Integration. We are now in the realm of memory devices and microprocessors.

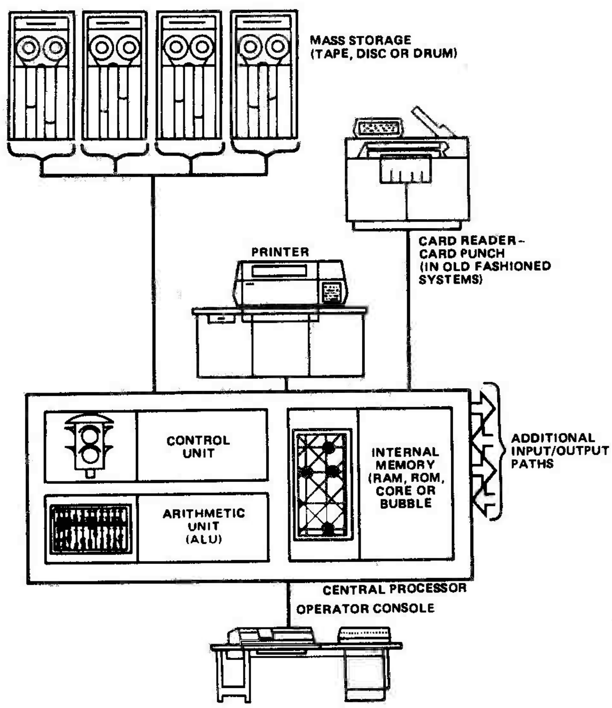


Fig.1. Block diagram of a computer system.

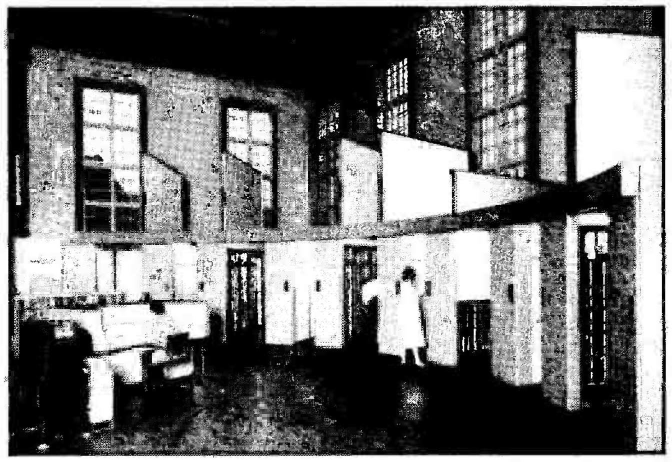
Common Concept

If we take a look at Fig.1 we can see a generalised block diagram of a computer. What kind of computer is not important; they all have the same functional blocks within them, be they micro or mainframe. The common misconception is that the "mighty chip" is a computer, far from it. Your average microprocessor still needs all the memory circuits, control circuits, mass storage devices and other components that even the old valve machines needed; they are merely smaller. The very first microprocessor came about in 1971 simply because it was realised that it would be possible to make a device of that complexity on a single chip. The device was called the 4004 and the company that made it was Intel. More on the micro next month — first some explanation on the basic building blocks of computers.

Eye Oh

The five fundamental elements of any digital computer are:- the ALU or Arithmetic Logic Unit, the control unit, the store or memory and the input and output devices. Taking these in the reverse order we have the input and output devices, often abbreviated to the I/O. Obviously the machine must be able to communicate with the outside world and vice versa, so the most common form of I/O is the Visual Display Unit or VDU. This has, to a very large degree, replaced the old-fashioned Teletype, a special electric typewriter often called a TTY, and is totally silent in operation, which is a welcome change from the racket the earlier device made. Other forms of I/O device are printers, for producing typed copy, plotters for producing graphical output or in the most esoteric cases digitisers and speech synthesisers.

The function of the I/O was simply to enable the user of the computer to load information for processing into the computer and to be able to get the answers back. Quite apart from this information there is the requirement of the computer programmer who wishes to put in information that will instruct the computer to perform certain operations. This, the program, is stored in the memory and of this vital component there are two types; general purpose memory and off-line or backing memory. The general purpose memory is made up of a large number of bistable elements manufactured in either magnetic or semiconductor materials. In the context of the micro we often refer to these as the user memory. The backing memory is generally of a mass storage type like magnetic tape in one of several forms or magnetic discs or drums. Whilst the computer may have immediate access to some few thousand



The business end of NPL's ACE computer, used to develop sophisticated mathematical techniques.

storage elements in the user memory, it can often store a few million elements in the backing stores. We will discuss the various types of memory in much greater detail at a later date — only the concept is important at this stage.

The control unit performs the task of making sure that all the various bits of the computer are working in the correct order. It would not be a very efficient machine that had to pause for information because it gave priority to looking after a printer and left the user waiting. The basis of all the control signals is a clock, in fact a very accurate oscillator circuit running at several million cycles per second. This is the heart of the machine and almost without exception all the functions within the computer are locked or synchronised to it.

The one remaining piece of the jigsaw is the ALU. This exists solely to perform arithmetic operations on the elements that are fed to it. Some of these elements are recognised as being instructions, others are simply information which is to be processed according to the previously received instructions. All this takes place at the level of binary signals, that is, each separate piece of information is represented by a pattern of logical ones or logical zeros and this is commonly called 'machine code'. Indeed, at this level of operation the computer is only aware of two groups of patterns — those which correspond to the defined set inside the machine, its "instruction set" in computer parlance, and those patterns which do not match this set which must be data.

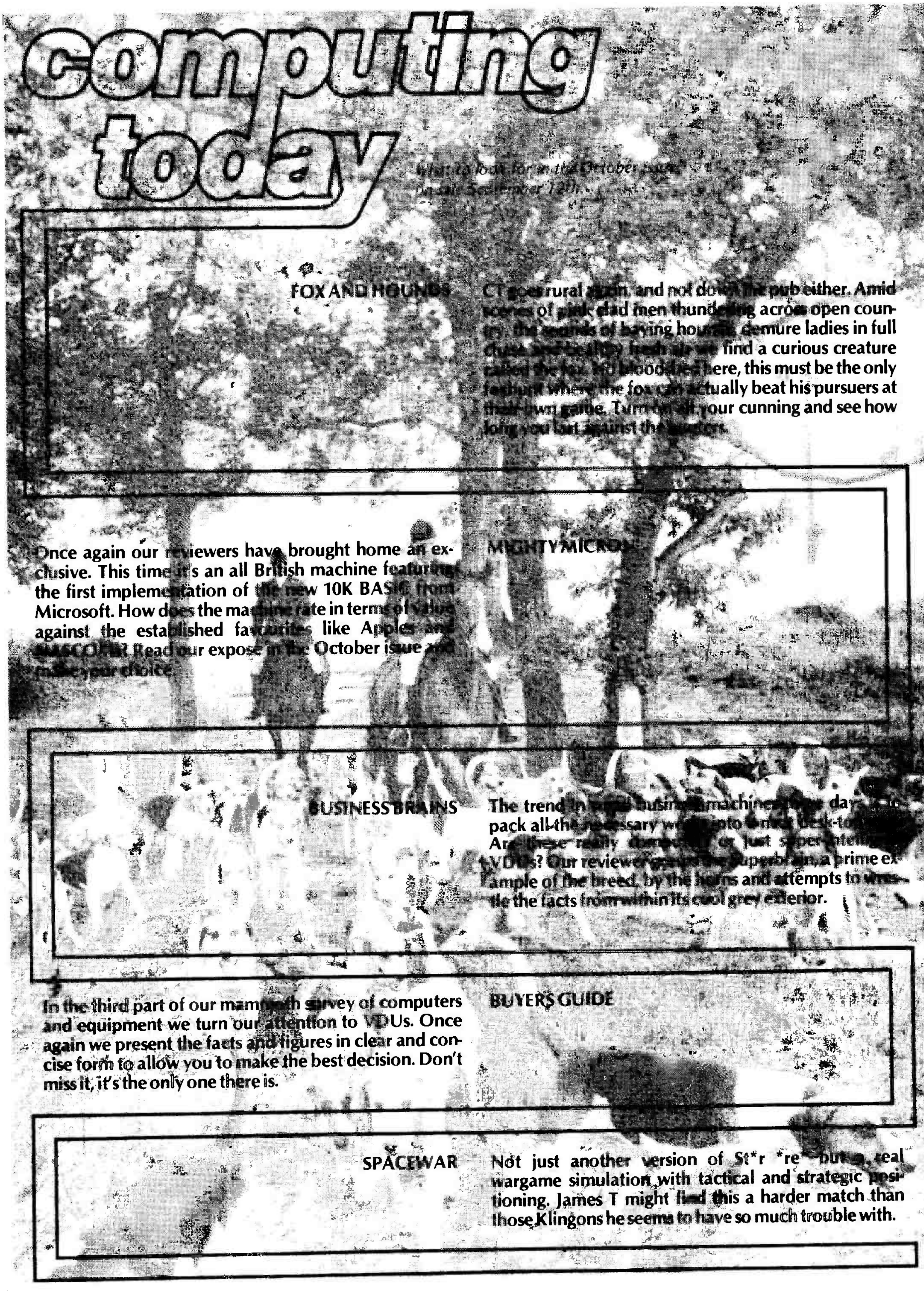
To Pastures New

That's the end of this month's offering. In the next part our concentration will lock on to the microprocessor itself and just what goes on inside that little lump of silicon. Those with a wish to pursue the hardware angle in books, might be interested in the following recommended texts on the subject: Introduction To Digital Computer Design by Woollons, published by McGraw Hill. Consumers Guide to Personal Computing and Microprocessors by Frieberger & Chew, published by Hayden.

ETI

computing today

What to look for in the October issue on sale September 12th.



FOX AND HOUNDS

CT goes rural again, and not down the pub either. Amid scenes of pink clad men thundering across open country, the sounds of baying hounds, demure ladies in full chase [illegible] fresh air we find a curious creature called the fox. No blood-[illegible] here, this must be the only foxhunt where the fox can actually beat his pursuers at their own game. Turn on all your cunning and see how long you last against the [illegible].

MIGHTY MICRON

Once again our reviewers have brought home an exclusive. This time it's an all British machine featuring the first implementation of the new 10K BASIC from Microsoft. How does the machine rate in terms of value against the established favourites like Apples and [illegible]? Read our expose in the October issue and make your choice.

BUSINESS BRAINS

The trend in [illegible] business machines [illegible] days [illegible] pack all the necessary [illegible] into [illegible] desk-to[illegible]. Are these really [illegible] or just super-intelli[illegible] VDUs? Our reviewer [illegible] Superbrain, a prime example of the breed, by the horns and attempts to wrestle the facts from within its cool grey exterior.

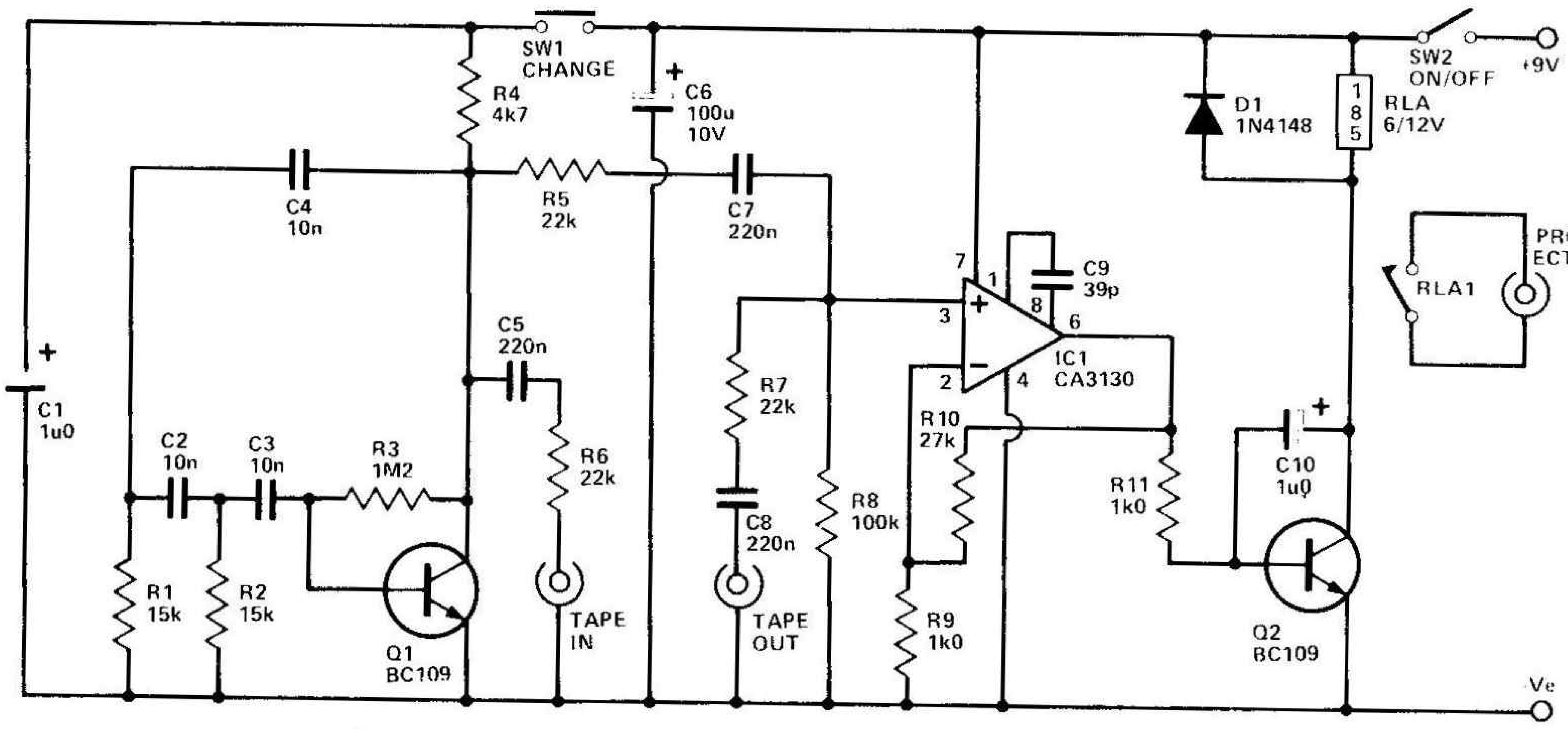
BUYERS GUIDE

In the third part of our mammoth survey of computers and equipment we turn our attention to VDUs. Once again we present the facts and figures in clear and concise form to allow you to make the best decision. Don't miss it, it's the only one there is.

SPACEWAR

Not just another version of St*r *re* but a real wargame simulation with tactical and strategic positioning. James T might find this a harder match than those Klingons he seems to have so much trouble with.

SPOT DESIGNS



Slide/Tape Synchroniser

With the aid of a tape recorder and a slide tape synchroniser it is possible to obtain programmed slide changing with an automatic projector. By using a synchroniser and a stereo tape deck or recorder it is possible to have music and a commentary recorded on one channel and signals to give automatic slide changes at the appropriate points on the other channel.

A slide/tape synchroniser has two sections; a tone generator and an electronic switch. The tone generator is used to record short bursts of tone onto the tape at the points where slide changes are required. The electronic switch is fed with the tone burst output of the tape recorder and closes a pair of relay contacts for the duration of each burst. The relay contacts are, of course, used to control the automatic slide change mechanism of the projector. Usually the output of the tone generator is coupled to the input of the electronic switch, so that operating the tone generator causes the relay contacts to close. This is useful when recording a tape. With the projector loaded with slides, the synchroniser connected to the projector, the output of the tone generator fed to one input of the recorder and the music/commentary signal ready to be fed to the other input, the tape is inserted. Then the music and commentary are recorded and the tone generator is operated at the appropriate times so that the slides are changed and the tone bursts are recorded onto the tape. If the tape is then rewound, the slide magazine is brought back to its starting point and the tone burst output of the tape recorder is fed to the input of the electronic switch, replaying the tape should give the slide show with accompanying sound track and automatic slide changing. The operator only has to start the tape at the beginning of the show and stop it at the end.

A similar technique is used when using the unit as a programmed slide timer, the only difference being that there is no soundtrack to bother with.

The tone generator uses Q1 in a straightforward phase shift oscillator operating at about 500 Hz, although the exact operating frequency is not of great importance. It is merely necessary to use one at which the recorder is capable of operating reasonably well. The output from the collector of Q1 is coupled to the tape recorder by DC blocking capacitor C5 and resistor R6. The latter attenuates the output. R6 also ensures that the oscillator cannot be so heavily loaded that it ceases functioning. SW1 is a non-locking, push to make switch. It is briefly pressed to connect the supply to the tone generator and produce the tone bursts.

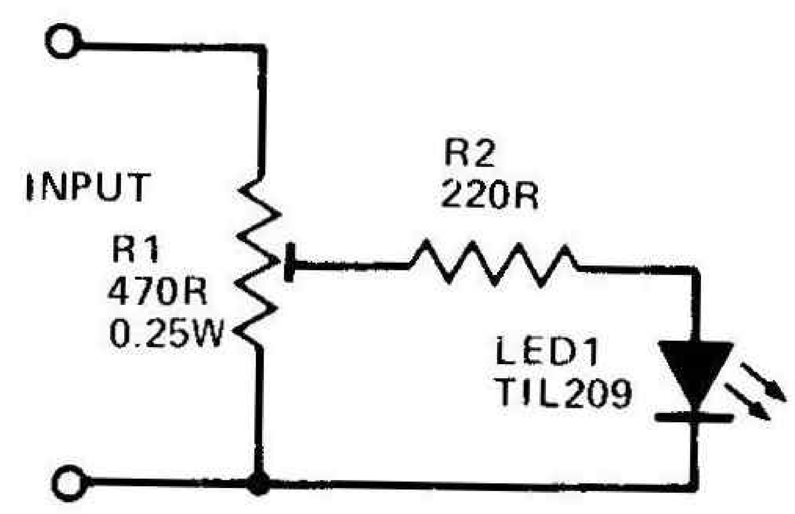
The tone generator is based on operational amplifier IC1, which is used in the non-inverting mode. Its voltage gain is set at about 28 by R9,10 and R8 biases the non-inverting input to the negative supply rail. R5,7 form a simple passive mixer at the input of IC1, so that it can be fed from either the tone generator or from the output of the tape recorder without the need for any changeover switching. The output of IC1 is used to drive common emitter amplifier Q2, which has the relay coil and protective diode D1 as its collector load. Normally IC1's output is low and Q2 is cut off, but in the presence of an input tone the output of IC1 goes strongly positive on positive going half cycles. C10 integrates these pulses so that Q2 is continuously switched on in the presence of an input tone and the relay is energised. The relay contacts then close and operate the slide change mechanism of the projector.

The current consumption of the unit is only about 500 uA, but rises to around 40 mA during the brief periods when the relay is activated. The relay can be any type having a 6/12 V coil with a resistance of about 185R or more, provided it has at least one set of normally open contacts of adequate rating.

Clipping Monitor

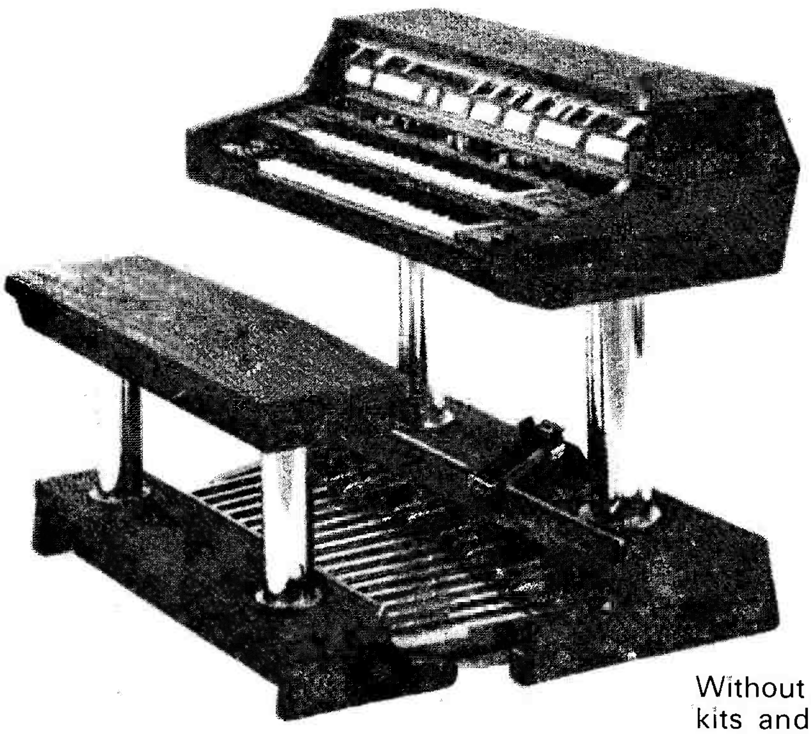
When using an amplifier at virtually its full output power there is a risk of "clipping" occuring. The amplifier is overdriven to the point where output peaks are flattened because the amplifier simply cannot provide a high enough output voltage. The distortion caused by clipping is often quite severe and readily apparent, but this is not always the case. It is not uncommon for the tweeters in loudspeakers to burn out due to overloading caused by clipping producing strong high frequency signals!

The circuit relies on the fact that with less than about 2 V applied to a LED it will not pass any significant current and will fail to light up. If the voltage applied to the LED is only marginally increased above 2 V, the LED avalanches, a heavy current flows and it glows brightly. R1 is adjusted so that the voltage applied to LED1 via current limiting resistor R2 is just sufficient to cause D1 to glow quite brightly when the amplifier is driven into clipping.



With the amplifier driven just below the clipping threshold there is just enough voltage applied to the circuit to cause LED1 to visibly glow, although it does so at less than full brightness. If the amplifier is driven significantly below the clipping level there will be insufficient voltage fed to D1 to cause it to conduct and it will not light up.

WERSI at AURA SOUNDS



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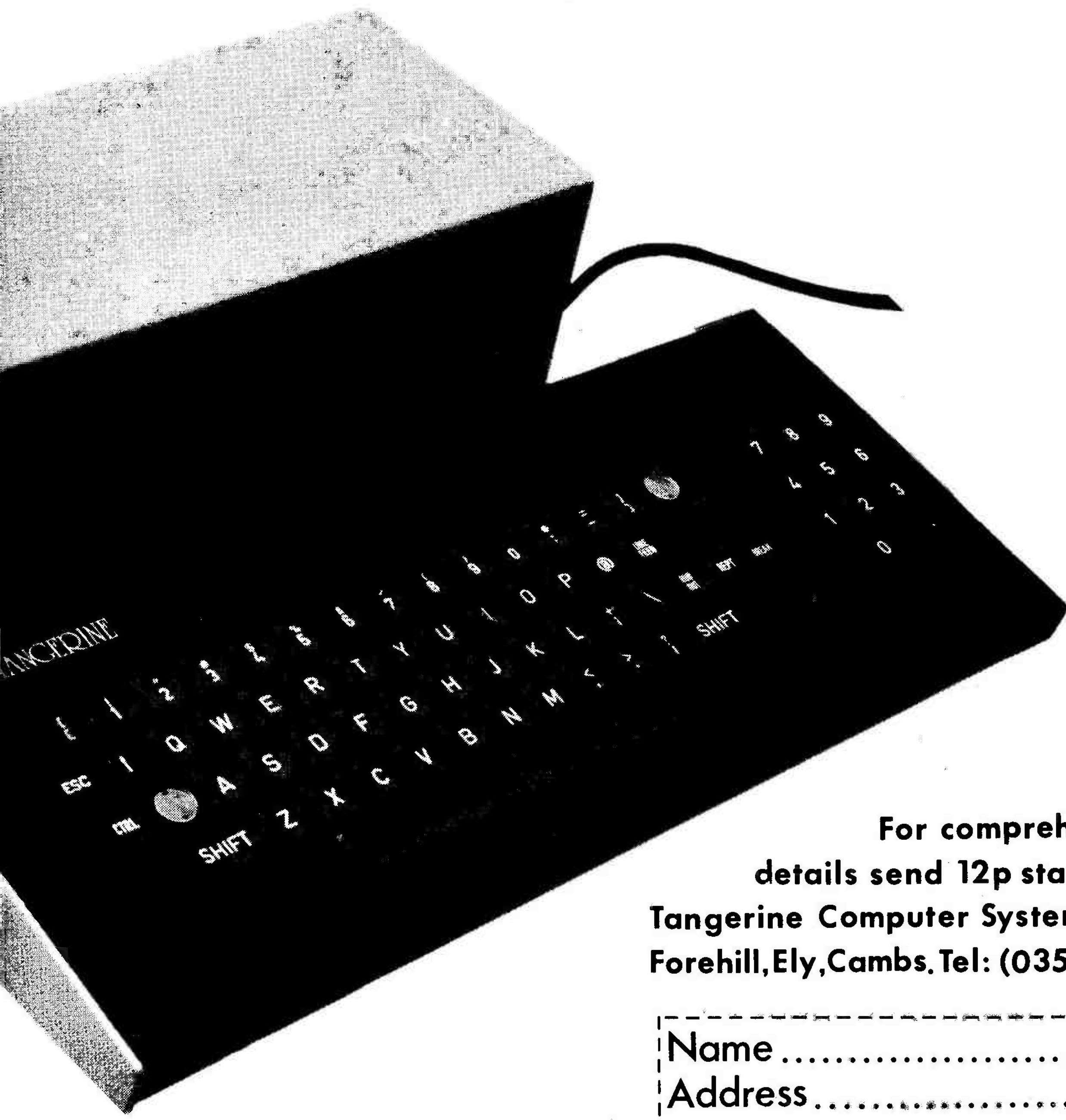

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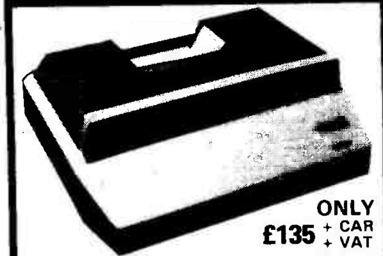

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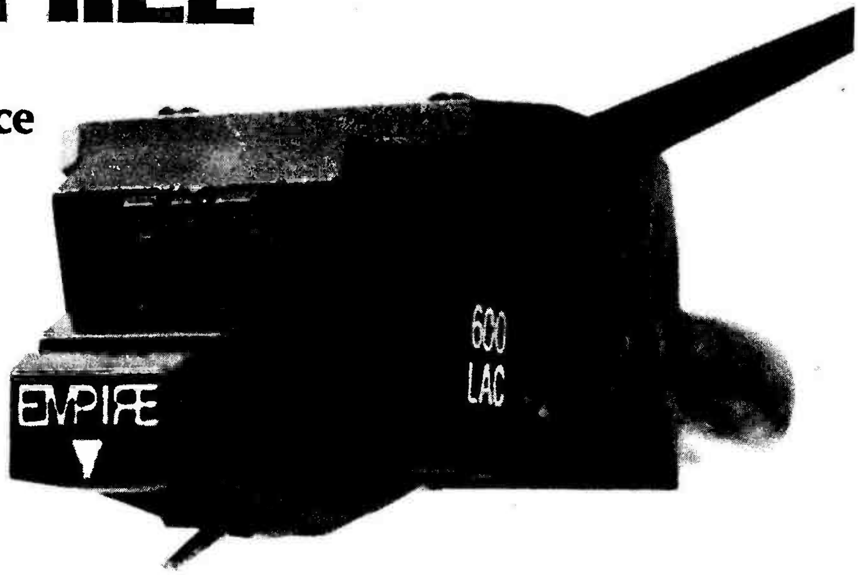
AUDIOPHILE

Empire's new Dynamic Interface series comes under scrutiny this month and Ron Harris has some second thoughts on metal tape tests.



After last months highly physical encounter with the JVC AX9 and its 37lbs of muscle rending weight, I decided to cheat the truss a little longer and return to the realm of the phono cartridge — where weight is measured in grams and a man (and his assets) can feel comfortable in their work.

A friend of mine — yes, even editors have friends — has for some time been muttering darkly about Empire cartridges being the best thing since the Big Bang. But after they managed to ignore my pleas for an EDR-9 when last I lined up the cantilevers I had all but given them up as a figment of his lurid imagination.

However, with the dawning of a new day — and the shuffling arrival of our geriatric postman — was delivered unto me a small brown parcel, containing not one but *two* Empire cartridges. Once more I am forced to revise my model of the Universe. Wrong again.

Having beaten off my friends grasping, avaricious little paws and refused all offers to kidnap Felicity Kendal in return for the contents of the box, I found myself confronted by the new Dynamic Interface series in the form of its 600LAC and 400TC manifestations.

Right then, into battle, SME raised against the fall of night and the howling of the wolves (i.e. neighbours).

Empire Strikes Back

These cartridges use a moving-iron principle to generate their millivolts, inherently more linear than the more common moving magnet. The top two in the range, the 600LAC and the 500ID also employ an 'internally dampened' cantilever to overcome the mechanical h.f. resonance at around 18 kHz.

Other innovations include a cantilever composed of an Aluminium alloy with Boron deposited into it, reduced tip mass and 'two position locking' for the stylus assembly to ensure that it is correctly located.

Benefits claimed are flatter frequency response due to close control of resonance, reduced IM distortion, increased trackability (sorry Shure!), good hum rejection and reduced record wear. In fact everything short of the power of regeneration. Maybe that comes with next year's model.

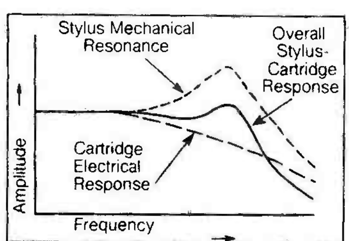
The basic engineering concept of these cartridges differs from the 'norm' in that here the coils and magnets are fixed in place within the body, a hollow iron armature is attached to the cantilever and generates the output in the coils by moving within the field from the three magnets situated next to them.

Unusual is Empire's use of two 'front' magnets to linearise the field through the pole pieces and coils, which also act to reduce hum pickup. Field strength is effectively concentrated in the gap where the armature is in motion. Empire say this also reduces microphonics (susceptibility to outside vibration).

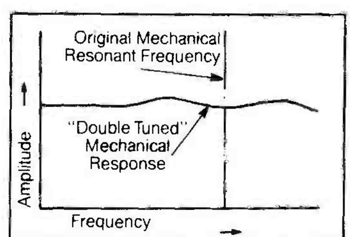
Inside Story

The 600LAC features the inertially dampened tuned stylus (IDTS) system, Empire's scheme to defeat h.f. resonance. This employs an assembly INSIDE the cantilever, consisting of elastomer ring and iron piecework, which provides an antiphase resonance at the critical point to produce a much flatter "twin peak" overall response around resonance.

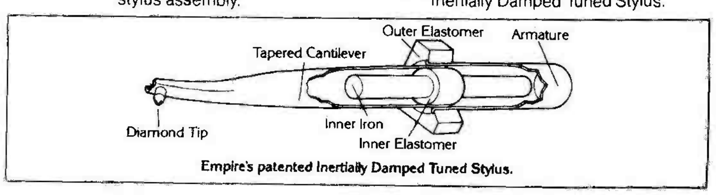
The diagrams explain this better than any combination of letters and spaces.



Frequency response of a conventional stylus assembly.

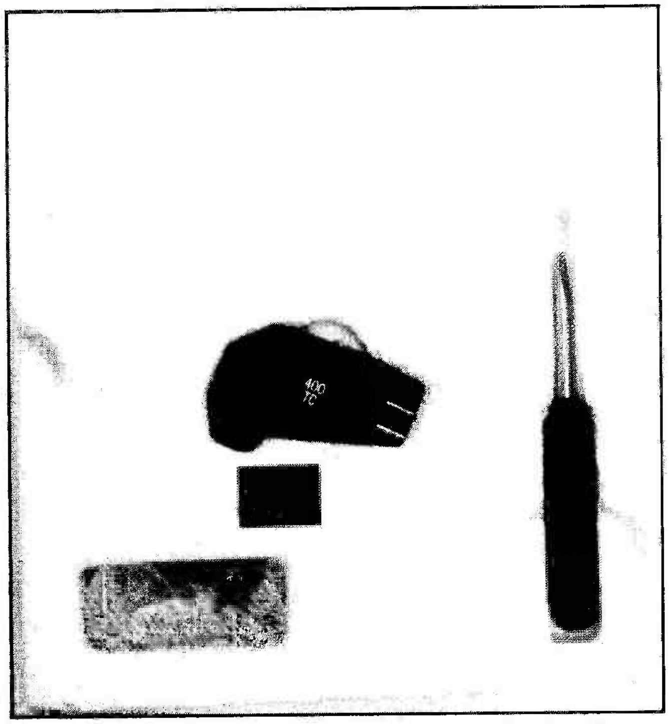


Frequency response using Empire's patented Inertially Damped Tuned Stylus.



Empire's patented Inertially Damped Tuned Stylus.

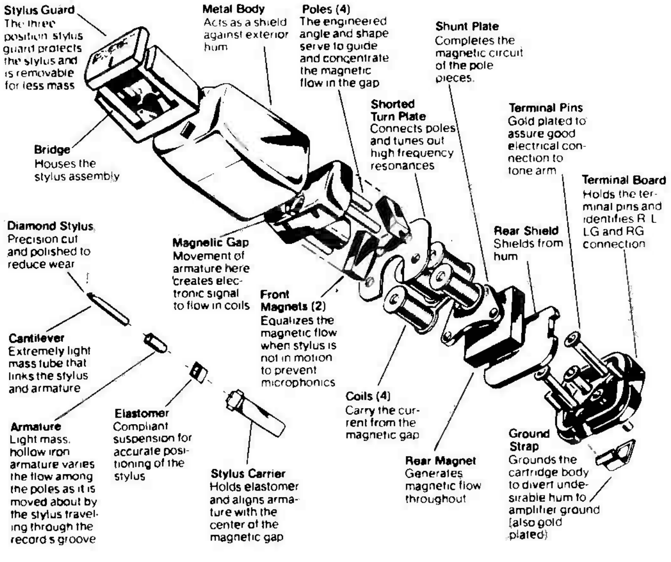
Says it all better than words — Empire's IDTS system.



The 400TC pickup reclining in its box awaiting the moment of truth and the SME. All the DI range are physically similar and are distinguished by the colour of the stylus carriers. In the case of the 400TC this is an extremely lurid red.

LAC stands for 'Large Area of Contact' and implies that lower record wear should be expected from the 600LAC than from a normal elliptical or spherical point. Under high-power magnification a very high order of finish was revealed on our sample, confirming the manufacturer's claim of having paid special attention to stylus polish. Such care would manifest itself in better preservation of those irrepairable grooves and lower surface noise.

The 400TC has the tapered cantilever of its more expensive brethren, and a lower tip mass than most units in this price range. The 400TC retails at around £30 and the 600LAC at



An exploded view of an Empire cartridge. Note the use of two small magnets ahead of the main assembly. This is to concentrate and linearise field strength in the region around the moving iron element.

about £75 — both in very competitive areas indeed. Good performance is not a bonus here, merely a basic requirement for (commercial) survival.

Packet In?

One immediate disappointment must be the presentation of the cartridges. Both arrive wedged into a block of polystyrene, along with fixing hardware and mandatory screwdriver. Outer packaging is a simple cardboard sleeve. Whilst one can applaud the avoidance of expensive trappings that do nothing to enhance performance, surely this is going a little *too* far — especially at the £80 or so of the 600LAC?

Indeed, the overall appearance of the cartridges themselves does not manifest the overtly confident engineering that one gets from something like a Shure or an Ortofon. Not that they are anything but well made — please don't go thinking that Audiophile is casting needless aspersions! The company offer a two year guarantee on all the range as proof of *their* confidence in the product. It is certainly not misplaced, I think.

Sound Evidence

After the measurements had been taken and the lab stool vacated for a more comfortable armchair, the 600LAC was auditioned mounted in the inevitable SME series III pickup arm — still the Rolls Royce of its field. Comparison was drawn against the Ortofon/SME 30 H and Coral MC81 (moving coil) units.

Whatever the criteria the 600LAC is a good cartridge. Its sound is characterised by a solid bass and a forward presentation. Treble is very well extended and smooth. Resonances are well controlled, so that damping is certainly effective audibly. The Empire works well with any type of music, but undeniably adds a certain amount of 'life' of its own that is most exciting with rock.

At times I could detect a slight 'edge' on difficult, heavily modulated passages although tracking was always impeccable and the 600LAC was never tricked into mistracking. It has a great deal of the sparkle and transparency of the best cartridges around, but loses out in the mid-range where it is a little veiled when judged absolutely. Nonetheless all hi-fi is a compromise of some sort or other, and this pickup gives away less to perfection than most. Good value, I thought.

Onto the 400TC, which was compared against the Shure M97EJ and Goldring G900 IGC reference. In a straight A-B comparison the Empire betters the Shure, but falls short of the more refined G900 IGC. It does offer very good returns on the £30 investment required to secure its services, however.

Like the 600LAC, the sound is forward in nature and projects the music outwards from the loudspeakers. Presentation is confident with a good low frequency performance and very smooth top end. As long as speakers are chosen to complement the distinctive style this Empire would be a worthy addition to any system in the £400-£600 price range.

In fact the 400TC is close enough to the 600LAC to make me wonder what place exists for the 5001D, a model that sells for £45 and sits between the two in the Empire range.

Conclusions

Overall then, two good units well placed to succeed and which should be added to shortlists for audition at the friendly neighbourhood dealers. Good features common to both were an insensitivity to surface noise, extended bass and smooth treble. Well worth a listen.

I can see Empire gathering quite a following for this new

	Model	600LAC	400TC
1	Frequency Response Bandwidth	6Hz – 50,000Hz	7Hz – 34,000Hz
2	Frequency Response	20Hz – 28,000Hz ± 1¾ dB	20Hz – 20,000Hz ± 2 dB
3	Tracking Force Range	1 to 2 grams	¾ to 2 grams
4	Recommended Tracking Force	1½ grams	1¼ grams
5	Separation @ 200Hz	21 dB	20 dB
	@ 1kHz	30 dB	28 dB
	@ 5kHz	20 dB	20 dB
	@ 12.5kHz	17 dB	16 dB
6	I.M. Distortion @ 3.54 cm/sec	0.1%	0.15%
	@ 14.5 cm/sec	0.4%	0.5%
7	Stylus Shape and Size	LAC	0.2 x 0.7 mil bi-radial
8	Cantilever	Boron vapored, inertially damped, tapered Aluminum alloy	Tapered Aluminum alloy
9	Effective Tip Mass	0.6 mg	0.6 mg
10	Compliance (Dynamic)	20×10^{-6} cm/dyne	20×10^{-6} cm/dyne
	(Static)	28.5×10^{-6} cm/dyne	23×10^{-6} cm/dyne
11	Tracking Ability @ 300Hz	17.9 cm/sec	17.9 cm/sec
	@ 1kHz	38 cm/sec	32 cm/sec
12	Channel Balance	within 1.0 dB	within 1.0 dB
13	Vertical Tracking Angle	20°	20°
14	Output @ 1kHz @ 3.54 cm/sec	4.0 mV	3.8 mV
15	Number and Type of Magnets	2 Samarium Cobalt, 1 Indox V	2 Samarium Cobalt, 1 Indox V
16	Load Resistance	47k Ohms	47k Ohms
17	Capacitance	150 pF	150 pF to 400 pF (350 pF optimum)
18	Hum Sensitivity @ 60Hz	0.34 µV/A/m	0.5 µV/A/m
19	Total Weight	5.3 grams	5.3 grams
20	Stylus Replacement No. & Color	S600LAC (Black)	S400TC (Red)

How about this for a set of specs? Empire are certainly unafraid to lay it all out in black and white. On test no significant differences were discovered. Hum susceptibility was not tested — you'll note that they have specified this at 60 Hz. Damn colonials again is it not? Tracking weight ranges are sensibly specified and I found that the lower values worked well.

range of cartridges without too much difficulty, and I can think of no higher praise than to comment that while auditioning the 600LAC I was in no hurry to return to the familiar tones of my reference unit.

Tape Measures

Up-cock on the measurement front it seems. Many moons ago I reviewed the TCK 55 II from Sony and in doing so apparently discovered that said machine would not function to the best of its considerable ability with Sony tapes. Metal variety, anyway. Since then Sony have made a valiant effort to completely bury me in cassettes, on the principle that the one I had was a bad sample and all others will work.

After clambering out from under the little plastic boxes and clearing a space to work, I sat down to do a retest with some other examples of their metallic machinations. Lo and behold. Better frequency response and improved linearity. Suspicious editorial mind begins to dream up fiendish Japanese plots to "fix" results. Is Audiophile having its statistics interfered with?

A strong desire for impartiality, together with a fair helping of cowardice led me to pack off the TCK 55 II and all its little metal ammunition for independent testing once more. I neglected to tell the engineer concerned about the initial discrepency on a particular tape type, just to see if he'd turn it up independently. Come to think of it, those Samurai warriors polishing their swords outside my door *may* have slipped my mind too — still I probably imagined it . . . .

It would appear from a consideration of both our results that there ws something wrong with the tape rather than the machine, after all. That probably clears Sony Tape Recorders Ltd off my back, but enrages Sony Cassette Production 1921 Ltd, or some other such edifice.

(Maybe it is no coincidence that everyone in my train compartment this morning was of oriental extraction and carried a long and curved thin brown paper parcel. Anyone know the Japanese for: "Me given up reviewing hi-fi, taken up knitting instead"?)

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7430	18p
7432	25p
7440	16p
7442	68p
7448	75p
7473	32p
7474	32p
7475	40p
7476	40p
7490	35p
7492	50p
7493	50p
7496	45p
74121	35p
74123	45p
74154	90p
74157	55p
74122	45p
74125	50p
74195	100p
74196	100p
74283	140p
74290	120p
74365	90p
74366	90p

74LS

74LS00	18p
74LS01	12p
74LSD4	15p
74LS08	20p
74LS10	19p
74LS11	30p
74LS12	30p
74LS14	60p
74LS15	38p
74LS20	19p
74LS30	19p
74LS32	25p
74LS40	26p
74LS42	56p
74LS47	78p
74LS48	85p
74LS49	99p
74LS73	30p
74LS74	30p
74LS75	39p
74LS86	39p
74LS90	40p
74LS107	40p
74LS123	69p
74LS125	50p
74LS132	79p
74LS138	69p
74LS151	75p
74LS153	75p
74LS155	65p
74LS161	78p
74LS163	90p
74LS164	90p
74LS168	190p
74LS174	99p
74LS175	99p
74LS195	87p
74LS221	110p
74LS244	175p
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4020	88p
4021	100p
4022	88p
4023	22p
4024	50p
4025	20p
4026	130p
4027	45p
4028	75p
4029	80p
4030	50p
4031	195p
4033	145p
4035	104p
4036	290p
4037	105p
4038	110p
4039	290p
4040	99p
4041	75p
4042	73p
4043	86p
4044	88p
4045	160p
4047	99p
4048	56p
4049	38p
4050	40p
4051	69p
4052	75p
4053	73p
4054	111p
4055	121p
4056	121p
4059	560p
4060	112p
4063	112p
4066	56p
4067	422p
4068	19p
4069	19p
4070	28p
4071	25p
4072	25p
4073	25p
4075	20p
4076	88p
4077	23p
4078	29p
4081	23p
4082	25p
4085	86p
4086	68p
4089	130p
4093	68p
4094	225p
4095	99p
4096	325p
4098	110p
4099	180p
4501	25p
4502	112p
4503	68p
4507	52p
4508	288p
4510	76p
4511	125p
4512	75p
4514	250p
4515	290p
4516	109p
4518	99p
4520	99p
4521	230p
4526	105p
4527	130p
4528	99p
4529	140p
4531	150p
4532	125p
4538	150p
4543	160p
4556	70p
4560	225p
4569	240p
4572	46p
4584	79p
4585	125p

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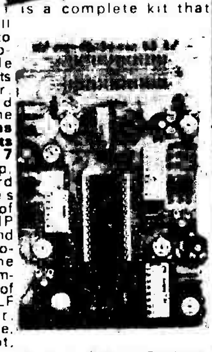

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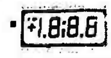

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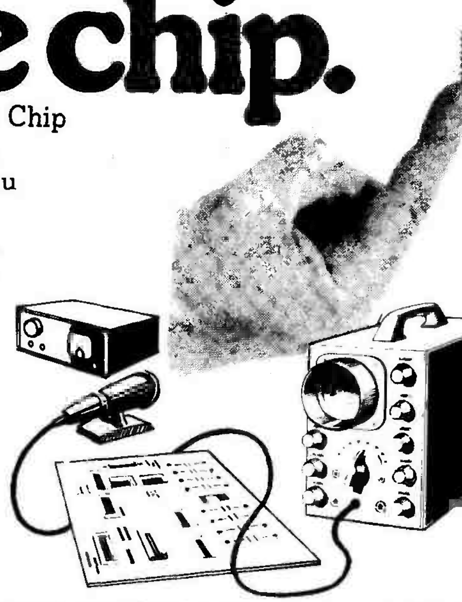

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RAVEN ON

Dave Raven of Metac Electronics chats about chips that answer back and discusses display developments.

Speech synthesis and voice recognition are techniques which are rapidly changing the interface between humans and their machines. Until now we have been content to read from a visual display or listen to pre-recorded non-intelligent voices which merely pass on information.

Today, however, it is possible to incorporate a human voice which is not a recording and can appear intelligent by varying its responses to the inputs received from humans or data produced by a machine. If, in the past, a colleague was seen listening or talking to a car, calculator, microwave oven or television set, he would most likely be advised to visit a psychiatrist at the earliest opportunity. But now thanks to new devices and computer software technologies, behaviour such as this will become commonplace.

Speak & Spell

The first consumer product which truly contains speech synthesis and which is on the market is Speak & Spell, developed by Texas Instruments. Working with a pair of 128-kilobyte read-only memories and a special version of TI's TMS1000 8-bit microcomputer, the silicon chip can produce a total of 200S of sound for a vocabulary of over 200 words. However, it is capable of accessing up to 2.1 megabytes of memory. Since the speech generator uses memory at a maximum rate of only 1200 bits per second, it could be designed to speak for as long as 30 minutes. The novelty value of Speak & Spell does not wear off quickly as may be imagined and from the reactions of my own young children, it was a clear favourite over other electronic games they have been shown. The word games and spelling tests produced a new angle for creating an interest from children in learning and I also found it quite compulsive myself.

Prior to the breakthrough by Texas Instruments in speech synthesis, earlier products which have surfaced over the last decade have been quite cumbersome and certainly more expensive. Now, with rapid advances taking place in large scale integrated circuits — both analogue and digital — and developments in signal processing, it is realistic to expect a flood of new consumer and industrialised products entering the markets.

Vocal Chips

The techniques used to design speech synthesis circuits are split into three different methods — formant synthesis, linear predictive coding and waveform digitisation with compression. Linear predictive coding is the technique chosen by Texas Instruments for their Speak & Spell Game. The chips which are incorporated represent an integrated circuit model of the vocal tract. Basic to the model is the linear predictive coding technique (LPC) which provides feedback values or coefficients for a digital lattice filter on the synthesiser chip. This linear filter mimics the major resonant modes of the vocal cavity in the human vocal tract. A microprocessor then performs the calculations to derive the filter coefficients. The third chip is a word-storage read-only memory that holds the speech parts broken into four parameters — voicing, pitch, amplitude and frequency. From this information a complex software algorithm manipulates the sound parameters to create the speech synthesis.

Swings And Roundabouts

There are advantages and disadvantages with each of the three speech synthesis techniques mentioned here since they can vary considerably in the quality of speech provided, the amount of data required to achieve acceptable quality and the cost of memory for storing speech data. The technique that is normally chosen depends upon the application for which it is required.

Products using formant synthesis are currently being included in a number of hobbyist computers, among them the TRS80 home computer and PET, as well as in medical and business applications.

During recent years probably one of the most misunderstood pieces of consumer electronic technology has been the liquid crystal display. I well remember an article appearing in ETI which quoted some very out of date information on the life of liquid crystal displays (LCD), and for years after, I experienced worried customers quoting this article back to me about the unreliable life-time of the display.

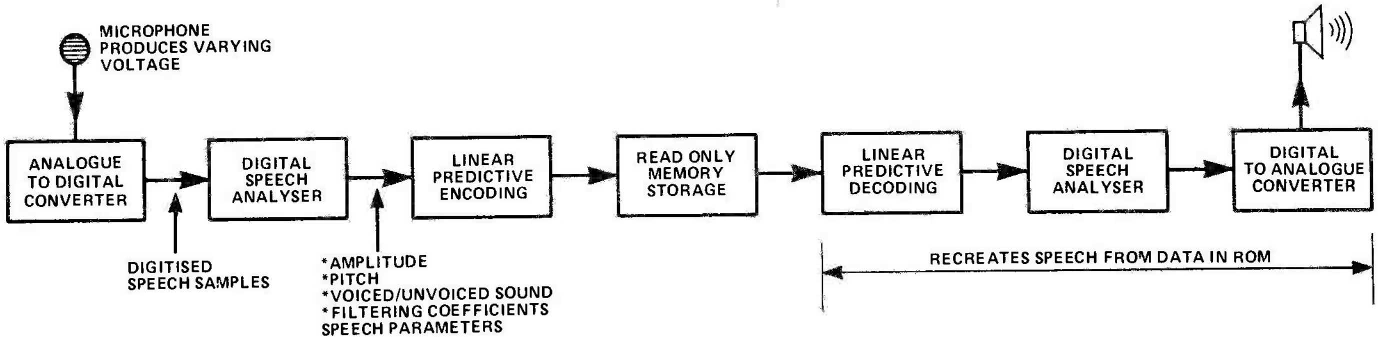


Fig.1. A block diagram showing the elements of a speech synthesiser chip.

They were of course referring to displays which appeared back in history during the very early seventies and it has been my experience that the LCD is probably one of the most reliable display forms currently available. I stuck my neck out in 1976 in an article published in ETI predicting that LCD would win the day over LED, (Light Emitting Diode) remember, and I propounded the reliability of this technique back in those dark days. Well, they say that the good always win and there is little doubt that LCDs have stood the test of time.

Physical Contact

Recent advances in the synthesis (that word keeps appearing this month) of new liquid crystalline materials have made it possible to manufacture plastic sealed LCDs having very long operating lives. This new technique permits economical production of large area displays and at the same time improves the performance of multiplexed addressing. Thus, these new displays are capable of handling an ever-increasing amount of information in alphanumeric or quasi-analogue form. One of the major problems facing designers in their attempts to increase the amount of information which can be displayed, is how to make physical contact with each segment of the display. This is also a problem for chip designers who are restricted by the amount of space for lead-outs. One solution which is getting around this difficulty is by reducing the number of outside contacts to a display, especially when the display has more than 40 separately addressable segments. This can be achieved by means of a technique known as time-multiplexed addressing, in which appropriate segments are connected together to form a group and are sequentially addressed by means of a

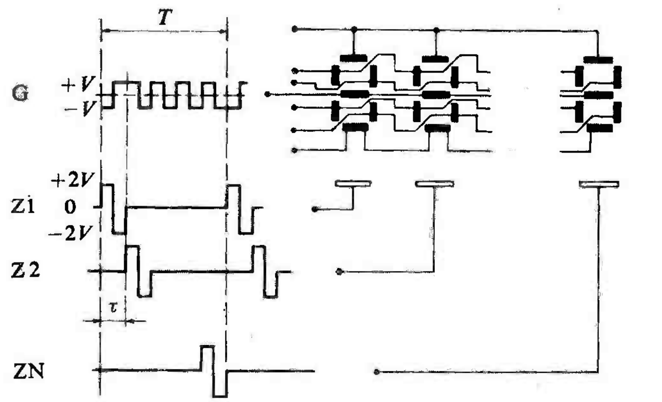


Fig.2. The principle of time-multiplexed operation. The selection interval for each digit, Z1 to ZN, is cyclically repeated at intervals of T. Only the driving signal for segment G is shown.

rear electrode consisting of several parts. Direct addressing of the LCD is presently employed in most watches and other measuring instruments which means there is a direct connection between each display element and a corresponding contact in the driving electronics, which is usually an integrated circuit. this addressing technique, whilst resulting in lots of connections, does have its advantages, since it affords much more freedom with respect to driving voltages and operating temperatures than do other addressing systems. For a directly addressing display it is easy to increase the driving voltage to obtain a display which is readable over a wide range of viewing angles.

ETI

DESIGNER'S NOTEBOOK

ETI project editor Ray Marston devotes this month's 'Notebook' to the rather unglamorous but vital subject of passive attenuators.

One of the most important types of artillery in the design engineer's armoury of 'vital weapons' is the apparently simple passive circuit known as the 'attenuator'. Naturally, these apparently simple weapons are full of nasty little surprises and have a tendency to explode in the face of the unwary designer. This month's 'Notebook' is devoted to a brief discussion of the subject.

Attenuators

Attenuators are used to reduce an awkward value input or output signal to a lower and more convenient level. The simplest example of a practical attenuator is the 'pot' circuit of Fig.1, which may be used as a volume control in an audio system or as an output level control in a simple audio generator, etc.

The input signal to the pot attenuator is connected across the total resistance chain and the output is taken from the pot slider. Note that the pot effectively comprises an upper (R1) and a lower (R2) resistive arm, thus forming a basic 'L'-type attenuator and that the degree of attenuation is determined by the ratio of lower arm resistance divided by the total resistance.

The precise amount of attenuation provided by a pot is generally of little importance and the control is usually left uncalibrated. If a precise amount of attenuation is required, a simple switched potential divider network of the type shown in Fig.2 may be used. It is important to note, however, that this circuit is designed to feed into an *infinite* impedance, or at least one that is very large compared to the total resistance of the divider chain.

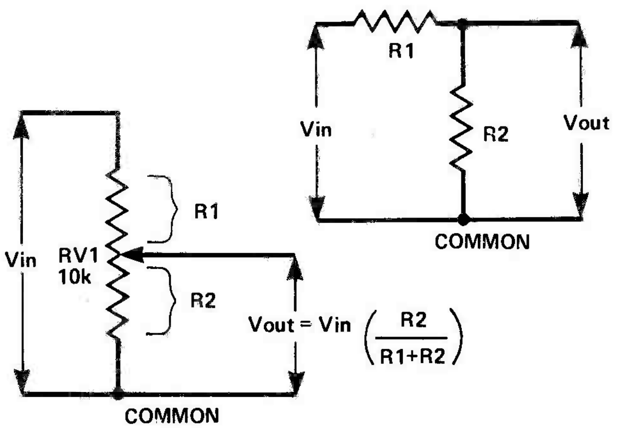


Fig.1 A simple 'pot' attenuator, as used for a volume control or an uncalibrated output level control (left) is a common version of the 'L' attenuator (right).

Design Tips

The first step in designing an attenuator of the Fig.2 type is to decide what its input impedance or total resistance is to be. Next, the values of the individual resistors are determined. Here the design is carried out in a simple sequence of logical steps, there being as many steps as there are attenuator switched positions. In each of these steps, the circuit is considered to consist of an upper and a lower half only. An example will help clarify matters.

Assume (as in our example) that the total resistance is to be 10k and that two attenuation positions (excluding unity) are required and are ÷10 and ÷100. The values for the greatest amount of attenuation are always determined first, so for ÷100 the lowest arm must contain 1/100th of the total resistance, or 100R. This gives the value for R3 and leaves the remaining 9900R in the 'upper' (R1 + R2) arm.

The values for the ÷10 position are next calculated and it is found that 1k0 is needed for the 'lower' arm. In this case, however, the 'lower' arm consists of R2 + R3, but as R3 is already known to be 100R, R2 must be 1k0 − 100R = 900R. The upper arm, R1, must obviously contain the remaining 9k0 of the 10k chain.

This simple design procedure may be expanded up to give as many attenuator steps as are required for a particular application.

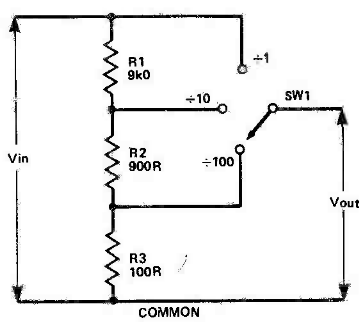


Fig.2 The method of designing this simple switched attenuator is explained in the text.

It should be noted that the simple attenuator circuit of Fig.2 is only accurate at low frequencies or when moderately low values of resistance are used. At high frequencies, stray capacitance will shunt the values of all resistors and may significantly reduce their values and thus the accuracy of the attenuator. This effect is particularly acute when high value resistors are used: a mere 2pF of stray capacitance represents a reactance of about 800k at 100 kHz and will have a very significant shunting effect on any resistor with a value greater than a few tens of kilohms.

Compensation

This problem can readily be overcome by shunting all resistors with correctly chosen values of capacitance, as shown in Fig.3.

Here, each resistor of the chain is shunted with a fixed capacitor, the reactance values of capacitance being in the same ratios as the resistive arms of the attenuator. The highest reactance (smallest capacitance) is connected to the largest resistor and typically has a value in the range 15 to 50pF, the value being large enough to 'swamp' strays but small enough to present an acceptably high impedance to input signals.

This 'compensated' type of attenuator is invariably used in 'scopes and various other types of high freqency test gear, as shown in the typical circuits of Figs.4 and 5. Once again, note that the compensated attenuator is intended to feed into a high impedance load.

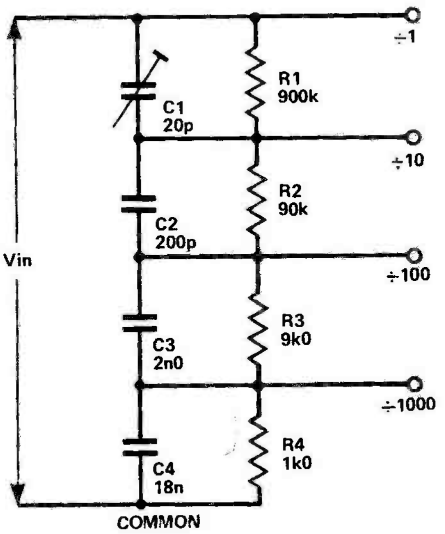


Fig.3 A method of providing frequency compensation (to give a wide frequency response) to a simple attenuator network.

Pot Pitfalls

At this point in our discussion it may have dawned on you that, because of the effects of stray capacitance, there can be certain pitfalls in using pots in some types of circuit. Suppose, for example, that you have designed an audio amplifier with a beautifully flat frequency response but have, in a moment of madness, fitted it with a 500k volume control. You will (hopefully) not be unduly surprised to consequently find that, at low volume settings, stray capacitance of a few picofarads across the upper arm of the pot causes the amplifiers treble response to be boosted by several dB at 12 kHz or so!

Again, suppose that you have disigned a superb LF sine/square generator which produces square waves with rise and fall times of a mere 50 nS or so, but have fitted the beast with a simple 10k pot as an output level control. Naturally, you will not be surprised to find that the few picofarads of strays across the upper arm of the pot acts as a reactance of only a couple of thousand ohms to your fast rise and fall time signals and consequently causes your square waves to appear incredibly 'spiky' at low amplitude settings.

Both of the above problems can be solved or minimised by using pots with sensible low resistance values, bearing in mind the effects of strays at the operating frequencies in question.

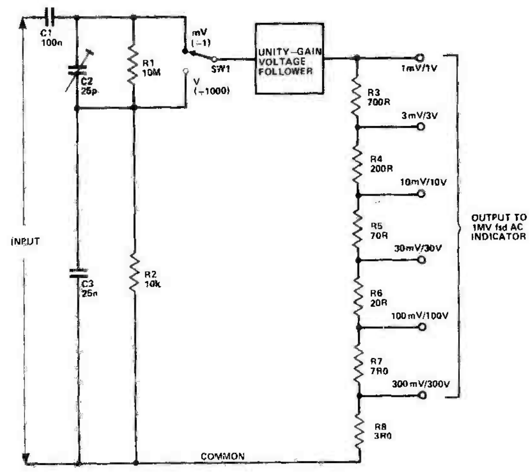


Fig.5 Typical attenuator sections of an AC millivoltmeter;

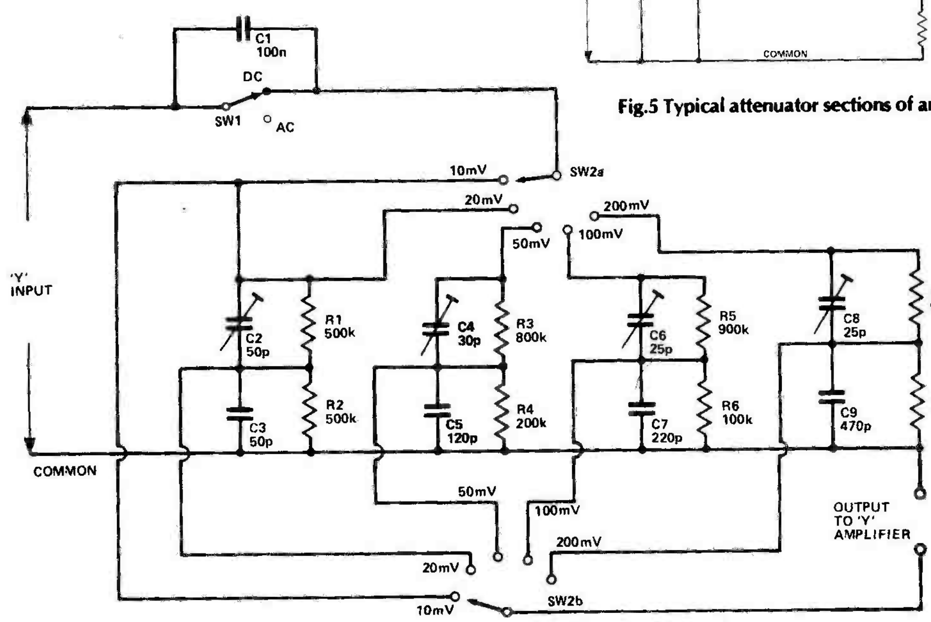


Fig.4 Section of a typical 'scope 'Y' amplifier attenuator.

Matched-Resistance Attenuators

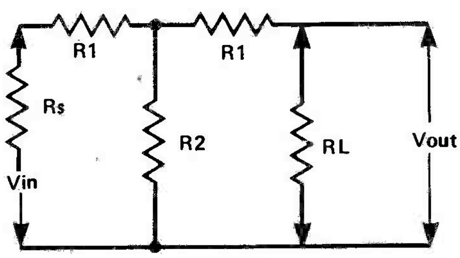
Often, an attenuator is needed to feed into and/or from a fixed load of some kind, in which case the simple potential divider types of circuit discussed above are of little use. Instead, one of the many versions of the so-called matched-resistance attenuator must be used. Two of the most popular attenuators of this type are shown in Fig.6, together with their basic design formulae. Note that these formulae are valid only when the attenuators are correctly terminated at each end.

The 'T'-type attenuator is a perfectly simple design and several sections can readily be cascaded to form variable attenuator networks, as shown in the practical circuit of Fig.7. Here, the attenuation can be varied from 0 dB to 60 dB in 20 dB steps by switching individual sections into or out-of the circuit.

The π attenuator sections cannot be directly cascaded, as is made clear in Fig.8. Nevertheless, sections can be cascaded in modified form to produce a laddered attenuator network, the most popular of all attenuator types.

Looking at Fig.8, you can see that if three individual π sections are wired in cascade (Fig.8a) their adjacent R2 sections connect in parallel to give an impedance of P/2 (Fig.8b) while the two R2 end sections have impedances of P. If an external load, RL, is simply switched to the different outputs of the cascaded π attenuator sections (Fig.8c) the load will clearly see impedances of roughly half of the correct value and so be severely mismatched. To put things right, the formula for the component values of the ladder network of Fig.8c are re-jigged as shown.

The ladder attenuator of Fig.8c is very widely used in AF and RF signal generators. Figure 9 shows the practical circuit of a fully variable 600R attenuator that can be used in sine/square generators, etc.. The odd resistor values (correct within 2%) can be made up by wiring pairs of resistors in series or parallel.

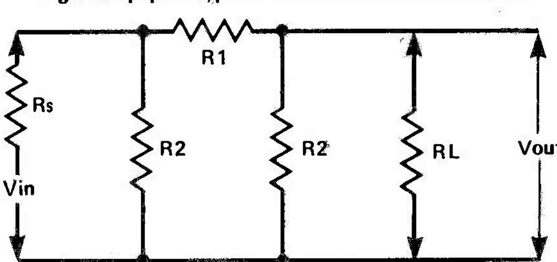


COMMON

'T' – TYPE ATTENUATOR

$$R1 = R\left(\frac{n-1}{n+1}\right) \quad R2 = R\left(\frac{2n}{n^2-1}\right)$$

Fig.6 Two popular types of matched-resistance attenuator.



COMMON

'π' – TYPE ATTENUATOR

$$R1 = R\left(\frac{n^2-1}{2n}\right) \quad R2 = R\left(\frac{n+1}{n-1}\right)$$

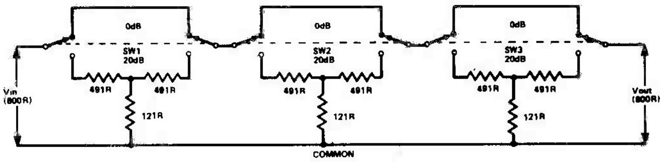
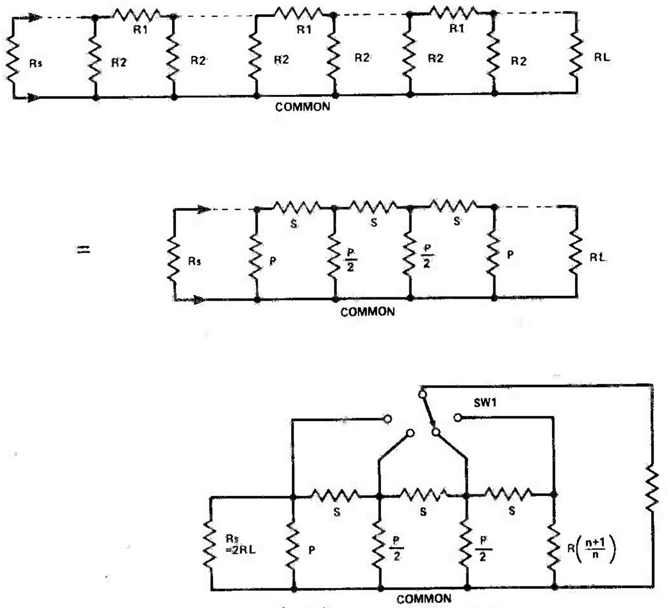


Fig.7 Three identical 20 dB 600R 'T' attenuators cascaded to make a 0-60 dB switched attenuator unit.



$$S = R\left(\frac{n^2-1}{n}\right) \qquad P = 2R\left(\frac{n+1}{n-1}\right)$$

Fig.8 The ladder attenuator (c) is a development of the basic π attenuator (a and b).

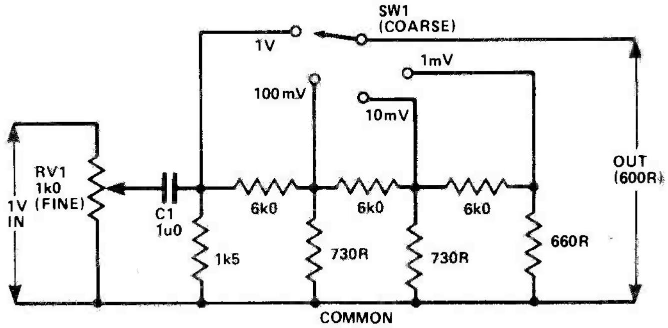


Fig.9 Practical 600R output attenuator network for a modern sine/square generator. RV1 gives fine control. SW2 gives coarse control.

ETI

Greenbank

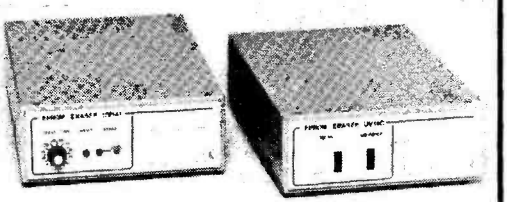
Greenbank Electronics
(Dept T9E) 92 New Chester Road, New Ferry
Wirral, Merseyside L62 5AG
(Tel. 051-645 3391)

TERMS. VAT. CWO. Cheques etc payable to Greenbank Electronics and crossed. Add VAT to all prices at 15% except where stated otherwise. Post etc: UK 35p (+5p VAT = 35p) per order. Export: NO VAT but add 35p (Eire). 75p (Europe) and £2.50 elsewhere. Access. Barclaycard. Visa. telephoned orders accepted. (Polys. universities. govt depts. etc can telephone their orders for immediate despatch on account.)

BARCLAYCARD

UV EPROM ERASERS

UV 140, UV 141



Two easy to use units designed for both the professional and amateur UV-prom user

Features

- Can erase up to 14 proms.
- Special short wave ultraviolet tube.
- Erase time variable between 5 and 50 minutes in 5 minute steps (preventing over exposure which may shorten prom life).
- Sliding tray carries proms on conductive foam.
- Safety interlock switch prevents the timing circuit from operating and switching on the tube with the tray open.
- "Mains On" and "Tube On" indicators.
- Smart textured case.
- Complete instructions supplied.

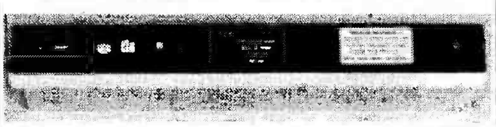
Supplied complete with mains plug and flex

Model UV141. Price £77.70

Also available without timer as

Model UV140: Price £61.20

Tex Microsystems "EPROMPT" UV ERASER



A low cost alternative to the above erasers (UV 140/141) claimed by the manufacturer to erase up to 32 chips in 15-30 mins. This is the cheapest eraser we have seen. The unit has no timer, power switch or safety interlock switch. The user places up to 32 chips into loose conducting foam in the erasure tray (16 along the base, 8 on each side). The chips are held in place by the UV tube which sits in the tray. (Unlike the UV 140/141, no special precautions have been taken to prevent the seepage of UV light, but the manufacturers state that "Incident light from this device is quite safe at distances above 12 inches".)

EPROMPT ERASER: Price £33.56

5204/2708 PROGRAMMING SERVICE: £7.50 each prom. (Price does not include prom, we accept handwritten/typed source code — must be hexadecimal).
PROM WASHING SERVICE: **50p each prom**

NEW COMPUTER BOARDS

The following computer boards have been added to the range for use with the Z80 (114×203mm fibreglass with gold plated edge connector).

IP2	8 line opto isolated input board	£9.40
OP2	8 line relay output board	£9.40
SIO	RS232 serial interface board	£9.40
MXD2	16K dynamic ram board	£9.40

SPECIAL OFFER

(Subject to stocks)

No monthly accounts for these prices:

	each	per 8
2114 (450nS) — 1K×4	£2.99	£22.40
2708 (450nS) — 1K×8	£5.25	£39.60
2516/2716 (450nS) — 2K×8 single 5v	£12.00	£88.00
4116 (250nS) — 16K×1 Dynamic	£3.99	£30.40

CMOS

These cut prices for Amateur Users and Export. Note: industrial users — quantity prices available. Mostly Motorola. RCA

4000	18p	4042	80p	4095	£1.97	4410	£8.55	4531	£1.45
4001	25p	4043	90p	4096	£1.97	4411	£10.72	4532	£1.30
4002	25p	4044	90p	4097	£5.98	4412VP	£14.93	4534	£5.60
4006	95p	4045	£2.63	4098	£1.92	4415V	£5.24	4536	£3.69
4007	18p	4046	£1.10	4099	£2.00	4422	£5.66	4537L	£26.10
4008	80p	4047	£1.71	40100	£1.92	4433	£12.30	4538	£1.20
4009	40p	4048	77p	40101	£1.59	4435V	£5.40	4539	97p
4010	50p	4049	45p	40102	£3.67	4450	£3.81	4541	£1.19
4011	25p	4050	49p	40103	£3.67	4451	£3.81	4543	£1.80
4012	18p	4051	80p	40104	£1.85	4461	£3.93	4549	£4.38
4013	50p	4052	80p	40105	£1.85	4462	£4.41	4552	£14.85
4014	84p	4053	80p	40106	92p	4490FP	£4.20	4553	£4.50
4015	84p	4054	£2.18	40107	£1.28	4490VP	£3.14	4554	£1.38
4016	45p	4055	£2.55	40108	£7.54	4500	£6.95	4555	78p
4017	80p	4056	£2.55	40109	£1.28	4501	29p	4556	72p
4018	89p	4059	£9.23	40110	£3.00	4502	£1.20	4557	£3.86
4019	45p	4060	£2.10	40114	£1.77	4503	70p	4558	£1.25
4020	99p	4062T	£10.00	40160	£1.54	4505	£5.71	4559	£4.38
4021	£1.10	4063	£1.90	40161	£1.54	4506	50p	4560	£2.50
4022	£1.00	4066	55p	40162	£1.54	4507	55p	4561	81p
4023	27p	4067	£7.21	40163	£1.54	4508	£2.90	4562	£5.60
4024	50p	4068	27p	40174	£1.54	4510	99p	4566	£1.59
4025	27p	4069	27p	40181	£5.03	4511	£1.50	4568	£2.38
4026	£3.25	4070	30p	40182	£1.90	4512	80p	4569	£2.50
4027	50p	4071	25p	40192	£2.41	4514	£2.65	4572	40p
4028	84p	4072	25p	40193	£2.41	4515	£3.00	4580	£4.77
4029	99p	4073	25p	40194	£3.27	4516	£1.10	4581	£2.62
4030	72p	4075	25p	40208	£7.54	4517	£4.46	4582	£1.14
4031	£4.31	4076	£1.07	40257	£2.31	4518	£1.00	4583	90p
4032	£1.31	4077	29p	4160	98p	4519	80p	4584	90p
4033	£2.63	4078	29p	4161	98p	4520	£1.00	4585	£1.27
4034	£2.00	4081	27p	4162	98p	4521	£2.50	4597	£2.44
4035	£1.10	4082	27p	4163	98p	4522	£1.11	4598	£2.98
4037	£1.99	4085	£1.35	4174	90p	4526	£1.08	4599	£6.95
4038	£1.20	4086	£1.35	4175	£1.15	4527	£1.50	4700	£1.75
4039	£2.78	4089	£2.91	4194	£1.16	4528	£1.20		
4040	£1.00	4093	80p	4408	£9.37	4529	£1.30		
4041	£1.59	4094	£2.50	4409	£9.37	4530	70p		

74C

		74C76	57p	74C163	£1.15	74C903	57p	74C925	£5.01
		74C83	£1.34	74C164	£1.08	74C904	57p	74C926	£5.01
		74C85	£1.34	74C165	£1.08	74C905	£7.53	74C927	£5.01
74C00	28p	74C86	67p	74C173	93p	74C906	57p	74C928	£5.01
74C02	28p	74C89	£4.62	74C174	93p	74C907	57p	74C929	£17.90
74C04	28p	74C90	89p	74C175	93p	74C908	£1.00	74C930	£17.90
74C08	28p	74C93	89p	74C192	£1.15	74C909	£1.69		
74C10	28p	74C95	£1.08	74C193	£1.15	74C910	£7.45	80C95	85p
74C14	90p	74C107	£1.27	74C195	£1.08	74C911	£7.39	80C96	92p
74C20	28p	74C150	£3.81	74C200	£7.46	74C912	£7.39	80C97	85p
74C30	28p	74C151	£2.55	74C221	£1.41	74C914	£1.46	80C98	92p
74C32	28p	74C154	£3.81	74C245	£2.98	74C915	£1.15	82C19	£6.20
74C42	95p	74C157	£2.29	74C373	£1.79	74C918	£1.10	88C29	£2.90
74C48	£1.43	74C160	£1.49	74C374	£1.79	74C921	£17.07	88C30	£2.90
74C73	57p	74C161	£1.15	74C901	57p	74C922	£3.78		
74C74	59p	74C162	£1.15	74C902	79p	74C923	£3.86		

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VDU 'G' } three	£9.40
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8k PROM board (2708s)	£9.40
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13″×14¾″ approx. Epoxy Glass. tinned
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(Add £1 for the 4MHz version of any of the above 3 chips.)

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SC/MP II (4MHz)	£8.82
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6800 MPU	£6.55
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6820. 6821 PIA	£3.96
6850 ACIA	£3.08
MC6880	£2.64

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6502	£7.95
6520 PIA	£6.22
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CMOS

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81LS95/6/7/8	£1.40
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IL74	48p

CRT Controller: Uarts

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AY-5-1013 UART TR 1602	£4.00
AY-5-1013A	£4.70
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AY-3-1015	£5.60

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(Descriptive leaflet available on above. Ref SW4. 5)

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74LS00	14p	74LS30	22p	74LS83	£1.15	74LS132	95p	74LS165	75p	74LS242	£2.32	74LS293	£1.28	74LS378	£1.84		
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74LS02	16p	74LS33	39p	74LS86	43p	74LS138	85p	74LS170	£2.88	74LS244	£1.70	74LS298	£1.68	74LS384	86p		
74LS03	16p	74LS37	39p	74LS90	60p	74LS139	85p	74LS173	£1.05	74LS245	£3.50	74LS324	£2.40	74LS386	86p		
74LS04	16p	74LS38	39p	74LS91	£1.04	74LS145	£1.08	74LS174	£1.06	74LS247	£1.90	74LS325	£2.90	74LS390	£2.30		
74LS05	20p	74LS40	28p	74LS92	89p	74LS147	£1.70	74LS175	£1.10	74LS248	£1.90	74LS326	£2.94	74LS393	£2.30		
74LS08	22p	74LS42	98p	74LS93	89p	74LS148	£1.73	74LS181	£3.98	74LS249	£1.90	74LS327	£2.86	74LS395	£2.18		
74LS09	22p	74LS47	90p	74LS95	£1.16	74LS151	96p	74LS183	£2.98	74LS251	£1.34	74LS347	£1.48	74LS396	£2.15		
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74LS11	22p	74LS49	£1.20	74LS107	44p	74LS154	£1.70	74LS191	£1.40	74LS257	£1.10	74LS352	£2.28	74LS399	£2.30		
74LS12	23p	74LS51	24p	74LS109	55p	74LS155	96p	74LS192	£1.30	74LS258	£1.46	74LS353	£2.28	74LS445	£1.50		
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74LS14	75p	74LS55	30p	74LS113	50p	74LS157	76p	74LS194	£1.66	74LS261	£4.50	74LS366	65p	74LS490	£1.80		
74LS15	30p	74LS63	£1.50	74LS114	50p	74LS158	96p	74LS195	£1.36	74LS266	52p	74LS367	65p	74LS668	£1.82		
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307.2 KHz	£3.92
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1.280 MHz	£3.92
1.8432 MHz	£3.62
2.000 MHz	£3.62
2.097152 MHz	£3.23
2.4576 MHz	£3.62
2.500 MHz	£3.92
2.56250 MHz	£3.62
3.000 MHz	£3.62
3.2768 MHz	£3.23
3.579545 MHz	£1.95
3.93216 MHz	£3.92
4.000 MHz	£2.90
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4.096 MHz	£3.23
4.194304 MHz	£3.23
4.433619 MHz	£1.25
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4.9152 MHz	£3.23
5.000 MHz	£3.23
5.0688 MHz	£3.23
5.120 MHz	£3.23
5.185 MHz	£3.23
6.000 MHz	£3.23
6.144 MHz	£3.23
6.400 MHz	£3.23
6.55360 MHz	£3.23
7.000 MHz	£3.23
7.168 MHz	£3.23
7.680 MHz	£3.23
7.86432 MHz	£3.23
8.000 MHz	£3.23
8.388608 MHz	£3.23
8.867237 MHz	£3.23
9.375 MHz	£3.92
9.800 MHz	£3.92
10.000 MHz	£3.23
10.245 MHz	£3.23
10.700 MHz	£3.23
10.92 MHz	£3.92
11.000 MHz	£3.92
12.000 MHz	£3.92
14.0 MHz	£3.92
14.31818 MHz	£3.23
16.000 MHz	£3.92
18.000 MHz	£3.23
18.432 MHz	£3.23
20.000 MHz	£3.62
20.1134 MHz	£3.23
27.0 MHz	£3.92
27.648 MHz	£3.92
38.6666 MHz	£3.23
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116.000 MHz	£3.23

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2½″×17″	£1.86
3¾″×3¾″	62p
3¾″×5″	69p
3¾″×17″	£2.40
4.7″×17.9″	£3.14

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DIL SOCKETS
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DATA

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113 page Electronic Projects Index 72-77 (North Tyneside Libraries)	£1.50
c650 page COSMOS Databook (RCA)	£4.95
c31 page 'A Guide to SC/MP Programming' by Dr. Drury (Kemitron)	£3.75
c20 page 'A Guide to Kitbug' (Kemitron)	75p
c24 page NIBL Reference Guide (National)	£3.45
Data for 4116 (Mostek)	50p
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c100 page CDP 1802 MPU User Manual (RCA)	£4.50
c45 page Fixed Point Binary Arithmetic Routines for COSMAC	£4.50
c31 page Floating Point Arithmetic Routines for COSMAC (listings excluded)	£4.50
c43 page COSMAC MPU Product Guide (RCA)	75p
c15 page CDP 1802 Instruction Summary	25p
c70 page Understanding CMOS (RCA)	£1.50
1 page COSMOS Pocket Selection Guide (RCA)	25p
c21 page COSMOS Digital Integrated Circuits (RCA)	75p

Z80 DATA PACK £14.95
This contains all the data we can obtain on the Z80 CPU and related chips, and the Z80 Programming Manual. Depending on our own supplier, the data is either loose sheets, photocopies or bound volumes, or a combination of both. The weight of the set of data is about 1½ kilos, and some information on other processors, memories, and systems is often included.

c50-page Finite State Fantasies (Cartoons putting programming on human level) (Matrix Press)	£2.00
c175 page Home Computers: Beginners Glossary and Guide by Miller and Sippl (Dilithium)	£4.95

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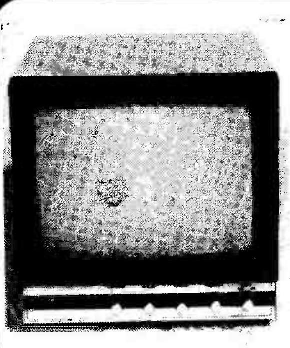

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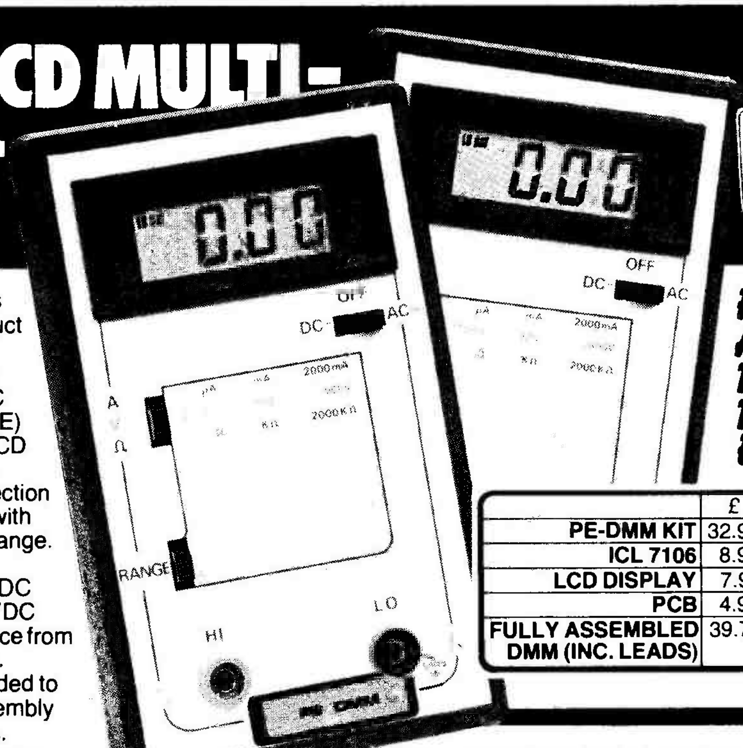

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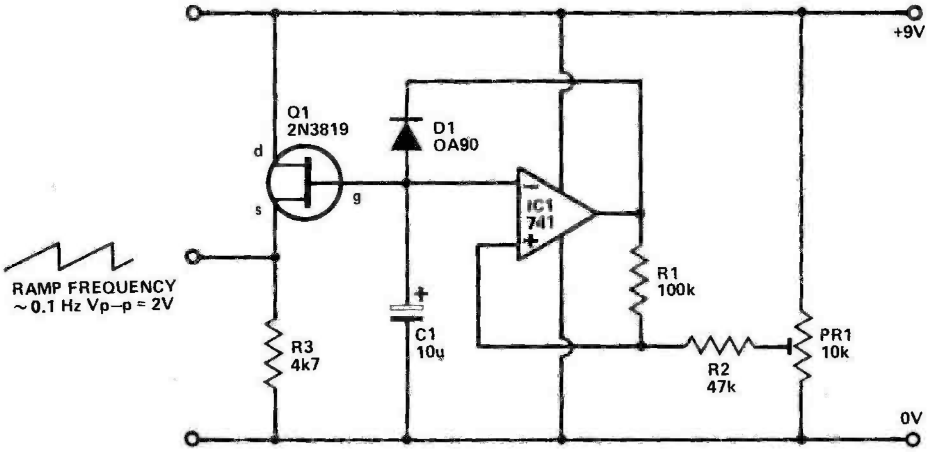
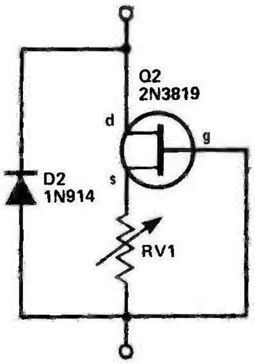




VLF Ramp Generator

C. Malloy, Whitby.

It is always satisfying to exploit the otherwise unwanted property of a device — the reverse bias current of a leaky germanium diode, in this circuit. This reverse saturation current is typically a few microamps for the OA90 and is relatively constant over 2-10 V. This constant current is used to linearly charge the capacitor in the relaxation oscillator built around the 741.

When the diode becomes forward biased the capacitor is rapidly discharged by the limited output current of the op-amp. Frequencies below 0.01 Hz are possible, though measures may have to be taken to improve the linearity of the ramp.

PR1 allows some degree of DC offset of the ramp and the source follower (Q1) reduces the loading on the capacitor which tends to degrade the ramp's linearity. For the same reason tantalum (ie low leakage) types should be used for large values of C3. Linearity can be further improved by the use of a FET input op-amp such as the 3140.

The frequency can be made variable by using the FET constant current generator shown in Fig. 2, which should replace the diode, D1. With RV1 at 100k the current will be about 30 uA and roughly inversely proportional to RV1. This constant current generator needs a voltage of about 3 V to function well. This may require an increased power supply. However, the resulting linearity is excellent, especially with the suggested FET input op-amp.

Car Radio Suppressor

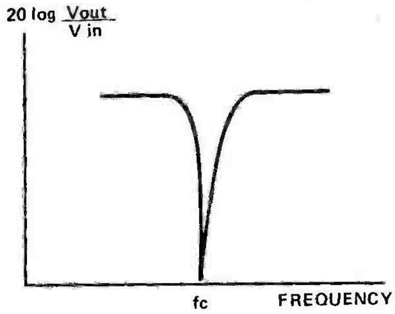
L. Marks, Lancs.

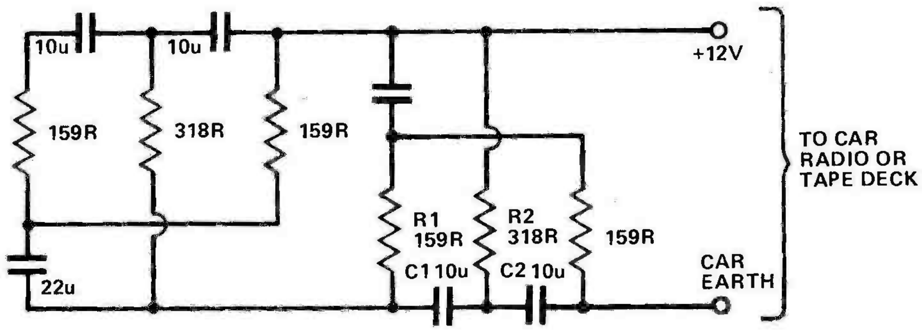
This circuit will suppress mains-borne interference every time the car drives over a buried power line. It may also be used for suppressing ignition HT by a modification to the following equation:

$$f_c = \frac{1}{2\pi \; R1 \; C1}$$

where $R1 = \frac{1}{2}R2$, $C1 = \frac{1}{2}C2$.

The circuit works as a band reject notch filter.





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

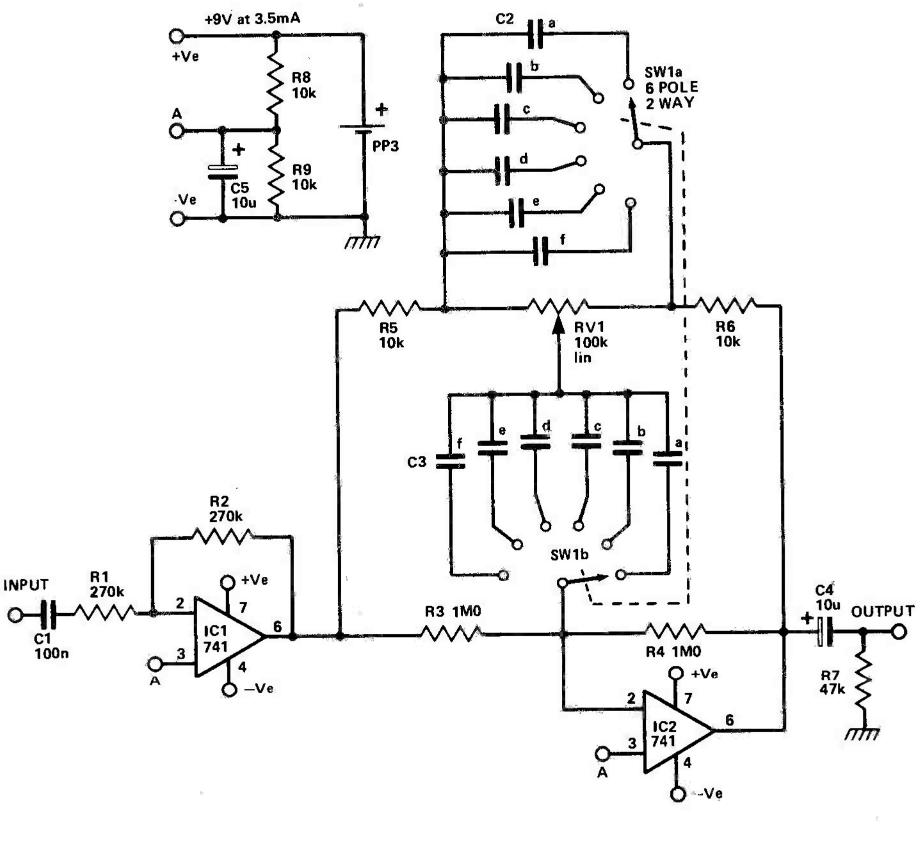
C.E. Read, Norwich

The parametric equaliser offers six bands of tone control separated by an octave in frequency, each frequency band being selected by the six position rotary switch.

Potentiometer RV1 permits the selected frequency band to be boosted or cut by 12 dB. The filter is particularly ideal for use with a guitar to modify and enhance the tonal qualities of the instrument.

For example, the 500 Hz setting with cut gives a hollow funky sound, whilst the 500 Hz setting with boost gives an overdriven valve amplifier, the raunchy sound favoured by many rock guitarists, but without the unpleasant muddy, harsh should resulting from boosting the entire audio frequency spectrum.

	FREQ (Hz)	C2 (pF)	C3 (pF)
a	125	47000	4700
b	250	22000	2200
c	500	12000	1200
d	1k	5600	560
e	2k	2700	270
f	4k	1500	150



PCBs From Film

I. Parker, Bath.

There is no doubt that the most professional method to produce printed circuit artwork is by the photographic method. Unfortunately this involves the use of expensive cameras and complex enlarging systems.

However, the amateur can use this simple cheap method that produces equally good results.

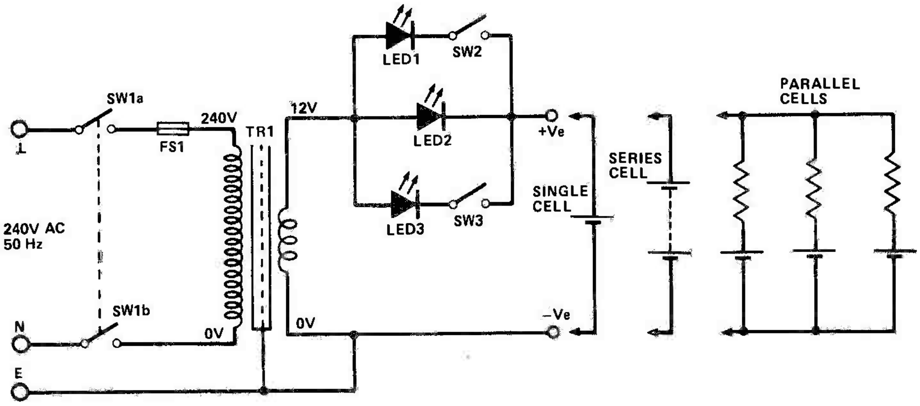
Take the printed circuit artwork (from the back of ETI) to a commercial printers and ask them to make an overhead transparency copy of it. This looks like an ordinary photocopy but instead of being printed onto paper the image appears on transparent film. Lay this on top of a piece of presensitised PCB (obtainable from most electronic retailers), use bulldog clips or adhesive tape to make sure of good contact. Then expose to sunlight for about half an hour, spray the board with the developer (following instructions carefully) and then etch the board in a normal solution of Ferric Chloride.

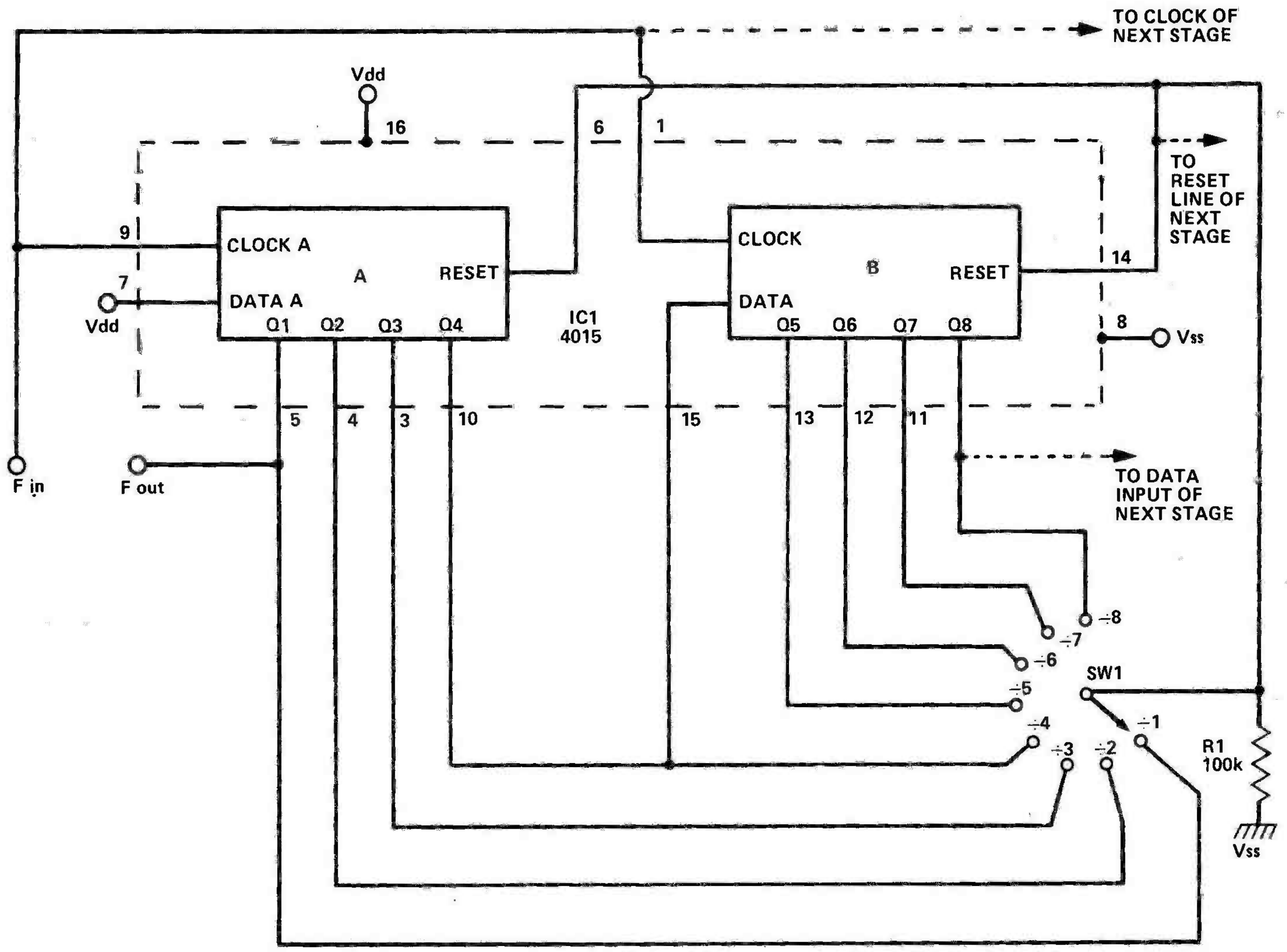
Ni-Cad Charger

J. Grainger, Rugby

This circuit makes use of the new constant current LEDs which are now available for about 50p (Radio spares). These devices pass a constant current of about 15 mA for applied voltages in the range 2-18 V and will also block up to 18 V peak in the reverse direction. Furthermore, they may be parallelled directly to give any multiple of 15 mA and, of course, they light up to give an indication that they are working.

The circuit shown will charge a single cell at 15, 30 or 45 mA, or cells in series up to the supply voltage limit (about 14 V). If it is desired to charge cells at less than 15 mA, several cells may be parallelled using suitable sharing resistors, which should drop about 10 V at the *cell* current. The LEDs will be damaged if the *peak* voltage of the supply exceeds 18 V (13 V RMS).





Burglar Alarm

P.N. Durrant, Chester.

The original circuit was developed as a car burglar alarm, but it could be used as a digital combination lock or, with slight modifications — removing counter 2 — a home burglar alarm.

A suitable 4 or 5 digit code is selected and, via a BCD switch wired to the appropriate latches of the 74118. Unused numbers commoned to the reset latch. Switch common is earthed through a push-button. Each is selected and entered by pressing the "enter" button. An incorrect number resets the latch. If the code is right then the unit is all reset and the relay is pulled in. The alarm is now disarmed.

If the code latch is reset a "0" appears at point A, counter 1 starts to count until it reaches eight, which sets the first RS latch, arming the detector latch.

A digital "0" from the detector switches resets the latch and starts counter 2, which allows a set time to elapse before RLA drops out and the alarm sounds.

Since originally designed for cars without external reset, the final delay was included to allow the owner to enter and reset before the alarm was activated. Therefore the oscillator is set to the fastest time the code can be set.

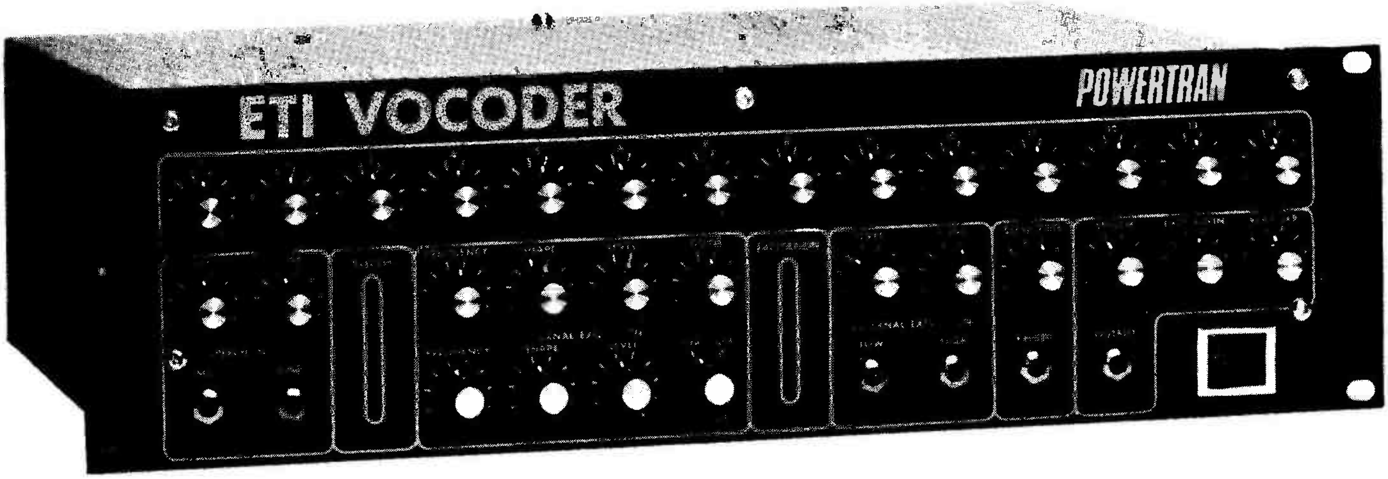
To arm the unit a noncode number is set in. This leaves enough time to leave the car before the unit is armed. I used an illuminated push-button and connected it to show when the counter had reached its reset point. This also has the advantage of showing the thief that your system is all go.

The power supply must be quite heavily smoothed as the unit was found to be quite sensitive to the noise found in car electrics. The coding switch was a thumbwheel type, since it fitted the holes already in the vehicle it was designed to be used in. A touch type keyboard could be substituted, but an enter button must also be fitted.

The whole unit can be built using CMOS, especially if it is required to run from a separate supply from the main battery. The relay is a reed type holding in a larger multicontact relay with its many enabling and disabling uses in a car. it will also operate many anti-theft devices in the home. A slow code input and 5 S clock acts as a reaction timer, which could be embarrassing after a "liquid lunch".

VOCODER

Change sex or orchestrate yourself (same thing, really) with the ETI Vocoder, designed by Richard Becker of Powertran.



A vocoder could be simply defined as a device which will, in real time, superimpose the spectral characteristics of one signal upon another. To leave it at that, however, would result in many a yawn and a few skipped pages. In fact vocoders are anything but boring! Put speech and the output of an instrument into a vocoder and the instrument, not the operator, appears to be doing the talking or singing! Use the internal excitation oscillators, change the frequency and the speaker suddenly changes sex. Use the noise generator and there is whispering in the breeze. Use the output of a cassette deck and the London Symphony Orchestra recites the Karma Sutra! Just a few of the possibilities!

Human speech is built up from two basic components — the sound from the vocal chords which buzz when air is passed over them and the sound of air rushing past the teeth. These sounds are used to produce voiced and unvoiced speech respectively. By opening and closing the mouth and the nasal cavity, and by moving the tongue, thereby adjusting the resonances, the basic sounds are modified in amplitude and harmonic content. If the variations in amplitude and harmonic content can be analysed and applied to suitable electronic control circuitry then the basic sounds of speech can be substituted for by almost anything and this is just what a vocoder does.

The first part of a vocoder is a spectrum analyser producing control signals which are a measure of the strength of the speech signal in each of the frequency bands (14 in this design). The substitution (excitation) signal is also split into a number of frequency bands (using identical filters to those used for analysis) and each of these signals is passed through a voltage controlled amplifier whose gain is determined by the control signals. The sum of the outputs of these amplifiers is the vocoder output.

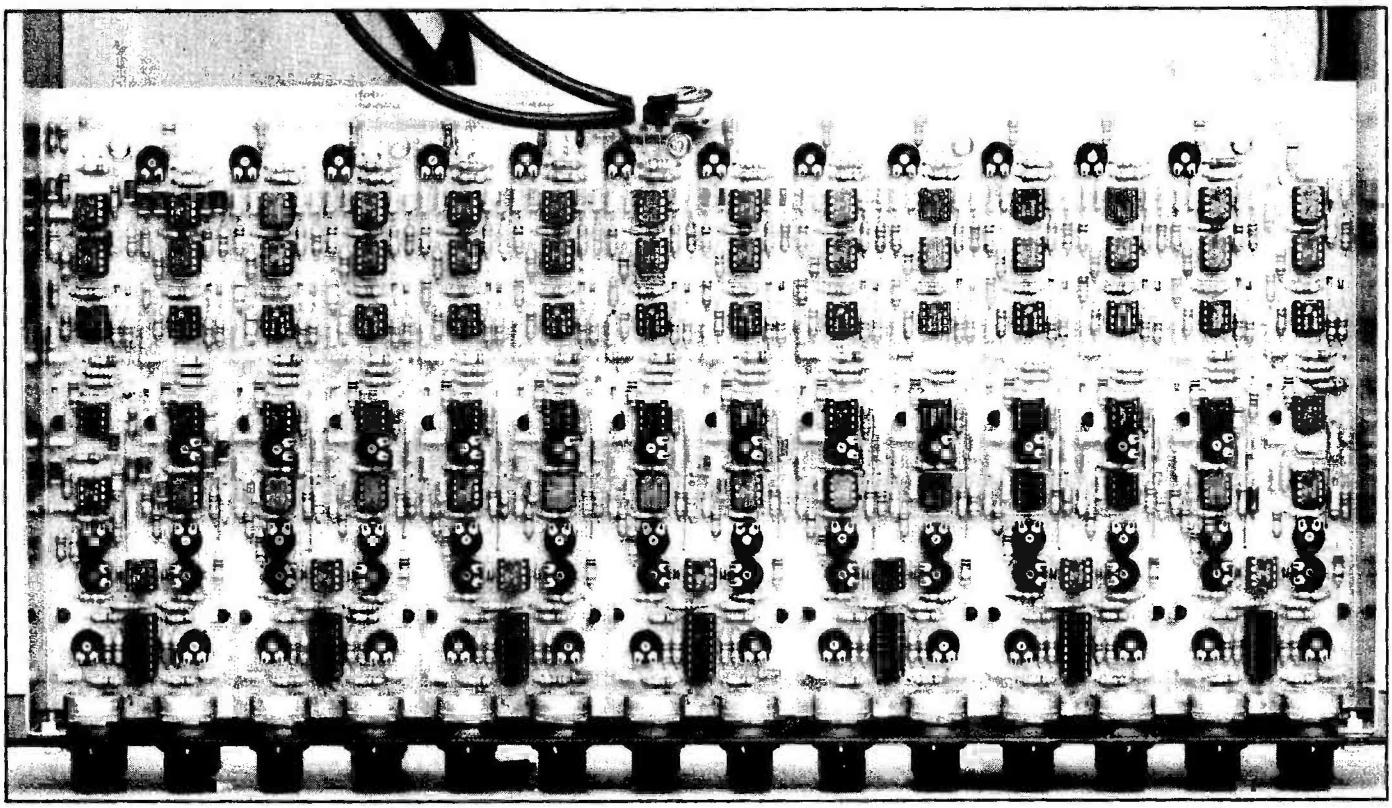
The system

The speech signal, after passing through the preamplifier and tone control stages, is separated into 14 bands by bandpass filters, a low pass filter and a high pass filter. The bandpass filters are double tuned that is to say each of the two stages has a slightly different resonant frequency. The effect of this is to broaden the band of accepted frequencies and give the response curve a flattened top. A high Q makes the filters cut off rapidly out of the pass bands.

The envelope followers consist of an active full wave rectifier and a low pass filter, the output of which is the control signal for the synthesiser section. The control signal passes through a sample and hold stage which is used to freeze the music, by means of a footswitch, at any required point of articulation. The stage is also used for slewing rate control which smooths out the control signals for slower and smoother changes in spectral balance and amplitude resulting in speech being changed into singing or chanting.

Holy Responses

In the synthesis section there is a filter bank identical to that of the analysis section. Voltage controlled amplifiers modulate the outputs of these with the control signals from the analysis section. The outputs are then summed to produce the output signal. Alternate channel outputs are inverted since there is a change in phase as a signal is swept through the resonant frequency of the filter. Therefore, at the midpoint between adjacent bands phase cancellation will occur producing deep holes in the overall frequency response. By having adjacent channels outputs inverted with respect to each other there is addition instead of subtraction at the midpoints.



The analysis/synthesis board occupies the front half of the case. All the potentiometers are PCB mounting for ease of construction. The Power Supply Unit (to be described next month) is a respectable distance away, mounted on the rear panel.

SPECIFICATION

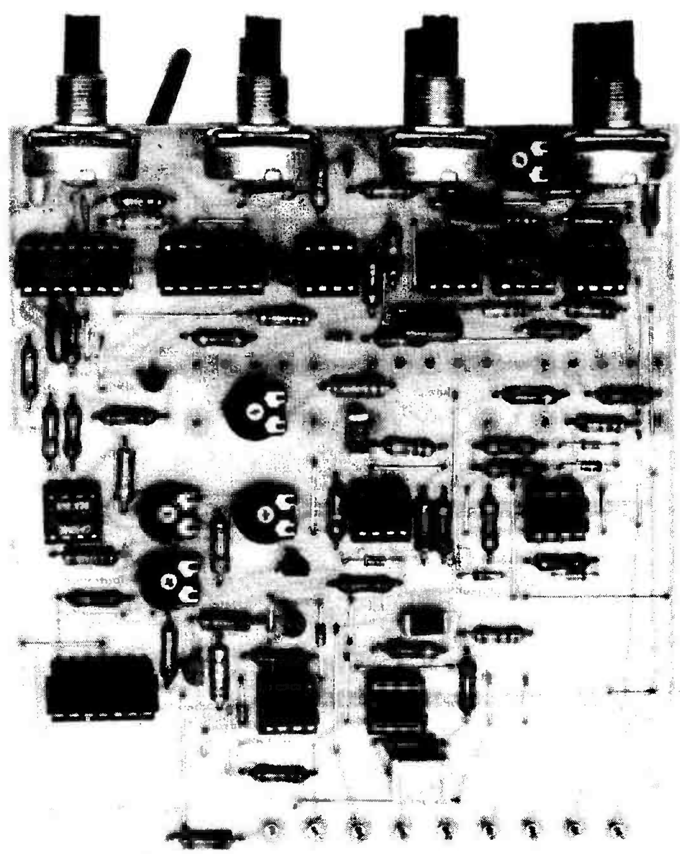
14 channel: Filters — 4th order with bandpass filters at ⅓ octave spacing.
LED Bar Display PPMs for both speech and excitation.
Speech input: amplifier:
mic input: sensitivity 1 mV
mic input: impedance 100k
line input: sensitivity 500 mV
line input: impedance 10k
tone control: ± 6 dB Treble boost — Bass cut/Bass Boost - Treble cut.
excitation input amplifier:
low input: sensitivity 10 mV
low input: impedance 100k
high input: sensitivity 500 mV
high input: impedance 10k
tone control: ± 6 dB Treble boost-Bass cut/Bass boost-Treble cut

Internal excitation:
pseudo-random counter noise generator
2 oscillators — range: 15 Hz-250 Hz
pulse width: fully variable

Slew rate control: 100:1 range. FREEZE by footswitch

Voice/unvoiced detector:
AGC on noise generator to follow excitation signal

Output amplifier:
mixing controls for vocoder, speech bypass and external excitation bypass
Output level: 1V



The internal excitation board.

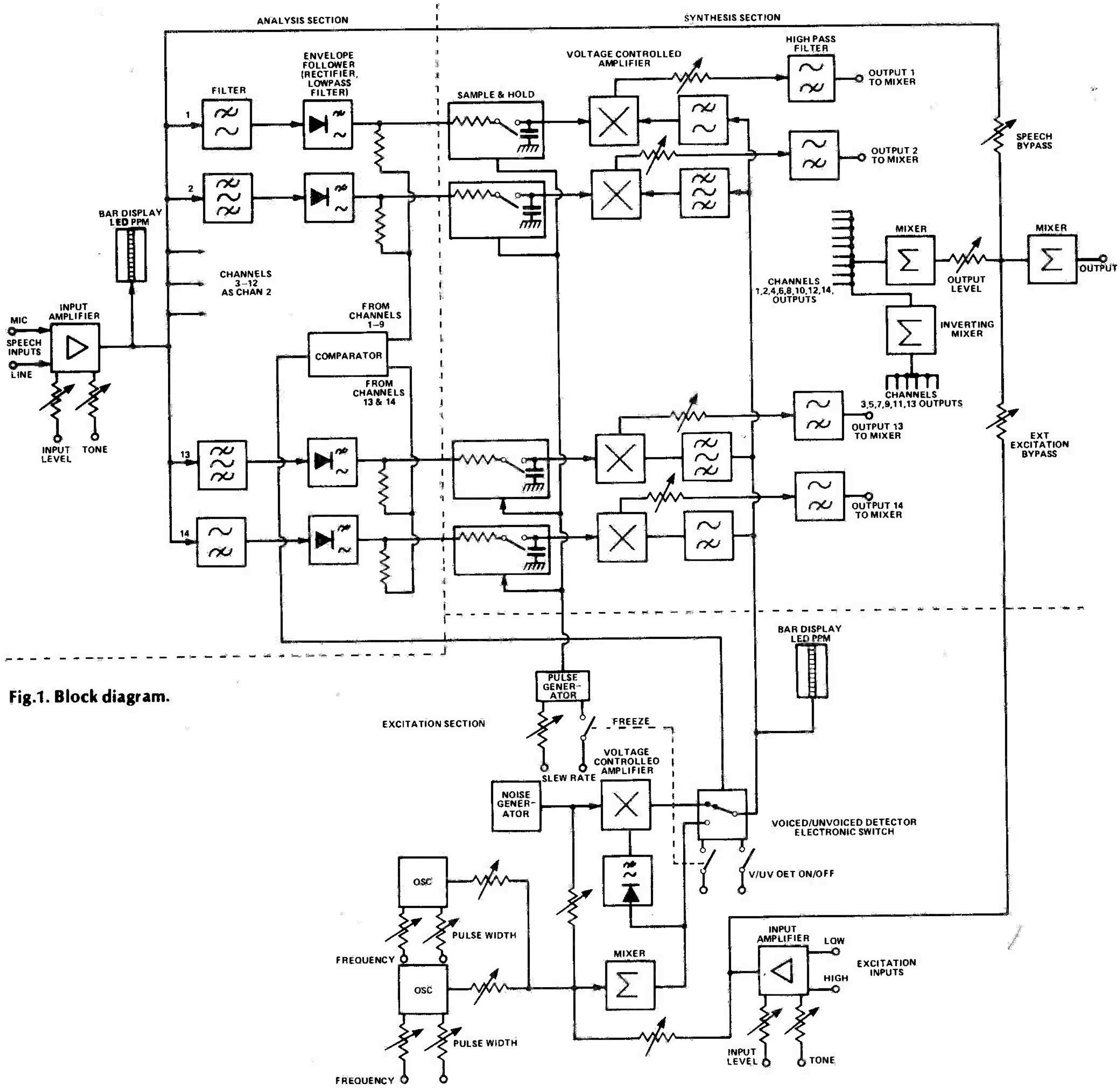
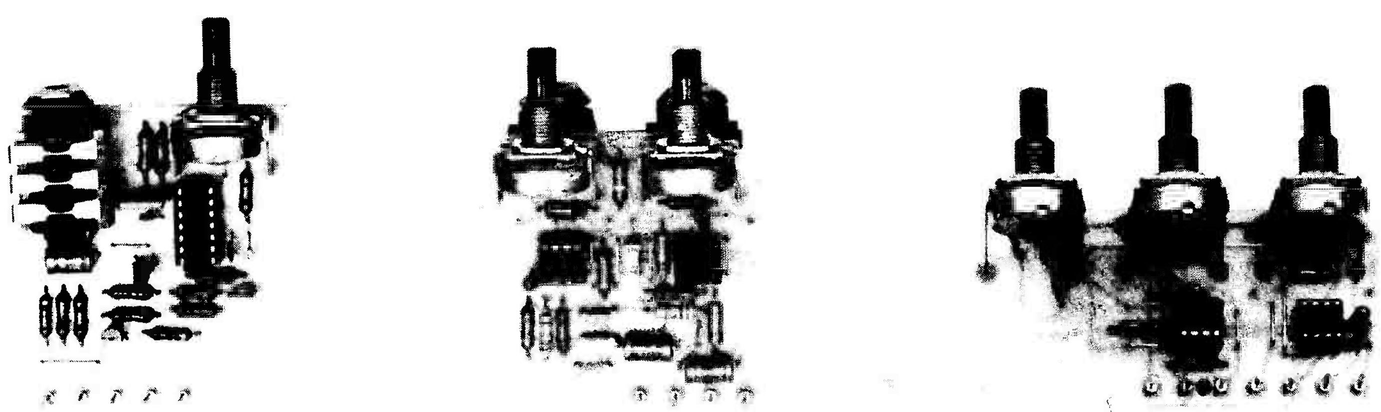
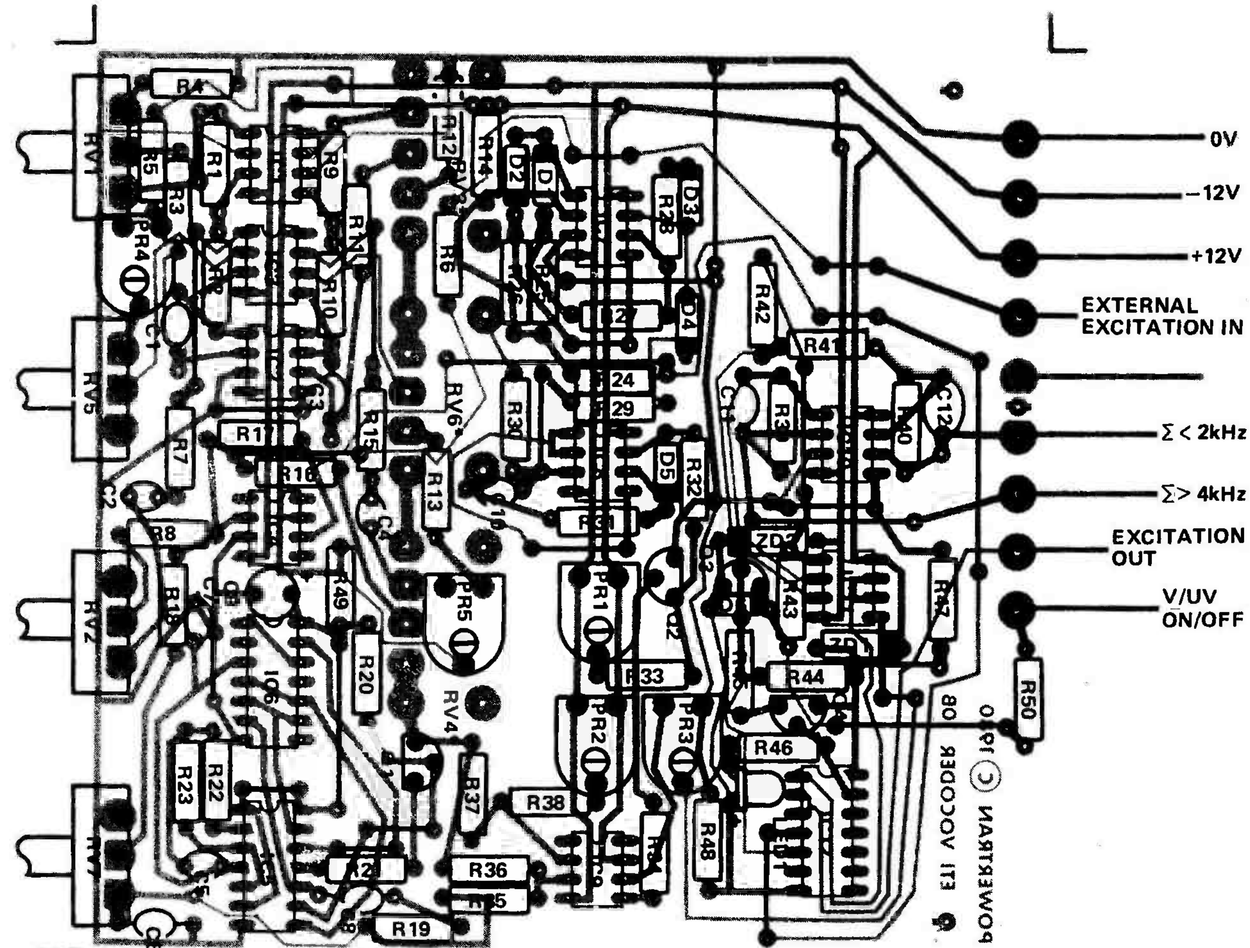


Fig.1. Block diagram.



Details of the smaller boards devoted to slew rate control (left), input amplifier (middle) and output amplifier (right) will be given in the concluding part of the Vocoder project next month.



NOTE:
*RV3, 4 & 6 ARE ON THE UNDERSIDE OF THE BOARD

Fig.2. Component overlay of the internal excitation board.

PARTS LIST

RESISTORS — ALL 2% METAL OXIDE

R1,9,29,34,40,44,45,50	10k
R2,10	5k6
R3,11	18k
R4,12	560R
R5,13	11k
R6,8,16,18,35,39,43	47k
R7,15	150k
R14,30,42	1M
R17	100k
R19	15k
R20,24,25,26,27,28	4k7
R21,32	22k
R22	330k
R23	27k
R31	3k9
R33,38	470k
R36,37,46	1k5
R41,47,48	1k
R49	3k3

POTENTIOMETERS

RV1,2,5,7	10k logarithmic
RV3,4,6	10k logarithmic
PR1,2	100k preset
PR3	220k preset
PR4,5	2k2 preset

CAPACITORS

C1,3	100n polyester
C2,4	10n ceramic
C5	220p ceramic
C6	33n polyester
C7	100p ceramic
C8	10n polyester
C9	10u 16V tantalum
C10	100n polycarbonate
C11	220n polycarbonate
C12	1u0 polycarbonate

SEMICONDUCTORS

IC1,2,7,10,11	1458
IC3,8	TL082 or LF353
IC4	741
IC5	4006
IC6	4030
IC9	CA3080
IC12	4016
Q1,3	BC182L
Q2,4	BC212L
ZD1,2	5V1 Zener
D1-D6	1N4148
LED 1	TIL209

MISCELLANEOUS

9 way connector and pins, IC sockets, terminal pins, rotary on/off switch.

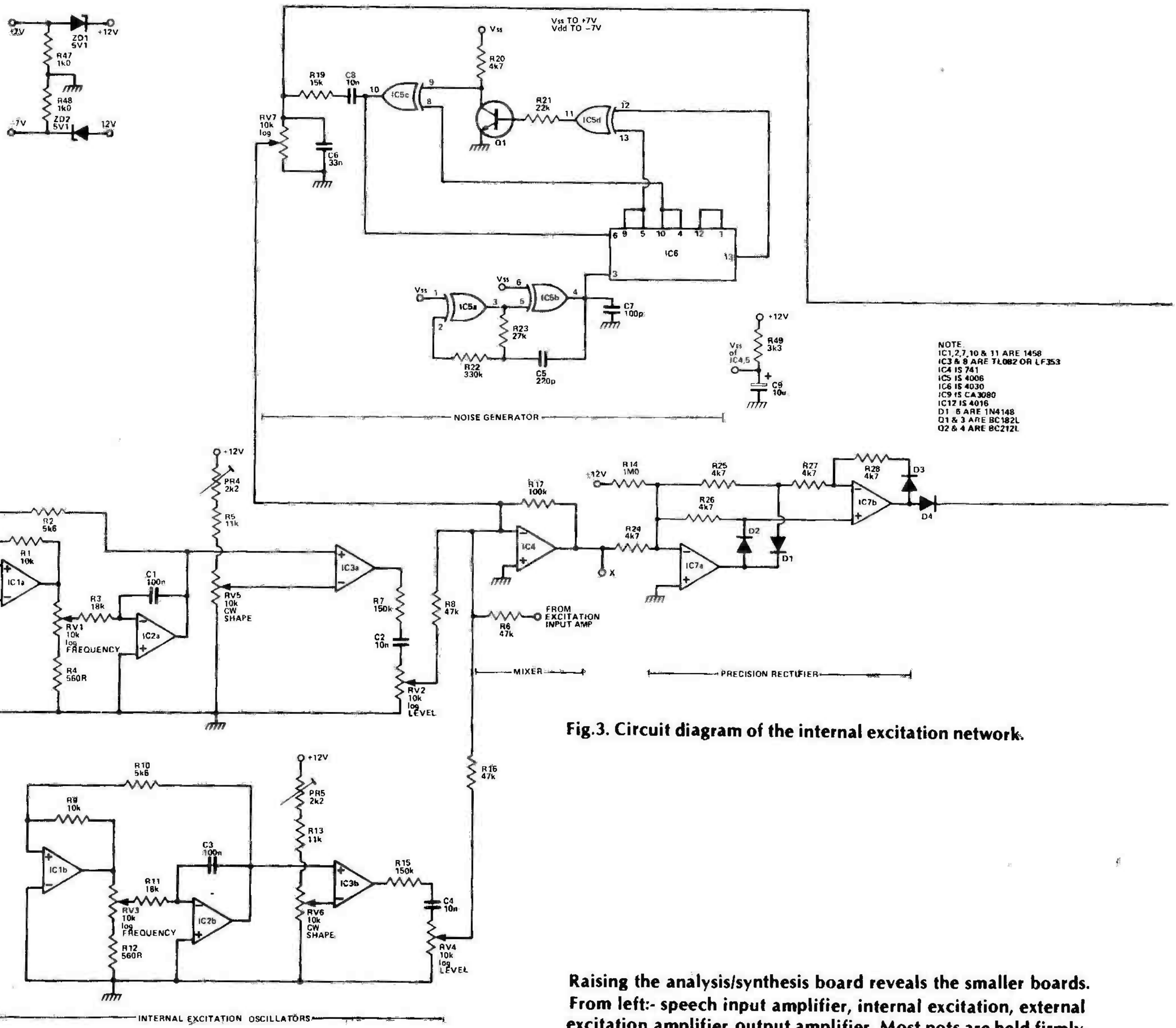
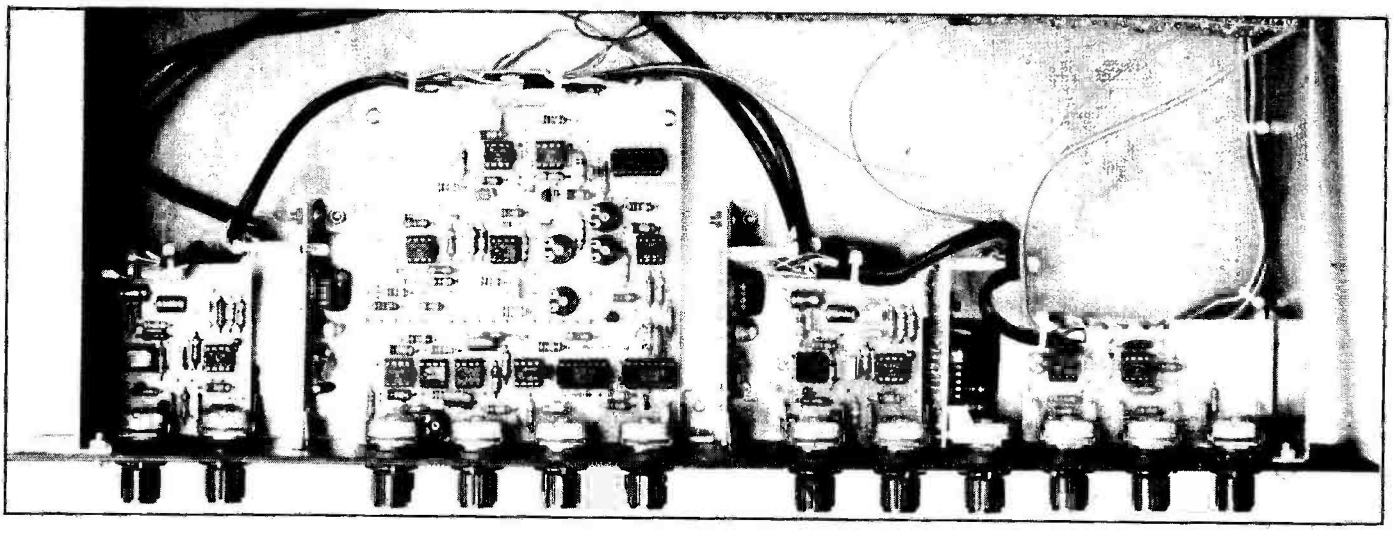
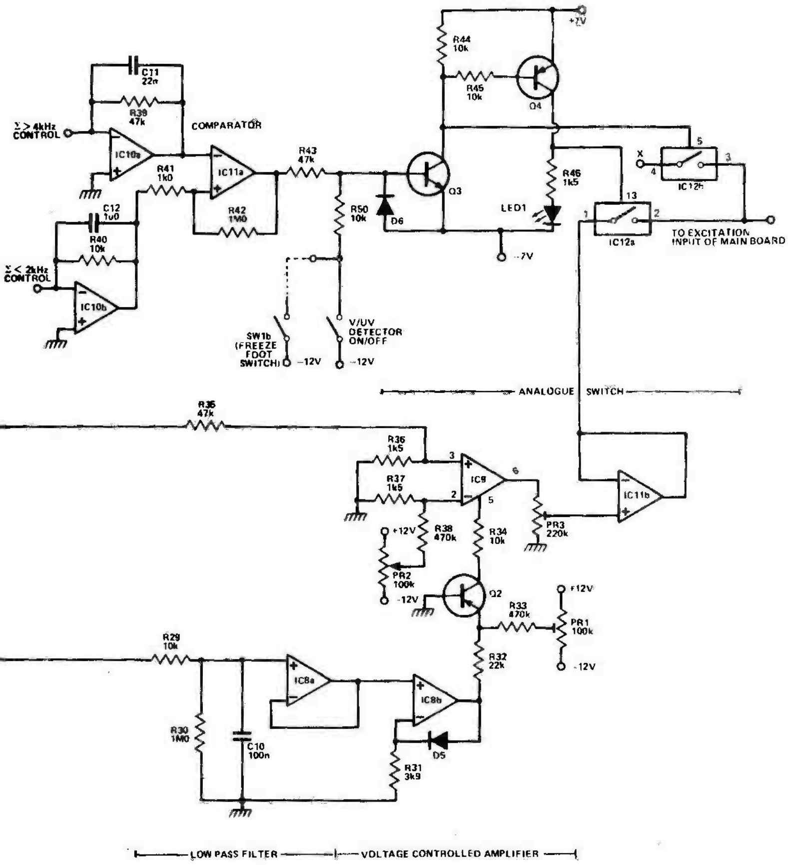


Fig.3. Circuit diagram of the internal excitation network.

Raising the analysis/synthesis board reveals the smaller boards. From left:- speech input amplifier, internal excitation, external excitation amplifier, output amplifier. Most pots are held firmly on their PCBs by pot mounting frames.





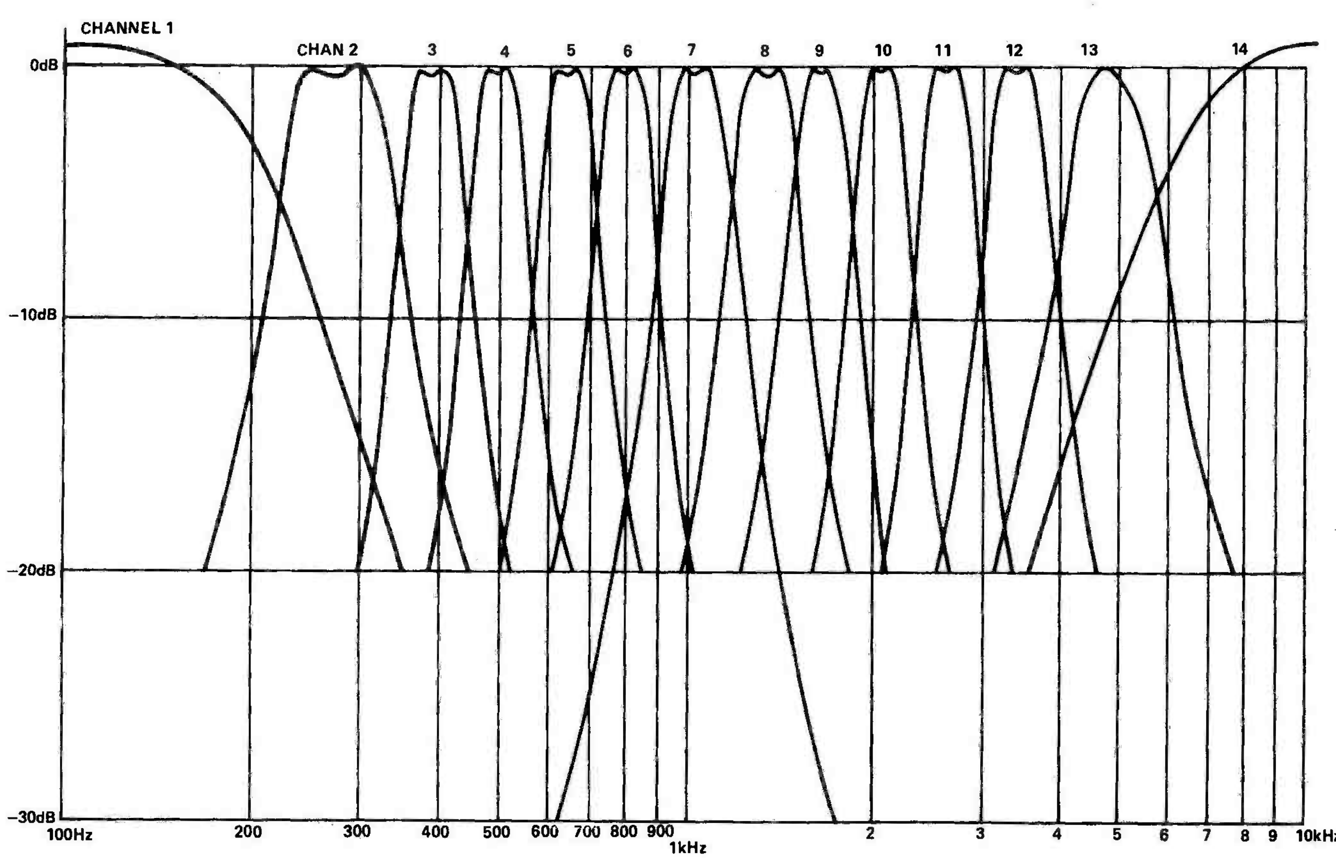
HOW IT WORKS

IC1, 2 form a pair of relaxation oscillators. IC2 is an integrator driven by the output of IC1. C1 is charged until it reaches about one third of the supply line voltage when the Schmidt trigger (IC1) changes state and C1 starts discharging until it reaches about one third of the supply line voltage in the opposite direction, making IC1 change state again. The output of IC2 is a triangular waveform which is compared with an adjustable DC voltage by IC3 to produce a pulse output of adjustable mark/space ratio. The outputs of the two oscillators are mixed with the external excitation and the noise by IC4.

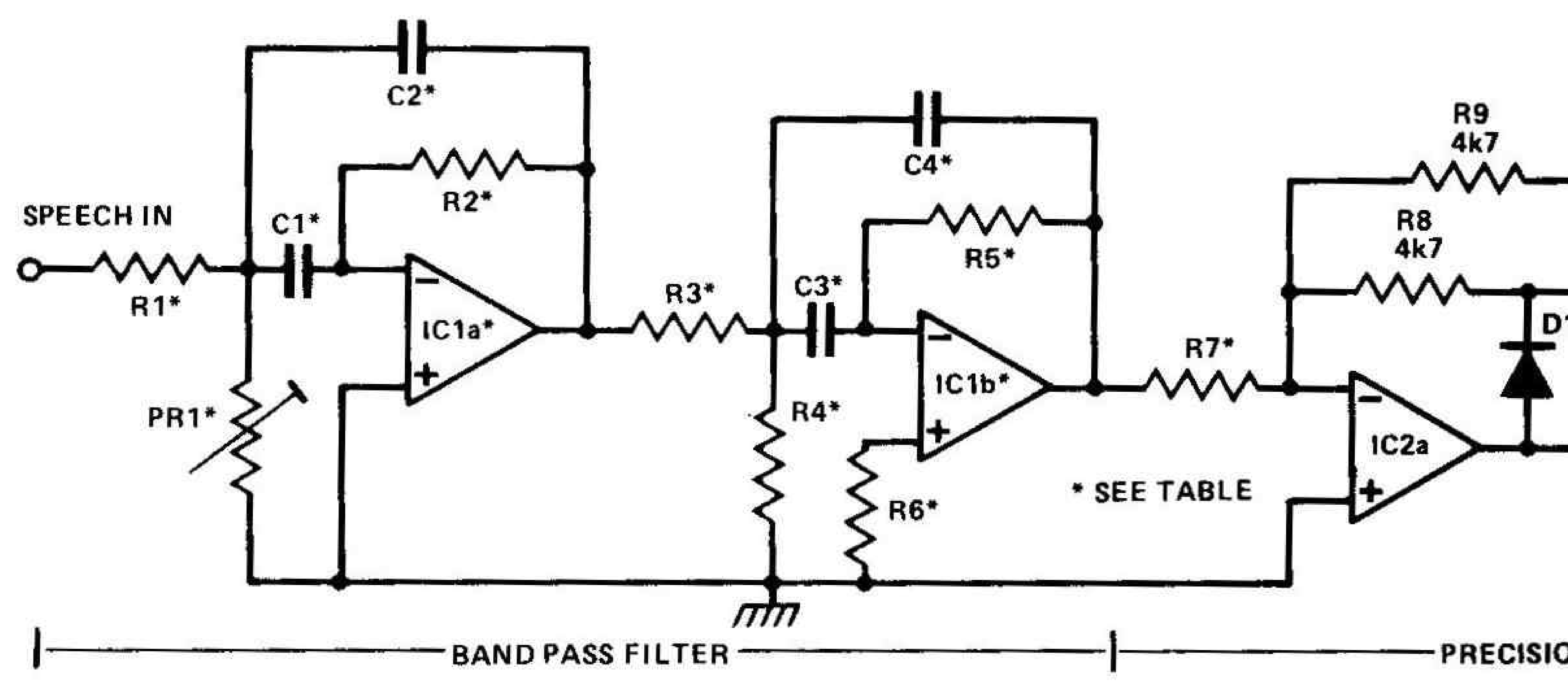
The noise generator is a pseudo-random counter. IC5a,b form an oscillator operator at about 40 kHz. This clocks IC6, which is an 18 stage shift register with feedback applied round it via IC5c, d and Q1. The output of IC5c is a complex pulse train, which, when filtered by C8, R19, C6 has the characteristics of random noise with a very even frequency response.

The key part of the voiced/unvoiced detector is the comparator IC11a, which compares the levels of the speech components over 4 kHz with those below 2 kHz. It is not necessary to use separate filters for this purpose as the control signals at the outputs of IC3 of the analysis section contain the necessary information and these are summed by IC10a, b before comparison. When voiced speech is present IC11a goes low, Q3 turns off, its collector goes high and the analogue switch IC12b is opened allowing the output of IC4 to pass to the synthesis section. To match the noise level to that of the excitation from IC4 there is AGC. IC7a is a full wave rectifier peak detector which is buffered by IC8a. IC8b and Q2 are a voltage to current converter to provide a control current for the OTA IC9 through which the noise is passed.

Fig.4.(below) Filter frequency response curves.



For external excitation, there is a pre-amplifier and tone control circuit similar to that used for speech. The output of this stage is mixed with the two oscillators (which generate pulses of variable width and frequency) and also with the output of the noise generator. The noise also passes through an AGC circuit to match its level to the excitation signals. This noise is then used to substitute for the other excitation signals by the voiced/unvoiced detector electronic switch when unvoiced speech is detected by the comparator which determines whether the majority of the energy in the speech is at low frequencies (2 kHz — voiced) or at high frequencies (4 kHz — unvoiced).



BUYLINES

Powertran Electronics, Portway Industrial Estate, Andover, Hampshire, are supplying a complete kit of parts for this project at £195.00 plus 15% VAT. Delivery by Securicor is £2.50 extra. Everything is included in the kit down to the last nut and bolt. They even give you a 'Freeze' footswitch and a test oscillator for setting it up!

Next month we conclude the Vocoder project with constructional details of the remaining boards and power supply, with notes on setting up and use.

HOW IT WORKS

IC1 in channels 2-13 is the analysis bandpass active filter. PR1 adjusts the first section in relation to the second. When correctly set up there is an overall voltage gain of 10. In channels 1, 14 IC1 is a low pass filter and a high pass filter respectively. IC2 rectifies the signal to demodulate it to convert it into a control signal for the VCA. IC3 is an active low pass filter with a cut off frequency of 200 Hz or one fifth of the frequency of the bandpass filter, whichever is the higher.

R14 takes the output of IC3 out for analysis by the voiced/unvoiced detector. IC4 is the slewing rate controller, Q1 and R15 acting as a variable resistor which, in conjunction with C7, forms an RC network adjustihe slewing rate controller, Q1 and R15 acting as a variable resistor, which, in conjunction with C7, forms an RC network adjusting the slewing rate of the stage. Being a FET Q1 could, on its own, be used as a variable resistor by simply varying the V_{GS}, but there are 14 of them to control simultaneously and without careful selection they would not track together. To deal with this Q1 is used instead as a switch which is turned on and off by a 1 kHz pulse signal of variable width. C7 is then charged and discharged at a rate dependent on the duty cycle of the pulse signal and R15. During the ON period V_{GS} is maintained at O by the feedback via R17.

IC5 and Q2 form a voltage to current converter, the gain of which is set by PR2 to compensate for variations in gain in IC6. For correct operation IC5's input must never go negative. To ensure that it doesn't, a bias voltage is applied via R15. This voltage together with the combined offset voltages of IC1-5 is nulled out by PR3.

IC6 is an OTA (operational transconductance amplifier), which could have been our old friend the CA3080, but a better device, the LM13600 is now available. It achieves very low distortion by having linearising diodes at the input. Bias current for these is supplied by R28. The gain is controlled by the current supplied to pin 1. The output of the OTA is taken to a volume control RV1 from where it goes back into IC6 to a buffer stage before being taken out via C12 and R30 to a virtual earth mixer. C12 and R30 serve as a high pass filter to remove breakthrough of the control signal. The excitation or music signal is applied to the OTA via IC7 which is a filter identical to that of IC1.

CHAN	PR1,5	R1,21	R2,22	R3,23	R4,24	R5,25	R6,26	R7	R12,13	C1,3,8,10	C2,4,9,11	C12	IC1,7
1	–	10k	10k	2k0	220R	10k	10k	4k7	68k	47n	150n	220n	TL082/LF353
2	2k2	2k0	82k	24k	910R	110k	110k	4k7	47k	68n	68n	47n	1458
3	1k0	6k2	180k	47k	560R	220k	220k	4k7	30k	39n	39n	33n	1458
4	1k0	6k2	180k	47k	430R	220k	220k	4k7	24k	33n	33n	27n	1458
5	1k0	6k2	180k	47k	430R	220k	220k	3k6	18k	27n	27n	22n	1458
6	1k0	6k2	180k	47k	430R	220k	220k	3k0	15k	22n	22n	18n	1458
7	1k0	6k2	180k	47k	560R	220k	220k	2k4	12k	15n	15n	15n	1458
8	1k0	6k2	180k	47k	560R	220k	220k	1k8	12k	12n	12n	12n	1458
9	1k0	6k2	180k	47k	510R	220k	220k	1k5	12k	10n	10n	10n	1458
10	1k0	6k2	180k	47k	470R	220k	WIRELINK	1k2	12k	8n2	8n2	8n2	TL082/LF353
11	1k0	6k2	180k	47k	430R	220k	WIRELINK	1k2	12k	6n8	6n8	6n8	TL082/LF353
12	1k0	6k2	180k	47k	560R	220k	WIRELINK	1k2	12k	4n7	4n7	4n7	TL082/LF353
13	2k2	2k0	82k	24k	1k1	110k	110k	1k2	12k	3n3	3n3	4n7	1458
14	--	13k	43k	2k0	220R	43k	13k	1k2	12k	1n0	1n0	4n7	1458

Table 1. Component values for the 14 channels of the analysis/synthesis section.

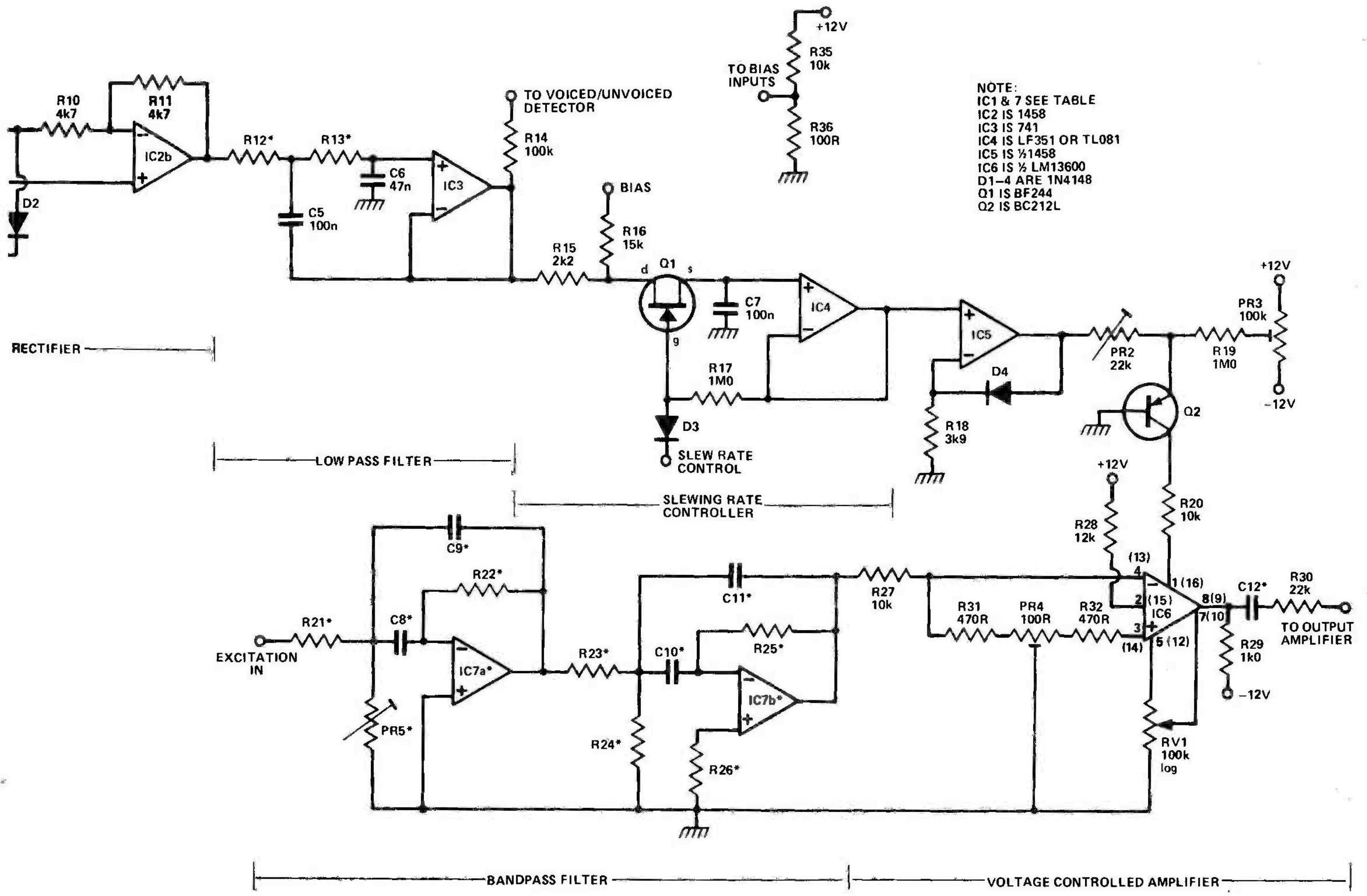


Fig.5a(above). Circuit diagram of analysis/synthesis section.

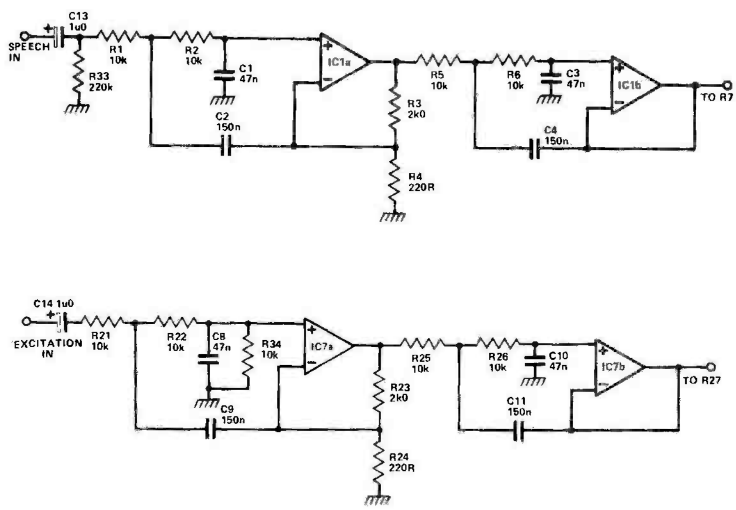


Fig.5b. In channel 1 band pass filters are replaced by the low pass filters shown above.

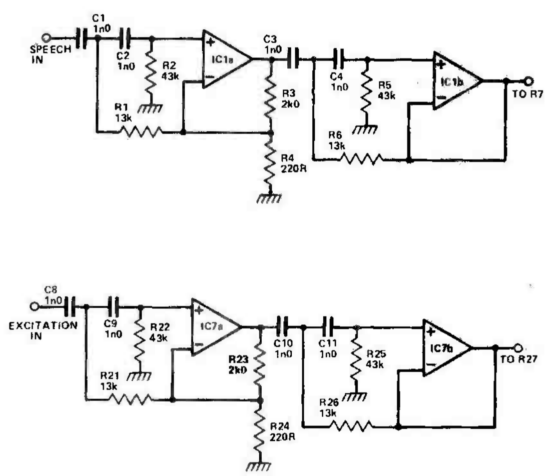


Fig.5c. In channel 14 band pass filters are replaced by the high pass filters above.

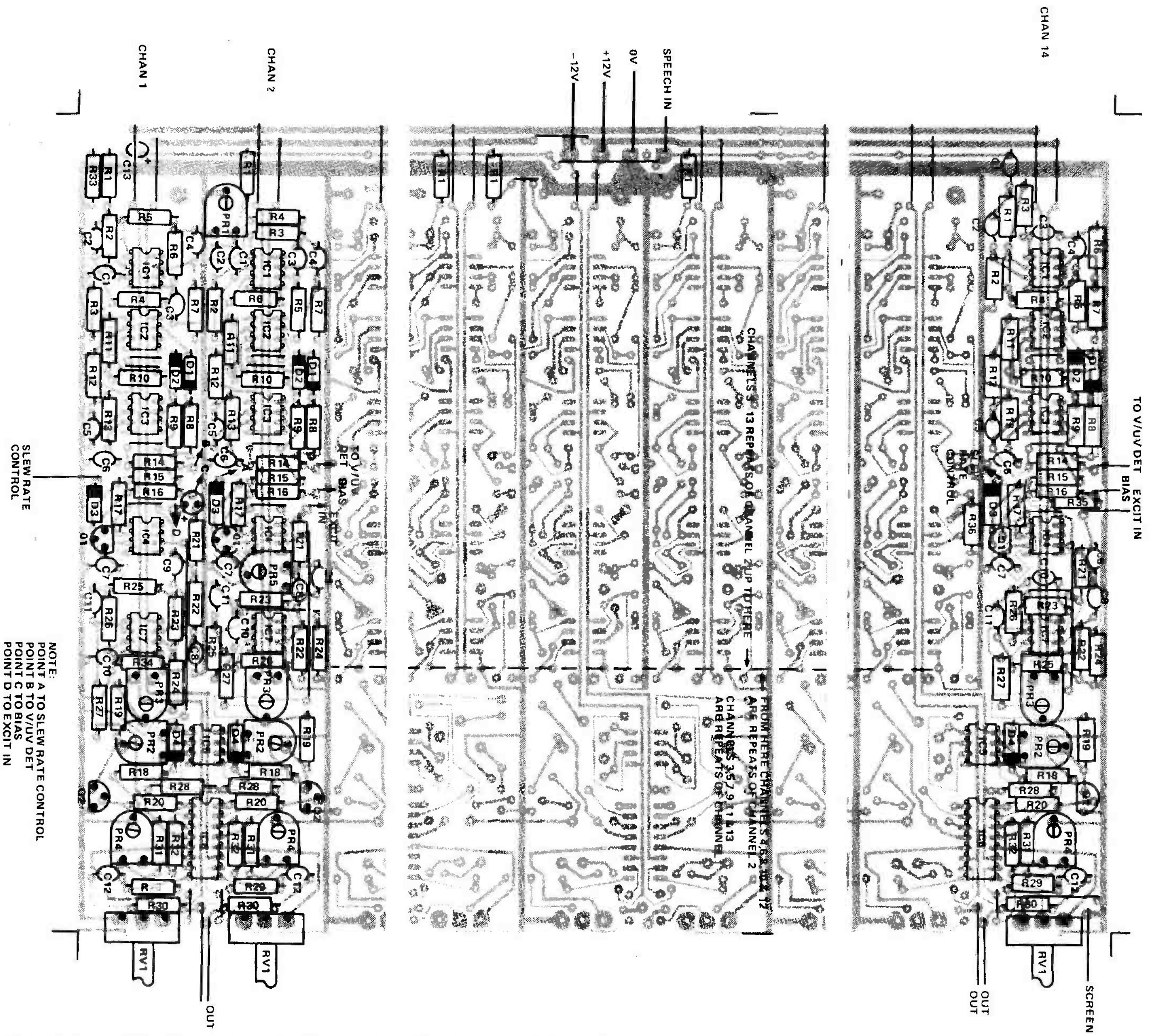


Fig.6. Component overlay of the analysis/synthesis section. We haven't shown the whole board, as the channels are very similar. The three parts of the board (above) show channels 1, 2 and 14 and the power connections in the middle.

PARTS LIST

PARTS COMMON TO ALL CHANNELS

RESISTORS ALL 2% METAL OXIDE

R1-7, 21-26	see Table 1
R8,9,10,11	4k7
R12,13	see Table 1
R14	100k
R15	2k2
R16	15k
R17,19	1M
R18	3k9
R20,27	10k
R28	12k
R29	1k
R30	22k
R31,32	470R

POTENTIOMETERS

RV1	100k logarthmic
PR1,5	see Table 1
PR2	22k preset
PR3	100k preset
PR4	100R preset

CAPACITORS

C1-4,8-12	see Table 1
C5,7	100n polycarbonate
C6	47n polycarbonate

SEMICONDUCTORS

IC1,7	see Table 1
IC2,5*	1458
IC3	741
IC4	TL081 or LF351
IC6*	LM13600
D1-4	1N4148
Q1	BF233C
Q2	BC212L

*only ½ of IC used in each channel

PARTS SPECIFIC TO CHANNEL 1

R33,34	220k
C13,14	1u0 tantalum

PARTS SPECIFIC TO CHANNEL 14

R35	10k

PARTS SPECIFIC TO CHANNEL 13

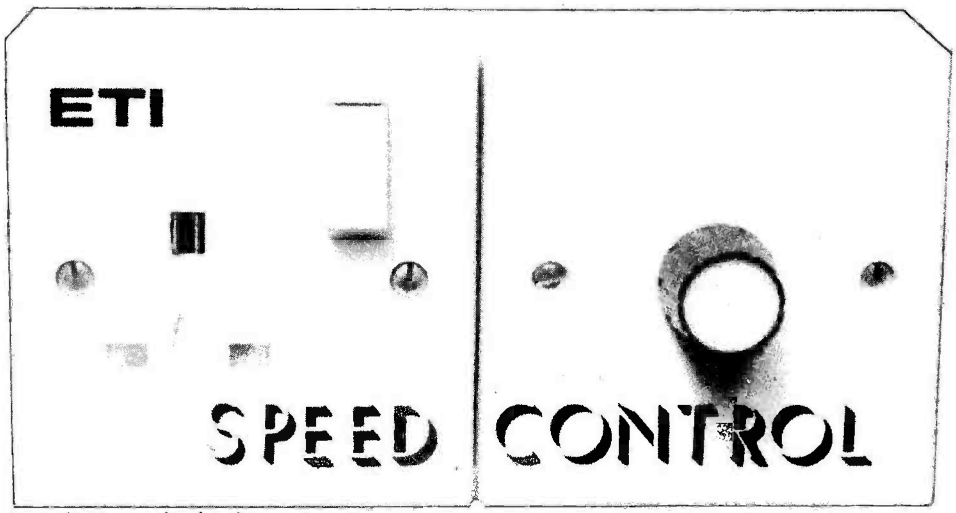
R36	100R

MISCELLANEOUS

IC sockets, 4 way connector, connector pins.

DRILL SPEED CONTROLLER

Keep your electric drill under control with this handy circuit . . . cheap and simple.



This circuit enables you to control the speed of any appliance that uses a 'universal' motor-drills, sanders, polishers, etc. Only a few components are required and this circuit is just about the simplest that can be built from discrete components. Don't let that put you off though! You get full-wave control from zero to full speed. Who could ask for more?

Construction

We built our unit on its PCB into a standard plastic switch-box and fitted the speed control onto a plastic blanking plate. No heatsink was used on the prototype and one will probably not be required for intermittent use.

Warning

Remember that when running an appliance at low speeds, the efficiency of the cooling fan normally built onto the motor-shaft will be severely reduced. This may result in your motor burning out, so remember to allow the windings to cool when running for an extended period or simply run the appliance at full speed off-load for a short while.

There are no special points to watch with this circuit. A PCB design is given, though any method of construction may be employed. Note that 400 V polypropylene capacitors were used in the prototype as these are better able to withstand connection to the AC mains. Despite its simplicity, this circuit will provide a smooth, wide-range control and amply repays the little effort involved in its construction.

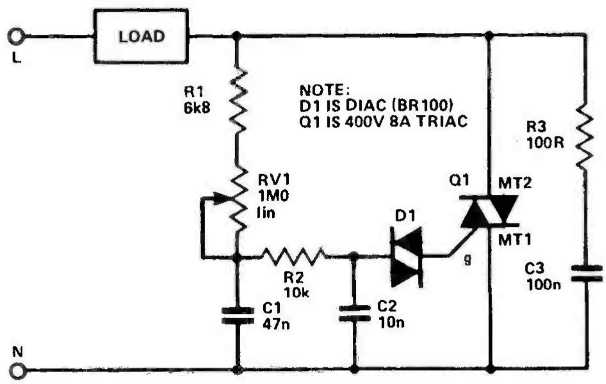


Fig.1. Circuit diagram.

HOW IT WORKS

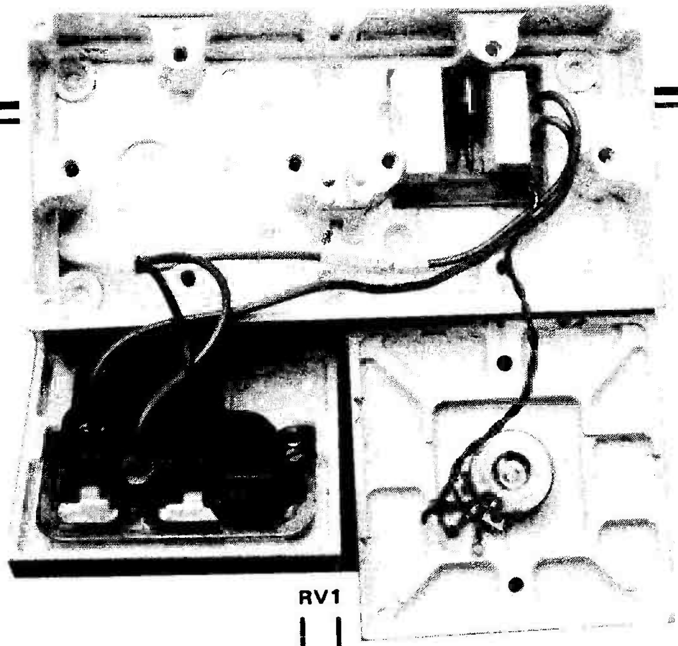
The essential feature of the circuit is triac Q1. This bi-directional electronic switch controls power flow through the load. This can be any 'universal' motor as may be found powering an electric drill, polisher, etc. The resistor-capacitor combination R3, C3 comprise a snubber network which prevents spurious switching effects in the triac. The triac is turned on when the current flow in its gate — MT1 junction exceeds a certain value. Direction of current flow is unimportant, though there will be a small difference in the sensitivity of the triac, and the device will switch on for both cycles of the alternating mains waveform.

The resistor-capacitor network built with R1, 2, RV1, C1, 2 cause an alternating waveform at mains frequency to appear at the 'hot' end of C2. Adjustment of RV1 controls the phase of this signal with respect to the mains input. When the voltage across C2 exceeds about 30 V, current will flow in the gate circuit of the triac, turning it on. It remains on until the applied mains voltage falls to zero. It then remains off until re-triggered. Dissipation in the triac is low as it is only ever either fully on or fully off and a heatsink is unlikely to be required.

BUYLINES

All the necessary components should be readily available from your usual suppliers. See mail order suppliers advertising in this issue. The polypropylene capacitors are available from Electrovalue Ltd, 28 St Judes Road, Englefield Green, Surrey TW20 0BH.

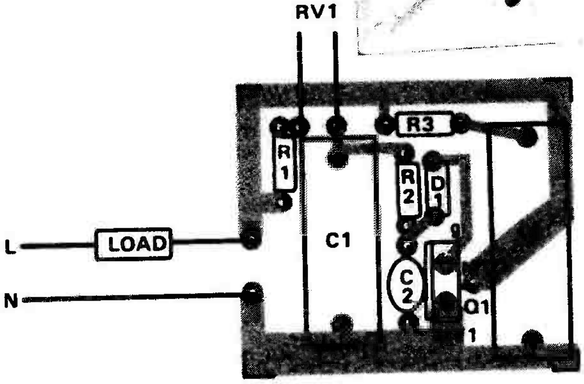
→



PROJECT: Drill Speed Controller

(Left) The PCB fits snugly into a standard plastic switch box and the speed control is mounted on a plastic blanking plate. A switched power socket completes the picture.

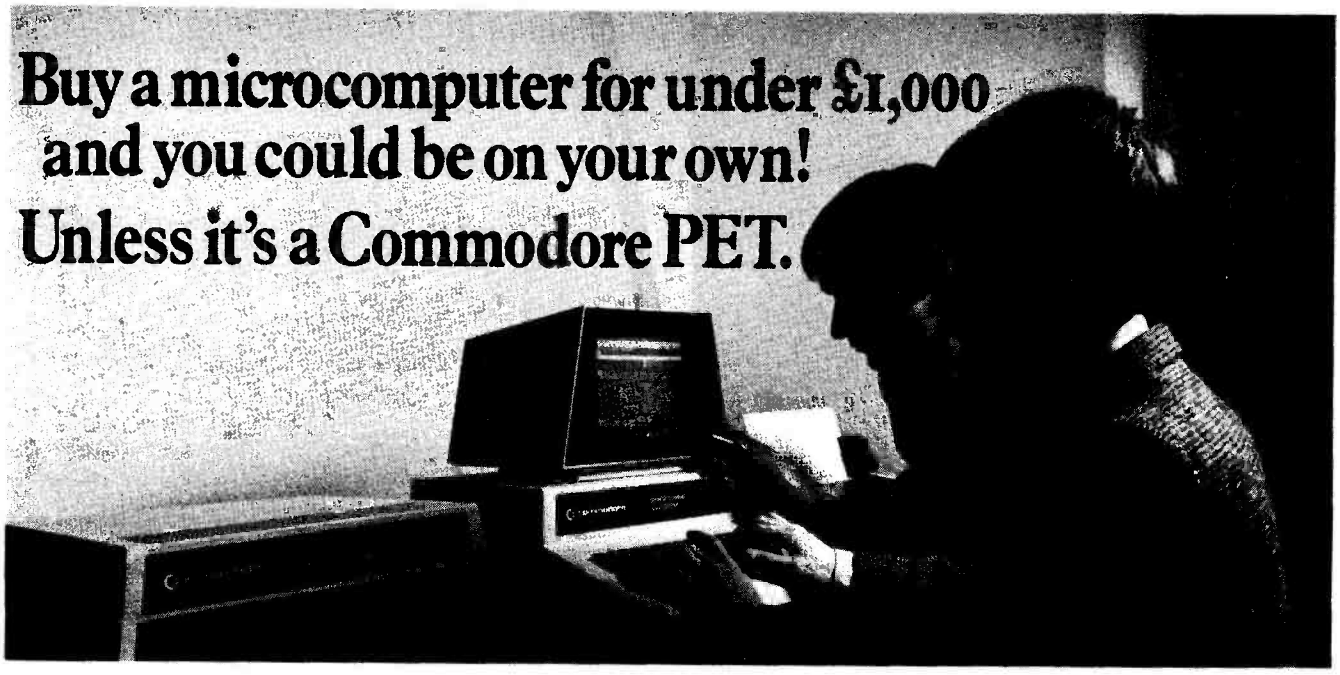
Fig.2 (bottom left). Component overlay



PARTS LIST

Resistors	
R1	6k8
R2	10k
R3	100R
Potentiometer	
RV1	1M0 linear
Capacitors	
C1	47n 400 V AC polypropylene
C2	10n polyester
C3	100n 400 V AC polypropylene
Semiconductors	
Q1	8 A 400 V triac
D1	Diac (BR100 or equiv.)
Miscellaneous	
Case, PCB, Power Outlet, etc.	

ETI



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TV SOUND TUNER

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The BBC frequently 'simulcasts' the sound channel of some of its television music presentations. As well as providing stereo, this gives a dramatic improvement in sound quality. In fact TV sound is transmitted with frequency modulation and can provide good quality (though in mono). The weak link in the system is the TV audio stage and small loudspeaker.

This unit enables you to feed a high quality TV audio signal into your hi-fi; so you will not have to chip your speakers from their concrete columns or mount the TV in the fireplace (even though the chimney does provide an excellent ventilating system!) Use of ready built and aligned modules makes the project very easy to build and it is not expensive!

Tuner Control

An ELC1043 varicap tuner and IF board are bought separately (see 'buylines') and assembled. A handful of other components mount on our PCB and provide power supplies and an optional monitor amp. The varicap tuner is controlled by a single tuning voltage of 0-30 V. We used a surplus push-button station selector unit but any source of a stable voltage may be pressed into service. If you are really up to date, you can even tune the system with your home computer.

Construction

The tuner mounts directly on the IF board. All the holes are there, as well as quite a few spares, though you will need to enlarge the holes for the screening can lugs. Two resistors set the AGC voltage and a capacitor filters the tuning voltage. Be careful when dealing with the IF board not to disturb any of the adjustments. Remember the units are pre-aligned.

To The Manor Borne

We had our board running within an hour but then it failed mysteriously. Manor quickly sorted us out and sent us away with strict warnings about playing football with the board! Remember that the TV signal comes in on a wing and a prayer at a few hundred MHz and even the IF operates at 38 MHz so show it some respect.

Construction of the PSU and amplifier PCB is straightforward. Take special care to connect the screening braids as shown to avoid hum pick-up. When the unit is assembled into its case, with an aerial connected, a station should be tuned in. A slight buzz may be present. This can be nulled out by adjusting the tuning control whilst making slight adjustments to the quad coil. This is preadjusted and should not need to be moved more than a turn to compensate for the effects of added stray capacitance from the case, etc.

Home Programming

Two versions of the tuner front-end are available. They are interchangeable. Our prototype used the cheaper GI device and we were unable to make any comparison with the more expensive Mullard unit. You pays your money and you takes your choice. Whichever you choose, this project will reward you with quality TV sound. We cannot help with the programmes . . .

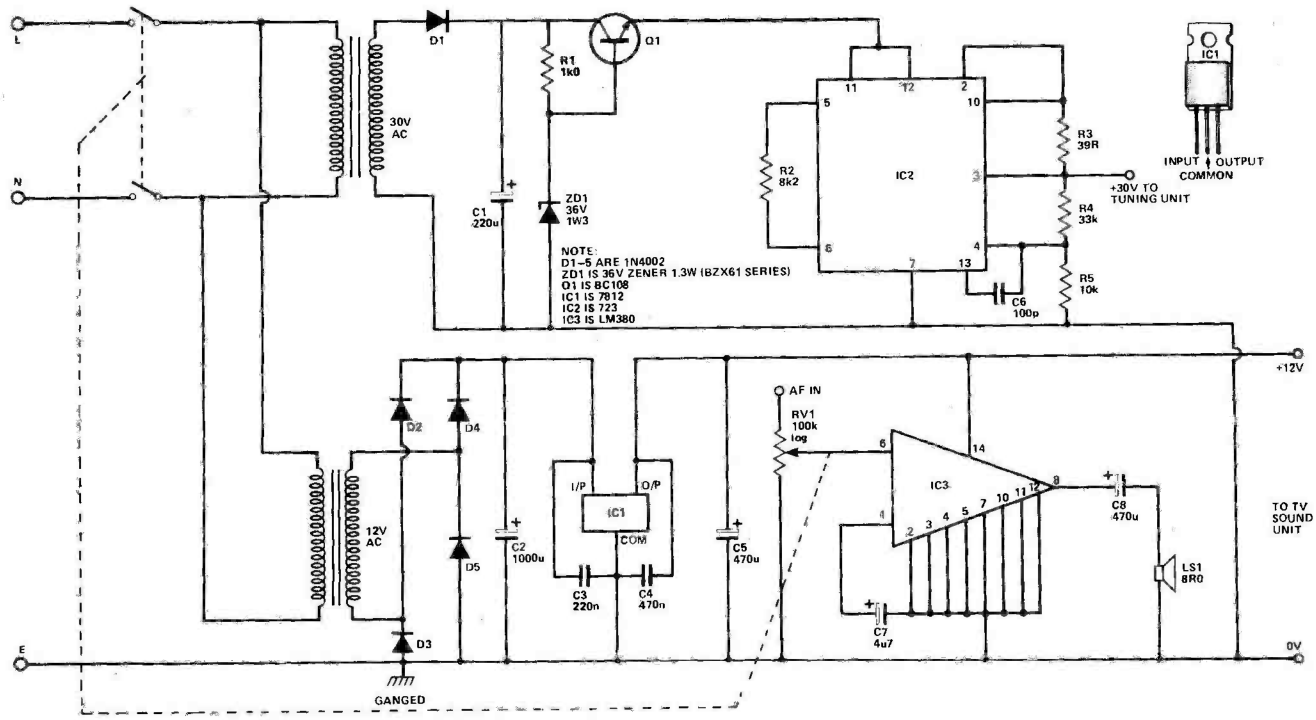


Fig.1. Circuit diagram.

HOW IT WORKS

The TV signal is converted from its UHF carrier frequency down to a more manageable 38 MHz intermediate frequency (IF) by the varicap tuner module ELC1043. 'Varicap' refers to the variable capacitance diodes which replace mechanical tuning capacitors in the front end. The capacitance of the diodes varies according to the reverse bias voltage applied to them. All diodes exhibit this effect but varicap diodes are optimised for operation as capacitors. A relatively high voltage is required and an extra 30 V supply is generated (channels 21 to 34 can be tuned with 0 to 12 V supply).

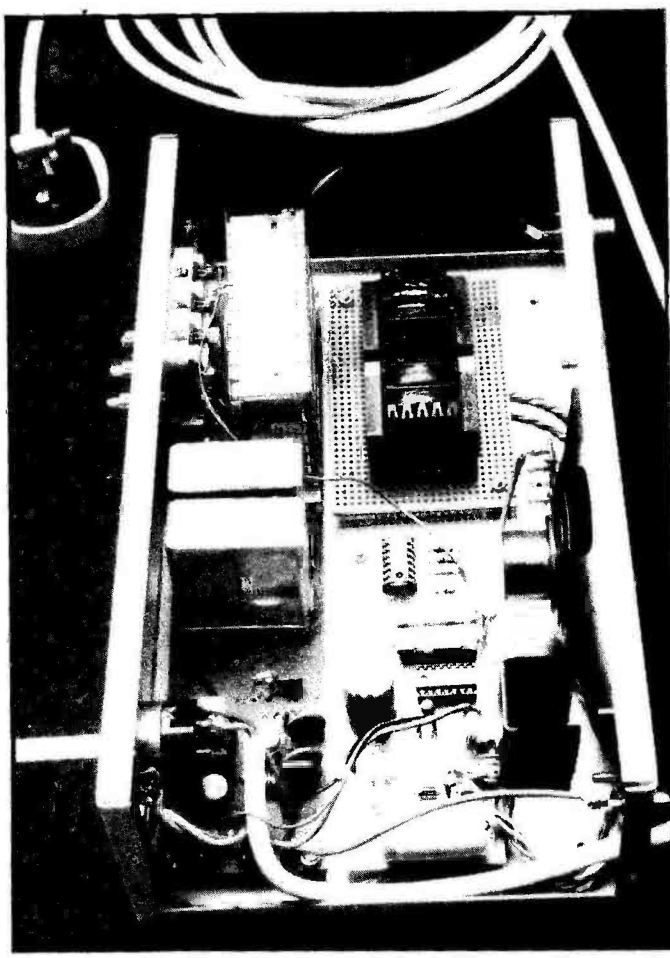
The output from the tuner module is coupled to the IF stage via a 1n0 capacitor. Our unit came with the capacitor mounted in place — a small disc ceramic is fine. The two cans on the IF sub-assembly are Philips G8 colour receiver modules. Their output is coupled to the TAA570 detector via a 6 MHz ceramic filter which removes the video signal but passes the 6 MHz FM sound carrier. Keep your wiring away from this area of the board. If you touch a finger to the ceramic filter you will hear a variety of AM broadcast stations come booming through! The audio output is coupled via a 1uF electrolytic capacitor.

Note that a video signal is available from the IF board. Although it has a reasonable level — around 1V0 peak-to-peak — you will need to buffer the signal before attempting to use it. Refer to the G8 service manual for suitable circuitry.

Both the tuner and IF board are supplied pre-aligned. A 100n capacitor is added to the board to filter any track noise from the tuning control and two resistors are used to preset the AGC for optimum gain. A TAA570 detects the sound signal and produces an AF output of a volt or so. This signal will drive your hi-fi directly or via a resistive divider if the amplitude is too high. We incorporated a simple monitor amplifier in our design.

The power supply is quite conventional. A 30 V AC winding is half wave rectified producing a DC voltage of about 43 V. This is pre-regulated by the circuitry around Q1 to reduce the supply below the 40 V absolute maximum required by IC2. This is a 723 regulator chip connected to provide a stable nominal 30 V supply for the station control unit which feeds the tuning voltage to the TV front end.

Output current is limited to about 20 mA though in normal operation only about 1 mA or 2 mA will be drawn. A 12 V AC winding is rectified and regulated with a 7812 IC regulator. This supplies the IF board (about 100 mA) and an on-board monitor amplifier — the LM380. If you do not require an amplifier then omit RV1, IC3, C7,8 and the loudspeaker. Note that IC1 runs rather warm and should have a small heatsink fitted. Although we used a surplus TV station selector unit, any multiturn pot(s) may be pressed into service. 100k units work well.



The ready-built IF sub-assembly fits along the front of the case, with our monitor amp behind.

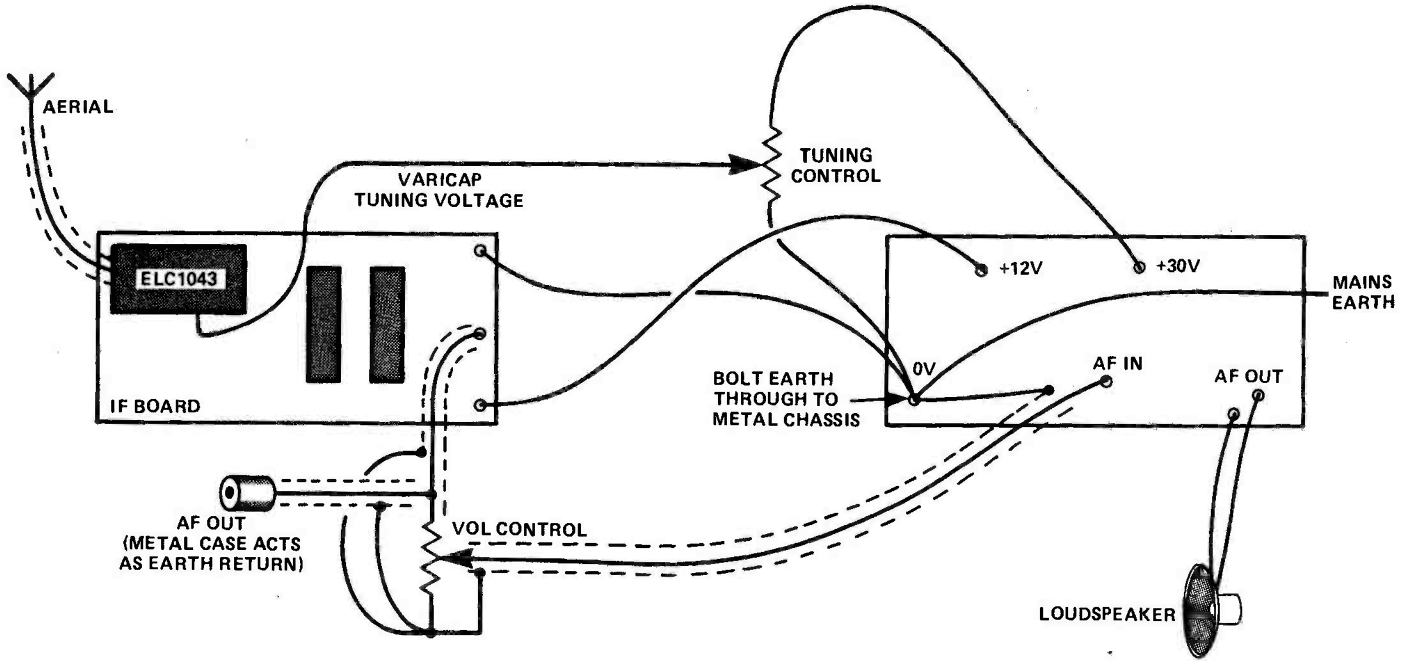


Fig.2. Connections between our amplifier and the ready-made IF board.

PARTS LIST

Resistors All ¼W 5%

R1	1k0
R2	8k2
R3	39R
R4	33k
R5	10k

one 6k8 and one 2k2 resistor are required to set the AGC level.

Potentiometer

RV1	100k log.

Capacitors

C1	220u 63V electrolytic
C2	1000u 25V electrolytic
C3	220n polyester
C4	470n polyester
C5,8	470u 25V electrolytic
C6	100p ceramic
C7	4u7 tantalum

one 100n capacitor is required to filter the tuning voltage.

Semiconductors

IC1	7812
IC2	723
IC3	LM380
Q1	BC108
D1–5	1N4002
ZD1	36V zener 1.3W (BZX61)

Miscellaneous

12V transformer, 30V transformer, heatsink, loudspeaker, varicap tuner, IF board, case.

BUYLINES

The ELC1043 varicap UHF tuner and IF sub-assembly are available from:
Manor Supplies,
172 West End Lane,
London NW6.
Tel: 01-794 8751.
They can also supply a suitable push-button station control unit.

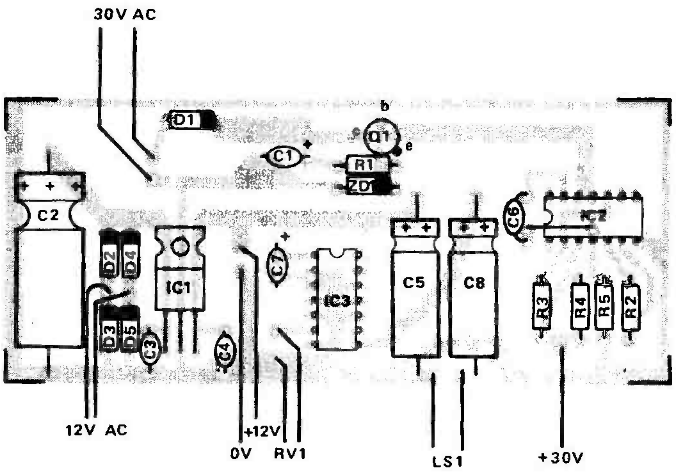
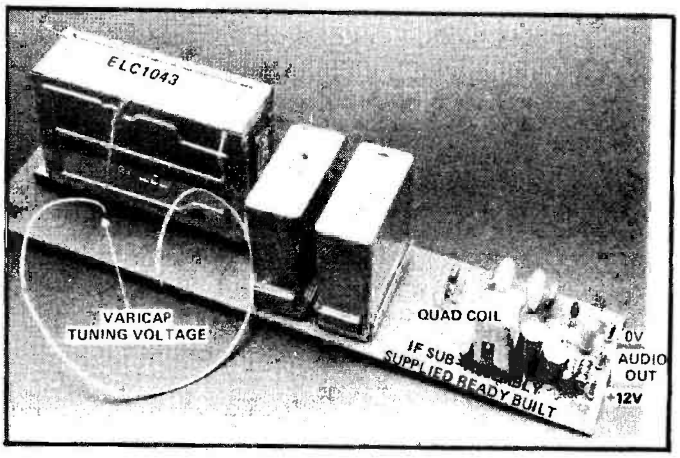
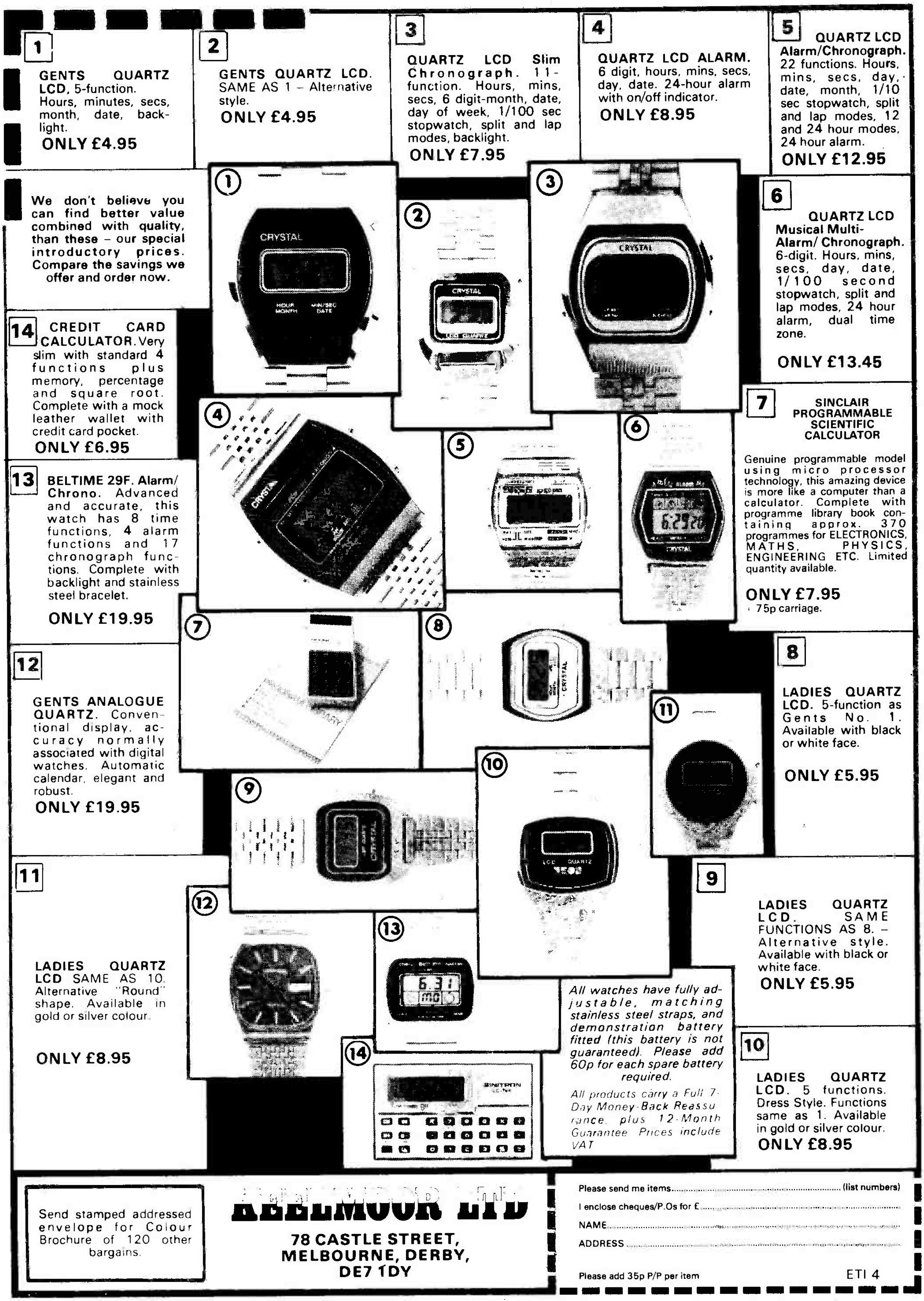


Fig.3. Component overlay.



The UHF tuner mounted on the IF sub-assembly.



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Two of the most useful pieces of modern electronic test gear are the Digital Multimeter (DMM) and the Digital Frequency Meter (DFM). These instruments are highly accurate, rugged and can be used in any attitude (vertical, horizontal, upside down, etc). Trouble is, they tend to be a bit expensive; a decent pair of such instruments costs about £200.

We have overcome the price by producing a unique 30-range digital instrument that acts as a combined 25-range DMM and 5-range DFM. We've decided to call this new instrument a Digital Test Meter, or DTM. Our DTM is designed around the very latest 3½ digit liquid crystal digital voltmeter module (thereby simplifying construction), is powered from two 6 V battery supplies and typically gives several months of operation from a single battery set.

The AV (alternating voltage) ranges of the DTM are frequency compensated; they are typical responses that are flat within 1% to 40 Hz or to within 1 dB to 120 kHz.

The resistance indicating section of the DTM uses a ratiometric measurement technique and a test voltage of about 300 mV maximum, thereby enabling in-circuit resistance measurements (such as a resistor in parallel with a semiconductor junction) to be made without forward biasing in-circuit junctions. The DTM is provided with an independent facility (via a specific test terminal) for testing semiconductor junctions.

The frequency meter section of the unit can be used to measure frequencies in the range 10 Hz to 1.999 MHz. The input impedance of the section is roughly 200 kHz and signal levels in the approximate range 10 mV to 100 V can be accepted.

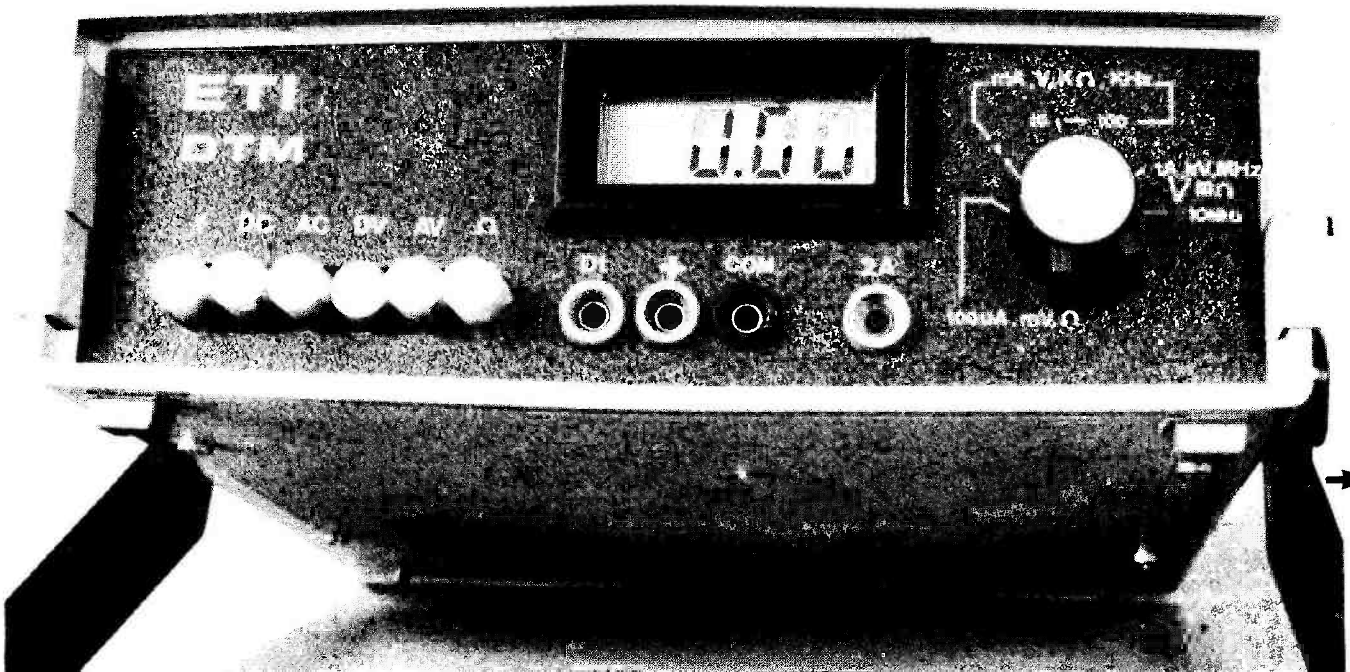
The DTM is provided with a built-in precision 1V2 DC reference, which can be used for basic calibration of the DC and DV ranges. Resistance calibration is automatically established by built-in standard resistors. The instrument must be compared with external standards to calibrate the basic AC, AV and frequency ranges.

Accuracy

The basic 3½ digit DVM module used in the DTM is intended to read 100 mV full scale, with 100% over-range capability (giving a maximum reading of 199.9mV.). The basic module is capable of reading with an accuracy that is within 0.1% (one digit, or 100 uV) of full scale, once it has been initially calibrated against a suitable reference standard.

In practice, all other ranges of the DTM are obtained by feeding inputs to the DVM module via resistive potential dividers, current ranging resistors and resistance standards.

In our prototype DTM we've used 1% resistors in all pertinent positions, thus giving the completed instrument an overall accuracy of 1% which we consider to be adequate for most practical purposes. If you want higher accuracy,



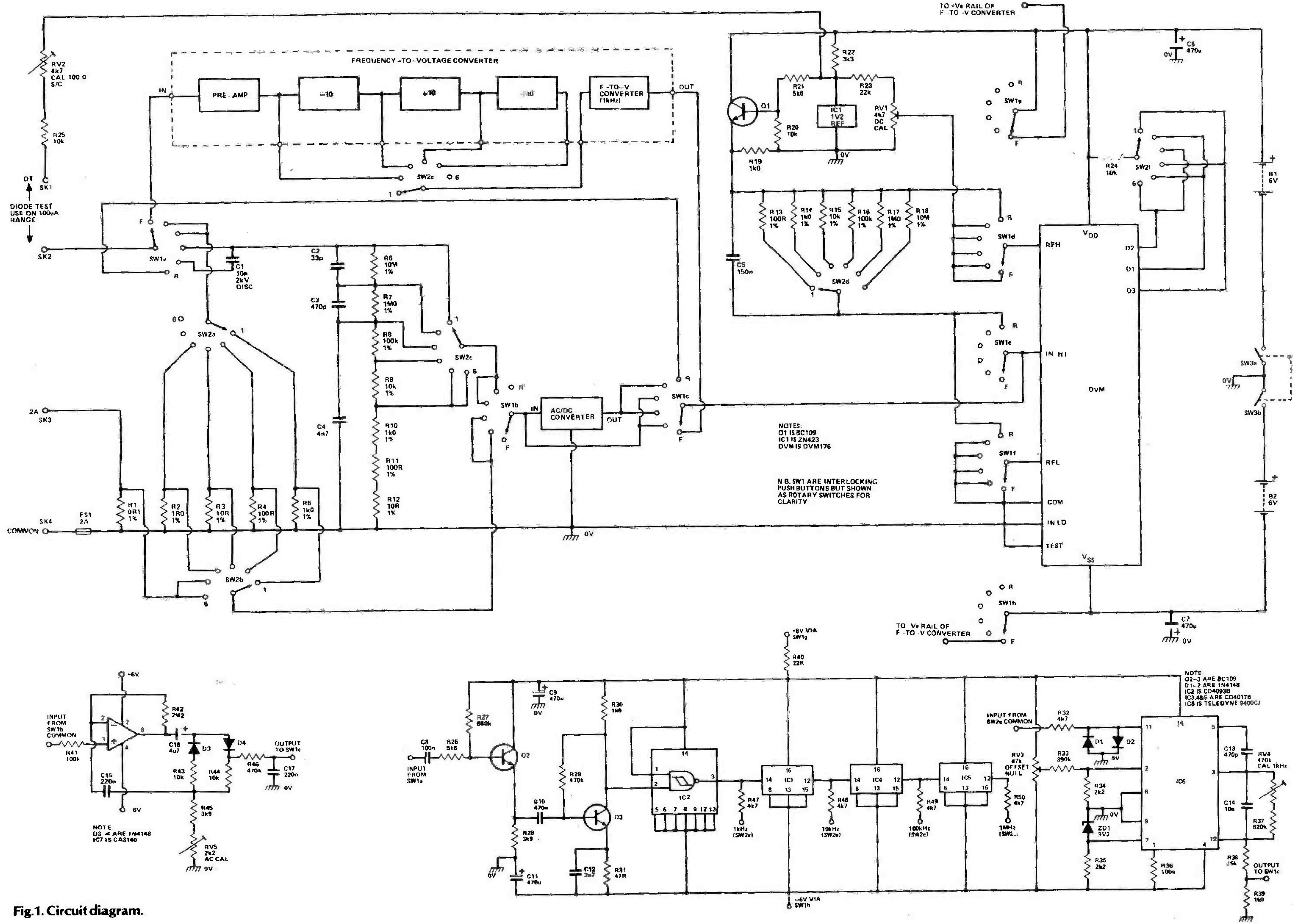


Fig. 1. Circuit diagram.

HOW IT WORKS

The heart of the DTM is a DVM 176M Rev C 3½ digit liquid crystal DVM module, available from Ambit International. This module has a built-in voltage reference and is intended to be powered from a single 9 V battery. The complete module (including the readout) typically draws only 1 mA of current and is intended to read 100 mV DC full scale with 100% over-range capability (giving a maximum reading of 199.9 mV).

In our particular application we need, for various reasons, to power the module from a split 12 V (6-0-6) battery supply, which makes it necessary to ignore the module's built-in voltage reference, and supply it with a reference voltage from an external source. IC1 and the RV1-R23 divider are used for this purpose.

In the completed DTM, voltage ranging is obtained by feeding inputs to the DVM module via the R6-R12 potential divider network. AC voltage ranging is obtained by feeding inputs to the DVM module via the same potential divider (which is frequency compensated via C2-C3 and C4) and via a precision AC/DC converter (designed around IC7).

Current ranging is obtained by feeding the test current through the appropriate one of the R1 to R5 ranging resistors and monitoring the voltages that they generate. In the DC mode, the generated voltages are fed directly to the input of the DVM module. In the AC mode, they are fed to the module via the AC/DC converter.

Frequency indication is obtained by feeding input signals to the DVM module via a precision frequency-to-voltage converter. The f-to-v converter has a basic range of 10 Hz to 1,999 kHz and frequency ranging is achieved by feeding input signals to the converter via switch-selected decade divider networks.

Resistance measurements are made by disconnecting the external reference from the DVM module and connecting the test resistor in series with the appropriate one of the R13 to R18 ranging resistors and powering the combination with a few hundred millivolts DC (via the IC1-Q1 network). The voltage of the ranging resistor is monitored at the reference-input terminals of the DVM module and the voltage of the unknown resistor is monitored at the module's signal input terminals. The DVM module compares the ratios of the two voltages (and thus the ratios of the resistors) and gives a readout that is interpreted directly in terms of resistance.'

This 'ratiometric' system of resistance measurement has two distinct advantages. First, maximum test voltages of only a few hundred millivolts are applied to the unknown resistor, thereby enabling in-circuit resistance measurements to be made without causing semiconductor junctions to become forward biased. Second, the accuracy of measurement is independent of the energising voltage and is determined solely by the accuracy of the ranging resistors, thus eliminating calibration problems. Our circuit measures resistances of 0R1 to 19.99M in six ranges.

In the DTM, multi-pole switch SW1 is used to select the mode of operation and SW2 is used for range selection. SW2 sets the decimal point of the display to a position appropriate for the selected range.

The DTM has a facility for testing semiconductor junctions. To use this facility, the unit is switched to the 100uA range in the DC mode and the test device is connected between the DT+ and + terminals of the instrument. The DT+ terminal is energised from the built-in 1V2 source via RV2 and R25 and the resulting device current is read out by the DVM module. Open circuit devices give a reading of zero. Short circuit devices give a reading of 100.0. Good silicon junctions give a forward reading of roughly 60.0.

The AC/DC converter section of the instrument is designed around IC7, which is connected as a precision rectifier. The gain of the circuit can be pre-set, for calibration purposes, via RV5. The output of the converter is integrated by the R46, C17 network and by an additional network that is incorporated in the DVM module.

Frequency to voltage conversion input test signals are fed to high-impedance (roughly 200k) input buffer Q2 via safety resistor R26 and are then amplified by Q3 and converted to square waves at the input frequency via IC2. The resulting square waves are then divided down by decade dividers IC3 to IC5.

The heart of the converter is IC6 which, quite simply, is a dedicated precision frequency-to-voltage converter chip, in which the input signal is fed to pin 11 via R32 and a proportional analogue voltage appears at the junction of R38-R39. In our application, the IC is configured to cover the basic range of 10 Hz to 1.999 kHz. Frequency calibration can be set via RV4 and offset nulling (zero output for zero input) can be achieved via RV3.

Frequency ranging of the complete converter circuit is obtained by feeding the input of IC6 from an appropriate point in the IC2-IC5 network via SW2e. Thus, on the 1kHz range IC6 is fed directly from the output of IC2; on the 1MHz range, IC6 is fed from the output of IC5.

SW2	SW1 'MODE' SETTINGS					
RANGES	f	DC	AC	DV	AV	R
1	–	100uA	100uA	100mV	100mV	100R
2	1kHz	1mA	1mA	1V	1V	1k0
3	10kHz	10mA	10mA	10V	10V	10k
4	100kHz	100mA	100mA	100V	100V	100k
5	1MHz	1A	1A	1kV	1kV	1M0
6	–	1A	1A	1kV	1kV	10M

Table 1. SW2 range details for the six meter functions.

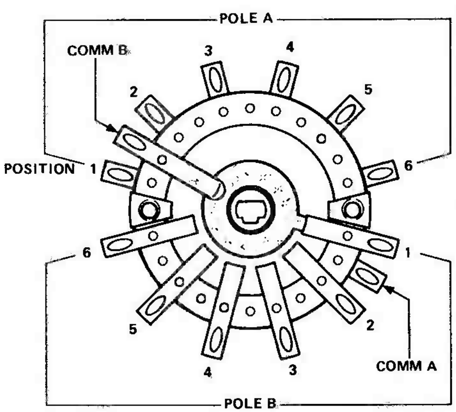


Fig.2. The wiring of SW2 (above) can become a veritable jungle if you're not careful. Lock yourself away from all distractions for half an hour and work round each pole in turn.

you'll have to locate a source of supply of ultra-precision resistors.

Construction of the unit presents a bit of a challenge, due to the complexity of the interwiring. Construction needs to be tackled in a methodical manner, with the unit being given a functional check at the end of each building stage. The following building sequence is recommended.

DV Ranges & AV Ranges

Gather all hardware together (switches, battery pack, sockets, fuse holder and the DVM module and bezel) and secure them in their final positions in the instrument case. On our prototype, we've used a bank of push-button switches for SW1 (mode selection) and a rotary switch for SW2 (range selection). On/off switch SW3 is mounted on the rear of the instrument. SW1 is mounted on a small PCB and fixed, via self-tapping screws and ⅛ inch spacers into studs moulded into the base of the case.

Make up PCB A as shown in the overlay, taking special care over the construction. Note that 1% resistors are used in the range-determining positions. Fit Veropins in all appropriate positions on the board, to facilitate wiring interconnections. Make up the power supply (+6 V, 0 V and −6 V) connections to the board via SW3.

Make up the following interconnections to the DVM module, noting that the module is a MOS device and can be damaged by static charges; V_{SS} to −6 V and V_{DD} to +6 V on PCB A. Connect COM, IN LO and TEST together and connect to the 0 V power supply line. Connect the 0 V line to the instrument's common input terminal via FS1. Connect RFL to the common terminal of SW1f. Connect RFH to the common terminal of SW1d. Connect IN HI to the common terminals of SW1c and SW1e.

Refer to the main circuit diagram and make the following connections. Wire up SW1d and make the connection to RV1 slider on PCB A. Wire up SW1f and make the connection to COM terminal on the DVM module. Trace the DV (direct voltage) path through the circuit and make the appropriate connections as follows. From SK2 to SW1a common; from SW1a DV to R6 and from the R6-R12 chain to the 1 to 6 pins of SK2c; from SW2c common to SW1b DV/AV; from SW1b common to SW1c DV and AC; from SW1c common to SW1e common and to the IN HI terminal of the DVM module.

With all the above connections made, double check the wiring and then switch the unit on. Short the instrument's input terminals and check that the DTM reads 000 on all ranges in the DV mode. Switch to the 1 V range, connect the unit's input terminal (SK2) to SK1 and trim RV1 to obtain a reading of 1V2 (1200). The unit is now approximately calibrated (within 5%) on all DV ranges. Remove the connection from SK1 and check that the unit is functional on all DV ranges.

If you have access to a precision DV source or to an accurate DMM, you can precisely calibrate the DTM by switching it to the 100 mV DV range, connecting a known input test voltage (100-199 mV) and adjusting RV1 for a correct reading.

Decimal Pointing

Refer to the main circuit diagram and make the connections from +6 V to SW2f common via R24 and from the SW2f range pins to the D1, D2 and D3 terminals on the DVM module. Switch the DTM on, on the DV ranges, and check that the decimal point appears in sensible positions on each range (eg 100 mV reads 100.0 on the 100 mV range or 100 on the 1 V range).

Refer to the main circuit diagram and trace the AV (alternating voltage) path, making additional connections as appropriate, as follows. From SK2 to the top of R6 via SW1a and C1; from the output of the R6-R12 chain to SW1b via SW2c; from SW1b common to R41 of the AC/DC converter on PCB A and to the DV and DC pins of SW1c; from R46 of the converter on PCB A and to the DV and DC pins of SW1c common to IN HI on the DVM module.

When the above connections are complete, set the unit to the 100 mV AV range, connect a 1 kHz sinewave of known amplitude (100-199 mV) to the input of the DTM and adjust RV5 for a correct reading. Switch the unit to the 1 V range, increase the input signal to a sensible value and check the frequency response of the instrument. The response should be virtually flat from 20 Hz to 40 Hz; if necessary, the value of C2 can be padded up slightly to obtain the required response. Check that the unit is functional on all other AV ranges.

DC Ranges & AC Ranges

Refer to the main circuit diagram, trace the DC (direct current) circuit path (via R1-R5), add all appropriate switching connections and then give the unit a functional check on all DC ranges.

Refer to the main circuit diagram, trace the AC (alternating current) circuit path, add any appropriate switching connections and give the unit a functional check on all AC ranges.

Resistance Ranges

Refer to the main diagram again, trace the resistance measuring circuit (via R13-R18 and SW2d, SW1d-SW1e-SW1f and from the IN HI pin of the DVM module to SK2 via SW1c and SW1a) and make all appropriate connections. Give the unit a functional check on all ranges by connecting appropriate test resistors to the DTM test terminals.

Note that, due to the low-voltage ratiometric resistance measuring technique used in this instrument, the readout tends to jitter somewhat when used to test resistors with values in excess of 200k or so. This tendency can be minimised by keeping test leads as short as possible, to avoid hum pickup.

Make the connection from R25 (on PCB A) to Diode Test Socket SK1. Short SK1 to SK2 and adjust RV2 for a reading of 100.0 on the 100 uA DC range. Remove the short and check that a reading of 00.0 is obtained. Connect a silicon diode between the two sockets and check that a reading of about 60.0 is obtained in the forward direction and 00.0 in the reverse.

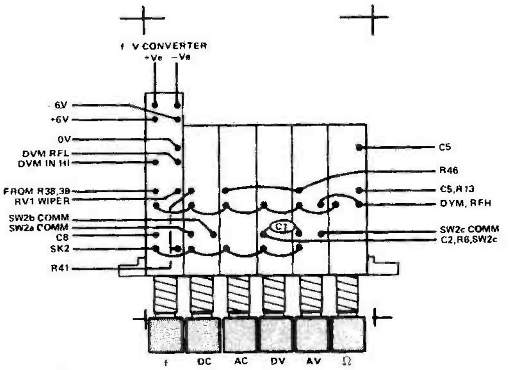
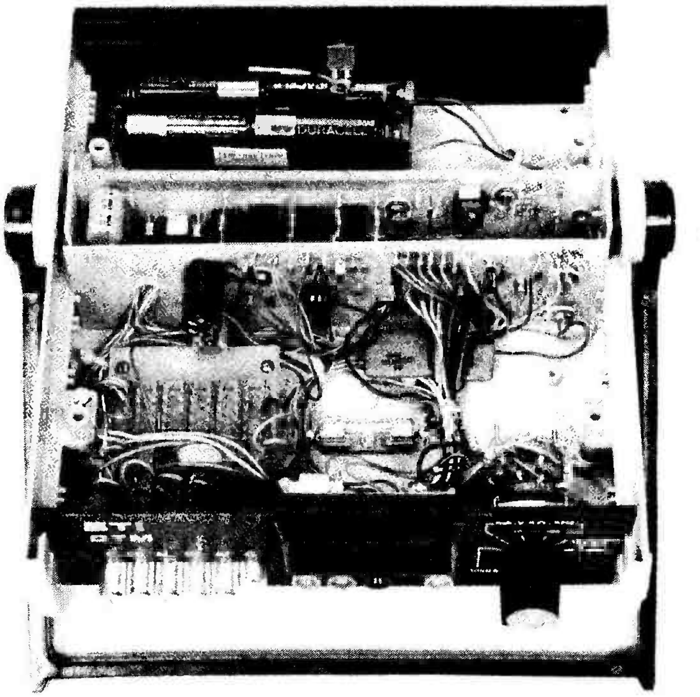
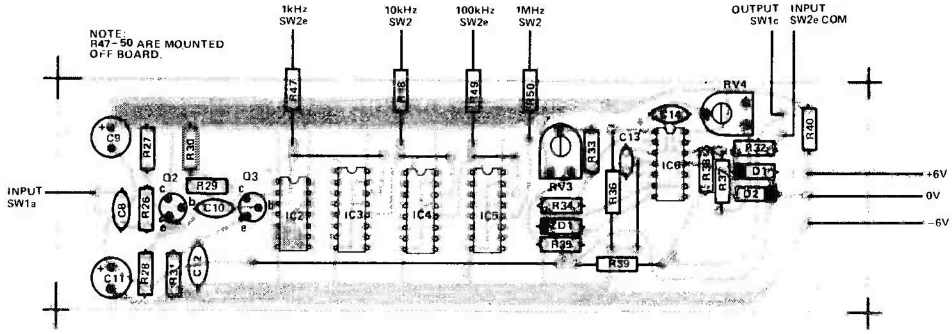


Fig.3. The mode switch assembly fits on its own PCB (above).

Frequency Ranges

Construct the frequency-to-voltage converter circuit on PCB B and make its supply connections via SW1g (+6 V) and SW1h (−6 V) and the supply common line. Make the input connection to the PCB from SW1a and the output connection to SW1c. Wire up SW2e as shown, noting that a 4k7 resistor is connected directly to each of the 1kHz, 10





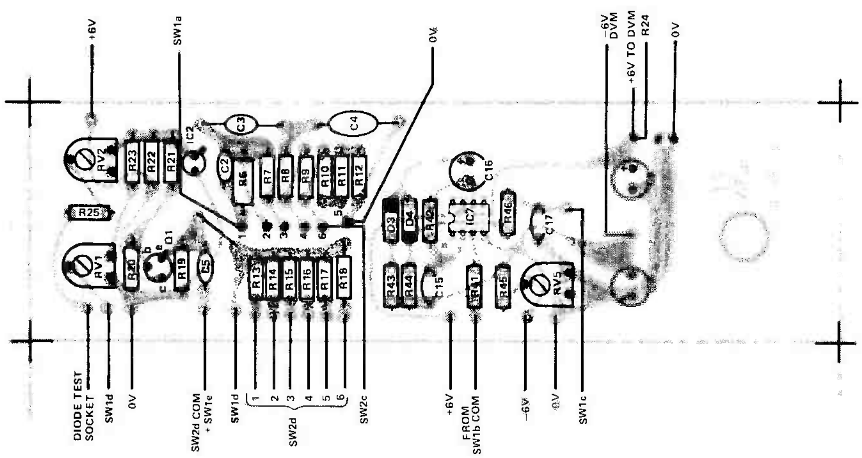


Fig.4. Component overlays of the two Digital Test Meter boards. Frequency ranging (top board) is achieved by feeding IC6 from an appropriate point in the IC2-5 chain.

Resistance measurements are made by using one of the resistance ranging resistors R13-18 (bottom board). IC7 is the heart of the AC/DC converter.

PARTS LIST

Resistors ¼W 5% unless specified	
R1	0R1 ½W 1%
R2	1R0 ½W 1%
R3,12	10R ½W 1%
R4,11,13	100R ½W 1%
R5,10,14	1k0 ½W 1%
R6,18	10M ½W 1%
R7,17	1M0 ½W 1%
R8,16	100k ½W 1%
R9,15	10k ½W 1%
R19,30,39	1k0
R20,24,25,43,44	10k
R21,26	5k6
R22	3k3
R23	22k
R27	680k
R28,45	3k9
R29,46	470k
R31	47R
R32,47,48,49,50	4k7
R33	390k
R34,35	2k2
R36,41	100k
R37	820k
R38	15k
R40	22R
R42	2M2
Potentiometers	
Rv1,2	4k7 miniature horizontal preset
Rv3	47k miniature horizontal preset
Rv4	470k miniature horizontal preset
Rv5	2k2 miniature horizontal preset

Capacitors	
C1	10n 2kV ceramic disc.
C2	33p silver mica
C3	470p silver mica
C4	4n7 silver mica
C5	150n polycarbonate
C6,7,9,11	470u 16v electrolytic, PCB type.
C8	100n polycarbonate
C10	470n polycarbonate
C12	2n7 ceramic
C13	470p ceramic
C14	10n polycarbonate
C15,17	220n polycarbonate
C16	4u7 electrolytic, PCB type
Semiconductors	
DVM	176M Rev. C.
IC1	Zn423
IC2	4093B
IC3,4,5	4017B
IC6	9400CJ
IC7	CA3140
Q1,2,3	BC109
D1-4	IN4148

Miscellaneous
SW1a, 8 pole change over interlocking push button
SW1,b,c,d,e, 6 pole change over interlocking push button
SW2a-f, 2 pole 6 way wafers (3 off) rotary switch
SW3, DPDT miniature toggle
SK1-4, 4 mm banana sockets
2 off, 4 section battery holders for HP7
1 off, 1¼" fuse & holder chassis fixing or similar
1 off, winged knob
Case (see buylines)

kHz, 100 kHz and 1 MHz output pins of PCB B, with the connections to SW2e made via these resistors.

When construction is complete, switch to the 1 kHz range in the 'f' mode, short the unit's input terminals and adjust RV3 for zero reading on the meter. Remove the input short, connect a 1 kHz input signal and adjust RV4 for a reading of 1.000 on the meter. Finally, check that the DTM is functional on all other frequency ranges.

BUYLINES

Watford Electronics have agreed to supply a full kit of parts for the ETI DTM.

Our Case for this project was obtained from OK Machine and Tool. (Order as CH23 Tan) Phone 0703-610944.

Ambit International Supply the DVM176 Rev. C.

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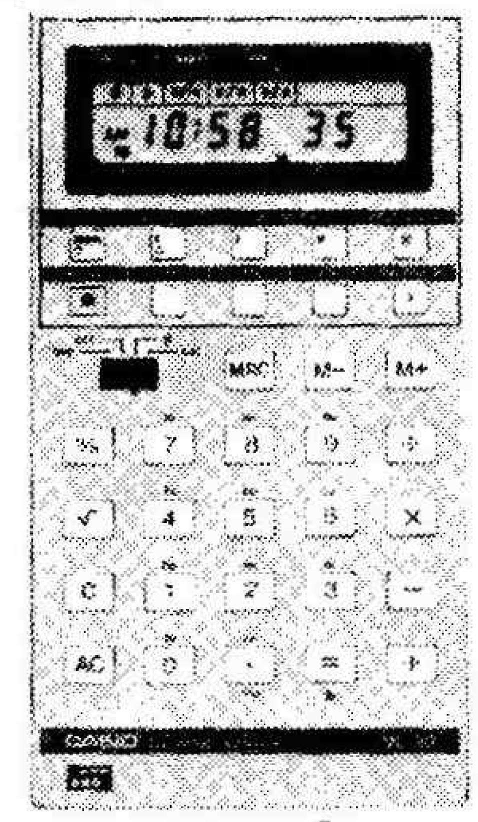

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2K Monitor — Nas-sys 1. 1K Video RAM (MK 4118). 1K work space/User RAM (MK 4118) (8K Microsoft Basic) (MK 3600 ROM) (8K Static RAM/2708E)

Microprocessors Z80A. 8 bit CPU. This will run at 4MHz but is selectable between 2/4 MHz. This CPU has now been generally accepted as the most powerful, 8 bit processor on the market.

INTERFACE

Keyboard New expanded 57 key Licon solid state keyboard especially built for Nascom. Uses standard Nascom, monitor controlled, decoding.

T.V. The lv peak to peak video signal can drive a monitor directly and is also fed to the on-board modulator to drive the domestic T.V.

I.O. On-board UART (Int. 6402) which provides serial handling for the on-board cassette interface or the RS232/20mA teletype interface.
The cassette interface is Kansas City standard at either 300 or 1200 baud. There is a link option on the NASCOM-2. For 2400 Baud.
The RS232 and 20mA loop connector will interface directly into any standard teletype.
The input and output sides of the UART are independently switchable between any of the options —
i.e. it is possible to have input on the cassette and output on the printer.

PIO There is also a totally uncommitted Parallel I/O (MK 3881) giving 16, programmable, I/O lines. These are addressable as 2 x 8 bit ports with complete handshake controls.

Documentation Full construction article is provided for those who buy a kit and an extensive software manual is provided for the monitor and Basic.

Basic The Nascom 2 contains a full 8K Microsoft Basic in one Rom chip with additional features like DEEK, DOKE, SET RESET for simple programming.

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- User defined functions
- READ and DATA statements
- Dump and load programs for cassette recorders
- Program editing command
- String function for text I/O
- BASIC can call user machine-code sub routine
- User machine-code interrupt handler interfaces with BASIC

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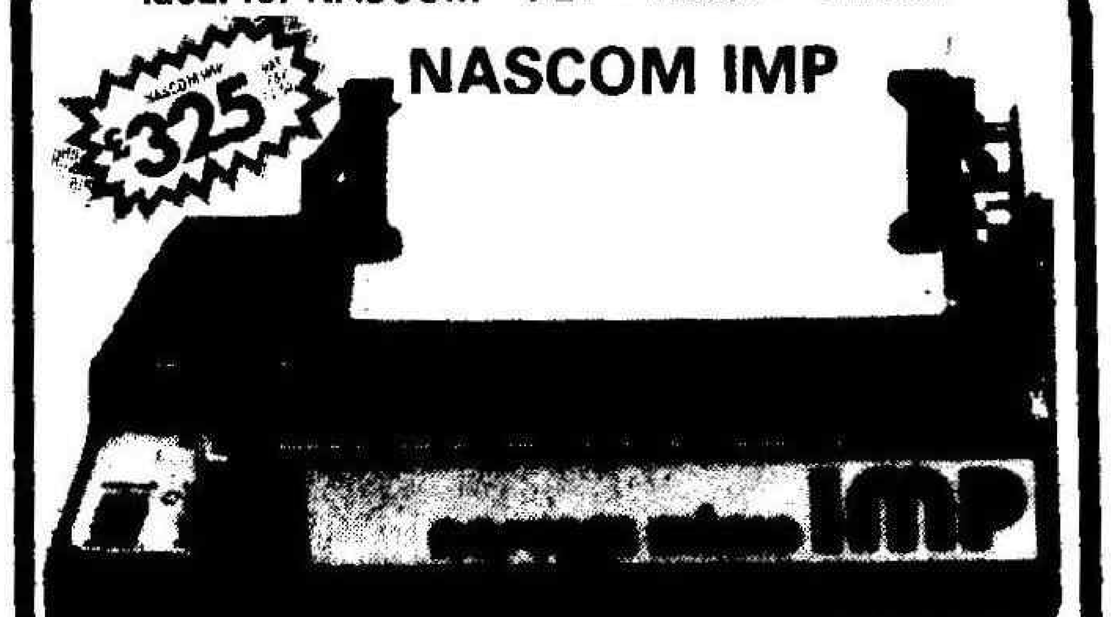

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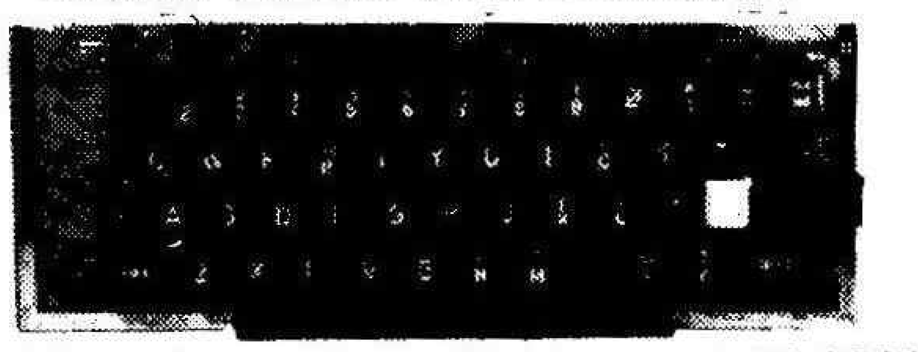

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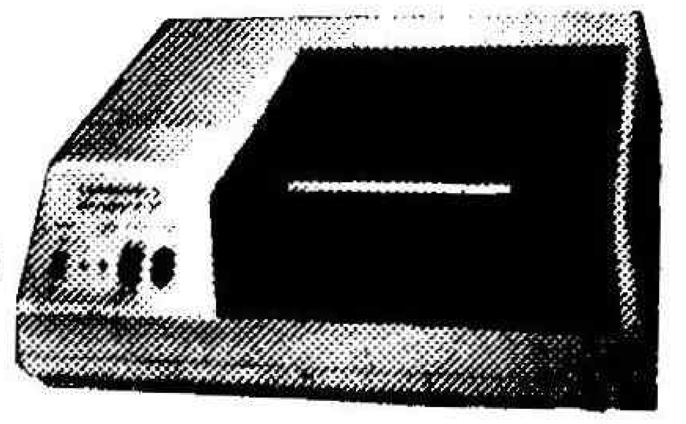

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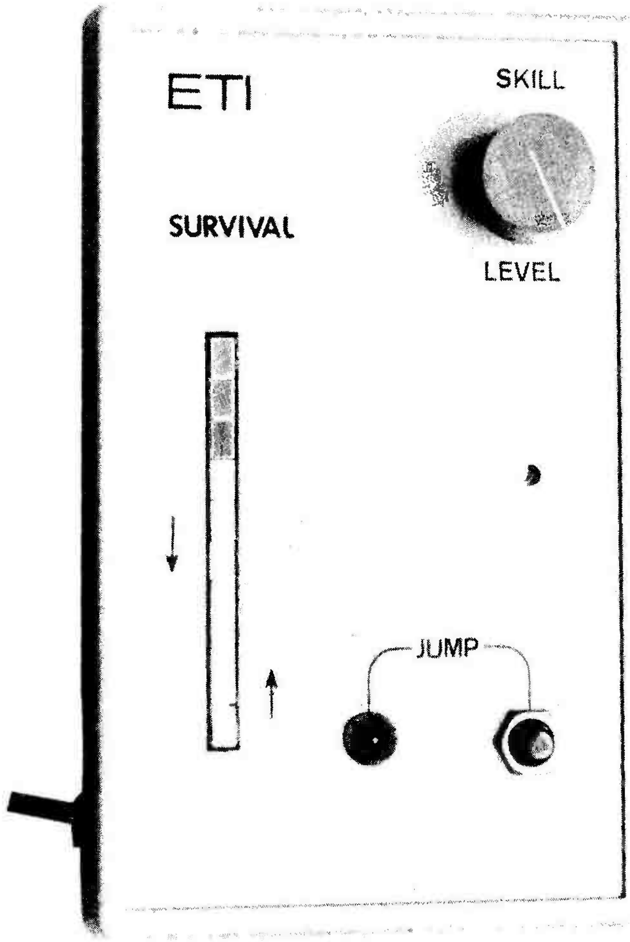
SURVIVAL GAME



A highly addictive but infuriating game. Escape from the tyranical machine if you can. Naturally, the game has sound effects, LED readouts and a skill level control.

Survival is a small hand-held game in which the contestant pits his wits against those of the machine. The machine is a tyrannical device, dedicated to enslaving you by repeatedly making threatening gestures towards you (indicated by a brief flash of a LED as the threat is unleashed). When a threat is made you can either submit, by doing nothing, or you can defy the tryant by pressing a JUMP button and trying to escape up a flight of steps (indicated by a vertical column of ten LEDs).

To escape, you must press the JUMP button only when the threat LED is on. Each time you make a successful jump, you move a discrete amount towards the top of the steps and eventual escape (indicated by a pulsed WIN sound as the top LED of the column illuminates). If you make a single wrong move while on the steps, however, the tyrant will instantly strike you (indicated by a 'bleep' sound) and send you tumbling back down to the bottom of the steps. Alternatively, if you submit to the threats (by doing nothing) the tyrant will slowly lure you down from your perilous perch.

An Evening's Work

The machine makes a threatening move once every second or so, but the actual threat lasts for only a fraction of this time. The game is provided with a SKILL level control, which enables the threat duration (and thus the escape time) to be varied from over 200 mS to less than 50 mS. At the lowest skill level, it is possible to escape from the tyrant in only four to five successful moves. At the top skill level, between thirty and forty successful moves are needed to ensure escape. The escape 'steps' are exponentially weighed, so that climbing becomes progressively more difficult with each move.

The SURVIVAL game is designed around three ICs and three transistors, is reasonably inexpensive to build and is powered from a single 9 V battery. The project can be built in one or two evenings.

Construction

Construction of this project should present few problems if the overlay is followed with care. Note that IC3 is a CMOS device and should be mounted in a suitable socket.

When construction of the PCB is complete you can either make temporary connections to the eleven LEDs and the transducer, etc and give the unit a functional check, or you can dive in and fit the whole shebang in a suitable box and give the unit a functional check afterwards. If you decide on the latter approach, note that the unit typically consumes some 30-40 mA and should ideally be powered from a PP7 or larger battery, but that our own prototype is in fact powered (or under-powered!) from a PP3.

It is advisable, before completing the interwiring, to functionally check the performance of each of the eleven LEDs used in the unit.

When construction is complete, switch the game on and check that LED 11 flashes briefly once every second or so and that the flash duration can be varied by RV1. You can check the action of C4 and the ten-LED read-out circuit by temporarily shorting the top of R8 to the positive supply line, in which case the LEDs in the column should sequentially illuminate and the WIN alarm (a pulsed tone) should sound when the upper LED (LED 10) turns on. Finally, remove the temporary short and press PB1 when LED 11 is off, checking that the column of LEDs turn off and a brief tone is generated. Your game is then complete and ready for use.

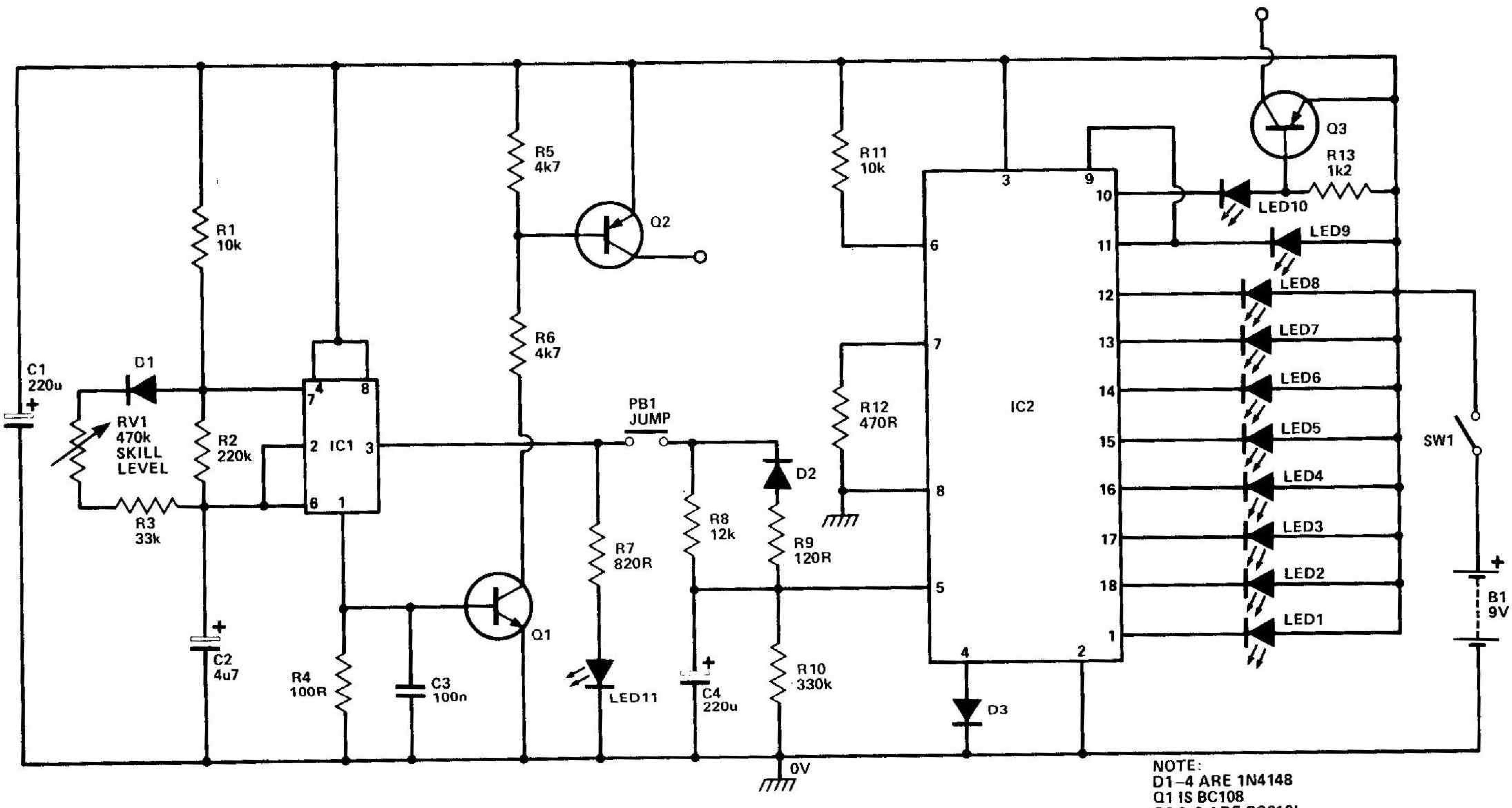
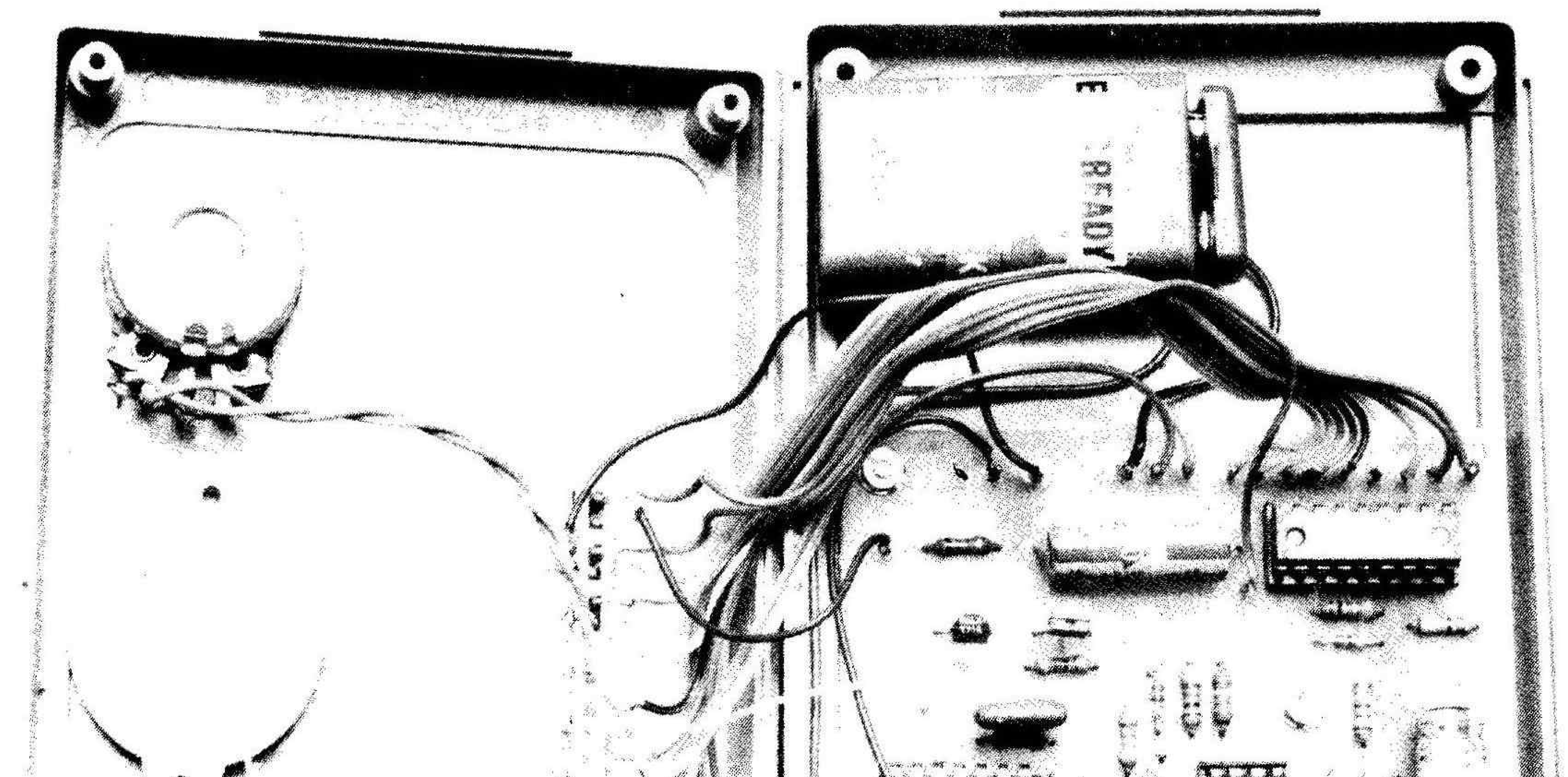


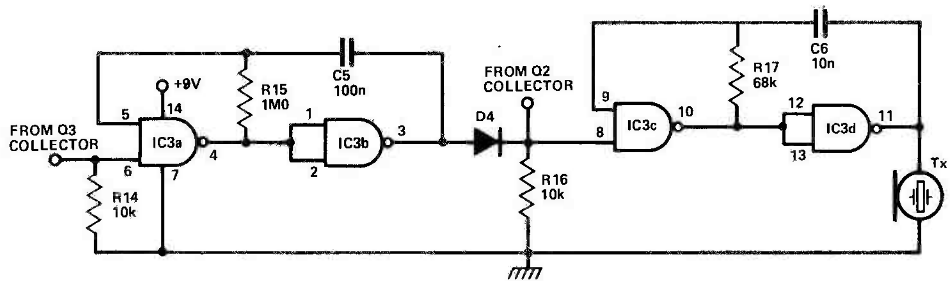
Fig.1a. Circuit diagram of the game. Q2,3 collectors connect to the sound effects part of the circuit (Fig.1b). Press PB1 every time LED 11 flashes on to ascend the ladder of LEDs 1—10.

NOTE:
D1–4 ARE 1N4148
Q1 IS BC108
Q2 & 3 ARE BC212L
IC1 IS 555
IC2 IS LM3914N
IC3 IS CD4011B
Tx IS AMBIT PB2720 PIEZO SOUNDER



Construction of the Survival game is relatively straightforward — PCB in one half of the case, LEDs and controls in the other.

Fig.1b. The sound effects generator consists of two gated astable multivibrators. The game just isn't complete without it.



HOW IT WORKS

The basic operating principle of the game is quite simple. IC1 is a low frequency (less than 1 Hz) astable; its output switches alternately between the low (zero) and high (+9 V) states, driving LED 11 on whenever the output is high. The idea of the game is to close PB1 whenever LED 11 is on, thereby causing C4 to slowly charge up via R8, but to ensure that PB1 is open whenever LED 11 is off, thereby preventing C4 from rapidly discharging via R9 and D2. The voltage of C4 is monitored by a LED voltmeter (IC2 and ten LEDs) and the game is won when C4 charges to roughly half supply voltage (LED 10 on). IC3 is used as a sound effects generator and produces a brief tone whenever C4 goes into the discharge mode or a pulsed tone when the game is won.

The operation of the IC1 astable is slightly unusual. Here, C2 alternately charges (LED 11 on) via R1-D1-RV1-R3 in parallel with R2 and discharges (LED 11 off) via R2 only, thereby producing a non-symmetrical output waveform in which LED 11 is on for a shorter period than it is off. The on/off ratio is variable via RV1, which thus acts as a Skill Level control.

The pin 1 ('ground') terminal of IC1 is taken to the 0V line via the base-emitter junction of Q1, shunted by R4 and C3. Whenever C4 is inadvertently discharged by closing PB1 at the wrong time, the capacitor discharges through this junction and turns Q1 on, thereby causing Q2 to turn on and activate the IC3c-IC3d half of the sound-effects generator circuit.

Capacitor C4 charges slowly in the exponential mode via R8 when PB1 is correctly closed and discharges rapidly via R9 and D2 when PB1 is incorrectly closed. The capacitor discharges very slowly via R10 when PB1 is open. The C4 voltage is monitored by LED voltmeter IC2, which drives a line of ten LEDs in the 'dot' mode. The voltmeter is programmed (via R11) to read full scale (LED 10 on) when C4 is charged to approximately half supply volts and is offset by approximately 600 mV via D3. The base-emitter junction of Q3 is wired in series with LED 10, causing Q3 to turn on and activate the IC3a-IC3b half of the sound effects generator when LED 10 turns on (game won).

The sound effects generator is made up of two gated astable multivibrators. IC3c-IC3d act as a fast (1 kHz or so) astable which directly drives a piezo transducer or sounder and is gated on via Q2 collector whenever PB1 is incorrectly closed. IC3a-IC3b act as a slow (a few Hertz) astable which is activated via Q3 collector when LED 10 turns on and pulses the fast astable on and off to produce a distinctive pulsed-tone GAME WON sound.

The entire circuit is powered from a 9 V battery. The circuit typically consumes some 30-40 mA, so this battery needs to be a PP7 or larger size.

PARTS LIST

Resistors all ¼W 5%	
R1,11,14,16	10k
R2	220k
R3	33k
R4	100R
R5,6	4k7
R7	820R
R8	12k
R9	120R
R10	330k
R12	470R
R13	1k2
R15	1M0
R17	68k
Potentiometer	
RV1	470k
Capacitors:	
C1,4	220u electrolytic axial
C2	4u7 electrolytic
C3,5	100n polycarbonate
C6	10n polycarbonate
Semiconductors:	
IC1	NE555
IC2	LM3914
IC3	4011B
Q1	BC108
Q2,3	BC212L
D1-D4	1N4148
LED 1-10	TIL 220 or square LEDs
LED 11	TIL 220 standard red 0.2"

Miscellaneous
PB1 momentary push button
SW1 SPST miniature toggle
B1 PP3
Tx1 transducer (See buylines)
Ceramic resonator
Case (See buylines)

BUYLINES

All components used in the ETI Survival game are common types and should present no problems.

The case for this project can be obtained from OK Machine & Tool Ltd. Phone: 0703-610944. Order as Series HP colour tan.

Ambit International are stockists for the transducer.

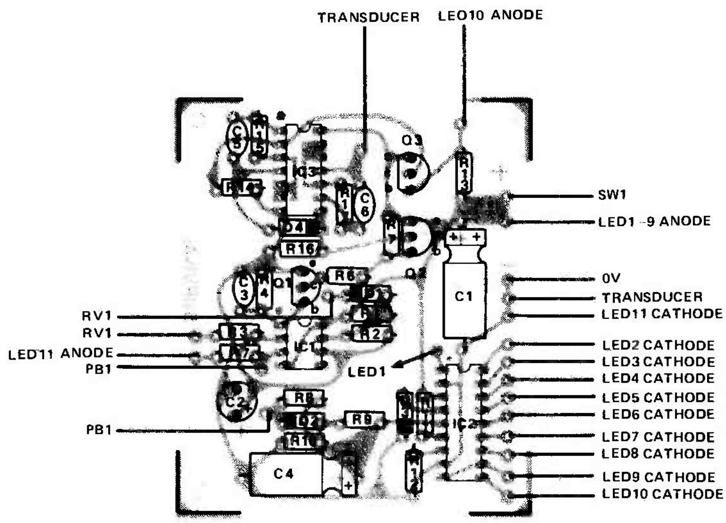


Fig.2. Component overlay. Lots o' LED leads to lace up — there's nothing to it.

ETI

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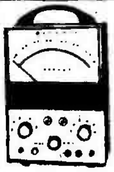
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K003 Polyester capacitors 10 each of these values 0.01, 0.015, 0.022, 0.033, 0.047, 0 068, 0.1, 0 15, 0.22, 0.33, 0 47µ, 110 altogether for **£5.07.**
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ELECTROLYTIC CAPS

2.2/25 R	**.028**	47/63 R	**.045**
2.2/63 A	**.032**	100/6.3 A	**.020**
4 7/10 R	**.022**	100/35 R PC	**.035**
4 7/25R	**.028**	220/16 A	**.055**
4 7/50 R	**.034**	220/25 R	**.065**
10/16 R	**.030**	220/70 A	**.075**
10/25 R	**.032**	330/50 A	**.075**
10/25 R PC	**.022**	330/100 A	**.085**
10/25 A	**.035**	470/16 R	**.060**
10/50 A	**.040**	470/100 RC	**.150**
10/100 R	**.042**	1000/40 A	**.230**
15/40 A	**.030**	1000/63 A	**.280**
22/10 R	**.021**	2200/10 A	**.080**
22/25 A	**.025**	2200/25 A	**.280**
22/25 R	**.027**	2200/40 RC	**.350**
22/63 A	**.040**	3300/10 A	**.090**
33/16 A	**.022**	3300/25 A	**.180**
47/6 A	**.015**	4700/10 A	**.100**
47/25 A	**.032**	4700/25 RC	**.250**
47/35 R	**.038**	4700/40 RC	**.35**
47/40 A	**.045**	10000/15 RC	**.250**

R = radial leads
A = axial leads
RC = tag ended can
R PC = short radial leads for PC mounting

POLYESTER CAPS

01	400V	C296	**.025**
.015	250V	C280	**.025**
022	400V	C280	**.025**
.068	250V	Advance	**.025**
.22	250V	C280	**.035**
22	250V	Advance	**.035**
.22	100V	Minibox	**.035**
.47	250V	C280	**.05**
.47	160V	C296	**.04**
1.0	250V	C280	**.055**
1 5	63V	Filmcap	**.085**
2.2	160V	Filmcap	**.096**
3 3	100V	Wima MKS	**.15**
4.7	100V	C281	**.195**
4.7	100V	Wima MKS	**.235**
6.8	100V	Wima MKS	**.285**

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22pF 125V 5%	**£8**/1000
27pF 125V 5%	**£8**/1000
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1.5/35	**.06**
3.3/25	**.08**
10/25	**.15**

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330pF 2% 100V	**£8**/1000
3300pF 10% 100V	**£13**/1000

Stettner min. ceramics:

330pF 5% 63V	**£7**/1000
022uF 63V	**£14**/1000
Lemco 047uF 63V	**£16**/1000

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741 **.12**, 555 **.19**, 7401 **.08**; 7405 **.09**; 74L74 **.21**; 4001 **.17**; 4011 **.17**, S1 signal diodes like IN4148 by TI on bandoliered reels of 10k **£80** (1k **£10**), IN4002 **£25**/k; IN4006 **£34**/k; IN4007 **£36**/k; Ge signal diode DK14 **£20**/k; SCRs. 2P4M (C106D) 4A 400V **.26**, 2N5060 .8A 30V **.15**; CR201 1A 200V **.18.**

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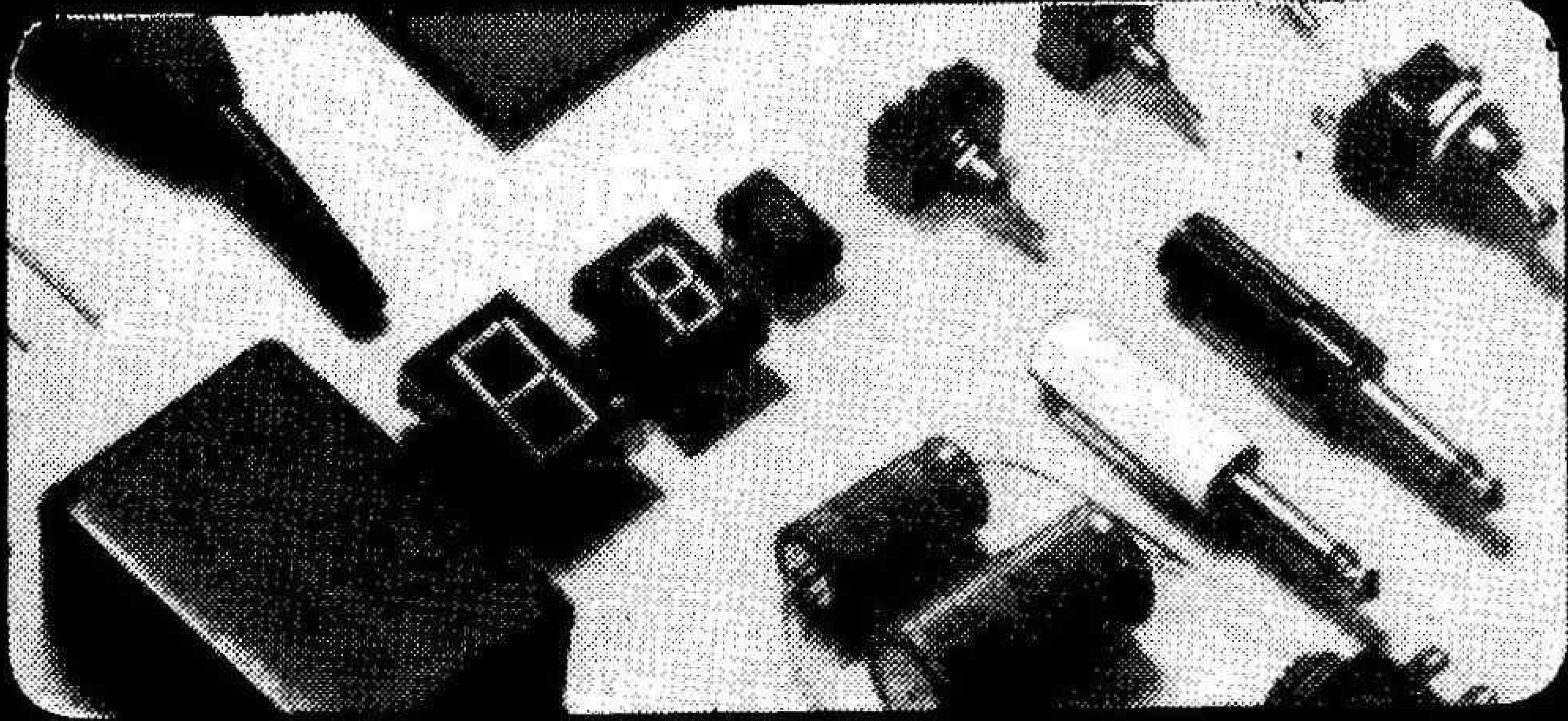

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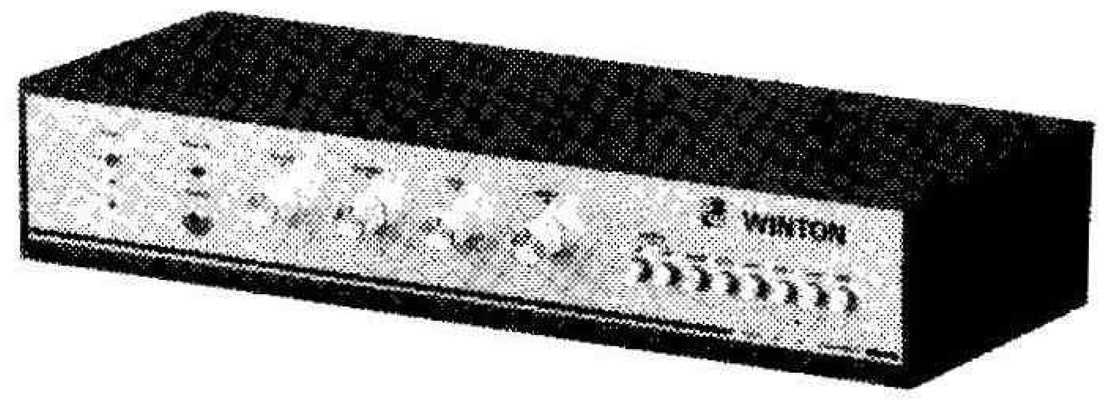

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Clips	3p	3p	

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DL704	0.3in	CC	130p
DL707	0.3in	CA	130p
FND500	0.5in	CA	100p

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				TIP30C	70p
				TIP2955	65p
				TIP3055	60p
				ZTX107	12p
AC127	25p	BC547	8p	ZTX108	12p
AC128	25p	BCY71	18p	ZTX109	12p
AD161	40p	BD131	35p	ZTX300	14p
AD162	40p	BD132	35p	ZTX500	15p
BC107	10p	BD139	35p	2N3053	25p
BC108	10p	BD140	35p	2N3055	55p
BC109	10p	BFX29	25p	2N3702	9p
BC147	9p	BFX84	26p	2N3703	9p
BC178	16p	BFY50	23p	2N3704	9p
BC182	10p	BFY51	23p	2N3819	22p
BC182L	10p	MJ2955	98p	2N3905	10p
BC184	10p	TIP29C	60p	2N5777	50p
BC184L	10p	DIODES			
BC212	10p	1N914	4p	1N4148	3p
BC212L	10p	1N4001	4p	1N4002	5p
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BC214L	10p	BZY88 series 8p each.			

LINEAR

		LM324	52p	MM57160	650p
		LM339	55p	NE531	140p
		LM348	100p	NE555	23p
741	18p	LM377	170p	NE556	60p
747	70p	LM378	230p	NE567	120p
748	40p	LM380	80p	RC4136	100p
7106	850p	LM381	140p	SN76477	230p
CA3046	70p	LM382	120p	TBA800	80p
CA3080	75p	LM386	90p	TBA810	110p
CA3130	100p	LM387	120p	TDA1022	630p
CA3140	60p	LM1458	40p	TL081	45p
LF347	170p	LM1830	180p	TL082	85p
LF351	45p	LM3900	60p	TL084	125p
LF353	90p	LM3909	72p	XR2206	390p
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		4026	150p	4081	30p
		4027	50p	4082	30p
		4028	90p	4085	85p
4001	25p	4029	110p	4093	80p
4002	25p	4040	110p	4095	110p
4006	95p	4042	85p	4510	90p
4007	25p	4046	110p	4511	100p
4011	30p	4048	60p	4518	90p
4013	45p	4049	50p	4520	110p
4015	85p	4050	50p	4527	165p
4016	48p	4052	80p	4528	100p
4017	80p	4060	120p	4532	125p
4018	90p	4066	63p	4543	170p
4020	110p	4068	25p	4583	80p
4022	100p	4069	25p	4585	115p
4023	25p	4070	25p		
4024	60p	4071	25p		

SKTS

Low Profile Texas

8 pin	9p	22pin	20p
14pin	11p	24pin	22p
16pin	12p	28pin	26p
18pin	16p	40pin	38p
20pin	18p		

SWITCHES

TOGGLE					
	Standard	SPST	40p	DPDT	55p
	Miniature	SPDT	80p	DPDT	90p
	Subminiature	SPST	65p	DPDT	85p

SLIDE Standard DPDT 17p. Miniature 16p each.
PUSH Push to make 16p. Push to break 22p.

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		7448	65p	74125	60p
		7472	35p	74126	60p
		7473	38p	74132	70p
7400	15p	7474	36p	74141	95p
7401	15p	7475	40p	74145	90p
7402	15p	7476	40p	74150	120p
7404	16p	7483	80p	74154	110p
7406	38p	7485	80p	74157	80p
7408	22p	7486	35p	74164	120p
7410	18p	7490	45p	74165	120p
7413	35p	7492	55p	74174	100p
7414	56p	7493	45p	74175	95p
7420	16p	7494	70p	74190	100p
7427	30p	7495	70p	74191	100p
7430	30p	7496	70p	74192	100p
7432	35p	74121	45p	74196	100p

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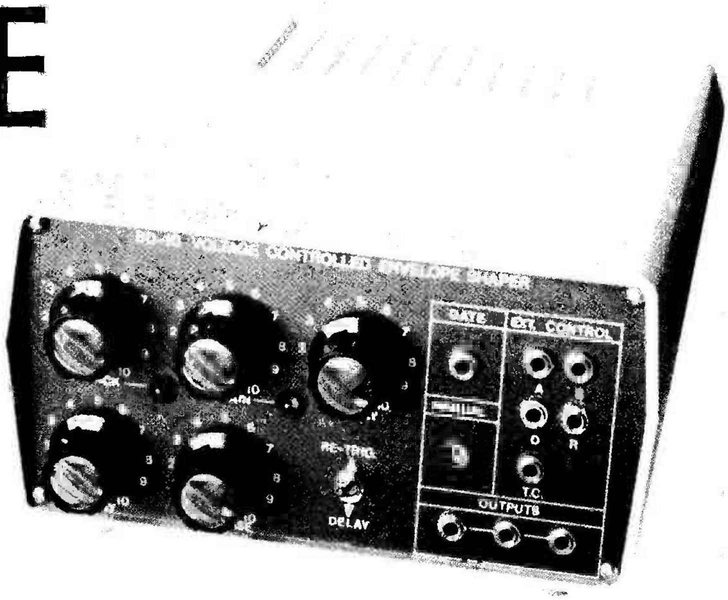
ENVELOPE SHAPER

Is it Mantovani or a Project 80 synthesiser? You can't tell the difference with this VCES designed by R.C. Blakey



Conventional ADSR envelope generators are adequate for most practical purposes since they are capable of providing a reasonable simulation of the amplitude envelopes of many musical instruments. The Project 80 Voltage Controlled Envelope Shaper (VCES) is provided for those who wish to obtain more realistic simulation or to obtain dynamic control over envelope shape. It is also a useful tool for innovative synthesis. The design incorporates the following features; bending of the standard exponential attack, decay and release curves to other shapes; alteration of attack, decay and release times by an external voltage thus allowing the envelope to be altered in proportion to the note played; the use of non linear sustain; built-in timer for re-triggering to create dual peak envelopes and also the generation of a delayed AD envelope.

Design and Application

The VCES is based on the CEM 3310 Voltage Controlled Envelope Generator produced by Curtis Electromusic Specialties. While it is well suited for use as a conventional ADSR envelope generator for both monophonic and polyphonic synthesisers the facilities provided on chip also make it ideal for configuring a complex envelope generator. The attack (A), decay (D), and release (R) parameters have a scale sensivity of 60 mV/decade (18 mV/octave) while sustain level (S) is linearly proportional to the voltage applied to pin 9. To facilitate generation of complex shapes each of the four inputs has been buffered by an op amp configured as a summer and our standard 0 to +10 V control voltages allow the A,D and R times to be varied from 2 mS to greater than 20 S. Likewise for the sustain input a voltage of 0 to +10 V varies the sustain level from 0 to 100% of the peak attack voltage which has also been normalised to +10 V.

The A, D and R responses follow an exponential curve. These characteristic curves may easily be altered in this design by taking a proportion of the output from the module and feeding it back to the appropriate input for the attack curve. The greater the amount of feedback the more convex the response and, although the overall time constant will increase, this may be adjusted over a wide range with the manual control provided. If the output is inverted prior to feedback then the attack curve will become concave in shape. Some of these curves are closer approximations to conventional instruments while others offer some novel responses. The shape of the decay curve, or the release curve, may be similarly altered and thus the VCES offers virtually unlimited scope for generation of envelope shapes. The use of low frequency waveforms to modify the time constants is also practical but setting up to obtain useful results is quite time consuming. Two attenuators, with or without inversion, are provided and the 80-5 Processor module may be used for distribution and attenuation when more complex patching is required.

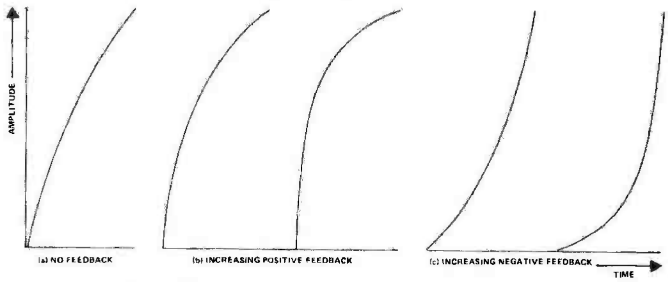


Fig.1. The effect of feedback on the attack response.

Tremolo

The sustain level also has provision for external control and one application is to apply a low frequency waveform to this input in combination with an attenuator and perhaps the manual control to produce a varying sustain. If this envelope is now used to control a VCA the effect is a tremelo only during the sustain part of the note. In the design both the upper and lower levels of the sustain control have been clamped for protection.

Another application for voltage control of envelope shape is the automatic alteration of the time constants or sustain level while the instrument is being played.

Time and Time Again

A simple timer has been incorporated in the design which allows re-triggering, or initial trigger delay, for periods up to about 2.5 S. The effect of re-triggering is to produce an envelope with two peaks, which is a transient effect exhibited by a number of conventional instruments. Often, however, as such instruments reach their peak output the

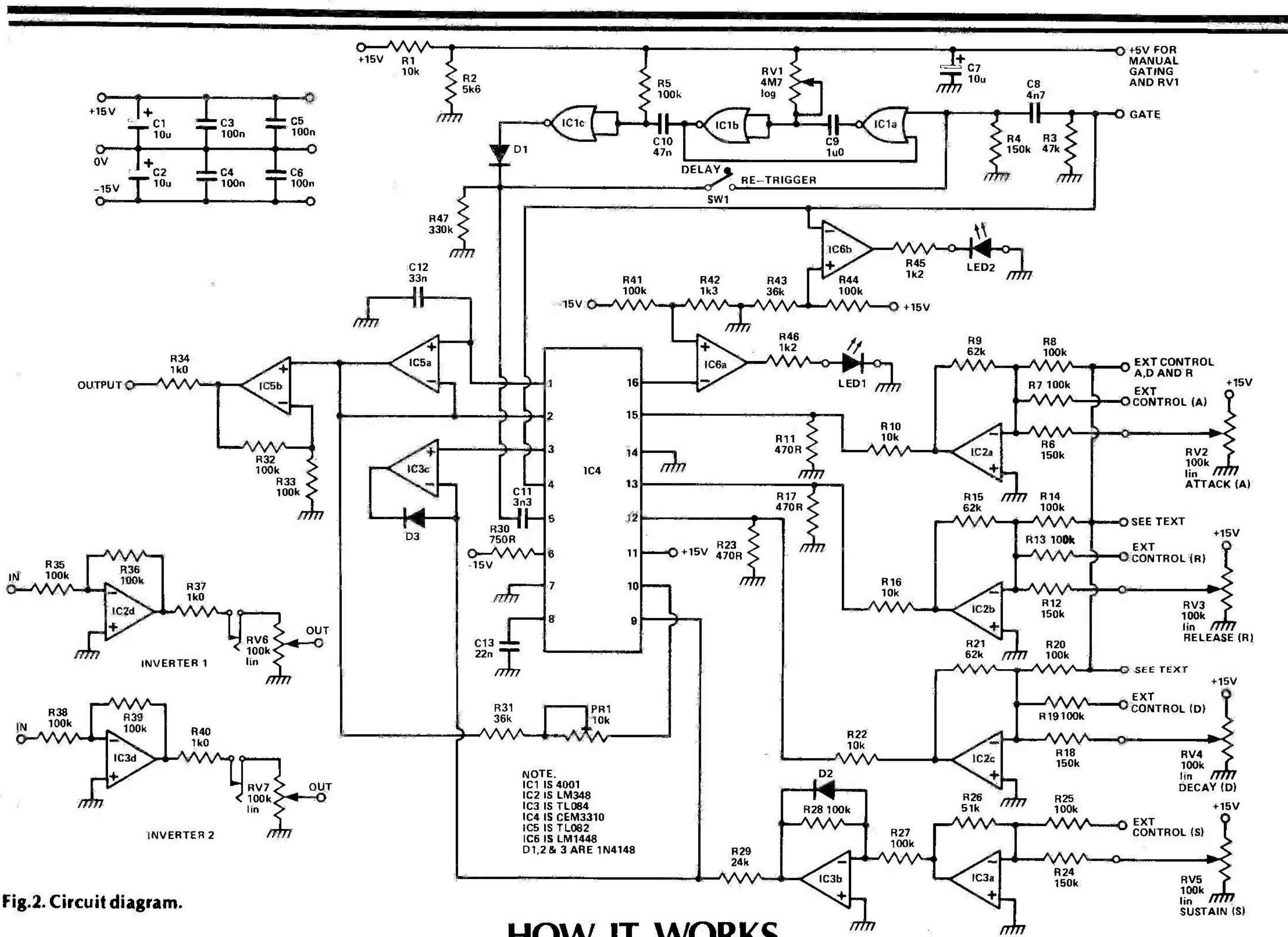


Fig.2. Circuit diagram.

HOW IT WORKS

The attack, decay and release control inputs (pins 15, 12 and 13 respectively) have a control sensitivity of 18 mV/octave and a 10k/470R attenuating network is place ahead of these inputs. The time constants of the attack, decay and release curves are determined by RxCx times the exponential multiplier, exp. $(-V_C/V_T)$; where Rx is R31 plus part of PR1; $C_X = C12$; $V_C =$ the control voltage at the appropriate pin; and $V_T = kT/q$. The values of Rx and Cx have been chosen to minimise errors and to retain the very low voltage feedthrough which is a feature of the CEM 3310. With the values used an increasing negative voltage at the 10k/470R attenuator will increase the time constant and a voltage from 0 to about $-5V6$ will give a range of 2 mS to 20 S for each time control input. To obtain both external and manual control of the time constants an inverting summer with a nominal gain of 0.62 has been placed ahead of the attenuating resistors; in the case of the attack control, using IC2a and associated resistors R6 to R9 ahead of attenuator R10/R11. Thus increasing positive voltages up to $+10$ V will now give the same control range. R7,8 are for external control voltages while RV2 via R6 provides manual control over the same range. R8 is connected with R14 (release control) and R20 (decay control) such that an external voltage applied to R8 will simultaneously change all three time constants.

Sustain level on the CEM 3310 is determined by the voltage at pin 9 and a voltage from 0 to $+5$ V will change the sustain level from 0 to 100% of the peak attack voltage. To obtain both manual and external control of sustain and retain the control polarity this input is preceded by IC3a and IC3b configured as two inverting summers with an overall gain of 0.5. Thus 0 to $+10$ V at R25 will produce the 0 to 100% sustain level control. Manual control is obtained with RV5 and R24. If the sustain voltage were to exceed the peak attack to 100% sustain level control. Manual control is obtained with RV5 and R24. If the sustain voltage were to exceed the peak attack voltage then the envelope will ramp up to this higher voltage level with undesirable results. Pin 3 of the CEM 3310 outputs the peak attack voltage and so the sustain level and pin 3 are connected to IC3c arranged as a precision peak follower to prevent the aforementioned situation.

The output buffer within the CEM 3310 (pin 2) has adequate drive capability for most applications but in this design it may be used to drive several inputs and overloading of the buffer will result in a loss of performance. The internal buffer has been by-passed by IC5a and the output increased to the Project 80 standard of $+10$ V by a non inverting amplifier, IC5b, which has a gain of two.

The attack output pin (pin 2) provides a voltage of between $-$ 0V4 and $-$1V2 only during the attack phase to provide a visual indication of the attack phase using LED 1. Pin 16 is connected to IC6a arranged as a comparator. IC6b is also a comparator and will turn on LED 2 when a gate voltage is present.

The CEM 3310 requires both gate and trigger pulses to generate an ADSR envelope. The 80-10 module is designed to operate with a gate voltage of $+5$ V and the trigger is generated by differentiating the gate pulse using C8 and R4 which is then applied to pin 5 via C11 (SW1 closed). To obtain the re-triggering and delay facilities IC1a and IC1b are used to form a monostable. The time delay is determined by the charging time of C9 via RV1 and when the voltage on C9 exceeds the threshold voltage of IC1b its output will go low and reset the monostable. IC1c is used to generate a second trigger pulse whose short duration is determined by the time required to charge up C10, to the threshold voltage level, via R5. With SW1 closed two trigger pulses are therefore generated when RV1 provides sufficient resistance to produce a noticeable delay. With SW1 open only the delayed trigger pulse is presented to pin 5 of IC4, which will allow it to operate in an AD mode.

To operate the CEM 3310 from $\pm$ 15 V supplies it is necessary to place a series current limiting resistor on the negative supply line to pin 6. The value of R20 has been chosen to comply with the general equation $R_{EE} = (V_{EE} - 7.2)/0.010$. For the timer a nominal $+5$ V is derived from the voltage divider formed by R1,2 since power supply to IC1 is not critical. These latter components may be changed to suit other gate voltages.

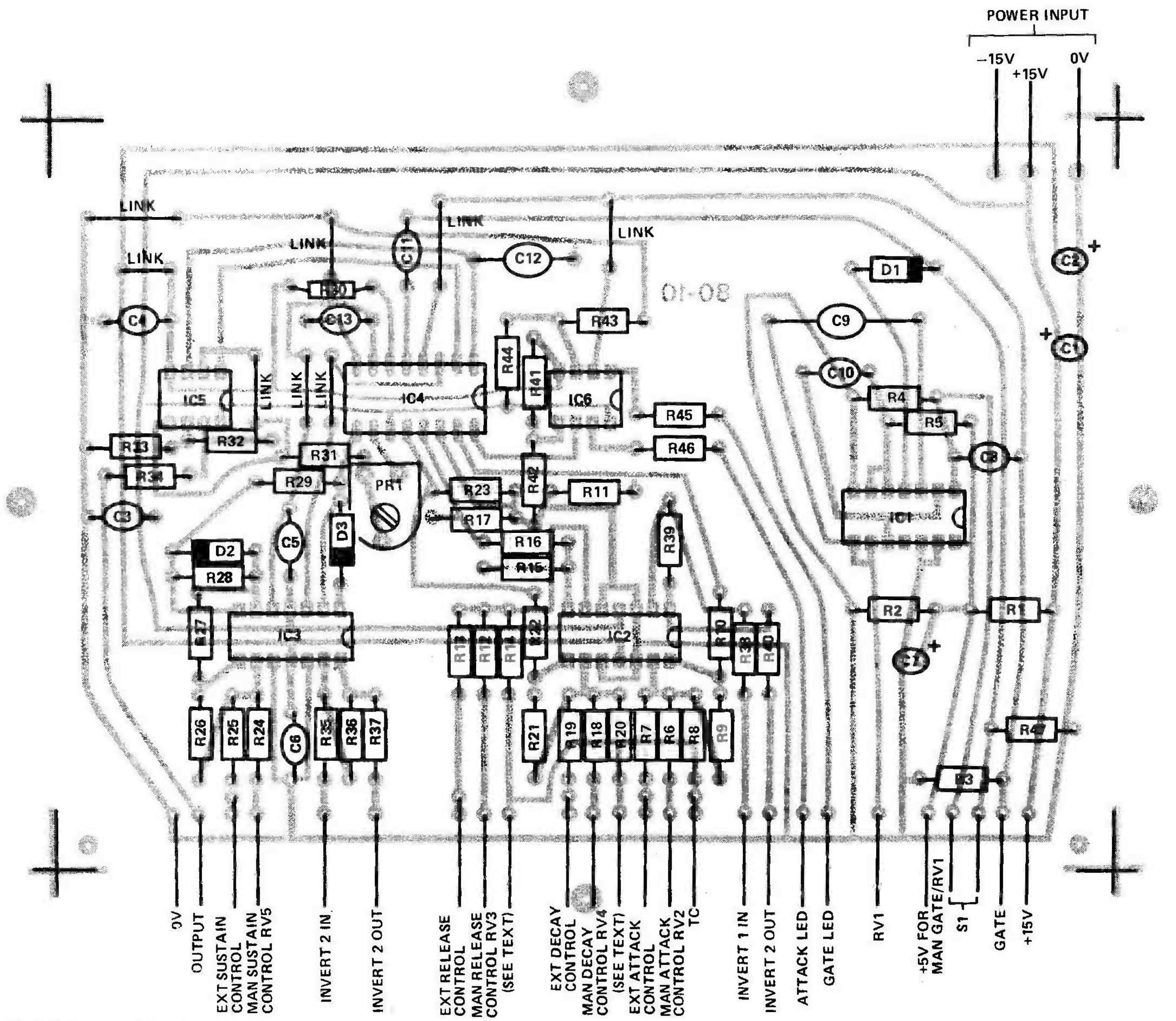


Fig.3. Component overlay

PARTS LIST

Resistors, ¼w, 5% carbon film unless specified.

R1	10k
R2	5k6
R3	47k
R4,6,12,18,24	150k
R5,7,8,13,14,19,20,25,27,28,32,33,35,36,38,39,41,44	100k
R9,15,21	62k
R10,16,22	10k 1% metal film
R11,17,23	470R 1% metal film
R26	51k
R29	24k
R30	750R
R31,43	36k
R34,37,40	1k0
R42	1k3
R45,46	1k2
R47	330k

Potentiometers

PR1	10k carbon
RV1	4M7 logarithmic
RV2,3,4,5,6,7	100k linear

Capacitors

C1,2,7	10u 25 V PCB electrolytic
C3,4,5,6	100n polyester
C8	4n7 polycarbonate
C9	1u0 polyester
C10	47n polyester
C11	3n3 polycarbonate
C12	33n polycarbonate
C13	22n polyester

Semiconductors

IC1	4001B
IC2	LM248N
IC3	TL084CP
IC4	CEM3310
IC5	TL082CP
IC6	LM1458N
D1,2,3	1N4148
LED 1	Red LED
LED 2	Green LED

Miscellaneous

SW1	SPST sub-miniature toggle switch
PCB, case, etc.	

sound alters due to the presence of noise and complex waveforms in the transient. A better simulation of this effect is obtained by using two envelope generators, two sound sources, a dual VCA and mixing the outputs from the latter together. In this example the VCES timer is in the delay mode and will initiate an AD envelope when the trigger occurs. It should be noted that only AD envelopes are practical in the delay mode since if the sustain level is above zero the voltage will ramp up to the set level when the gate pulse is received.

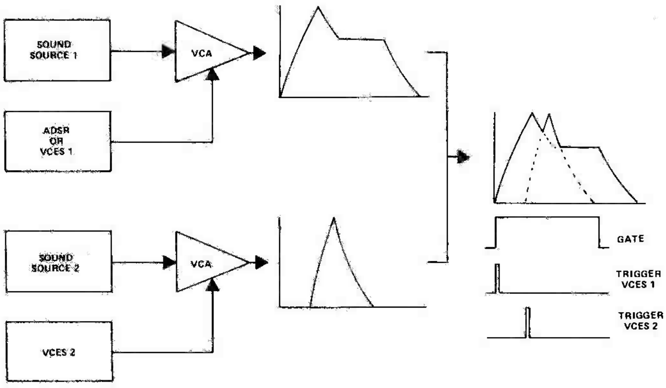


Fig.4. Patch for obtaining realistic transient effects.

Construction

In common with other Project 80 modules the Voltage Controlled Envelope Shaper may be panel mounted or installed in a Teka Alba A23G case. The latter, however, does not have sufficient panel area to neatly accommodate all of the facilities provided. In the cased module illustrated we have omitted the two inverters and controls RV6 and RV7.

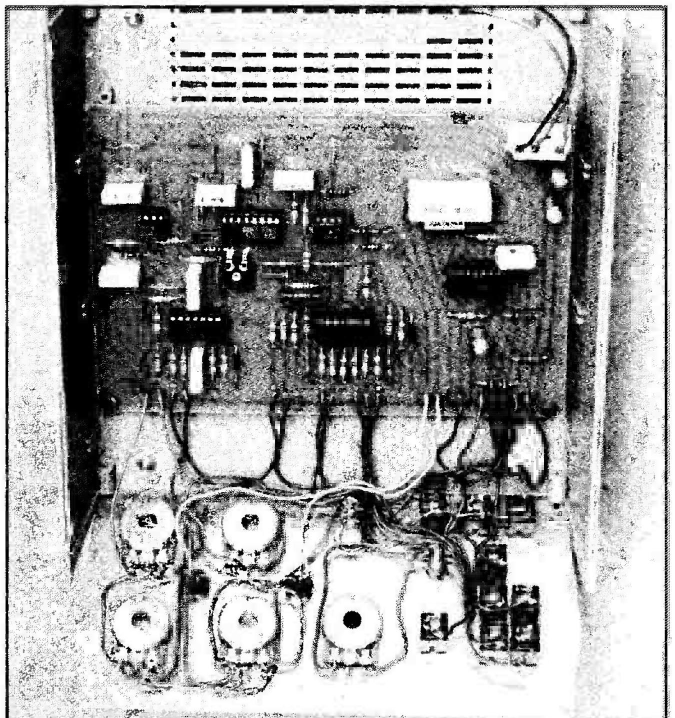
The panel markings for the inverters are −, + and A1 (or A2) with the latter being associated with the attenuating potentiometer RV6 (or RV7). Taking Inverter 1 as the example: R35 is wired to the jack socket marked − at the connection which makes contact with the jack plug; the output of the inverter (R37) is wired to the jack socket marked + but to the connection disabled when a jack plug is inserted, whereas the other connection on this socket is wired to RV6; finally the wiper of RV6 is wired to the make connection on the A1 jack socket. This allows a jack plug into the − socket to access the inverter and the output is obtained at A1, with attenuation when required. For non-inverted voltages which require attenuation these are obtained via the + socket with the output at A1.

One external control of attack, decay and release times is commoned and accessed on the PCB at R8. This allows all three time constants to be altered simultaneously and is connected to jack socket marked TC, denoting time constants. If required, however, the constructor may obtain two independent controls for each time constant by cutting the PCB tracks that join up the inputs of R8, R14 and R20. PCB connections are provided at R14 and R20 to cater for this modification.

The module may be manually gated by connecting a push-to-make switch from the +5 V line to the gate input.

Calibration and Testing

The attack, decay and release manual controls are numbered 0-10 for reference purposes since once external voltages are applied a time calibration becomes meaningless.



Tackle the control wiring methodically, otherwise you're in for a case of the wiring jungles.

PR1 allows more than one module to have the same time constants for a given input voltage. For precise calibration a triggered timing device is required but in most instances the following technique is adequate. Set PR1 to mid-position and connect a voltmeter between ground and the junction of R6 and R9. Turn RV2 until a voltage of −5V6 is obtained. Set all other control pots to zero. Gate the module manually and time the attack time as shown by the attack LED being on. The manual push button is held down until the LED goes off. Gate the unit several times to allow all components to stabilise for this long attack time and then commence adjusting PR1 to give an attack time of 20 S.

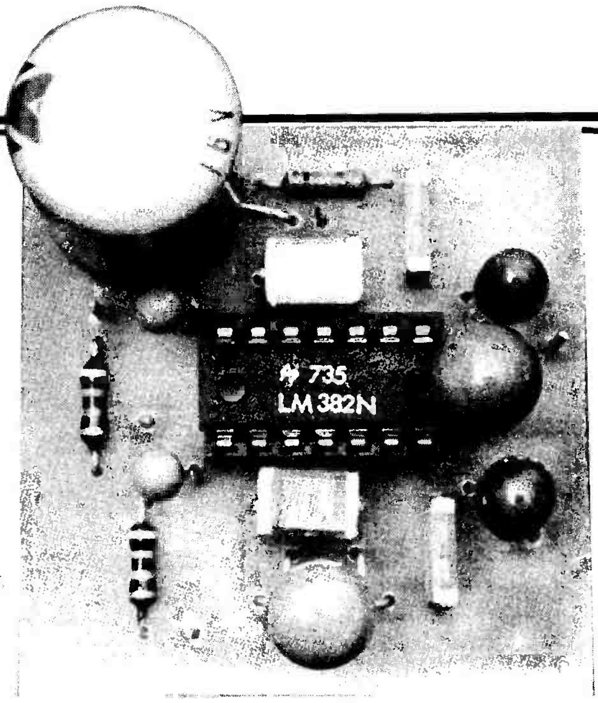
Note that the gate LED is only on while the manual button is depressed. Next set the attack time for a short duration, switch to re-trigger mode, turn RV1 fully clockwise and manually gate the module and keep push button held down until the test is complete. The attack LED should come on when the button is first depressed and again about 2.5 S later when the unit re-triggers. Keep settings the same but put the switch into delay mode. In this test the attack LED should come on about 2.5 S after manually gating the unit. Finally connect the output to a VCO which is in turn connected to an audio amplifier and set the attack, decay, sustain and release controls to about mid-position. Gate the module and release the push-button when a steady note is obtained. The test is a simple means of checking that the A,D,S and R functions are all operational. The functioning of the inverters may also be checked in the same way by putting the output from the VCES through the inverters without attenuation prior to the VCO. In this test the envelope will be inverted, that is, the frequency starting high, decreasing, holding steady and then finally going high again.

BUYLINES

An 80-10 Voltage Controlled Envelope Shaper module kit (PCB plus components) is available for the inclusive price of £19.20 from Digisound Limited, 13 The Brooklands, Wrea Green, Preston, Lancs. PR4 2NQ.

ETI

RIAA PREAMP



Fit a magnetic cartridge to your stereo system with our economical pre-amp design

Ceramic or crystal cartridges have found wide application in lo to mid-fi stereo systems. Manufacturers like them because they are cheap. As they have a high output level (100mV-2V) no preamp is required enabling a simple and economical system to be readily assembled. Of course, the disadvantage is that the quality of reproduction reflects the cost.

The next step up the hi-fi ladder is the use of a magnetic cartridge. However, you cannot simply plug one in. Magnetic cartridges have a comparatively low output level and their playback response coupled with all the jiggery-pokery that goes into the manufacture of a record results in a very squeaky sound.

Stylish Motion

Ceramic and magnetic cartridges are distinguished by their different responses to the movement of the stylus as it follows the fluctuations of the groove. A ceramic transducer produces an output proportional to the deflection amplitude of the stylus, whereas the output of a magnetic cartridge reflects the rate of change (velocity) of the stylus. Recordings could be made in either a constant velocity or constant amplitude (against frequency) mode. Each has its advantages. In fact a combination of the two is used in an attempt to get the best of both worlds and a standard was set out by the Record Industry Association of America (RIAA — get it?).

Ideal Response

Our graph show the RIAA playback equalisation curves with the ideal response shown dotted and what you actually get indicated with a solid line. With a 0 dB freference at 1 kHz, it can be seen that the response ranges over nearly +20 dB between 20 Hz and 20 kHz, a scale of 100 to 1. The high gain at low frequencies means that care must be taken to avoid mains hum pick up and screened connecting cables are essential.

Two into One

The preamp and equalisation are neatly combined in one circuit. Our design utilises a single chip from National which features dual amplifiers with an internal resistor matrix. Use of the internal resistors enables an RIAA response to be achieved with just a few components. The unit exhibits a gain of 46 dB (200) at the 0 dB reference frequency of 1 kHz and may be powered from any 10-14V supply. Current consumption is around 16 mA maximum.

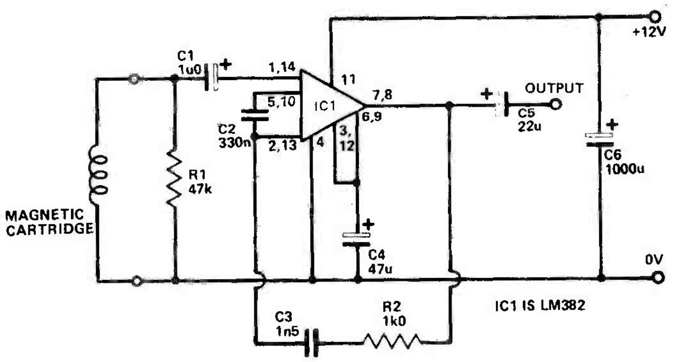


Fig.1. Circuit diagram.

HOW IT WORKS

The desired RIAA frequency response is achieved through the use of a resistor-capacitor network in the feedback loop of an op-amp. Use of an internal resistor matrix in the LM382 chip enables a very simple practical circuit to be used. The circuit is absolutely conventional. A 12 V supply was chosen as the LM382 is characterised for operation in automobiles and its output is biased to 6 V.

The circuit offers a gain of 46 dB (200x) at the RIAA 0 dB reference frequency of 1 kHz. As the output of a typical magnetic cartridge is in the range 2-7 mV, this should result in a preamp output of around 1 V, an ideal level for the 'line' input of most amps. A 47k resistor at the input provides the standard cartridge load and a single 1,000 uF capacitor is used for overall supply decoupling.

Note that the integrated circuit pins are identified for the left and right channels with pairs of numbers on the circuit diagram. Also that all components except IC1 and C6 are duplicated on the component overlay.

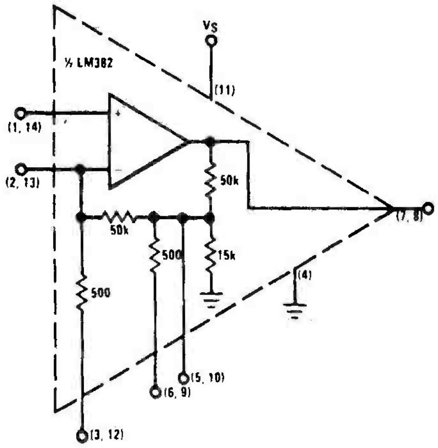


Fig.2. Internal structure of the LM382.

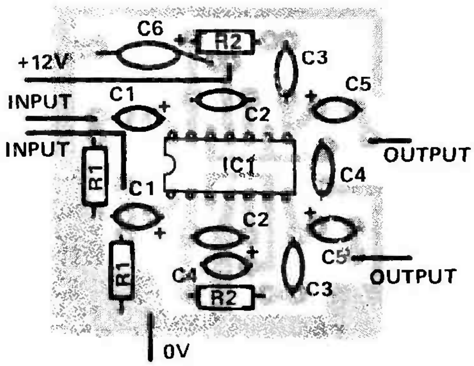
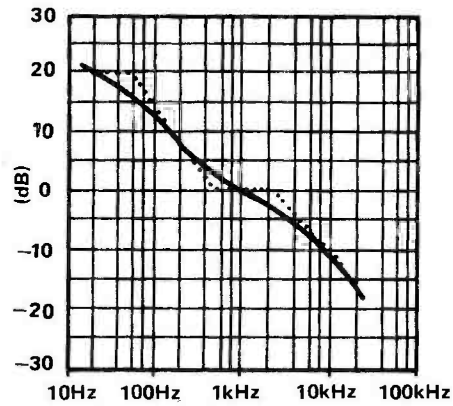


Fig.3.(left) Component overlay.
Fig.4.(below) RIAA playback equalisation curve.



PARTS LIST

Resistors	
R1	47k
R2	1k0
Capacitors	
C1	1u0 tantalum
C2	330n polyester
C3	1n5 polyester
C4	47u tantalum
C5	22u tantalum
C6	1000u electrolytic
Semiconductor	
IC1	LM382

BUYLINES

No problems here. All the components should be readily available from your usual suppliers.

The LM382 can be obtained from Watford Electronics & Delta Tech and Co.

Construction

Use of a printed circuit board is recommended for this project. If you use another method of construction, ensure that connecting leads are kept short and locate the decoupling capacitor close to the supply pins of the integrated circuit. The unit may be assembled into a metal case for good screening. Once assembled, just connect your cartridge to the inputs and connect the outputs to your amp, either directly to the 'line' input or via the passive tone controls if you have them. Then put on your favourite disc and relax and enjoy it.

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